Embedded Energy in Water Pilot Programs Impact Evaluation

Appendices

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Acknowledgements

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Appendices

Appendix 1: Water Agencies Appendix

1.1 Potable Water, Wastewater and Recycled Water Utility Survey Instruments

Water and Wastewater Utilities Data Collection Instrument

Water Agency:
Contact Name:
Contact Phone:
Contact Email:
Interviewer:
Date:

Water Treatment System Questionnaire

INTRO

We are developing data to quantify the amount of energy utilized in the water supply and wastewater treatment systems. The purpose of developing this information is to help prioritize energy and water conservation programs. This part of the project is focused on the energy in water supply, specifically energy purchased from [PG&E, SDG&E, SCE].

For the Pilot program we are studying, we have participating customers in your service area. The data requested will relate specifically for water supplied and treated in these areas.

1. **Water System Design Overview**
   Please provide copies of system diagrams, if available, that describe (a) the agency's overall systems and processes and how they are interconnected; and (b) metering points and energy requirements for each major system and/or process.

   If diagrams are not available, please describe the water supply system. Specific information needed includes the following:

   - Sources of water:
   - Conveyance system (# and location of pumps):
   - Treatment facilities (number and location):
   - Storage facilities (location and capacity):
   - Distribution facilities (# and location of pumps):

   Describe water storage (if applicable) for treated and raw water:

   - Storage for Treated Water: Capacity:
   - Storage for Raw Water: Capacity:

Describe generally how the water system is operated:

SOURCE WATER

2. Water
Identify current water sources.

Please provide water flow data for 2008 for each water source at the most detailed level available (hourly, daily, monthly, or annually).

3. Energy
Provide the most detailed level of electric and gas use data available, i.e., hourly, daily or monthly, for each source water facility described above for 2008. (Exclude non water-related energy, i.e., the energy used to power lights, etc.)

Identify the energy sources for each source water facility (i.e., self-generated, IOU, Energy Service Provider):

- If more than one energy source is used for a particular facility, provide the fraction that each energy source provides.

WATER CONVEYANCE SYSTEM (SOURCE TO TREATMENT)

4. Water
Provide the most detailed level (hourly, daily, monthly) of water flow data for each pump station for the conveyance system for 2008.

5. Energy
Provide the most detailed level (hourly, daily, monthly) electric and gas use data for each pump station for the conveyance system for 2008.

Identify energy sources for the Water Conveyance System, i.e., self-generated, IOU, or ESP.

- Energy Source(s):
- If more than one energy source is used for a particular facility, provide the fraction that each energy source provides.

Is the conveyance system also used to generate hydroelectric power? Y / N

- If so, describe where in the system this generation occurs.
- Describe by what means this generation occurs.

How much daily/monthly/annual energy is produced by the system?

- Daily:

- Monthly:
- Annual:

Who are the users of this energy?

WATER TREATMENT FACILITIES (FROM RAW WATER SOURCES TO DISTRIBUTIONS SYSTEM)

6. Water
Provide the most detailed level (hourly, daily or monthly) of water flow data for each treatment plant for 2008.

7. Energy
Provide the most detailed level (hourly, daily or monthly) electric and gas use for each treatment plant for 2008.

Identify energy sources for the Water Treatment Facilities, i.e., self-generated, IOU, or ESP.

- Energy Source(s):
- If more than one energy source is used for a particular source, provide the fraction that each energy source provides.

WATER DISTRIBUTION SYSTEM (FROM TREATMENT PLANT TO THE CUSTOMER)

8. Water
Provide the most detailed level of water flow data for each pump station in the distribution system for the measure site for 2008.

Provide a list of all treated water storage reservoirs in your system. Include the following information:

- Name
- Capacity (MG)

9. Energy
Provide the most detailed level of electric and gas use data for each pump station in the distribution system for the measure site for 2008. (Exclude non water-related energy use, e.g., energy to power lights, etc.)

Identify energy sources for each pump station, i.e., self-generated, IOU, or ESP.

- If more than one energy source is used for the water treatment system, provide the fraction that each energy source provides.

Wastewater Treatment System Questionnaire

We are developing data to quantify the amount of energy utilized in the water supply and wastewater treatment systems. The purpose of developing this information is to help prioritize energy and water conservation programs. This part of the project is focused on energy use in wastewater treatment, specifically purchased from PG&E, SDG&E, and SCE.

For the Pilot program we are studying, we have participating customers in your service area. The data requested will relate specifically for water supplied and treated in these areas.

1. **Overview**

Provide a general overview of the wastewater treatment system and how it is operated.

Is there storage of wastewater before treatment? Y / N

- If so, what is its capacity and how is it operated?

Describe how storm flows are handled.

WASTEWATER COLLECTION SYSTEM

2. **Wastewater**

Provide the most detailed level (hourly, daily, monthly) of wastewater flow data for 2008 for each pump station between the pilot site and the wastewater treatment facility.

3. **Energy**

Provide the most detailed level (hourly, daily, monthly) of electric and gas use data for 2008 for each of the above pump stations. (Exclude non water-related energy use, e.g., energy to power lights, etc.)

Identify energy sources for the Wastewater Collection System, i.e., self-generated, IOU, or ESP.

- Energy Source(s):
- If more than one energy source is used for the water treatment system, provide the fraction that each energy source provides.

WASTEWATER TREATMENT FACILITY

4. **Wastewater**

Provide the most detailed level (hourly, daily, monthly) of data available regarding wastewater flow for the wastewater treatment facility for 2008.

5. **Energy**

Provide the most detailed level (hourly, daily, monthly) of data available regarding electric and gas utility bills for each wastewater treatment facility for 2008. (Exclude non water-related energy use, e.g., energy to power lights, etc.)

Identify energy sources for the Wastewater Treatment Plant, i.e., self-generated, IOU, or ESP.

- Energy source(s):
- If more than one energy source is used for the plant, provide the fraction that each energy source provides.

OFF-SITE PUMPING, SUCH AS EFFLUENT DISCHARGE PUMPING

6. **Wastewater**

Provide the most detailed level (hourly, daily, monthly) of data available regarding wastewater flow data available for 2008 for each pump station.

7. **Energy**

Provide the most detailed level (hourly, daily, monthly) electric and gas use for 2008 for each pump station associated with wastewater discharge.

Identify energy sources for the Wastewater Discharge System, i.e., self-generated, IOU, or ESP.

- Energy source(s):
- If more than one energy source is used for the water treatment system, provide the fraction that each energy source provides.

Recycled Water Data Collection Instrument

Agency:
Contact Name:
Contact Phone:
Contact Email:
Interviewer:
Date:

Recycled Water Questionnaire

INTRO

We are developing data to quantify the amount of energy utilized in producing recycled water. The purpose of developing this information is to help prioritize energy and water conservation programs. For the Pilot program we are studying, we have participating customers in your service area. This part of the project is focused on the energy in water supply, specifically energy purchased from [PG&E, SDG&E, SCE].

1. **Water System Design Overview**

Please provide copies of system diagrams, if available, that describe (a) the recycled water facility and how it is interconnected with the rest of the system; and (b) metering points and energy requirements for each major system and/or process.

Provide a general overview of the wastewater and recycled water treatment systems and how they are operated.

Is there storage of wastewater before treatment? Y / N

- If so, what is its capacity and how is it operated?

Describe how storm flows are handled.

Describe generally how the recycled water system is operated:

WASTEWATER AND RECYCLED WATER TREATMENT FACILITIES

We are interested in the additional energy required to treat wastewater so that it can be used in recycled water applications. In order to do this, we will need to collect data on wastewater that is treated for recycled water applications and wastewater that is treated and discharged to a sewer outfall.

2. **Water**

Provide the most detailed level (hourly, daily or monthly) of wastewater flow data for the wastewater treatment plant for 2008. In addition, please provide detailed flow data on wastewater that is treated to recycled water standards.

3. **Energy**
Provide the most detailed level (hourly, time-of-use, daily or monthly) electric and gas use for the wastewater treatment plant for 2008. If possible, please provide detailed electric and gas use associated with the production of recycled water. Recall that we are only interested in electricity and gas purchased from PG&E, SDG&E, and SCE. *Please also provide the account numbers and meter numbers for this energy use.*

Identify energy sources for the wastewater and recycled water treatment system, i.e., self-generated, IOU, or ESP.

- Energy source(s):
- If more than one energy source is used for the water treatment system, provide the fraction that each energy source provides.

EFFLUENT DISCHARGE PUMPING SYSTEM (FROM WW TREATMENT PLANT TO THE OUTFALL)

8. **Treated Wastewater**

Provide the most detailed water flow data (hourly, daily, monthly) for each pump station associated with wastewater discharge for 2008. These data should only included treated wastewater that is discharged to a sewer outfall (should not include recycled water).

9. **Energy**
Provide the most detailed level (hourly, time-of-use, daily, monthly) electric and gas use for 2008 for each pump station associated with wastewater discharge. These data should not include energy used to distribute recycled water. *Please also provide the account numbers and meter numbers for this energy use.*

Identify energy sources for the wastewater discharge system, i.e., self-generated, IOU, or ESP.

- Energy source(s):
- If more than one energy source is used for the water treatment system, provide the fraction that each energy source provides.

RECYCLED WATER DISTRIBUTION SYSTEM (FROM WW TREATMENT PLANT TO THE CUSTOMER)

1. **Water**
Provide the most detailed level (hourly, daily, monthly) of water flow data for each pump station for the recycled water conveyance system for 2008.

2. **Energy**
Provide the most detailed level (hourly, time-of-use, daily, monthly) electric and gas use data for each pump station for the recycled water conveyance system for 2008. *Please also provide the account numbers and meter numbers for this energy use.*

Identify energy sources for the recycled water conveyance system, i.e., self-generated, IOU, or ESP.

- Energy Source(s):
- If more than one energy source is used for a particular facility, provide the fraction that each energy source provides.

Is the conveyance system also used to generate hydroelectric power? Y / N

- If so, describe where in the system this generation occurs.
- Describe by what means this generation occurs.
-

How much daily/monthly/annual energy is produced by the system?

- Daily:
- Monthly:
- Annual:

Who are the users of this energy?

1.2 Water Agency Descriptions and Energy Intensity

Sonoma County Water Agency

The Sonoma County Water Agency (SCWA) is a retail and wholesale water service provider. SCWA provides water directly to customers in the City of Sonoma. It also provides water to nine cities and districts, including the cities of Santa Rosa, Rohnert Park, Cotati, Petaluma, and Marin, which deliver water to 600,000 residents.

SCWA obtains water from two primary sources. A river diversion system (inflatable dam) diverts water from the Russian River into infiltration ponds. Water from these ponds then percolates and filters through the ground and is pumped by six Raney collectors. Water is not pulled from underneath the Russian River but actually from beneath these ponds. The Raney collectors are segmented into two sections: Mirabel and Wohler. Each section contains 3 Raney collectors and one chlorination plant. Water from the Mirabel facility goes to Petaluma and though the Kastiana pumps to Marin. The Wohler facility mainly serves Santa Rosa and Sonoma, though there is an intertie that serves Petaulma and Marin as well. Wohler and Mirabel have an emergency intertie between the two systems near the Russian River. If one set of pumps are down, the other can provide water to meet demand. SCWA supplements water from the Russian River with 3 major groundwater pumps on the Mirabel side of the water system that produce around 1.5 million gallons per day (MGD).

Potable water is distributed to the retail water agencies using booster pumps. Although the terrain is moderately hilly, the pressure created at the Mirabel and Wohler chlorine plants are sufficient enough to get water to most places in the service area. The booster pumps are primarily used to add pressure to the lines and increase flow if needed. Most booster pumps are designed with an aqueduct bypass. Water can be boosted in pressure through the pump, or can bypass the pump and continue to flow through the system. Once the water enters the retail customer service area, SCWA does not track energy used to distribute water.

SCWA operates eight sanitation zones and districts throughout Sonoma County. Most of the wastewater flows to the treatment plant occur by the force the gravity, although pumping is required in some areas. Once at the plant, the wastewater receives either secondary or tertiary treatment. After treatment, wastewater is discharged into the environment or delivered to recycled water customers. Because SCWA does not actually sell recycled water to its contractors, it is not considered part of SCWA's water supply system and is not included here.

SCWA obtains the majority of its energy from the Power and Water Resources Pooling Authority (PWRPA), a Joint Powers Authority that organized in 2004 to manage individual power assets and loads as a group. PG&E powers the Mirabel and Wohler backup generators, the wastewater pumps, and one recycled water pump. All other facilities obtain their energy from PWRPA.

Water and energy data were provided to CIEE-CPUC Water Energy Study 2 and input into the Access database. Tables 1 and 2 provide total and IOU energy intensity estimates for each phase of SCWA's water and wastewater system. Note that data from only two of the eight wastewater treatment plants in the region were included in this analysis. The total energy intensity of the potable water system is 2,337 kWh per million gallons, of which only 5 kWh per million gallons represents energy purchased from an IOU. The energy intensity of the wastewater system is considerably higher, totaling 3,455 kWh per million gallons for all energy sources, of which only 2 kWh per million gallons is provided by an IOU.

Table 1: Energy Intensity of Sonoma County Water Agency Water System

Phase	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Supply Conveyance Treatment	5	1,895
Distribution	0	442
Potable Water System	**5**	**2,337**

Table 2: Energy Intensity of Sonoma County Water Agency Wastewater System

Phase	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Wastewater Collection	2	2
Wastewater Treatment	0	3,454
Wastewater System	**2**	**3,455**

Note: Only two of the eight wastewater treatment plants were included in this analysis. These two plants employ tertiary treatment. Three other wastewater treatment plants employ only secondary treatment.

Sources

Pollard, C. Personal communication. Water Conservation Specialist. Sonoma County Water Agency.

Sonoma County Water Agency. Website: http://www.scwa.ca.gov/water-supply/. Accessed on April 16, 2010.

City of Santa Rosa

The City of Santa Rosa provides water service to a population of more than 154,000. The City of Santa Rosa obtains 90% of its water from the Sonoma County Water Agency, which is provided through a series of 31 turnouts along the Santa Rosa, Sonoma, and Petaluma Aqueducts and the Kawana Pipeline. Santa Rosa obtains an additional 10% from local groundwater. Groundwater meets peak water demand and is typically operated from May through October. Groundwater receives sand media filtration with some additional chlorine treatment. There is no storage for groundwater; rather this water is pumped directly into the distribution system.

Santa Rosa's distribution system consists of 22 treated water reservoirs and 16 booster pump stations. The storage capacities of the storage tanks range from 0.1 to 4.0 million gallons (MG) and have a combined capacity of 27 MG. The pump station capacity ranges from 150 gallons per minute (gpm) to 5,000 gpm.

The City operates a wastewater treatment facility that serves Santa Rosa, as well as Rohnert Park and Sebastopol. Wastewater receives tertiary treatment. The City of Santa Rosa has a handful of recycled water customers, and the remainder goes to Healdsburg to be used in The Geysers for energy production. The City also operates a separate wastewater treatment plant that provides water for golf courses in Oakmont, a small community on the edge of Santa Rosa. Once the golf course ponds are filled, the facility is shut down. The Oakmont facility is not included in this study because it operates as an independent system and none of the pilot programs are focused on reducing water use at these particular golf courses.

The booster pumps are largely powered by electricity purchased from PG&E, although natural gas is used for back-up generators throughout the system. The wastewater treatment facility, however, is powered by a variety of energy sources, including solar panels, a biogas recovery system, and electricity and natural gas purchased from PG&E. Based on data provided by the City of Santa Rosa staff, we estimate that cogeneration provided nearly 50% of the energy requirements of the wastewater treatment facility in 2008.

Water and energy data were collected by the Study Team and input into the Access database. Here, we report on average annual energy intensity estimates for each phase of the water system. The City of Santa Rosa obtains water from two sources: imported water from the Sonoma County Water Agency and local groundwater wells. In 2008, imported water accounted for 94% of the supply, whereas groundwater accounted for only 6% of the supply. The energy requirements for groundwater pumping are fairly low, averaging 147 kWh per million gallons. This estimate includes energy requirements for extracting, conveying, and treating groundwater. Water imported from SCWA has an energy intensity of 2,337 kWh per million gallons. SCWA, however, obtains the vast majority of its energy from PWRPA, a non-IOU energy provider. The IOU energy intensity of water imported from SCWA is only 5 kWh per million gallons. Using a weighted average of supply for 2008, we estimate that supply, conveyance, and treatment of water in the City of Santa Rosa service area had an energy intensity of 2,206 kWh per million gallons, of which only 14 kWh per million gallons was provided by an IOU (Table 3).

Table 3: Energy Intensity of Supply, Conveyance, and Treatment for the City of Santa Rosa

	Energy Intensity (kWh/MG)	
	Imported Water (Total Energy)	Groundwater
Supply		147
Conveyance	5 (2,337)	
Treatment		
Fraction of Supply	94%	6%
Weighted Average for 2008	14 (2,206)	

Note: Energy requirements for water imported from SCWA are largely provided by a non-IOU. Total energy requirements are shown in parentheses, where applicable.

Additional energy is required to move water throughout the service area. Water distribution within the City of Santa Rosa has an energy intensity of 475 kWh per million gallons. While much of this energy is supplied by electricity purchased from an IOU, a small amount of natural gas is used to power the distribution pumps; the natural gas intensity of distribution is 0.15 therms per million gallons, all of which is provided by an IOU. In total, we estimate that potable water within the City of Santa Rosa has an energy intensity of 0.15 therms per million gallons plus 2,680 kWh per million gallons. Of the electricity use, only 488 kWh per million gallons is provided by IOU.

Table 4. Energy Intensity of City of Santa Rosa Water System

	Natural Gas	Electricity	
	IOU Energy Intensity (therms/MG)	**IOU Energy Intensity (kWh/MG)**	**Total Energy Intensity (kWh/MG)**
Supply/Conveyance/Treatment		14	2,206
Distribution	0.15	475	475
Potable Water System	0.15	488	2,680

Energy requirements for wastewater treatment are considerably higher, although co-generation offsets some of these requirements (Table 5). Wastewater collection within the City of Santa Rosa has an energy intensity of 60 kWh per million gallons. All of this energy is purchased from an IOU. Wastewater treatment requires an addition 4,128 kWh per million gallons. Nearly half of this energy, however, is supplied through co-generation. Thus, the IOU energy intensity of wastewater treatment is 2,105 kWh per million gallons. Unlike many systems, a significant amount of pumping is required to discharge treated wastewater. In 2008, all treated wastewater was pumped to the Geysers, where it was used for renewable energy generation. The energy requirements for wastewater discharge were 989 kWh per million gallons. If this water had not been pumped to the Geysers, it would have been pumped and discharged into the Russian River. No data were available for 2008 by which to estimate energy requirements of wastewater discharge into the Russian River.

Table 5. Energy Intensity of City of Santa Rosa Wastewater System

	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Wastewater Collection	60	60
Wastewater Treatment	2,105	4,128
Wastewater Discharge	989	989
Wastewater System	3,154	5,176

Note: Co-generation provides nearly 50% of the energy requirements for wastewater treatment. The "Total Energy Intensity" column include energy provided by an IOU plus the energy provided through co-generation.

Sources

City of Santa Rosa. 2005. Urban Water Management Plan.

Muelrath, D. Personal communication. Conservation Manager for the City of Santa Rosa

City of Santa Rosa. Website: http://ci.santa-rosa.ca.us/departments/utilities/Pages/default.aspx. Accessed on April 16, 2010.

Marin Municipal Water District

Marin Municipal Water District (MMWD) provides water service to an area covering 147 square mile in Marin County with a population of 190,000 people. MMWD operates 7 local surface water reservoirs and imports treated water from the Sonoma County Water Agency. MMWD also operates a recycled water plant that serves 250 customers in northern San Rafael. Recycled water is used for non-potable purposes, including landscaping, car washes, cooling towers, and flushing toilets.

Raw water is then conveyed from 7 local surface reservoirs to one of two water treatment facilities. Water from local surface reservoirs is subject to conventional treatment, consisting of coagulation, sedimentation, filtration, and the addition of chloramines. Water imported from Sonoma County Water Agency (SCWA) is pumped from groundwater wells and receives minor treatment prior to delivery to Marin. MMWD monitors water imported from SCWA and makes minor pH adjustments and additions of chlorine and fluorine, as needed. Ninety-five pump stations then distribute treated water to customers for use.

Water and energy data were collected by CIEE-CPUC Water Energy Study 2 and input into the Access database. Here, we report on average annual energy intensity for the MMWD water system. In 2008, local surface water accounted for 75% of MMWD's supply. Water imported from SCWA accounted for the remaining 25%. Local surface water had an energy intensity of 333 kWh per million gallons for conveyance and an additional 56 kWh per million gallons for treatment. Water imported from SCWA has an energy intensity of 2,337 kWh per million gallons. SCWA, however, obtains the vast majority of its energy from PWRPA, a non-IOU energy provider. The energy intensity of SCWA from IOU energy providers is only 5 kWh per million gallons. Using a weighted average of supply for 2008, we estimate that treated water (prior to distribution) in the MMWD service area had an energy intensity of 876 kWh per million gallons for all energy sources combined. For IOU energy providers, however, the energy intensity of treated water is 294 kWh per million gallons (Table 6).

Table 6: Energy Intensity of Source, Conveyance, and Treatment for the Marin Municipal Water District

	Energy Intensity (kWh/MG)	
	Local Supply	Imported Water (Total Energy)
Source	-	5 (2337)
Conveyance	333	
Treatment	56	
Fraction of Supply	75%	25%
Weighted Average for 2008	294 (876)	

Note: Energy requirements for water imported from SCWA are largely provided by a non-IOU. Total energy requirements are shown in parentheses, where applicable.

Water distribution requires an additional 544 kWh per million gallons. In total, we estimate that potable water has an energy intensity of 1,421 kWh. Of that amount, 838 kWh per million gallons is provided by IOU energy providers (Table 7).

Table 7: Energy Intensity of Marin Municipal Water District Water System

	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Supply/Conveyance/Treatment	294	876
Distribution	544	544
Potable Water System	838	1,421

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 2: Water Agency and Function Component Study and Embedded Energy-Water Load Profiles. Prepared by GEI Consultants/Navigant Consulting.

Marin Municipal Water District. 2005. Urban Water Management Plan.

Marin Municipal Water District Website. http://www.marinwater.org/. Accessed on April 15, 2010.

Sanitation District No. 2 (Corte Madera)/Central Marin Sanitation Agency

Sanitation District No. 2 collects wastewater from Corte Madera and surrounding areas, including the City of Marin. Wastewater flows in dry weather total about 1 MGD but can reach 7 or 8 MGD in wet weather. Wastewater is conveyed via 19 pump stations to the Central Marin Sanitation Agency (CMSA). CMSA is a Joint Powers Agency formed by its members in the Ross Valley and San Rafael areas of Central Marin County, California. CMSA treats wastewater and discharges it into the San Francisco Bay. CMSA also operates and maintains Sanitation District No. 2's pumps.

CMSA operates a biogas recovery system, which is capable of generating enough energy to operate the wastewater treatment plant for 12 hours per day. They also purchase natural gas from a 3rd party (not PG&E) to supply the remainder of the plant needs. CMSA purchases some electricity from PG&E, which is used to ensure that pumps are able to turn on and off as needed.

Water and energy data were collected by the Study Team and input into the Access database. Based on these data, we estimate that the energy intensity of wastewater collection is 883 kWh per million gallons. Wastewater treatment requires an additional 1,374 kWh per million gallons, of which 170 kWh per million gallons is provided by an IOU.[1] In total, the wastewater system has an energy intensity of 2,257 kWh per million gallons, of which 1,053 kWh per million gallons is provided by an IOU (Table 8).

Table 8. Energy Intensity of Sanitation District #2/Central Marin Sanitation Agency

Phase	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Wastewater Collection	883	883
Wastewater Treatment	170	1,374
Wastewater System	1,053	2,257

Notes: Wastewater collection flows were not available for 9/21/08 through 10/18/08; this period was excluded from the energy intensity calculations for wastewater collection. Energy requirements for wastewater treatment include electricity purchased from PG&E, energy produced through co-generation, plus natural gas purchased from a non-IOU energy provider. Data on natural gas use from the non-IOU provider were not available, thus the estimates shown in Table 8 include only the energy purchased from PG&E and energy produced through co-generation.

Sources

Brennan, N. Personal communication. Treatment Plant Manager at the Central Marin Sanitation Agency.

Hogue, B. Personal communication. Sanitary Services Manager. Town of Corte Madera/Sanitary District #2.

[1] Energy requirements include electricity purchased from PG&E plus energy produced through cogeneration. Natural gas was also purchased from a non-IOU provider, although this data was not included here.

City of Sunnyvale

The City of Sunnyvale is located near the southern tip of San Francisco Bay, about 40 miles south of San Francisco. The City, with a population in 2005 of 133,000, is home to the high-tech industry, including parts of the Silicon Valley. Sunnyvale has four sources of water supply (with the percentage of supply in parentheses): San Francisco Public Utilities Commission (40%), Santa Clara Valley Water District (47%), seven city-owned groundwater wells (6%), and recycled water (7%).[2] Several pockets of the City are served by California Water Service Company (these areas were once part of unincorporated Santa Clara County).

The City operates a water distribution system consisting of more than 280 miles of pipes, with a pipe diameter ranging from 4 to 30 inches. Due to the hilly nature of the area, the City consists of three pressure zones. Booster pumps are sometimes used in Zones 2 and 3 to maintain the desired system pressure. Booster pumps are not required in Zone 1, as the downstream pressure from the Hetch-Hetchy pipeline are sufficient to maintain the desired operating system pressure. The City has ten potable water storage reservoirs with a combined storage capacity of 27.5 million gallons, enough water to provide one day's average demand. The City also has a 2 million gallon recycled water reservoir.

The City of Sunnyvale is also a wastewater service provider. Wastewater receives advanced tertiary treatment at the Water Pollution Control Plant (WPCP), which has a capacity of 29.5 million gallons per day (MGD). Treated wastewater is then discharged to the South San Francisco Bay via the Guadalupe Slough. About 10% of wastewater is treated to recycled water quality standards and is diverted for landscape and industrial uses in the City of Sunnyvale.

The Study Team was unable to obtain energy data for the water system or wastewater collection system. However, the Study Team collected water and energy data for wastewater discharge. We estimate that wastewater treatment in Sunnyvale requires 24 kWh per million gallons and 79 therms per million gallons. The City of Sunnyvale also employs cogeneration to power their wastewater treatment facility, although data on the percent of the energy requirements that cogeneration provides is not available.

Table 9. Energy Intensity of Wastewater Treatment for the City of Sunnyvale

Phase	IOU Energy Intensity (kWh/MG)	IOU Energy Intensity (therms/MG)
Wastewater Treatment	24	79

Note: Estimate includes only IOU energy. The wastewater treatment facility also uses co-generation, although this energy use is not included here.

[2] http://sunnyvale.ca.gov/NR/rdonlyres/57C1074F-6808-49F2-9B7B-77C2EA03E0DE/0/UWMP2005Rev806.pdf

Sources

City of Sunnyvale. 2005. Urban Water Management Plan.

City of Sunnyvale. Website: http://sunnyvale.ca.gov/Departments/Public+Works/Water+Supply/

East Bay Municipal Utility District

The East Bay Municipal Utility District (EBMUD) provides water and wastewater service to 1.3 million people in portions of Alameda and Contra Costa Counties. EBMUD gets the majority of its water from the Mokelumne River. Two surface reservoirs in the Sierra foothills, Comanche and Pardee, capture water from the Mokelumne River and are owned and operated by EBMUD. Raw water is then conveyed 90-miles through the Mokelumne Aqueduct to the terminal reservoirs within the EBMUD service area. Although much of the water conveyed to the EBMUD service area is done through the force of gravity, five booster pumps are located at various points to supply additional energy to convey raw water to the terminal reservoirs. Some water is also obtained from runoff within the service area and stored in the local terminal reservoirs.

Water in the terminal reservoirs is then treated at one of five treatment plants. Treatment consists of chlorination, fluoridation, and the addition of lime or sodium hydroxide. At one treatment plant, ozone is used for disinfection. Treated water is then distributed through a topographically diverse service area, consisting of both flat and hilly areas. Nearly 50 percent of treated water is distributed to customers using gravity, while the remaining customers are served by a distribution system consisting of 4,100 miles of pipe, 140 pumping plants, and 170 treated water storage tanks.

Water and energy data were provided to CIEE-CPUC Water Energy Study 2 and input into the Access database. Here, we report on average annual energy intensity estimates for each phase of the water system. Although EBMUD operates a wastewater system, no data were provided, and we are unable to calculate the energy intensity of wastewater.

As noted above, EBMUD has two water sources. In 2008, 90 percent of the agency's water came from the Mokelumne River and the remaining 10 percent came from local runoff. Because these are surface sources, the energy intensity of supply is 0. Water from the Mokelumne River is subject to conveyance, which has an energy intensity of 156 kWh per million gallons. Local runoff flows naturally to the terminal reservoirs and thus does not have conveyance energy associated with it. Thus the weighted average of supply and conveyance is low at an estimated 140 kWh per million gallons (Table 10).

Table 10: Energy Intensity of Supply and Conveyance for the East Bay Municipal Utility District

Phase	IOU Energy Intensity (kWh/MG)	
	Mokelumne River	Local Runoff
Supply	0	0
Conveyance	156	0
Fraction of Supply	90%	10%
Weighted Average for 2008	140	

Note: EBMUD staff indicated that conveyance system operations were not typical during June and July due to a water rights pump test. Thus water flows and energy use for these months were excluded from the annual energy intensity estimates.

Both sources are then treated and distributed to customers within the same facilities. Treatment and distribution require 232 kWh and 515 kWh per million gallons, respectively. The total energy intensity of the potable water system is 887 kWh per million gallons (Table 11). All of this energy is provided by an IOU.

Table 11: Energy Intensity of East Bay Municipal Utility District Water System

Phase	IOU Energy Intensity (kWh/MG)
Supply/Conveyance	140
Treatment	232
Distribution	515
Potable Water System	887

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 2: Water Agency and Function Component Study and Embedded Energy-Water Load Profiles. Prepared by GEI Consultants/Navigant Consulting.

East Bay Municipal Utilities District. 2005. Urban Water Management Plan.

Santa Clara Valley Water District

The Santa Clara Valley Water District (SCVWD) is a wholesale water service provider that sells treated water to 13 water retailers, including five private companies. These retailers, in turn, provide water to approximately two million people — 1.8 million residents and 200,000 commuters — in 15 cities and unincorporated areas in Santa Clara County. The District is also responsible for flood protection within the county.

The SCVWD relies on a diverse portfolio of water resources, including local surface and groundwater; water imported from the Central Valley Project, the State Water Project, and the

Hetch Hetchy system; and recycled water. SCVWD owns and operates 10 water reservoirs and manages groundwater throughout the County. It also owns and operates three water treatment facilities, two of which use ozone, rather than chlorine, as the primary disinfectant. After treatment, the SCVWD distributes treated water to its 13 water retailers.

Water and energy data were not requested from the SCVWD because it is a wholesale water agency and not within the scope of this study. SCVWD, however, provides water to San Jose Water Company, which is one of the agencies included in the pilot projects. Because we felt it was important to quantify the total energy savings from the Pilot projects, we relied on an analysis done by CIEE-CPUC Water Energy Study 1 and data from the Santa Clara Valley Water District to develop an estimate of the energy intensity of the SCVWD. Based on this information, we estimate that the energy intensity of imported water for the SCVWD is 2,214 kWh per million gallons, of which 194 kWh per million gallons is provided by an IOU (Table 12).

Table 12: Energy Intensity of Water Imported to the Santa Clara Valley Water District

	Total Energy Intensity (kWh/MG)	IOU Energy Intensity (kWh/MG)	Fraction of Imported Water	Data Source
CVP Imports	2,670	401	48%	CIEE-CPUC Water Energy Study 1
SWP Imports	3,462	0	27%	CIEE-CPUC Water Energy Study 1
SFPUC Imports	2	2	25%	CIEE-CPUC Water Energy Study 1
Weighted Average	2,214	194		Calculated

In addition to imported water, the SCVWD also relies on local surface and groundwater. A study conducted by the SCVWD indicates that groundwater has an energy intensity of 1,995 kWh per million gallons. This estimate includes the energy requirements for extracting this water from the ground as well as the modest treatment that occurs at the wellhead. Unlike groundwater, surface and imported water must be treated at one of the three water treatment facilities, with energy requirements of 307 kWh per million gallons.

Data provided by CIEE-CPUC Water Energy Study 2 indicates that imported water provided 49% of the District's water supply in 2008, whereas local groundwater and surface provided 46% and 5%, respectively. Given this mix of water resources, we estimate that water supply and treatment has an energy intensity of 2,168 kWh per million gallons, of which 1,179 kWh per million gallons is provided by an IOU. In addition, treated water is distributed to retail water agencies throughout Santa Clara County, requiring 982 kWh per million gallons. In total, we estimate that water imported from the SCVWD has an energy intensity of 3,150 kWh per million gallons, of which 2,161 kWh per million gallons is provided by an IOU (Table 13).

Table 13. Energy Intensity of Santa Clara Valley Water District Water System

Santa Clara Valley Water District	Energy Intensity (kWh/MG)		
Water Sources	Groundwater	Surface	Imports
Source	1,995[a]	0	194 (2,214)
Treatment	0	307[a]	307[a]
Fraction of Supply[b]	46%	5%	49%
Water Supply/Treatment (Weighted Average)		1,179 (2,168)	
Water Distribution		982[a]	
Total for SCVWD Potable System		2,161 (3,150)	

Note: Energy requirements are met by an IOU as well as non-IOU energy providers. Total energy requirements are shown in parentheses, where applicable.
Data sources:
a = Santa Clara Valley Water District. 2007. From Watts to Water: Climate Change Response through Saving Water, Saving Energy and Reducing Air Pollution. Santa Clara, California.
b = CIEE-CPUC Water Energy Study 2

Sources

Santa Clara Valley Water District. 2008. Valley Water: A Profile of the Santa Clara Valley Water District. Santa Clara, California.

Santa Clara Valley Water District. 2007. From Watts to Water: Climate Change Response through Saving Water, Saving Energy and Reducing Air Pollution. Santa Clara, California.

San Jose Water Company

The San Jose Water Company (SJWC) provides water service to nearly one million residents in Santa Clara County, including San Jose, Campbell, and Cupertino, and Saratoga. SJWC has three primary water sources. Between 40% and 60% of its supply comes from groundwater aquifers managed by the Santa Clara Valley Water District. Groundwater is recharged naturally by precipitation and artificially by a series of local reservoirs and percolation ponds (thus the recharged groundwater may have embedded energy; although ignored here). Groundwater treatment requires the addition of sodium hypochlorite, which occurs at the groundwater pumping station. Carbon dioxide is also injected to prevent scaling. The energy requirements for treating groundwater are modest and cannot be distinguished from the pumping requirements.

Local surface water supplies between 5 percent and 10 percent of SJWC's water supply. Surface water from the Santa Cruz Mountains is gravity-fed to the treatment plants. Two creeks require pumping to convey raw water to the treatment plant. SJWC purchases 40 percent to 60 percent of its water supply from the Santa Clara Valley Water District. This water has already been treated and is put directly into the water distribution system. Santa Clara Valley Water District obtains water from a variety of sources, including the State Water Project, the Central Valley Project, and local surface and groundwater.

The SJWC supplies potable water to its customers through a single distribution system extending about 2,450 miles. The terrain in the region varies from flat to hilly. The system is divided into sixty pressure zones, although each zone is served by at least 2 water sources. Because of the difficulty it developing separate energy intensity for each zone, we developed a single estimate for the entire distribution system. Water conservation and efficiency are typically offered to all customers and a single estimate is a practical approach for capturing the average distribution energy savings.

Water and energy data were provided to CIEE-CPUC Water Energy Study 2 and input into the Access database. Here, we report on average annual energy intensity estimates for each phase of the water system. The energy intensity of supply, conveyance, and treatment of groundwater is 1,665 kWh per million gallons. Local surface water has an energy intensity of 110 kWh per million gallons, which includes energy requirements for capturing and conveying water to the water treatment plant. Treating surface water requires an additional 273 kWh per million gallons. As described in the profile on the Santa Clara Valley District, we estimate that treated water imported from the SCVWD has an energy intensity of 3,150 kWh per million gallons, of which 2,161 kWh per million gallons is provided by an IOU.

Because the water resource portfolio varies from year to year, the energy intensity of water supply and treatment also varies. In 2008, an estimated 49% of SJWC's supply was from imported water, whereas groundwater and local surface water provided 46% and 5%, respectively (CIEE-CPUC Water Energy Study 2). Using the energy intensity of each supply, we estimate that the average energy intensity of treated water in the SJWC service area in 2008 was 2,329 kWh per million gallons, of which 1,844 kWh per million gallons is provided by an IOU (Table 14). Water distribution requires an addition 967 kWh per million gallons, all of which is provided by an IOU. In total, we estimate that potable water in the SJWC service area has an energy intensity of 3,296 kWh per million gallons, of which 2,811 kWh per million gallons is provided by an IOU (Table 15).

Table 14: Energy Intensity of Supply, Conveyance, and Treatment for the San Jose Water Company

	Energy Intensity (kWh/MG)		
Phase	Groundwater	Surface Water	Imported Water
Supply	1,665	0	2,161 (3,150)
Conveyance		110	
Treatment		273	
Fraction of Supply	46%	5%	49%
Weighted Average for 2008	1,844 (2,329)		

Note: Energy requirements are met by an IOU as well as non-IOU energy providers. Total energy requirements are shown in parentheses, where applicable. Data on the fraction of supply that each water source represented in 2008 was provided by CIEE and CPUC (2010).

Table 15: Energy Intensity of the San Jose Water Company Water System

	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Supply/Conveyance/Treatment	1,844	2,329
Distribution	967	967
Potable Water System	2,811	3,296

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 2: Water Agency and Function Component Study and Embedded Energy-Water Load Profiles. Prepared by GEI Consultants/Navigant Consulting.

Santa Clara Valley Water District. 2007. From Watts to Water. Santa Clara, California.

Oceanside

The City of Oceanside provides water service to a population of nearly 190,000 in the Los Angeles area. They also operate two wastewater treatment facilities, one of which produces a small amount of recycled water that is used to irrigate a local golf course.

Oceanside has two primary water sources: imports from the San Diego County Water Authority (SDCWA) and brackish groundwater. Oceanside obtains more than 90% of its water from the SDCWA. About 35% of this water is already treated and is put directly into the distribution system. The remaining 65% is untreated and is conveyed to the Weese Filtration Plant. Water from the SDCWA was purchased from the Metropolitan Water District of Southern California (MWD) and originates from the State Water Project and the Colorado River. The City operates 6 groundwater wells that pump brackish water. After pumping, this water is conveyed to the Mission Bay Desalting Facility where is undergoes treatment by reverse osmosis. All water sources are distributed through a single distribution system that consists of 500 miles of pipeline.

The City of Oceanside operates two wastewater treatment facilities: the San Luis Rey Wastewater Treatment Plant and the La Salina Wastewater Treatment Plant. The wastewater system consists of 400 miles of pipeline and 34 sewer lift stations. Treated wastewater is discharged into the ocean. The City also reclaims nearly 300,000 gallons of wastewater each day to irrigate a golf course and augment a lake.

Energy and flow data were provided to CIEE-CPUC Water Energy Study 2 and input into the Access database. Table 16 shows the energy intensity of source, conveyance and treatment for each of Oceanside's water supplies. The energy intensity of brackish groundwater is 1,277 kWh per million gallons. Imported raw water from the SDCWA has an energy intensity of 7,464 kWh per million gallons. The energy intensity of this water is high because it is transported long distances through the State Water Project and Colorado River Aqueduct. This energy is largely provided through long-term purchasing contracts and generation by MWD. Thus, the IOU energy intensity of imported water is 0 kWh per million gallons. City of Oceanside applies an additional 53 kWh per millions for treatment. Oceanside also imports treated water from the SDCWA, although estimates on the energy requirements for treatment by the SDCWA are not available. Here, we assume that energy requirements for treatment by the SDCWA are the same as those applied by Oceanside (53 kWh per million gallons).

In 2008, brackish groundwater accounted for 7% of the total supply. Water imported from the SDCWA accounted for 93% of the total supply. Using the energy intensity of each supply, we estimate that the average energy intensity for supply, conveyance, and treatment in the Oceanside service area in 2008 was 7,080 kWh per million gallons, of which 139 kWh per million gallons is provided by an IOU (Table 16). Water distribution requires an addition 178 kWh per million gallons. In total, we estimate that potable water in Oceanside has an energy intensity of 7,258 kWh per million gallons, of which 317 kWh per million gallons is provided by an IOU (Table 17).

Table 16: Energy Intensity of Source, Conveyance, and Treatment for the City of Oceanside

	Brackish Groundwater	Imported Water (SDCWA)
Source		
Conveyance	1,277	0 (7,464)
Treatment		53
Subtotal	1,277	53 (7,517)
Weighted Average for 2008	139 (7,080)	

Note: Energy requirements are met by an IOU as well as non-IOU energy providers. Total energy requirements are shown in parentheses, where applicable.

Table 17: Energy Intensity of the City of Oceanside Water System

	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Supply/Conveyance/Treatment	139	7,080
Distribution	178	178
Potable Water System	317	7,258

Wastewater collection requires 442 kWh per million gallons, while wastewater treatment requires 1,086 kWh per million gallons. In total, the wastewater system has an energy intensity of 1,528 kWh per million gallons (Table 18). All of this energy is provided by an IOU. In 2009, the wastewater treatment facility was equipped with a cogeneration system that is estimated to reduce its energy use by 20%. Under these new operating conditions, we estimate that the wastewater system would have an energy intensity of 1,311 kWh per million gallons.

Table 18: Energy Intensity of the City of Oceanside Wastewater System

	IOU Energy Intensity (kWh/MG)
Wastewater Collection	442
Wastewater Treatment	1,086
Wastewater System	1,528

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 1: Statewide and Regional Water-Energy Relationship. Prepared by GEI Consultants/Navigant Consulting.

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 2: Water Agency and Function Component Study and Embedded Energy-Water Load Profiles. Prepared by GEI Consultants/Navigant Consulting.

City of Oceanside. Website. http://www.ci.oceanside.ca.us/datarelation.aspx?Content=10. Accessed on April 16, 2010.

Los Angeles County Sanitation District

The Los Angeles County Sanitation District (LACSD) is a partnership of 24 independent special districts that provides wastewater and solid waste management service to about 5.7 million people in Los Angeles County. The service area covers approximately 820 square miles and encompasses 78 cities and unincorporated territory within the county. Each city and special district is responsible for wastewater collection through local sewers. LACSD operates 1,400 miles of pipeline and 11 wastewater treatment plants throughout the region, treating approximately 510 million gallons of wastewater each day. Of this amount, an estimated 200 million gallons per day is treated to recycled water standards and is available for reuse.

Water and energy data were provided to CIEE-CPUC Water Energy Study 2 and input into the Access database. Here, we report on average annual energy intensity estimates for the wastewater system. The energy intensity of wastewater collection is 201 kWh per million gallons, of which 197 kWh per million gallons is provided by an IOU.[3] Wastewater treatment has an energy intensity of 3,212 kWh per million gallons. An estimated 60% of this energy, however, is produced through co-generation (LACSD 2009); thus the IOU energy intensity of wastewater treatment is 1,281 kWh per million gallons. In total, collecting, treating, and disposing of wastewater requires 3,413 kWh per million gallons, of which 1,478 kWh per million gallons is provided by an IOU.

Table 19: Energy Intensity of the Los Angeles County Sanitation District Wastewater System

Phase	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Wastewater Pumping	197	201
Wastewater Treatment	1,281	3,212
Wastewater System	1,478	3,413

Note: LACSD uses energy from a variety of sources, including electricity and natural gas purchased from an IOU, electricity purchased from a non-IOU, and energy produced through co-generation. The values in the table reflect energy purchased and produced from all sources, except natural gas.

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 2: Water Agency and Function Component Study and Embedded Energy-Water Load Profiles. Prepared by GEI Consultants/Navigant Consulting.

Los Angeles County Sanitation District. Website: http://www.lacsd.org/about/default.asp. Accessed April 16, 2010.

Los Angeles County Sanitation District. 2009. County Sanitation Districts of Los Angeles County Annual Energy Report. Fiscal Year 2007/2008. Prepared by Energy Recovery Engineering Section, Solid Waste Management Department

Metropolitan Water District of Southern California

The Metropolitan Water District of Southern California (MWD) is a wholesale water service provider that sells raw and treated water to 26 cities and water districts. These retailers, in turn, provide water to nearly 19 million customers in parts of Los Angeles, Orange, San Diego, Riverside, San Bernardino, and Ventura counties. On average, MWD delivers 1.7 billion gallons of water each day across a 5,200-square mile service area.

[3] A small amount of electricity for wastewater pumping is provided by the Los Angeles Department of Water and Power.

MWD imports water from two sources - the Colorado River and the Sacramento-San Joaquin Delta. Water from the Delta is delivered through the State Water Project. The Colorado River Aqueduct, which was built and is owned by MWD, takes Colorado River water through the W. P. Whitsett Intake Pumping Plant at Lake Havasu. From there, a series of canals, siphons, pipelines and four more pumping plants move the water west to Metropolitan's reservoirs.

MWD delivers this water through a regional distribution system that includes hundreds of miles of pipelines, five water treatment plants, and nine reservoirs. While water flows through much of the region via gravity, five pumping plants are required to move water along the Colorado River Aqueduct. These plants lift water more than 1,600 feet using 45 pumps that range in size from 4,300 to 12,500 horsepower. To capture some of the energy within the system, MWD also operates and maintains 16 hydroelectric plants that have a capacity to produce 127 megawatts of power.

Study 1 evaluated the energy intensity of water within the MWD service area. CIEE-CPUC Water Energy Study 1 found that relatively little energy is used by MWD to deliver water. However, its embedded energy is high because water is imported over long distances and steep terrain through the State Water Project and the Colorado River Aqueduct. CIEE-CPUC Water Energy Study 1 estimates that the average energy intensity of water delivered by MWD to its customers is 7,589 kWh per million gallons. This energy is largely provided through long-term purchasing contracts and generation by MWD. Thus, we estimate that the IOU energy intensity is 0 kWh per million gallons is provided by an IOU. Note that the focus of CIEE-CPUC Water Energy Study 1 was energy required for conveyance, e.g., conveying raw water, and this estimate does not include energy for treating raw water to drinking water standards.

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 1: Statewide and Regional Water-Energy Relationship. Prepared by GEI Consultants/Navigant Consulting.

Metropolitan Water District of Southern California. 2010. MWD At a Glance. Accessed on May 23, 2010 at http://www.mwdh2o.com/mwdh2o/pages/news/at_a_glance/mwd.pdf.

Metropolitan Water District of Southern California. 2008. MWD Profile. Accessed on May 23, 2010 at http://www.mwdh2o.com/mwdh2o/pages/news/at_a_glance/mwd_profile.pdf.

San Diego County Water Authority

The San Diego County Water Authority (SDCWA) is a wholesale water provider that sells treated water to its 24 member agencies. These member agencies provide water to 3 million residents and support a $171 billion economy in San Diego. SDCWA obtains water from a variety of sources. The vast majority - nearly 80 percent - is provided by the Metropolitan Water District of Southern California (MWD). Twelve percent is provided through transfers from the Imperial Irrigation District and the lining of the All American Canal; the original source of which is the Colorado River. The remainder is provided from local surface and groundwater and recycled water. In order to deliver this water, the SDCWA operates and maintains about 300 miles of pipeline

CIEE-CPUC Water Energy Study 1 evaluated the energy intensity of water within the SDCWA service area. As described above, 80 percent of water within the SDCWA is purchased from MWD. Study 1 found that no energy is required to import water from MWD, as the system is primarily gravity fed. While there are pumps located throughout the SDCWA conveyance system, these pumps, and the associated energy requirements, are used to move local surface and groundwater around the region**.** CIEE-CPUC Water Energy Study 1 estimates that the energy intensity of water delivered by SDCWA is 7,464 kWh per million gallons. This energy is largely provided through long-term purchasing contracts and generation by MWD. Thus, we estimate that the IOU energy intensity of water imported from SDCWA is 0 kWh per million gallons. Note that the focus of Study 1 was energy required for conveyance, e.g., conveying raw water, and this estimate does not include energy requirements for water treatment.

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 1: Statewide and Regional Water-Energy Relationship. Prepared by GEI Consultants/Navigant Consulting.

San Diego County Water Authority. No date. San Diego County Water Authority: An Overview. Accessed on May 23, 2010 from http://www.sdcwa.org/about/pdf/overview.pdf.

Otay Water District

The Otay Water District serves over 200,000 people and provides potable water, recycled water, and sewer service to the communities in the southeast region of San Diego County. The agency is divided into two separate sub-districts: the North District and South District. The North District serves San Diego County above Sweetwater Reservoir and the South District serves the City of Chula Vista and Otay Mesa. All potable water distributed through the Otay Water District is imported from the San Diego County Water Authority (SDCWA) or Helix Water District (which imports water from SDCWA). Imported water has already been treated and is distributed directly to customers.

Water and energy data were collected by the Study Team and input into the Access database. Because treated water is imported from regional wholesalers, the only energy requirements within the Otay Water District service area are for distributing treated water. CIEE-CPUC Water Energy Study 1 estimates that the energy intensity of water delivered by SDCWA is 7,464 kWh per million gallons. This energy is largely provided through long-term purchasing contracts and generation by MWD. Thus, we estimate that the IOU energy intensity of water imported from SDCWA is 0 kWh per million gallons. Once within the Otay Water District service area, an additional 979 kWh per million gallons is required to distribute water to customers. All of this energy is provided by an IOU. In total, we estimate that the energy intensity of water within the Otay Water District service area is 8,443 kWh per million gallons, of which 979 kWh per million gallons is provided by an IOU (Table 20).

The SDCWA energy intensity was taken from Study 1, which did not include treatment in the energy intensity calculations. Thus energy used for treatment is not captured in the energy intensities reported here.

Table 20: Energy Intensity of Otay Water District System

	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Supply/Conveyance	0	7,464
Distribution	979	979
Potable Water System	979	8,443

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 1: Statewide and Regional Water-Energy Relationship. Prepared by GEI Consultants/Navigant Consulting.

Granger, W. Personal communication. Water Conservation Manager. Otay Water District.

Otay Water District. Website: http://www.otaywater.gov/owd/index.aspx. Accessed May 27, 2010.

Vaclavek, J. Personal communication. Water Systems Supervisor. Otay Water District.

Apple Valley Ranchos Water District

Apple Valley Ranchos Water District (AVRWD) serves over 65,000 people within its 50 square mile service area located in the Mojave River Basin. Apple Valley obtains 100 percent of its potable water supply from groundwater within the community. Water is drawn from 24 wells and then pumped to consumers through 4 booster pump stations; no treatment is required because of the natural filtration of the groundwater. The groundwater is periodically recharged by Mojave Water Agency using water from the State Water Project, but this is not done regularly and the amounts can vary.

Water and energy data were collected by the Study Team and input into the Access database. As Table 21 below shows, Apple Valley Ranchos Water District obtains 100 percent of its supply from local groundwater. The energy intensity for the groundwater supply is 2,079 kWh per million gallons. Water distribution requires an additional 146 kWh per million gallons. In total, the energy intensity of water within Apple Valley Ranchos Water District is 2,225 kWh per million gallons. All of this energy is provided by an IOU. Note that groundwater in the region is periodically recharged by water from the State Water Project. Recharge occurs irregularly, and is not included here.

Table 21: Energy Intensity of the Apple Valley Ranchos Water District

Phase	IOU Energy Intensity (kWh/MG)
Supply	2,079
Distribution	146
Potable Water System	2,225

Source

Apple Valley Ranchos Water District. Website: http://www.avrwater.com/index.php. Accessed May 28, 2010.

Kinnard, J. Personal communication. Production Supervisor. Apple Valley Ranchos Water District.

Lopez, J. Personal communication. Assistant General Manager. Apple Valley Ranchos Water District.

Lake Arrowhead Community Services District

Lake Arrowhead Community Services District (LACSD) serves over 8,000 water customers and 10,500 sewer customers in the mountainous region surrounding Lake Arrowhead. LACSD relies on a combination of groundwater, water drawn from Lake Arrowhead, and imported water to serve its potable water customers. Groundwater is pumped from 5 wells in the region, treated at the Grass Valley IX Plant, and then fed into the distribution system. Raw water withdrawn from Lake Arrowhead is treated at one of two water treatment plants (Bernina or Cedar Glen) prior to discharge into the water distribution system. Treated water is imported from the San Bernardino Valley Municipal Water District (MUNI) via the Crestline Lake Arrowhead Water Agency (CLAWA). In 2008 LACSD imported approximately 25 percent of its water that was distributed to customers.

Flows and energy data were received on a monthly basis for all phases of the LACSD system for calendar year 2008. The energy intensity for imported water was taken from Study 1 for the CLAWA water imported from the State Water Project at Silverwood Lake. The production of this water is energy intensive because of the high elevations the water must pass over, resulting in an energy intensity of 13,274 kWh per million gallons by the time it reaches LACSD. Local supply and conveyance of raw water from Lake Arrowhead has an energy intensity of 1,524 kWh per million gallons. Treatment requires an additional 1,006 kWh per million gallons. Supply and conveyance of local groundwater is 6,430 kWh per million gallons. Treating groundwater requires an additional 1,006 kWh per million gallons.

The flows data show that in 2008, 75 percent of the water distributed by LACSD was produced locally as groundwater or drawn from the lake while 25 percent was imported. Based on a weighted average of the energy intensity of these water sources, we estimate that water supply, conveyance, and treatment within the LACSD service area has an energy intensity of 5,461 kWh per million gallons, of which 2,143 kWh per million gallons is provided by an IOU (Table 22).

Distributing water within the LACSD service area requires an additional 681 kWh per million gallons, all of which is provided by an IOU. In total, we estimate that potable water within the LACSD service area has an energy intensity of 6,142 kWh per million gallons, of which 2,824 kWh per million gallons is provided by an IOU (Table 23).

Table 22: Energy Intensity of Supply, Conveyance and Treatment for Lake Arrowhead CSD

<table>
<tr><th></th><th colspan="3">Energy Intensity (kWh/MG)</th></tr>
<tr><th>Phase</th><th>Raw Water</th><th>Groundwater</th><th>Imported Water (Total Energy)</th></tr>
<tr><td>Supply
Conveyance</td><td>1,524</td><td>6,430</td><td rowspan="2">0 (13,274)</td></tr>
<tr><td>Treatment</td><td colspan="2">1,006</td></tr>
<tr><td>Fraction of Supply</td><td>70%</td><td>5%</td><td>25%</td></tr>
<tr><td>Weighted Average for 2008</td><td colspan="3">2,143 (5,461)</td></tr>
</table>

Table 23: Energy Intensity of the Lake Arrowhead CSD System

	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Supply/Conveyance/Treatment	2,143	5,461
Distribution	681	681
Potable Water System	2,824	6,142

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 1: Statewide and Regional Water-Energy Relationship. Prepared by GEI Consultants/Navigant Consulting.

Lake Arrowhead Community Services District. Website: http://www.lakearrowheadcsd.com/Index.aspx. Accessed May 28, 2010.

Veysey, Mark. Personal communication. Water Resources Planner. Lake Arrowhead Community Services District.

Veysey, Mark. Lake Arrowhead Community Services District. *Equipment List.doc.* Received April 20, 2010.

Las Virgenes Municipal Water District

Las Virgenes Municipal Water District (LVMWD) provides potable water to 65,000 customers in a 122 square mile area in western Los Angeles County. Communities served include Agoura Hills, Calabasas, Hidden Hills and Westlake Village. LVMWD imports 100 percent of its water supply from the Metropolitan Water District of Southern California (MWD). The imported water has already been treated and a majority of it is distributed directly to customers via pumping stations, although a small portion of water is stored in the Las Virgenes Reservoir as an emergency supply. Water stored at the Las Virgenes Reservoir is treated at the Westlake Filtration Plant prior to distribution to customers.

Flows data for LVMWD were provided on an hourly basis and converted to daily data for input into the Access tool along with energy data for 2008. Water imported from MWD has an energy intensity of 7,588 kWh per million gallons. None of this energy is supplied by an IOU. This estimate does not include energy requirements for treatment. Treatment of water stored at the Las Virgenes Reservoir requires an additional 710 kWh per million gallons. Because treatment requirements were not available for water imported from MWD, we apply this estimate to all water imported from MWD. Distribution requires an additional 1,189 kWh per million gallons. In total, potable water within LVMWD has an energy intensity of 9,487 kWh per million gallons, of which 1,899 kWh per million gallons is provided by an IOU.

Table 24: Energy Intensity of the Las Virgenes Municipal Water District

	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Supply/Conveyance	0	7,588
Treatment	710	710
Distribution	1,189	1,189
Potable Water System	1,899	9,487

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 1: Statewide and Regional Water-Energy Relationship. Prepared by GEI Consultants/Navigant Consulting.

Eubanks, M. Personal communication. Facilities and Operations Administrative Services Officer. Las Virgenes Municipal Water District.

Las Virgenes Municipal Water District. Website: http://www.lvmwd.com/index.aspx. Accessed June 3, 2010.

Irvine Ranch Water District

Irvine Ranch Water District (IRWD) serves 331,500 people in a 181 square mile service territory that includes the city of Irvine as well as parts of Tustin, Newport Beach, Costa Mesa, Orange and Lake Forest. IRWD imports about 35 percent of its potable water from the Metropolitan Water District of Southern California (MWD), with water originating in the Colorado River and Northern California. The remaining 65 percent of water is drawn from local wells within the district. There are 18 wells at the Dyer Road Wellfield, 2 of which produce water that must be treated to remove color before entering the distribution system. Treated water from MWD enters the distribution system through a number of turnouts throughout the district.

IRWD has two treatment plants for wastewater, the Michelson Water Reclamation Plant and the Los Alisos Water Reclamation Plant. Treated wastewater is distributed for use in landscape and agricultural irrigation. The IRWD system also includes 34 potable water reservoirs, 13 recycled water reservoirs, and Irvine Lake, which stores untreated domestic water.

Potable water and wastewater flows and energy data for 2008 were input into the Access database. Table 25 below shows the energy intensity for the Supply/Conveyance/Treatment phases for the IRWD potable water system. Imported water from MWD has an energy intensity of 7,588 kWh per million gallons, which does not include energy used for treatment. The IRWD treatment intensity was not added to the imported intensity because the treatment done by IRWD is limited and specific to color-removal for groundwater and would not be typical of treatment done by MWD. Based on a weighted average of the energy intensity of local and imported water, we estimate that water supply, conveyance, and treatment within IRWD has an energy intensity of 5,967 kWh per million gallons, of which 3,311 kWh per million gallons is provided by an IOU.

Table 26 shows total energy intensities for the IRWD potable system. Distribution intensity is 885 kWh per million gallons of IOU energy. The potable system energy intensity is 6,851 kWh per million gallons, of which 4,196 kWh per million gallons is IOU-provided energy.

Table 25: Energy Intensity of Supply, Conveyance and Treatment for Irvine Ranch Water District

	Energy Intensity (kWh/MG)	
	Groundwater	Imported Water (Total Energy)
Supply	1,692	0 (7,588)
Conveyance		
Treatment	3,401	
Fraction of Supply	65%	35%
Weighted Average for 2008	3,311 (5,967)	

Table 26: Energy Intensity of the Irvine Ranch Water District Potable Water System

	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Supply/Conveyance/Treatment	3,311	5,967
Distribution	885	885
Potable Water System	4,196	6,851

Table 27 shows that IRWD wastewater collection requires just 3 kWh per million gallons of IOU energy, while wastewater treatment requires 129 kWh per million gallons. In total, the IRWD wastewater system uses 132 kWh per million gallons, all of which is IOU-provided energy.

Table 27: Energy Intensity of the Irvine Ranch Water District Wastewater System

	IOU Energy Intensity (kWh/MG)
Wastewater Collection	3
Wastewater Treatment	129
Wastewater System	132

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 1: Statewide and Regional Water-Energy Relationship. Prepared by GEI Consultants/Navigant Consulting.

Irvine Ranch Water District. Website: http://www.irwd.com/index.php. Accessed June 3, 2010.

Irvine Ranch Water District Fact Sheet. Website: http://www.irwd.com/MediaInfo/factsheet.pdf. Downloaded April 22, 2010.

Shih, J. Personal communication. Water Resources Engineering Technician. Irvine Ranch Water District.

City of San Diego

The City of San Diego Water Department (CSDWD) serves more than 1.3 million people in approximately 330 square miles. San Diego has nine raw water storage facilities that hold rainwater and runoff until receiving treatment and entering the distribution system. Typically 10 to 20 percent of San Diego's water is supplied this way, while the other 80 to 90 percent, depending on the year, is imported from the San Diego County Water Authority (SDCWA) and the Metropolitan Water District of Southern California (MWD). Almost all imported water is treated at one of three treatment plants: Miramar in the north, Otay in the south, or Alvarado in central San Diego. A small portion of imported water comes in treated and directly enters the distribution system. CSDWD has one groundwater well, the San Vicente Production Well, however it only produced 0.2 percent of the city's potable water supply in 2008.

In addition to potable water, the CSDWD treats and distributes wastewater for use in irrigation, manufacturing, and other non-potable purposes. The North City and South Bay water reclamation plants are used for this purpose and have a combined capacity of 45 million gallons per day (MGD). The North City reclamation plant is larger, treating up to 30 MGD, and is powered primarily by landfill gas. Four pumps bring influent wastewater to the plant and after thorough treatment the effluent water is distributed for industrial or agricultural use. The South Bay reclamation plant is smaller with a wastewater treatment capacity of 15 MGD and uses energy supplied by SDG&E. After treatment at South Bay, effluent is either discharged to the ocean or distributed as reclaimed water to the South Bay area. The overall energy intensity of tertiary water treatment at the North City and South Bay Water reclamation plants was calculated to be 3,529 kWh per million gallons by the California Sustainability Alliance. The Point Loma wastewater treatment plant is the largest in the system, with a capacity of 240 MGD, and treats water before discharging all effluent to the ocean; no water is recycled at the Point Loma Plant.

Data for potable water flows and energy use were obtained for calendar year 2008 and formatted for input into the Access tool. Wastewater flows and energy were provided for fiscal year 2007. To convert this data to a format fitting calendar year 2008 an adjustment was made by taking data from January to June 2007 and July to December 2006, inserting a zero for energy and flows on February 29 to account for the leap year day. Energy data were not received for the Miramar treatment plant, so the treatment energy intensity shown below in Table 28 is lower than might be expected.

As shown in Table 28 approximately 85 percent of the City of San Diego potable water is imported from SDCWA at an energy intensity of 7,464 kWh per million gallons. Based on a weighted average of the energy intensities of the different water sources, we estimate that water supply, conveyance, and treatment within CSDWD has an energy intensity of 6,387 kWh per million gallons, of which only 43 kWh per million gallons is provided by an IOU. This IOU energy intensity is likely a low estimate due to the fact that we did not receive energy usage data for all facilities, specifically the Miramar treatment plant.

Table 29 shows that distribution of potable water utilizes IOU energy at an intensity of 338 kWh per million gallons. The potable water system energy intensity is 6,726 kWh per million gallons, of which 381 kWh per million gallons is provided by an IOU.

Table 28: Energy Intensity of Supply, Conveyance and Treatment for City of San Diego Potable Water System

	Energy Intensity (kWh/MG)		
Phase	Raw Water	Groundwater	Imported Water (Total Energy)
Supply			
Conveyance	50	1,808	0 (7,464)
Treatment			35
Fraction of Supply	15%	<1%	85%
Weighted Average for 2008		43 (6,387)	

Table 29: Energy Intensity of the City of San Diego Potable Water System

	IOU Energy Intensity (kWh/MG)	Total Energy Intensity (kWh/MG)
Supply/Conveyance/Treatment	43	6,387
Distribution	338	338
Potable Water System	381	6,726

Table 30 below shows the CSDWD energy intensities for the wastewater system. Wastewater collection has an energy intensity of 749 kWh per million gallons, while wastewater treatment is lower, at 303 kWh per million gallons. In total, the CSDWD wastewater system requires 1,052 kWh per million gallons, all of which is IOU-provided energy.

Table 30: Energy Intensity of the City of San Diego Wastewater System

	IOU Energy Intensity (kWh/MG)
Wastewater Collection	749
Wastewater Treatment	303
Wastewater System	1,052

Sources

California Institute for Energy and Environment (CIEE) and the California Public Utilities Commission (CPUC). 2010. Study 1: Statewide and Regional Water-Energy Relationship. Prepared by GEI Consultants/Navigant Consulting.

California Sustainability Alliance. May 2, 2008. The Role of Recycled Water in Energy Efficiency and Greenhouse Gas Reduction. Prepared by Navigant Consulting.

The City of San Diego Water Department. Website: http://www.sandiego.gov/water/. Accessed June 8, 2010.

The 2005 City of San Diego Urban Water Management Plan. Website: http://www.sandiego.gov/water/pdf/uwmpfinal.pdf.

Fikhman, T. Personal communication. Associate Engineer - Civil. City of San Diego Water Department.

McKinney, C. Personal communication. Deputy Director, Wastewater Treatment and Disposal Division. City of San Diego Public Utilities Department.

Morales, R. Personal communication. Associate Engineer - Civil. City of San Diego Water Department.

Ramos, J. Personal communication. Assistant Engineer - Civil. City of San Diego Water Department.

Appendix 2: PG&E Large Commercial Customer Pilot Program

2.1 Ozone Laundry Systems M&V Plan

NOTE: THIS EVALUATION PLAN WAS UTILIZED FOR SITES: P01, P07, P09, P15, P16, P17 AND P18.

THE ACTUAL DATA THAT ARE INCLUDED PERTAIN TO SITE P01 ONLY.

SITE-SPECIFIC MEASUREMENT AND VERIFICATION PLAN

PG&E WEP-LCC – SITE P01

June 17, 2009

SUMMARY INFORMATION

PROJECT

Program Name	PG&E Large Commercial Customer Program
Measure Type	Ozone Laundry Treatment in Hospitality
Customer Name	
Site Name	
Site Address	

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

INVESTOR-OWNED UTILITY MANAGER

Name		**Telephone**	
E-mail		**Company**	

WATER AGENCY

Name		**Telephone**	
E-mail		**Company**	

SITE LEAD

Name		**Telephone**	
E-mail		**Company**	

BACKGROUND

The Large Commercial Customer Program offers audits to participating large commercial and industrial customers to recommend water efficiency improvements at a selected facility. The program also offers financial incentives to help offset the cost of the improvements that are implemented by the customer within the one-year duration of the pilot program. For ozone retrofits in laundry facilities, the audit is performed by the ozone vendor. For all other water efficiency improvements, the audit is performed by a combination of water agency staff and consultants retained by PG&E. Each audit will include a review of existing water bills and facility information, a physical inspection of the customer's facility, preparation of an inventory of water-using equipment, processes and operating times, and identification of options to reduce water use.

The following M&V plan documents our planned evaluation approach. It is based upon the best information currently available, and is subject to change as the project proceeds.

Measure Description

Efficiency Improvement

The energy efficiency upgrade at the hotel is the installation of an ozone injection system in the laundry room of a hotel. The use of ozone for washing laundry decreases the amount of hot water and chemicals required. Minimizing chemicals reduces the number of rinses necessary for each load of laundry.

Pre-retrofit Equipment and Operation

This hotel contains 775 guest rooms, and is served by a laundry facility that contains four washers. Machines #1 and #2 are 350-lb, machine #3 is 240-lb and machine #4 is 100-lb. The laundry operating schedule is unknown currently. Average daily laundry production is estimated at 10,000 lbs/day, with the laundry operating 365 day/year.

Post-retrofit Equipment and Operation

The equipment installed for this measure consists of an ozone generator and associated distribution and control hardware. The equipment is expected to reduce the water used during the rinse cycle and possibly shorten the wash cycle. The equipment has not been installed as of the date of this plan.

Variability in Schedule

For this hotel, the busiest months are typically during late spring and summer (May-August), and the slowest months are in the winter and especially during the holidays. April to May constitutes the shoulder season. This will be confirmed with the occupancy data provided by the site contact.

Algorithms for Estimating Water Savings

Utility Algorithms

The project sponsor performed preliminary calculations of the water savings associated with the retrofit using the following equations. The first equation is used to calculate the daily water usage for both the pre-retrofit and post-retrofit conditions.

$$AvgDailyWaterUse(gallons/day) = \frac{Laundry(Lb)}{Day} \times \frac{Gallons\_Water}{Laundry(Lb)}$$

Where

Laundry(Lb) = Pounds of laundry washed per day, either light or medium soil.

Gallons_Water = Gallons of water, either hot or cold, required to wash a pound of laundry.

The daily hot and cold water usage for laundry is calculated and then they are summed together. The yearly water savings value is calculated using the following equation.

$$YearlyWaterSavings = (AvgDailyWaterUse_{pre} - AvgDailyWaterUse_{post}) \times 365$$

Annual Ex Ante Measure Savings:

The ex ante savings were estimated using information provided by the customer, chemical representative and national averages instead of site specific analysis. As such the baseline consumption and percentage savings are different from that expected if the calculations were based on metered baseline data. The savings were calculated using the key assumptions shown in Table 1 below.

Table 1: Summary of Assumptions for Ex Ante Savings Calculations

	Assumptions:	Ozone	Traditional
		-	-
1	Gallons/pound - light soil	1.500	3.000
2	Gallons/pound - medium/heavy soil	2.000	3.500
3	Percentage hot water - light soil	20%	70%
4	Percentage hot water - medium/heavy soil *	30%	80%
5	Pounds/ per day	10,000	10,000
6	Percentage of linen - light soil	80%	80%
7	Percentage of linen - medium/heavy soil	20%	20%
8	Average ambient water temperature	65	65
9	Average hot water temperature at boiler/heater	120	120
10	Cost per therm of heating source	$1.45	$1.45
11	Cost of Water/sewer per/1,000 gallons **	$3.00	$3.00
12	Hours of dryer usage per day	35	58
13	Labor rate per pound	$0.08	$0.08
14	% Labor savings	10%	0%
15	Annual Linen Replacement ***	$80,000.00	$80,000.00
16	% Linen replacement savings	20%	0%
17	Days per year of operation	365	365

* Items 1-4 were compiled through testing done by nationally recognized washer mfg. Using a nationally known chemical co.'s traditional cycles vs. Total Ozone Solutions ozone cycles in conjunction with lab test swatches proving as good if not better results.
** Items 5-11 are actual costs / % / temperatures at your property/facility per your records or if records were not available local avg's.
*** Item 15 is actual cost per your records or industry averages per a nationally recognized consulting firm.

Ex ante calculations estimated annual water savings of 5,475,000 gal/yr, as shown in Table 2 below. This represents annual water savings in laundry of 48%.

Table 2: Ex Ante Savings Estimate

	Cold	Hot	Total
Traditional Wash (gal/yr)	3,139,000	8,176,000	11,315,000
Ozone Wash (gal/yr)	4,526,000	1,314,000	5,840,000
Savings (gal/yr)	-1,387,000	6,862,000	5,475,000

Evaluation Algorithms – Water Savings

To estimate average daily water savings from this measure, we will use an algorithm similar to that used by the utility. We will then input our evaluated average daily water savings into the

Energy Savings and Avoided Costs Calculator prepared by Jeff Hirsch (Embedded Energy Calculator) to compute annual water savings. The Embedded Energy calculator requires four input parameters to compute annual water savings – daily water savings profile, day type multiplier, monthly multiplier, and average savings per day. An additional input parameter, measure life, is then used to compute lifetime savings. The input data for the Embedded Energy calculator are described below.

Daily water savings profile: accounts for differences in water savings between hours of the day.

Day type multiplier: accounts for differences in water savings between weekdays and weekends.

Monthly multiplier: accounts for differences in water savings between months of the year.

Measure Life (yrs): accounts for the life of the equipment, we will apply the measure life used by the IOU for the laundry ozone treatment program.

Pre-installation data collected at the hotel include the water consumption for Machine 2 (350 lb) and Machine 4 (100 lb) and the load counts for all four machines, while the post-installation data include the time-of-use water usage meters for the metered machines

On two of the four washers and post installation water usage, time and usage and load count data will be collected for a 3-week period of time.

Daily Water Savings Profile (unit-less ratio): Time-of-use data are only available for post-installation water use as the ozone injection system was installed before SBW could meter the site. As a result we are unable to compute a daily pre-retrofit water savings profile. However, as per facility staff the clothes washers are typically operated everyday from 7-am to 8-pm, with no significant change in loading habits from pre- to post-installation. As such it is safe to assume that the water savings profile will be similar to water use profile obtained from the post-installation time-of-use monitoring, where laundry water use is generally between 7-am and 8 pm, but can be shorter or longer hours on occasion. The 24 data point, water savings (use) profile is computed as a ratio of the average water use for a given hour in a twenty-four hour period, divided by the average daily water use. If n is any hour in a 24-hour period, then the water use ratio for the n^{th} hour will be computed as shown below.

Data Collection

The system vendor installed meters at the main supply pipes to the laundry machines. As the water supply pipes are larger than normal, it was not possible to meter both hot and cold pipes for all four machines, so meters were installed on the hot and cold water pipes for one of the 350-lb washing machines and the 100-lb washing machine. Metering began on April 13, 2009 and the most recent meter reading was recorded on June 8, 2009, for a total of 56-days worth of pre-installation data. According to the installation vendor, the total annual water consumption for the pre-ozone installed condition, based on metered data, is 9,392,649 gal/yr.

The meters installed by the ozone vendor did not collect time-of-use information, however, the meters installed by the evaluation team for the post installation evaluation will, and these data will be used to build a daily water savings (use) profile as explained earlier. This will also help track the number of loads of laundry completed on the two metered machines daily. The time-of-use metering will be done for a minimum period of 20 days. In addition, daily occupancy data and pounds of laundry washed will be provided by the site contact for the entire year of 2008 and up until the end of the metering period in 2009 to build a seasonal water use profile. This, combined with the time-of-use water consumption data, will be used to establish a relationship between the occupancy and the water consumption and between laundry use and water consumption. An additional means of confirming the load counts and time of use on all four machines included the installation of motor loggers on all of the machines to track when and how long the machines operate. The table below describes the parameters that will be measured by our installed metering equipment, which will provide time-of-use measurements. If possible total monthly water use will also be metered for a longer period of up to one year

Table 5: Evaluation Measurements

Description	Evaluation
Equipment monitored	Washers #2 and #4
Parameter measured	1. Hot and cold water supply volumes (cumulative gallons) 2. Hot and cold water time of use (one pulse per gallon)
Measurement equipment	1. In-line turbine-type totalizing water meter, Clark CLXC20DHS, with pulse output 2. Hobo event logger.
Installation method	1. Plumbed into water supply line. 2. Connected to temporary water meters.
Observation frequency	1. Continuously throughout pre and post metering periods. 2. Each time a gallon flows (can record about 20,000 events/gallons)
Measurement duration	At least one month after ozone system is installed.

Sampling Strategy

Water measurements will be taken from the pipes that supply water to the machines in the laundry. It may not be possible to measure post water consumption for a full year after installation. In such a case, the post water consumption will be extrapolated for the missing months of data using occupancy information. No sampling will be done, as we will continue monitoring the 4 water supply pipes metered by the ozone vendor during the pre-installation period.

Schedule

Program pre-retrofit metering occurred in April-June 2009. The ozone system is expected to be installed in June 2009. Post-retrofit metering will begin soon after the ozone system has been installed and will continue for about a month.

Data Products

We will produce the following data products as part of the evaluation:

Post water usage data, including both time-of-use and cumulative volumes.

Excel workbook containing calculations of evaluated average daily water savings.

Embedded Energy Calculator with annual water savings and corresponding energy savings profiles.

2.2 High Efficiency Dishwasher (P03) M&V Plan

SITE-SPECIFIC MEASUREMENT AND VERIFICATION PLAN

PG&E WEP-LCC: SITE P03

May 4, 2009

SUMMARY INFORMATION

PROJECT

Program Name	PG&E Large Commercial Customer Program
Measure Type	Efficient dishwasher
Customer Name	
Site Name	P03
Site Address	

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

INVESTOR-OWNED UTILITY MANAGER

Name		**Telephone**	
E-mail		**Company**	

WATER AGENCY

Name		**Telephone**	
E-mail		**Company**	

SITE LEAD

Name		**Telephone**	
E-mail		**Company**	

Background

PG&E's Water-Energy Pilot Large Commercial Customer Program (WEP-LCC) offers financial incentives to help offset the cost of customer water efficiency improvements. One avenue that

PG&E uses to develop projects for this program is to work with partner water utilities, such as East Bay Municipal Utility District, to identify promising water-saving projects.

This commercial dishwasher replacement project will take place in the dormitory cafeteria at P03.

The following M&V plan documents our planned approach for evaluating water savings. It is based upon the best information currently available, and is subject to change as the project proceeds.

Measure Description

Efficiency Improvement

The efficiency improvement at this facility consists of replacing the existing flight-type commercial dishwasher with a high-efficiency model.

Pre-retrofit Equipment and Operation

The existing dishwasher is a Stero Model STPCW three-tank flight-type machine. It is rated as being able to process 17,858 dishes/hour, and with a flowrate of 336 gallons/hour. In the energy audit provided by the new equipment vendor, the dishwasher was assumed to operate 10 hours/day, seven days/week.

During a pre-installation inspection, we observed the following:

1. The dishwasher operator would turn off the conveyor for long periods of time while she pre-rinsed dishes and stacked them to one side until she had enough to run, and then she would turn on the machine and run the dishes until the stack was finished.

2. When the dishwasher was first turned on, hot water flowed at around 25 gpm, presumably to fill the tanks. Thereafter, while the conveyor was running, hot water would alternately turn on for a few minutes, at around 5 gpm, and then off for a while. The machine appeared to use only a pumped power rinse. We did not discern any continuous non-pumped rinse, nor were we able to determine clearly the reason for the observed intermittent flow.

3. At no time was any cold water flow registered. It appears that cold water is not used by the machine as part of the normal dishwashing cycle.

Post-retrofit Equipment and Operation

The proposed dishwasher is a Hobart Model FT900D with Opti-Rinse™. It is also a flight-type unit, with a continuous racking automatic conveyor that can handle up to 15,333 dishes/hour, with a flowrate of 90 gallons/hour. A manufacturer press release discusses the Opti-Rinse™ feature thusly:

> *…Hobart's new Opti-Rinse™ System… uses technologically advanced rinse spray nozzles (patent pending) that utilize 50 percent less water and energy than the industry-standard fan-spray nozzles and yet deliver stronger performance.*

> *…Our C-line Opti-Rinse System significantly reduces water consumption, sanitary sewer usage, and energy (electric, gas or steam) required to heat the water."*
>
> *The industry's existing rinse nozzles produce a fan spray pattern. The flow of the fan spray nozzles tend to be heavier on the outside edges and more atomized (smaller droplets) in the center of the fan-like shape.*
>
> *…Hobart warewashers using the Opti-Rinse System are able to spray larger drops of water onto ware during the rinse cycle more uniformly and with greater force while achieving needed temperatures with less water. The standard fan-spray nozzles cause water to lose heat faster because the water droplets are smaller resulting in greater heat loss to the surrounding air.*

Variability in Schedule

The quantities of dishes vary depending on the academic schedule and corresponding number of students eating at the cafeteria. Based on initial information from university staff, we expect that dishwashing demand will diminish significantly during the summer term (roughly late May through late August).

Algorithms for Estimating Water Savings

Utility Algorithms

The vendor energy audit estimated water savings through simple spreadsheet calculations. The basic algorithm is as follows:

Water use = Nominal water flowrate × Annual hours of use × Final rinse percentage

Where:

- *Nominal water flowrate* was 336 and 90 gallons/hour (5.6 and 1.5 gpm) for the existing and proposed dishwasher, respectively.
- *Annual hours of use* were 3,640 hours/year, based on 10 hours/day operation every day of the year.
- *Final rinse percentage* was 70%, representing a vendor assumption that final rinse occurs 70% of the time that the dishwasher was in use.

Water savings equaled the difference between calculated annual pre-installation water use and annual post-installation water use.

Annual Ex Ante Measure Savings

The program application predicted annual potable water savings of 626,808 gallons/year, or 1,717 gallons/day.

Evaluation Algorithms

The evaluation team will estimate verified water savings through simple spreadsheet calculations. The basic algorithm will be as follows:

Average daily water savings = (Pre flowrate, measured average annual - Post flowrate, measured average annual) × Annual hours of use / Days per year

Where:

- *Flowrates* will be average gallon/hour values, as determined from short-term metering, staff interviews, and posted academic calendars. We will extrapolate the data to estimate average values that best represent a typical year.
- *Annual hours of use* will be the best estimate of typical hours, based on pre and post evaluation data.
- *Days per year = 365.*

We will then input our evaluated average daily water savings into the Energy Savings and Avoided Costs Calculator prepared by Jeff Hirsch (Embedded Energy Calculator) to compute annual water savings. The Embedded Energy calculator requires four input parameters to compute annual water savings – daily water savings profile, day type multiplier, monthly multiplier, and average savings per day. An additional input parameter, measure life, is then used to compute lifetime savings. The input data for the Embedded Energy calculator are described below.

- *Daily water savings profile: accounts for differences in water savings between hours of the day.*
- Day type multiplier: accounts for differences in water savings between weekdays and *weekends.*
- Monthly multiplier: accounts for differences in water savings between months of the year.
- *Measure* Life (yrs): accounts for the life of the equipment; we will apply the measure life used by the IOU for this technology.

Data Collection

The table below describes the parameters that will be measured by evaluator-installed metering equipment. Note that the pre-installation data collection has already begun, in advance of the approval of this plan. We started this process early, because the opportunity for collecting suitable pre data was going to end soon.

Table 3: Evaluation Measurements

Equipment monitored	Dishwasher
Parameter measured	1. Average flowrates and total volume through 1" hot and 3/4" cold water supply lines leading to the dishwasher. 2. Dishwasher operating ("on") hours.
Measurement equipment	• Panametrics PT868 dual channel ultrasonic flowmeter. • Dent Instruments SmartLogger time-of-use motor logger.

Installation method	1. Sensors strapped onto water pipes temporarily. 2. Placed near dishwasher drive motor temporarily.
Observation frequency	1) Every 6 minutes (averaged). 2) Every change of state (on/off event).
Measurement duration	1) April 28, 2009 until late May 2009 (pre). At least a month in fall 2009 (post). 2) Pre-installation: April 28, 2009 until early summer, just prior to when existing dishwasher is removed (pre). Post-installation: Soon after new dishwasher is installed, through at least a month in fall term of 2009.

In addition, after the post-installation metering data collection is complete, we will interview site contacts about their experiences with dishwashing levels throughout the year, particularly summer months and school breaks.

We will also probe about any unusual conditions or changes that might have dishwasher water use during the metering periods, or are highly likely to occur in the future. These could include, but are not limited to:

Appendix 1: Changes in usage levels.

Appendix 2: Changes in operating strategies, such as adding or eliminating a rinse stage.

Appendix 3: Planned or unplanned outages, such as for maintenance.

Sampling Strategy

No sampling will be required for this effort.

Schedule

The evaluation team began pre-retrofit metering April 28, 2009. The new dishwasher is expected to be installed by during the summer of 2009, prior to the start of the fall term in August. Post-retrofit metering will begin soon after the new dishwasher has been installed and will continue for at least a month.

Data Products

We will produce the following data products as part of the evaluation:

Pre and post water usage data, including both time-of-use and cumulative volumes.

Excel workbook containing calculations of evaluated average daily water savings.

Embedded Energy Calculator with annual water savings and corresponding energy savings profiles.

2.3 Recycled Water System (P04) M&V Plan

SITE-SPECIFIC MEASUREMENT AND VERIFICATION PLAN

PG&E WEP-LCC: SITE P04

April 28, 2009

SUMMARY INFORMATION

PROJECT

Program Name	PG&E Large Commercial Customer Program
Measure Type	Recycled water use in cooling tower
Customer Name	
Site Name	P04
Site Address	

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

INVESTOR-OWNED UTILITY MANAGER

Name		**Telephone**	
E-mail		**Company**	

WATER AGENCY

Name		**Telephone**	
E-mail		**Company**	

SITE LEAD

Name		**Telephone**	
E-mail		**Company**	

Background

PG&E's Water-Energy Pilot Large Commercial Customer Program (WEP-LCC) offers financial incentives to help offset the cost of customer water efficiency improvements. One avenue that

PG&E uses to develop projects for this program is to work with partner water utilities to identify promising water-saving projects.

This recycled water project is at Site P04, a designer and manufacturer of medical testing equipment.

The following M&V plan documents our planned approach for evaluating water savings. It is based upon the best information currently available, and is subject to change as the project proceeds.

Measure Description

Efficiency Improvement

The efficiency improvement at this facility consists of adding a recycled water supply line to provide makeup water to three cooling towers. Using recycled water in place of potable water will reduce the embedded energy necessary to supply the water to the towers.

Pre-retrofit Equipment and Operation

Currently, the customer has three cooling towers on the roof of Building X, which reject heat from the HVAC and process cooling system. In September 2008, the customer added the third cooling tower, which along with a third chiller, provide cooling for two new buildings. Cooling tower water lost to evaporation and blowdown is resupplied via a potable water supply line. The cooling towers are equipped with a conductivity meter that measures dissolved solids and pH. Blowdown occurs when total dissolved solids concentrations reach 1,600 ppm.

Post-retrofit Equipment and Operation

This measure will result in the installation of a recycled water line that taps into South Bay Water Recycling's recycled water network, which runs down the street adjacent to the facility. This line will feed the Building X cooling towers, and will be plumbed to provide a redundant supply. In other words, while the facility expects to use recycled water exclusively for the cooling towers, if a problem occurs, they can immediately switch back to using potable water temporarily.

Variability in Schedule

The offices and production areas at the facility are in use year-round. Cooling tower use, and corresponding water use, should increase during warmer times of year.

Algorithms for Estimating Water Savings

Utility Algorithms

The customer estimated water savings by performing a system-wide energy analysis using TRACE® 700 v6.2 energy modeling software. This analysis calculated overall cooling loads, and the corresponding cooling tower energy and water usage, based on most recent operating conditions.

Annual Ex Ante Measure Savings

The program application predicted annual potable water savings of 7,825,000 gallons/year, or 21,438 gallons/day.

Evaluation Algorithms

To estimate average daily water savings from this measure, we will use extensive water use data trended by the customer. We will also make adjustments using typical hourly temperatures for the San Jose area to estimate savings for a typical year. The expected calculation steps are as follows:

1. Using at least several months' worth of data, develop as good a correlation as possible between metered *makeup water use* and actual *dry bulb outside air temperature*, with the latter being the independent variable. While we hope to generate a strong correlation with hourly data, it may be necessary to use daily average values instead, so that we can generate a function of the form:

Makeup water use = f(*dry bulb outside air temperature*)

2. Apply typical hourly temperatures to the function developed above to develop an annual savings estimate. These temperatures will be the TMY2 hourly temperatures for a typical year for Climate Zone 4, as developed by the California Energy Commission.
3. Adjust the annual savings estimate to account for any potable water use in the post-installation period. While this is not expected, if it does occur, we will investigate the reasons why, and if it appears likely that potable water use will continue in the future, we will prorate the savings accordingly. We will also adjust for any other unusual conditions, such as production cutbacks or maintenance outages.
4. Divide the adjusted annual savings estimate by 365 to yield average daily water savings.

We will then input our evaluated average daily water savings into the Energy Savings and Avoided Costs Calculator prepared by Jeff Hirsch (Embedded Energy Calculator) to compute annual water savings. The Embedded Energy calculator requires four input parameters to compute annual water savings – daily water savings profile, day type multiplier, monthly multiplier, and average savings per day. An additional input parameter, measure life, is then used to compute lifetime savings. The input data for the Embedded Energy calculator are described below.

a. Daily water savings profile: accounts for differences in water savings between hours of the day.
b. Day type multiplier: accounts for differences in water savings between weekdays and weekends.
c. Monthly multiplier: accounts for differences in water savings between months of the year.

d. Measure Life (yrs): accounts for the life of the equipment; we will apply the measure life used by the IOU for this technology.

Data Collection

The table below describes the parameters that will be measured by customer- and utility-installed metering equipment.

Table 4: Evaluation Measurements

Equipment monitored	Cooling towers atop Building X (qty. 3)
Parameter measured	3. Potable water supply - cumulative volumes and instantaneous flow rates. 4. Recycled water supply - cumulative volumes.
Measurement equipment	• Ultrasonic meter (customer's existing, type to be established during site visit) • In-line totalizing revenue meter (type TBD by South Bay Water Recycling).
Installation method	3. Strap-on, permanent. 4. In-line, permanent.
Observation frequency	3) Cumulative volumes: intermittent reads every 1 hour – 6 days. Flow rates: every 5 minutes. 4) Cumulative volumes: beginning and end of post metering period, perhaps supplemented by intermediate meter reads provided by the customer.
Measurement duration	3) Cumulative volumes: March 13, 2009 until date when recycled water line is in use (June 30 expected). Flow rates: January 2009 until date when recycled water line is in use (June 30 expected). 4) Cumulative volumes: At least two months after recycled water line is in use.

In addition, after the post-installation metering data collection is complete, we will interview site contacts about any unusual conditions or changes that might have affected cooling tower water use during the metering periods, or are highly likely to occur in the future. These could include, but are not limited to:

a) Potable water use after the recycled water line is in place.

b) Changes in production levels.

c) Changes in operating strategies, such as altering the cooling tower TDS concentration threshold, or condensing water set point.

d) Planned or unplanned outages, such as for maintenance, production equipment failure, or remodeling.

Sampling Strategy

No sampling will be required for this effort.

Schedule

Program pre-retrofit metering data are currently available for a period beginning in January 2009. The recycled water line is expected to be installed by the end of June 2009. Post-retrofit metering will begin soon after the line has been installed and will continue for at least two months.

Data Products

We will produce the following data products as part of the evaluation:

1. Pre and post water usage data, including both time-of-use and cumulative volumes.
2. Excel workbook containing calculations of evaluated average daily water savings.
3. Embedded Energy Calculator with annual water savings and corresponding energy savings profiles.

2.4 Ozone Laundry Systems Site-Specific Report

NOTE: RESULTS FOR SITES P01, P07, P09, P15, P16, P17 AND P18.

June 15, 2010

SUMMARY INFORMATION

PROJECT

Program Name	PG&E Large Commercial Customer Program
Measure Type	Ozone Laundry Treatment in Hospitality

INVESTOR-OWNED UTILITY MANAGER

Name		**Telephone**	
E-mail		**Company**	

WATER AGENCY

Name	

SITE LEAD

Name		**Telephone**	
E-mail		**Company**	

Background

The Large Commercial Customer Program offered audits to participating large commercial and industrial customers to recommend water efficiency improvements at a selected facility. The program also offered financial incentives to help offset the cost of the improvements that were implemented by the customer within the one-year duration of the pilot program. For ozone retrofits in laundry facilities, the audits were performed by the ozone vendor. For all other water efficiency improvements, the audit was performed by a combination of water agency staff and consultants retained by PG&E. Each audit included a review of existing water bills and facility information, a physical inspection of the customer's facility, preparation of an inventory of water-using equipment, processes and operating times, and identification of options to reduce water use.

This Program ultimately included seven projects that installed ozone laundry treatment systems in hotel facilities. This M&V report documents our evaluation methodology and findings, individually and in aggregate, for these ozone projects.

Measure Description

Efficiency Improvement

The water efficiency upgrade involved the installation of an ozone injection system in the laundry room of seven hotels. The use of ozone for washing laundry decreases the amount of hot water and chemicals required. Minimizing chemicals reduces the number of rinses necessary for each load of laundry.

Pre-retrofit Equipment and Operation

Table 5: Laundry Equipment and Operation

Hotel	# of Washers	Total Washer Capacity	Laundry Operating Hours
P01	5	565 lbs	7AM-7PM, year round
P07	4	1,040 lbs	7AM-8PM (24 hours/day when busy, 10 hours/day when slow)
P09	3	255 lbs	8AM-4:30PM, 7 days
P15	2	180 lbs	6AM-9PM (7AM-5PM Sundays)
P16	3	160 lbs	8:30AM-7PM (11PM when busy)
P17	2	100 lbs	8:30AM-7PM, 7 days, year round
P18	4	220 lbs	11AM-7:30PM, 7 days

Post-retrofit Equipment and Operation

The equipment installed at each hotel consists of an ozone generator and associated distribution and control hardware. The use of ozone in the laundry water greatly reduces or eliminates the need for hot water by using cold water instead. The equipment is also expected to reduce the water used during the rinse cycle and possibly shorten the wash cycle. Therefore, net water use should decrease. Number and capacity of existing washers as well as operating hours did not change as a result of the installation of the ozone equipment.

Variability in Schedule

Typically, these hotels are busier during late spring to early fall, busiest during the summer, and slowest during the winter.

Algorithms for Estimating Water Savings

Utility Algorithms

The system vendor performed preliminary calculations of the water savings associated with the retrofit using the following equations. The first equation is used to calculate the daily water usage for both the pre-retrofit and post-retrofit conditions.

$$AvgDailyWaterUse(gallons/day) = \frac{Laundry(Lb)}{Day} \times \frac{Gallons\_Water}{Laundry(Lb)}$$

Where

Laundry(Lb) = Pounds of laundry washed per day, either light or medium soil.

Gallons_Water = Gallons of water, either hot or cold, required to wash a pound of laundry.

The daily hot and cold water usage for laundry is calculated and then they are summed together. The yearly water savings value is calculated using the following equation.

$$YearlyWaterSavings = \left(AvgDailyWaterUse_{pre} - AvgDailyWaterUse_{post}\right) \times 365$$

Table 6 shows ex ante savings values for each hotel obtained from the utility tracking spreadsheet.

Table 6: Annual Ex Ante Savings

Hotel	Savings (gallons/year)
P01	*1,698,980*
P07	*2,564,393*
P09	*318,290*
P15	*280,400*
P16	*214,968*
P17	*292,000*
P18	*459,000*
Total	***5,828,031***

Evaluation Algorithms – Water Savings

The original evaluation algorithms in the M&V plans included adjustments for occupancy and/or number of loads. Occupancy data and load counts were not available for all hotels; therefore, planned adjustments could not be made, as explained further in Section 0 Key Findings. To estimate average daily water savings from this measure, the following equation is applied.

$$AvgDailyWaterUse(gallons / day) = \frac{(End_{Cold} - Start_{Cold}) + (End_{Hot} - Start_{Hot})}{DaysElapsed}$$

Where

End = Meter reading at end of period (gallons)

Start = Meter reading at start of period (gallons)

Cold = Meter on cold water tap

Hot = Meter on hot water tap

DaysElapsed = number of days in period between meter reads

The annual water savings value is calculated using the following equation.

$$AnnualWaterSavings = (AvgDailyWaterUse_{pre} - AvgDailyWaterUse_{post}) \times 365$$

Data Collection

At each of the seven ozone project sites, the system vendor installed meters at the main water supply pipes to the laundry washing machines to collect pre- and post-implementation water use data.

At P07, as the water supply pipes are larger than normal, it was not feasible to meter both hot and cold pipes for all four machines, so meters were installed on the hot and cold water pipes for one of the 350-lb washing machines and the 100-lb washing machine. However, load counts were available for all four washers via a load count meter. The vendor recorded load data along with washer capacity for the two unmetered washers. These results along with water meter reads from the 350-lb washer were used to model water use for the unmetered washers.

Table 7 describes the parameters measured by our installed metering equipment, which provide time-of-use measurements. According to the plan, we originally collected time-of-use data to support estimating key parameters (such as average hourly water savings profiles for different day types and months) in the Embedded Energy Calculator. The upstream methodology for estimating embedded energy impacts, however, has evolved, so that such hourly profiles are no longer necessary for that purpose, and are not addressed in this report. Instead, the time-of-use data will be made available as a separate deliverable.

The evaluation team made significant efforts to collect occupancy, load count and pounds of laundry data, but often the customer did not have such data. The plan had been to determine the relationship between occupancy and/or laundry use and water consumption. Unfortunately, this scheme was complicated by the fact that for most of the ozone projects, their completion and inclusion in the program was uncertain until the end of 2009, when the program concluded. Adding sites so late in the evaluation process made it difficult, if not impossible, for us to collect the aforementioned supplemental data at many of the sites. Furthermore, at the first site selected for evaluation, we attempted to establish a more detailed data collection protocol that would have carefully recorded load counts, but the customer eventually declined providing us with that information.

Section 0 - Key Findings - provides more details and a table listing the types of data collected from each hotel.

Table 7: Evaluation Measurements

Description	Evaluation
Equipment monitored	*Washers*
Parameter measured	*1. Hot and cold water supply volumes (cumulative gallons)* *2. Hot and cold water time of use (one pulse per gallon)*
Measurement equipment	*1. In-line turbine-type totalizing water meter, Clark CLXC20DHS, with pulse output* *2. Hobo event logger.*
Installation method	*1. Plumbed into water supply line.* *2. Connected to temporary water meters.*
Observation frequency	*1. Continuously throughout pre and post metering periods.* *2. Each time a gallon flows (can record about 20,000 events/gallons)*
Measurement duration	*See Table 8: Installation and Metering Schedule*

Sampling Strategy

All washers impacted by ozone equipment installation were metered as feasible.

Schedule

Table 8 shows dates of ozone equipment installation as well as pre/post-retrofit metering date ranges and durations.

Table 8: Installation and Metering Schedule

Hotel	Ozone Installation	Metering Period[1]	Days Metered in Pre-Retrofit Period	Days Metered in Post-Retrofit Period
P01	*Fall 2008*	*3/12 – 9/22/08 (pre)* *11/3/08 - 3/12/10*	*194*	*495*
P07[2]	*Late June 2008*	*4/13 - 7/26/09*	*66*	*33*
P09	*July 29, 2009*	*7/1/09 - 2/18/10*	*28*	*205*
P15	*Late Fall 2009*	*9/28/09 - 2/17/10*	*49*	*65*
P16[3]	*Late Fall 2008/ Earl Winter 2009*	*9/24 – 11/5/08 (pre)* *2/3-3/23/09, 2/10-2/19/10 (post)*	*42*	*57*
P17	*October 29, 2008*	*9/24/09 – 2/18/10*	*35*	*478*
P18	*Fall 2008*	*5/29/09 – 2/17/10*	*113*	*496*

1 Metering period encompasses pre and post unless otherwise noted.

2 Washer 2 metered until 8/19/09. Ozone installed on Washer 4 mid September 2009. Metering on that machine took place until 2/16/10.

3 Meter reset between 3/23/09 and 2/10/10.

Data Products

The evaluation resulted in an Excel analysis spreadsheet that contains raw data as well as the calculations used to compute pre and post water consumption and savings for the measures.

Evaluation results

Results Summary

Total annual ex post savings from all seven hotels is 3.82 million gallons or 5,107 CCF. Comparing to total annual ex ante savings of 5.83 million gallons gives a realization rate of 66%. See **Table 9** for a break down by hotel.

Table 9: Annual Ex Post Total Savings Summary By Hotel

Hotel	Total Savings (gallons/year)	Realization Rate
P01	963,967	57%
P07	1,767,145	69%
P09	441,720	139%
P15	375,684	134%
P16	290,094	135%
P17	13,891	5%
P18	-32,524	-7%
All	**3,819,978**	**66%**

Key Findings

Overall, the installation of the ozone systems resulted in reduced water consumption in the hotel laundry facilities, although not as much as the program estimate. Observe in **Table 10** that in all cases cold water use increased and any savings achieved came from reduction in hot water use. One may also note the reduction in hot water used as a percentage of total laundry water consumed in the pre- and post-retrofit periods.

The data from P18 were carefully reviewed in search of an explanation for the negative total savings. The only inconsistency from the data of the other hotels is an exceptionally long span (465 days) between meter reads in the post-retrofit period. Other possible explanations are elaborated upon below.

Table 10: Annual Ex Post Cold and Hot Water Savings Summary By Hotel

Hotel	HotWater Savings (gallons/year)	Cold Water Savings (gallons/year)	% Hot Water Pre-Retrofit)	% Hot Water Post-Retrofit
P01	1,100,665	(136,698)	65%	44%
P07	4,506,791	(2,739,645)	49%	0%
P09	944,009	(502,288)	68%	8%
P15	733,035	(357,351)	78%	5%
P16	458,975	(168,881)	72%	8%
P17	174,032	(160,141)	79%	29%
P18	517,515	(550,039)	67%	31%
All	**8,435,022**	**(4,615,044)**	**58%**	**12%**

Normalized Results

Table 11 shows ex post savings normalized by pounds of laundry capacity. While the normalized average of savings is close to the median of 1,703 gal/yr/lbs capacity, there are two outliers, P17 and P18, which need further explanation. However, the relevant data required to explain the differences in outcome were unavailable for the reasons discussed in the Section 4 Data Collection. For example, the variations could be due to how promptly and aggressively the laundry operators adjusted laundry formulas to reduce hot water usage and chemical additives thus decreasing cold water usage as well. If information describing adjustments to post-retrofit laundry operations had been collected, this discrepancy could have been investigated further.

Table 11: Ex Post Savings Normalized by Pounds of Laundry Capacity

Hotel	Water Savings (gal/yr/lbs capacity)	Hot Water Savings (gal/yr/lbs capacity)	Cold Water Savings (gal/yr/lbs capacity)
P01	1,706	1,948	-242
P07	1,699	4,333	-2,634
P09	1,732	2,778	-1,046
P15	2,087	4,072	-1,985
P16	1,813	2,869	-1,056
P17	139	1,740	-1,601
P18[1]	-148	2,352	-2,500
Average	**1,516**	**3,347**	**-1,831**

1 See Figure 10 for more detailed explanation of results

P07 provided detailed laundry data from which a monthly average of pounds washed per day could be derived. For comparison, a monthly average of laundry water use per day was found. Then averages were determined for the pre and post periods for both water use and pounds washed. Finally, water use reduction normalized by pounds washed was found to be 3,572 gallons/year/pounds-washed for P07.

P16 provided loads data for 2008. The ozone system was installed sometime between 11/5/08 and 2/3/09, but the exact date is unknown. There is approximately two months worth of overlapping water use and loads-washed data in the pre-retrofit period and no overlapping data post-retrofit. Therefore, water savings cannot be normalized by loads washed for P16.

None of the other hotels provided loads or pounds washed data.

Correlation Analysis

It was assumed that laundry water use correlated well with occupancy; however, as can be seen in Table 12 this was not found to be the case for any of the hotels that provided monthly occupancy data. For the two hotels that provided loads- and/or pounds- washed data, not enough data overlapping with water consumption trends were available to establish whether there is any correlation. See Figures 1 through 10 in Supporting Analysis for more details on the correlation analysis. Therefore, the results of metered data could not be extrapolated based on occupancy or load data. As a result, annual savings were found by simply multiplying the average daily water savings found from the metered data by 365 days.

The finding of no correlation between laundry water consumption and occupancy based on available data seems counter-intuitive. Perhaps data collected in more consistent increments could have led to a more credible conclusion. If any correlation is to be found, then more information about laundry operations is needed. For example, perhaps the laundry staff do not change their operations based on how much laundry is to be washed resulting in less than optimal operation such as washing smaller loads.

Table 12: Data Collected and Correlation Analysis

Hotel	Time-of-Use	Occupancy	Loads	Correlation[1]
P01	*Yes*	*Yes*	*No*	*None*
P07	*Yes*	*Yes*	*Yes*	*None*
P09[2]	*Yes*	*Yes*	*No*	*None*
P15	*Yes*	*Yes*	*No*	*None*
P16[3]	*Yes*	*Yes*	*Yes*	*None*
P17	*Yes*	*No*	*No*	*n/a*
P18	*Yes*	*Yes*	*No*	*None*

1 Correlations considered if data available: Water Use vs. Occupancy, Water Use vs. Loads, Occupancy vs. Loads.
A finding of "none" reflects that no correlation was found based on data available.

2 P09 provided two year average occupancy, rather than monthly like the others.

3 P16 Load data provided for pre-retrofit period only.

Supporting Analysis

Correlation Analysis

The following figures show attempts to correlate laundry water use, occupancy and load data.

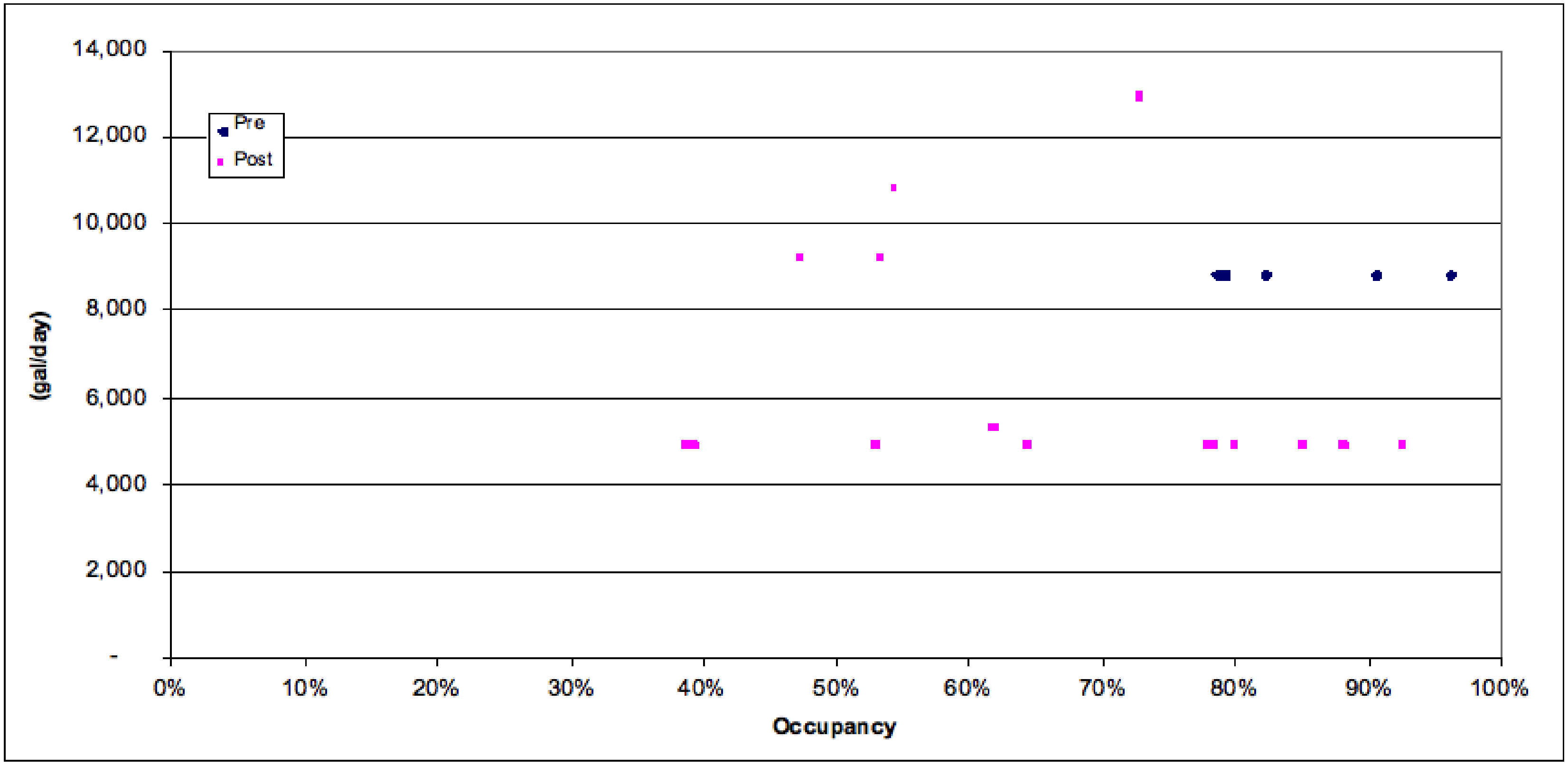


Figure 1: P01 Monthly Average Laundry Water Use Per Day vs. Monthly Occupancy

Meter reads generally did not occur frequently enough to track laundry water use with hotel occupancy, particularly in the pre-retrofit period, i.e., any given daily average water use may be based on a period of multiple months.

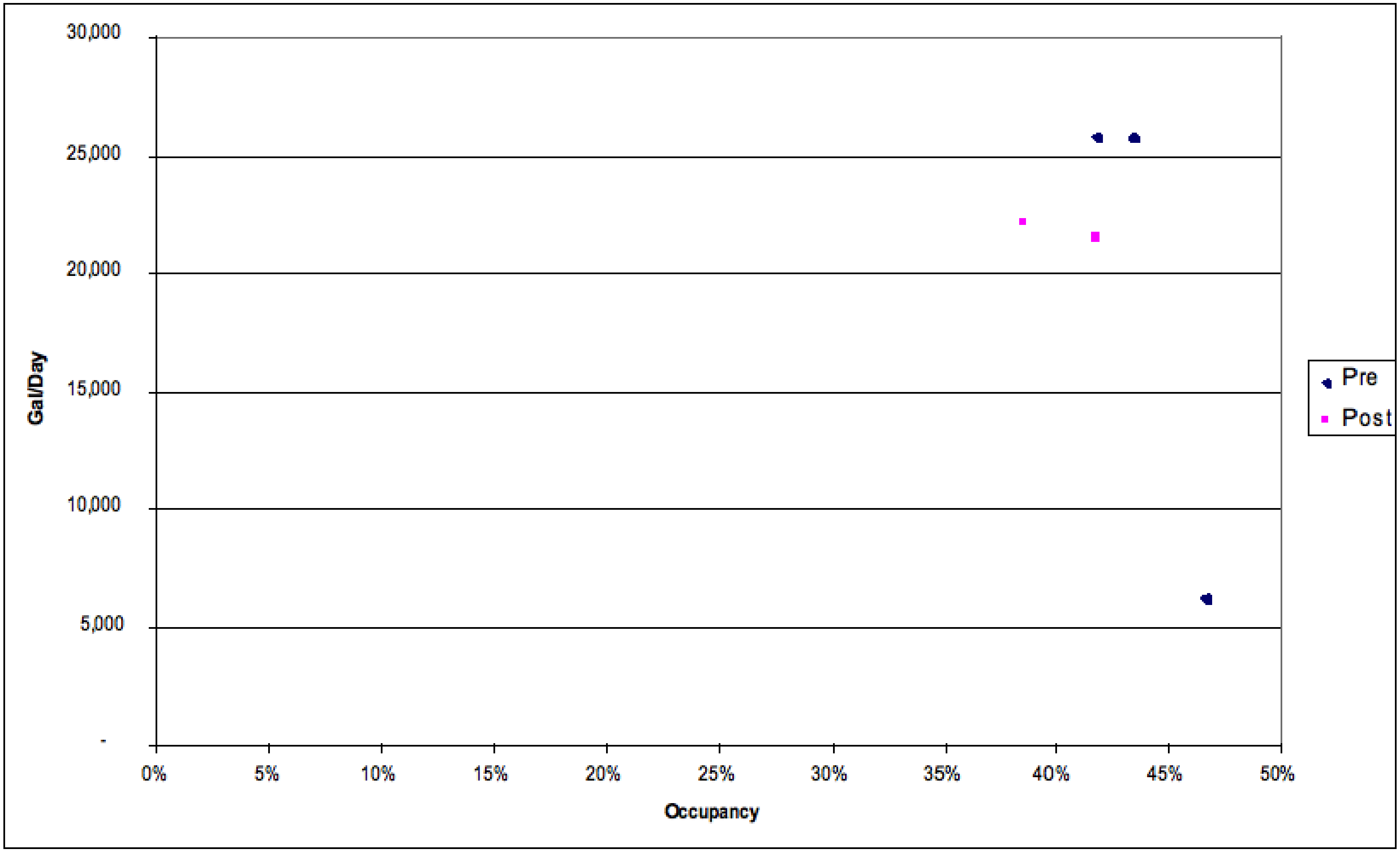


Figure 2: P07 Monthly Average Laundry Water Use Per Day vs. Monthly Occupancy

There is no pattern of water use increasing with higher occupancy; however, one can note the decrease in water consumption in the post data.

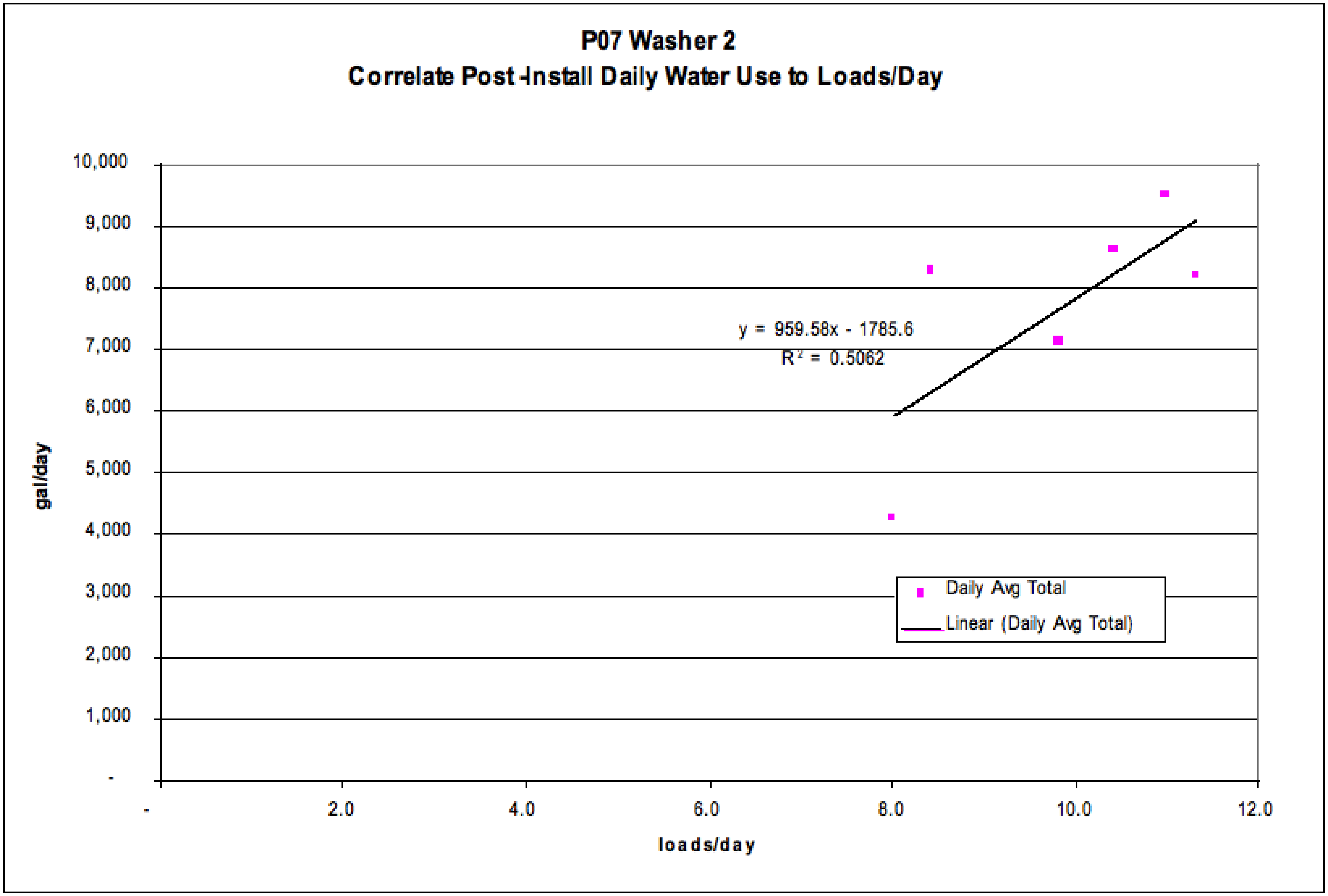


Figure 3: P07 Washer 2 Average Daily Laundry Water Use vs. Average Daily Loads Washed

In this comparison of water use to loads washed, the R-squared value is approximately 0.5, which was considered too low to be reliable. Indeed, one can observe a significant jump (4,000 gpd) in water consumption for only a small increase in load/day (<0.5 load/d) but this pattern is not seen in the remaining data points.

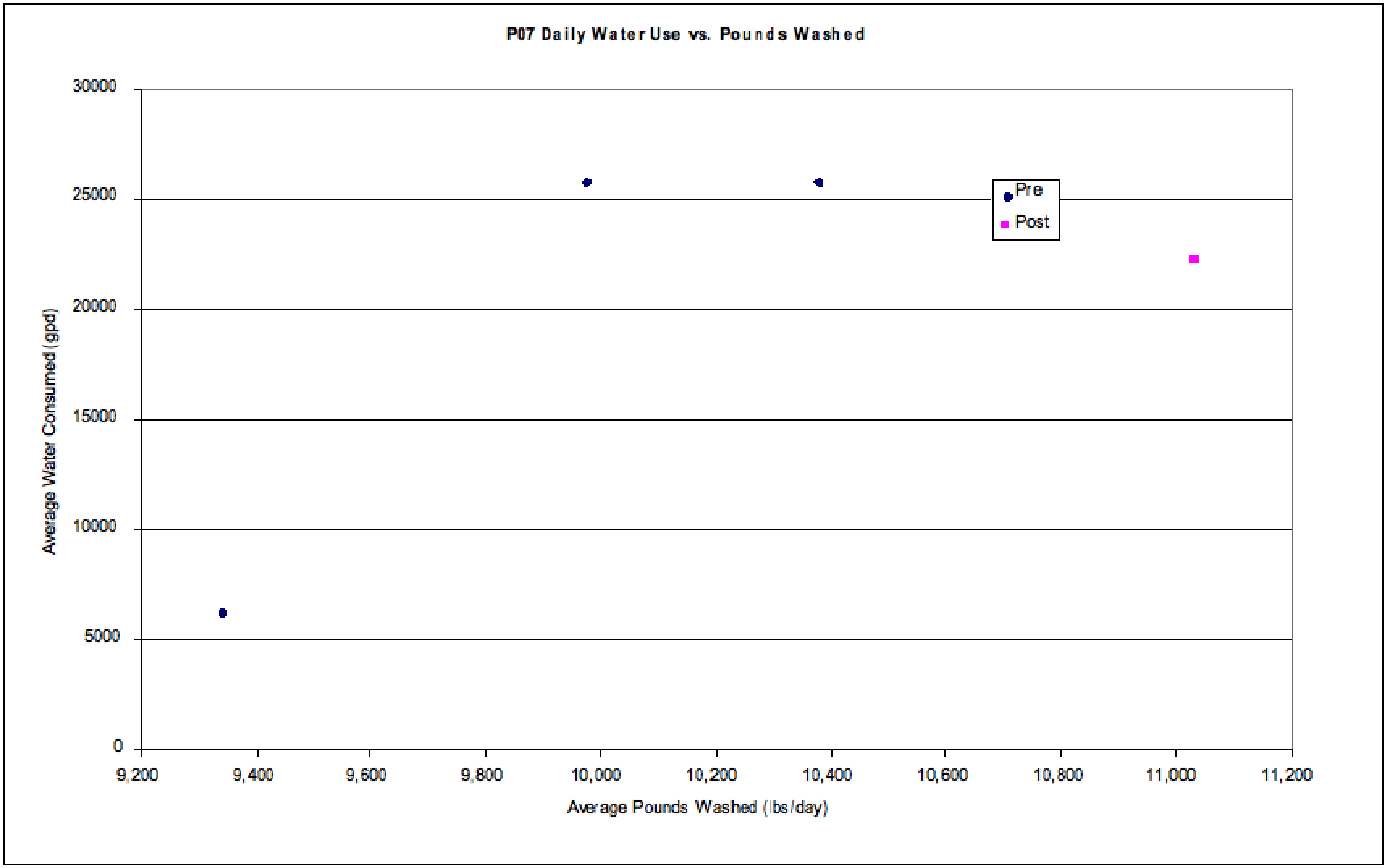
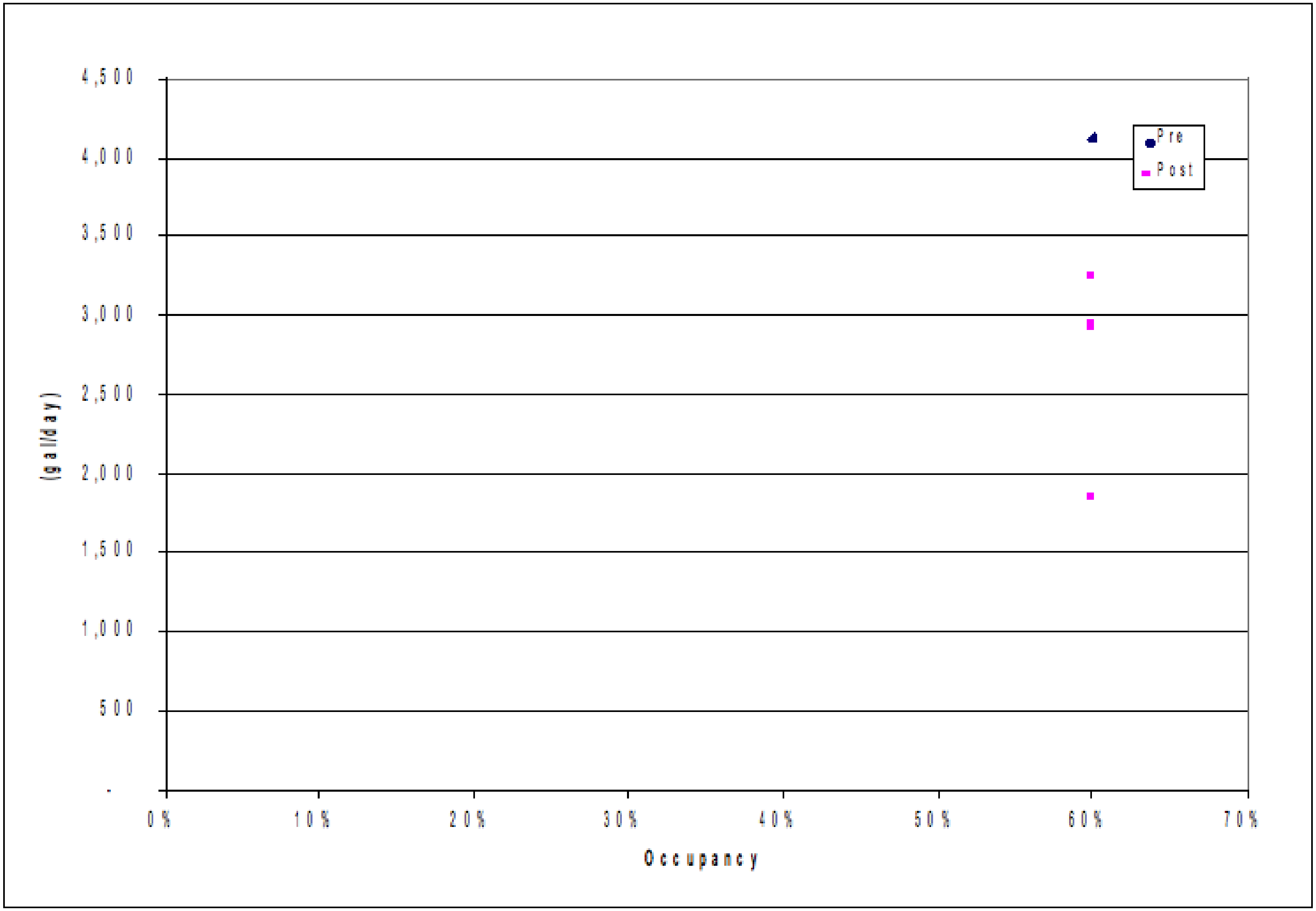


Figure 4: P07 Washer 2 Average Daily Laundry Water Use vs. Average Daily Pounds Laundry Washed

There are not enough data points to establish a correlation.


4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
(gal/day)
0%
10%
20%
30%
40%
50%
60%
70%
Occupancy
Pre
Post

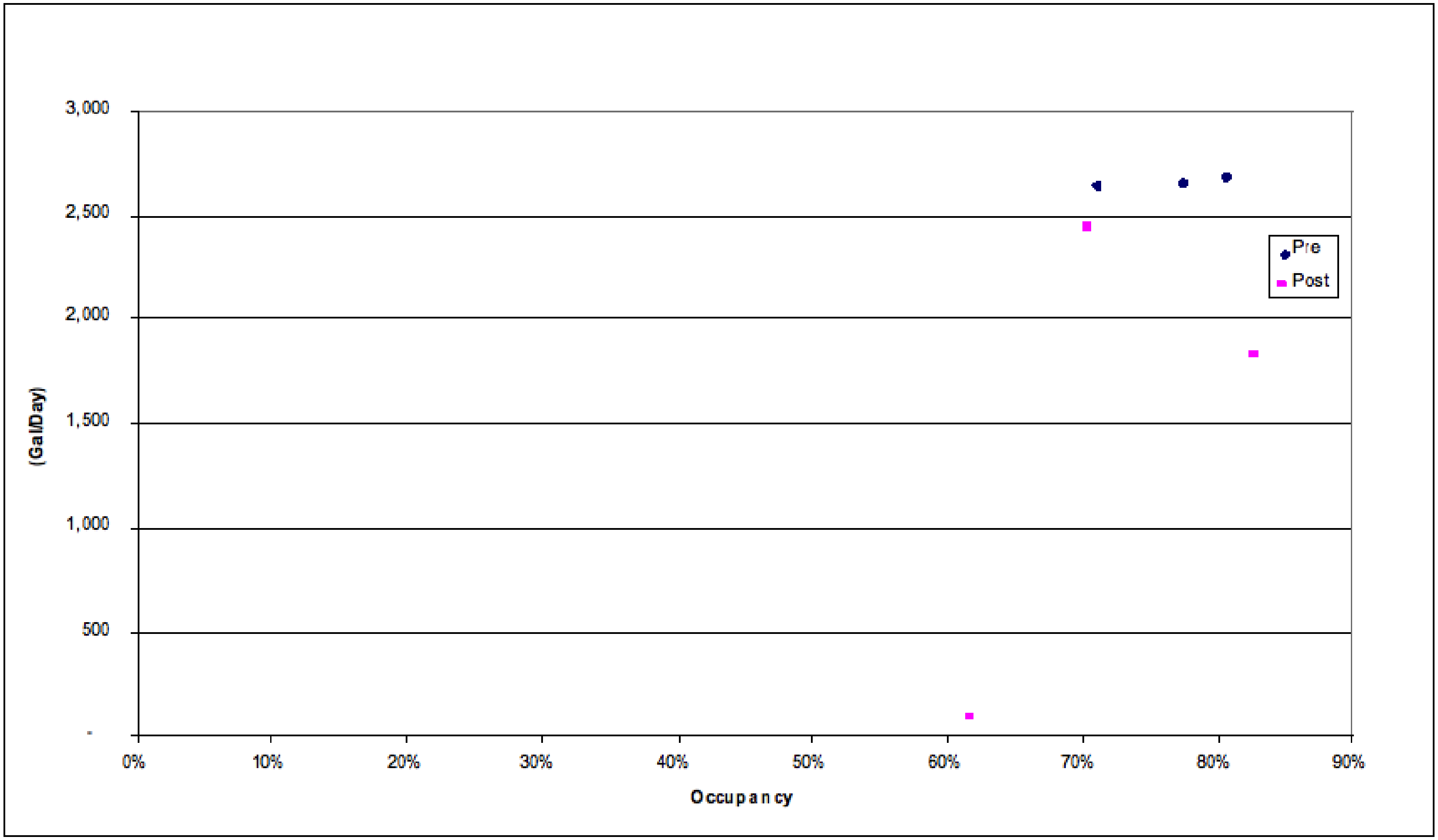


Figure 5: P09 Monthly Average Laundry Water Use Per Day vs. Monthly Occupancy

This hotel only provided a single two year average for hotel occupancy; therefore, no correlation could be found.

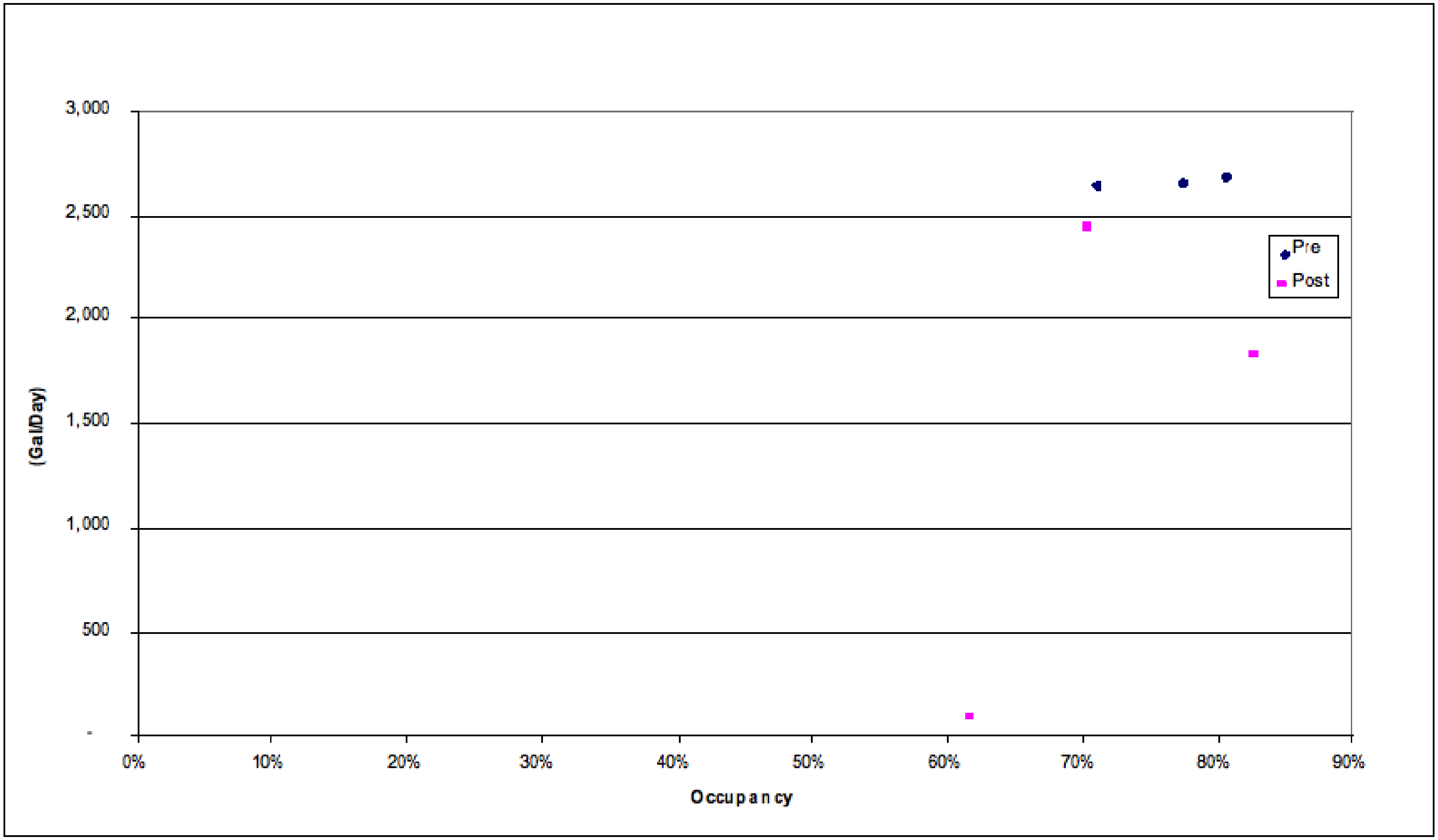


Figure 6: P15 Monthly Average Laundry Water Use Per Day vs. Monthly Occupancy

In the pre-retrofit period, there appears to be very little change in water use with occupancy. In the post-retrofit period, there is no consistent pattern of increase in water use with increasing occupancy.

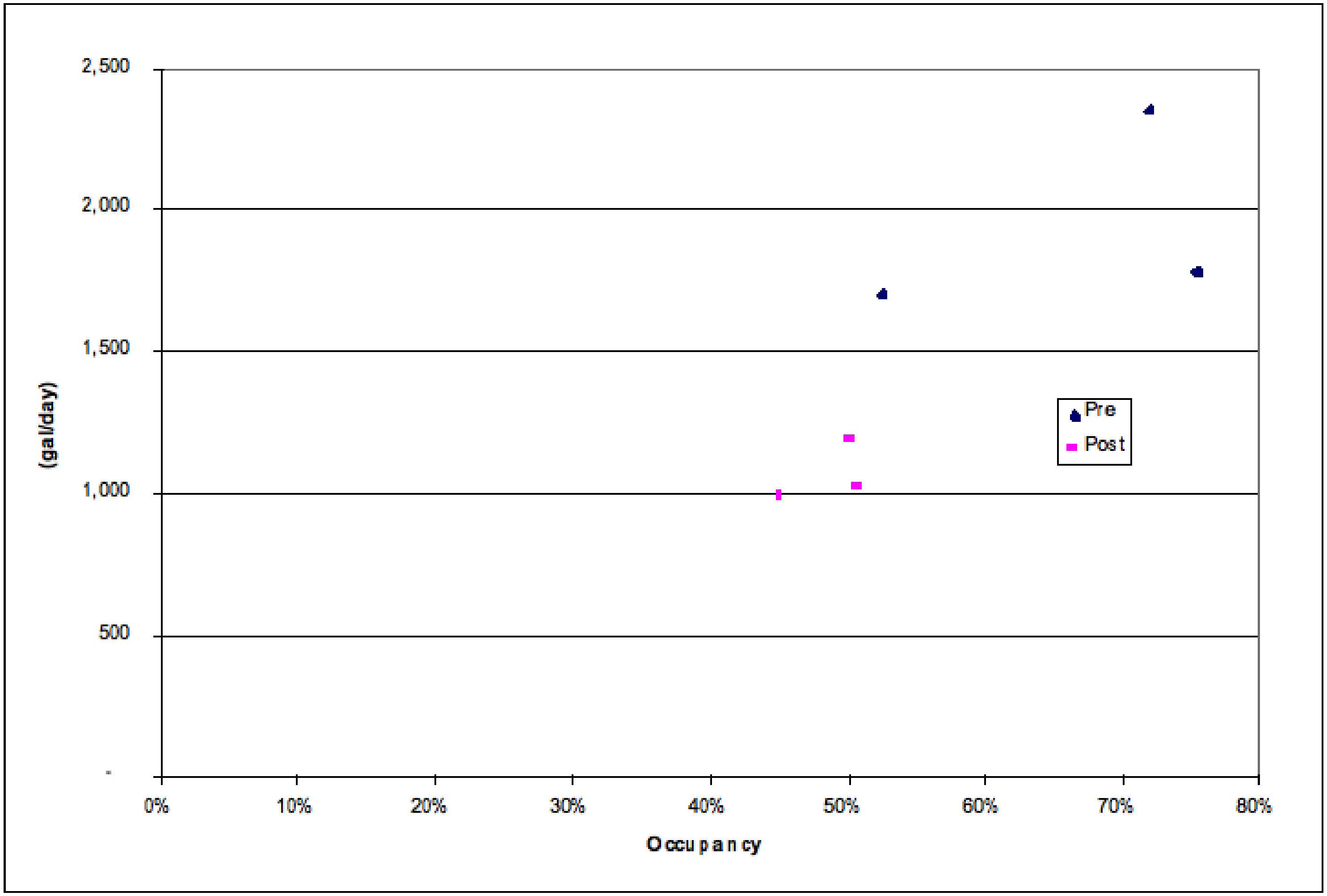


Figure 7: P16 Monthly Average Laundry Water Use Per Day vs. Monthly Occupancy

While at first glance there does appear to be an upward trend, analyzing pre- and post-data separately shows that water usage does not consistently increase with higher occupancy. However, one can observe the lower water usage in the post data.

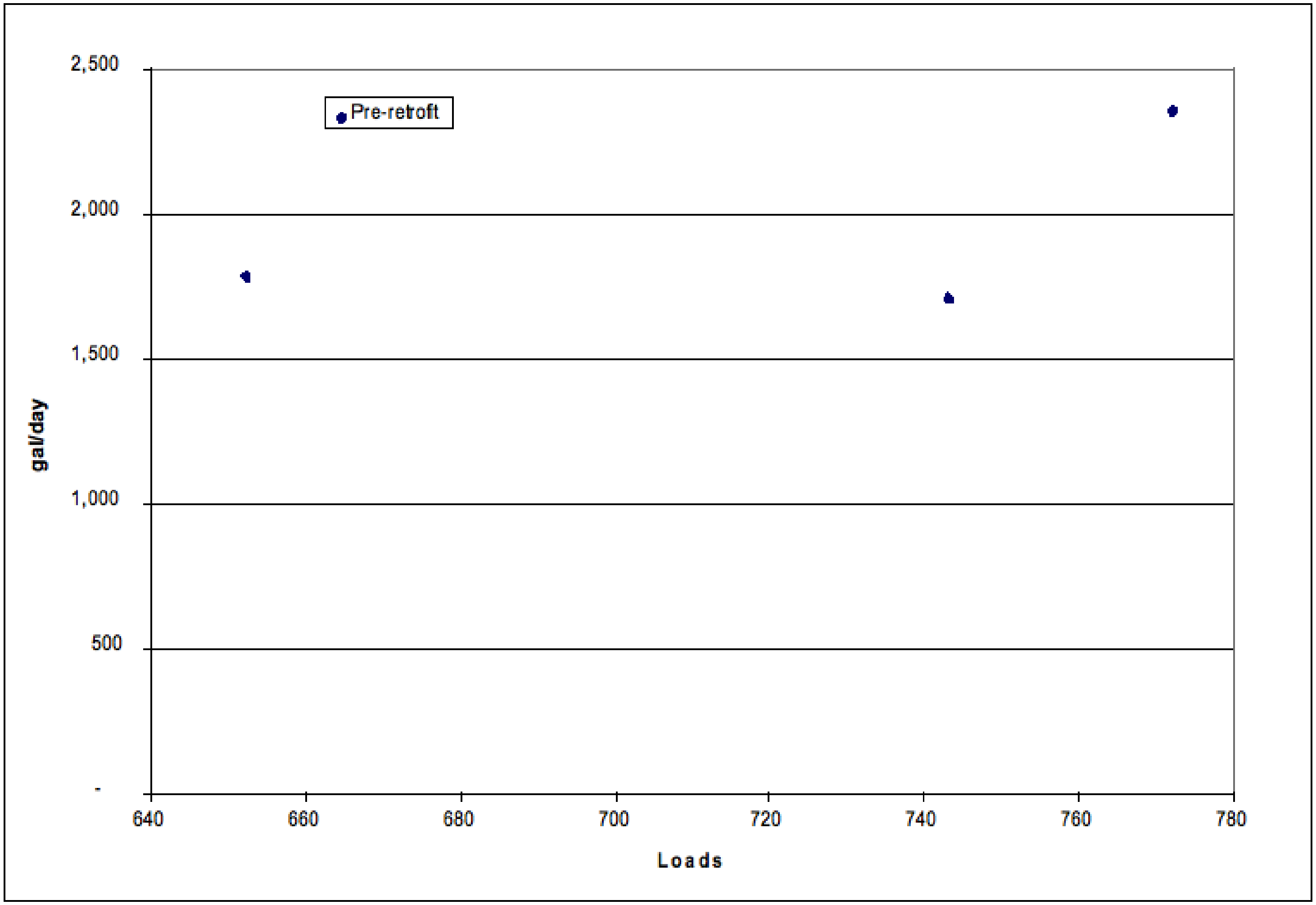


Figure 8: P16 Monthly Average Laundry Water Use Per Day vs. Monthly Total Loads

Loads washed data were collected in the pre-retrofit period and shows no consistent pattern of increase in water use for increasing loads washed.

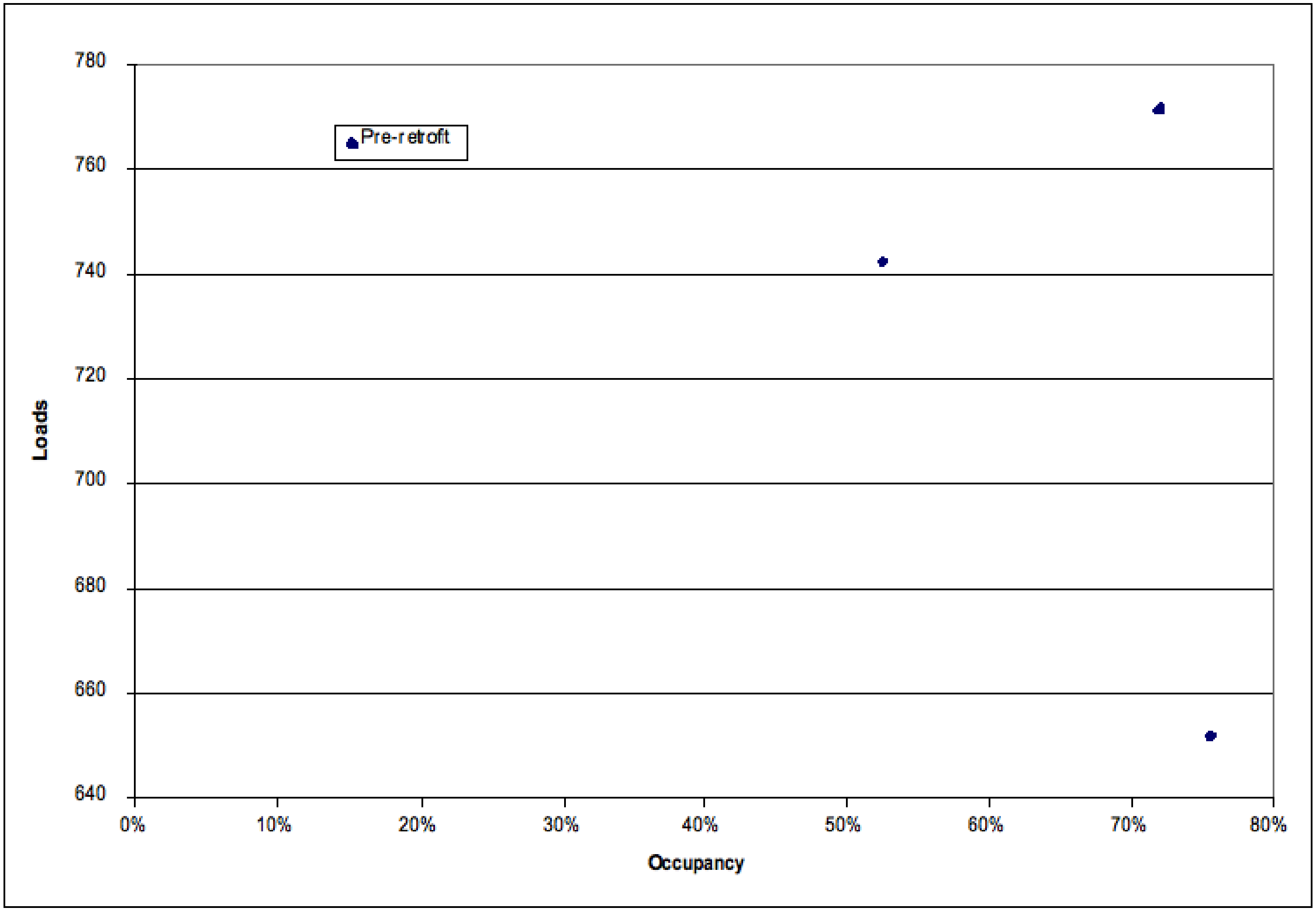


Figure 9: P16 Monthly Total Loads vs. Monthly Occupancy

This loads washed vs. occupancy chart shows no correlation as well.

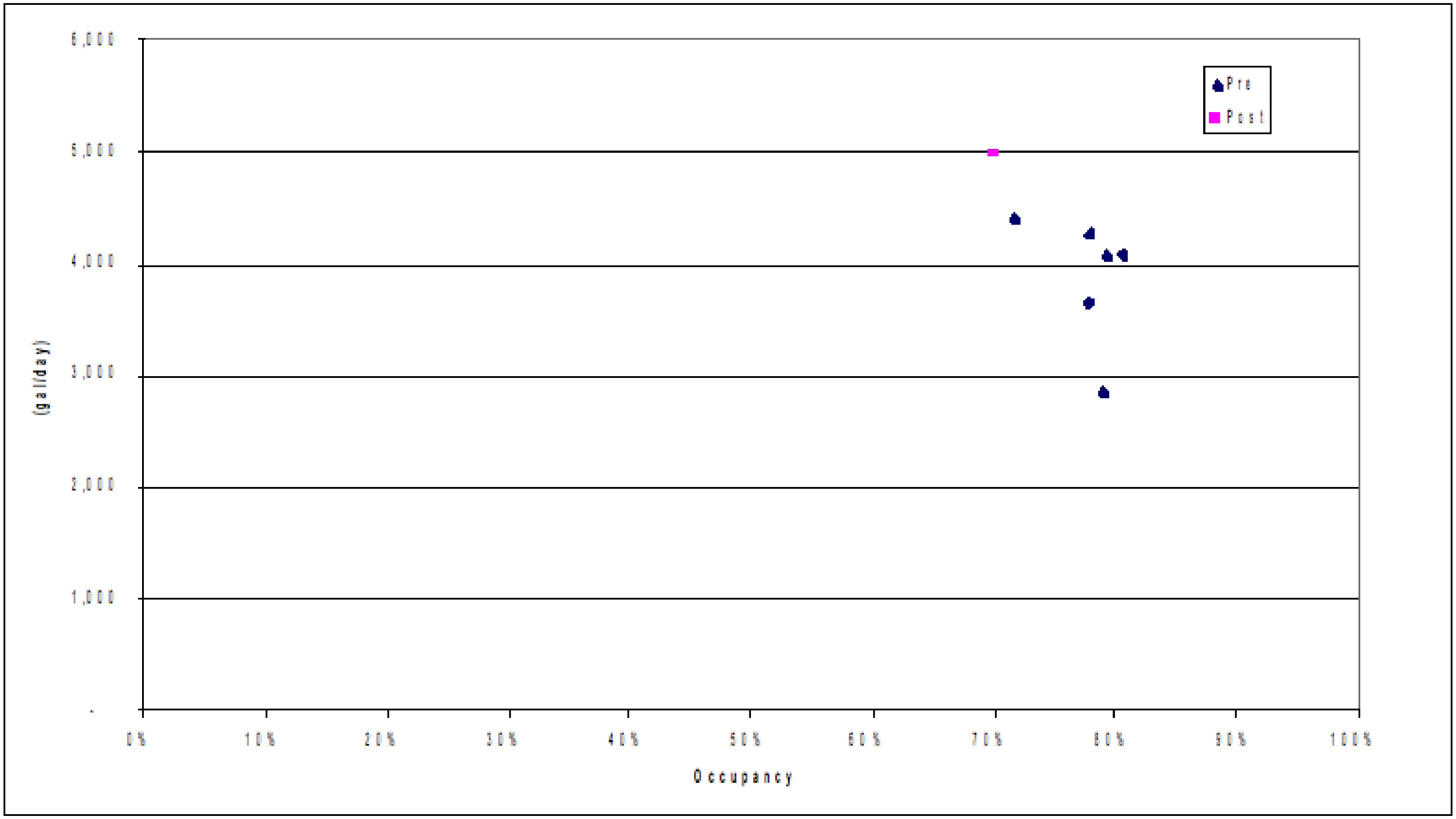


Figure 10: P18 Monthly Average Laundry Water Use per Day vs. Monthly Occupancy.

If any pattern of water use is to be taken from this chart, it is that water use decreases with increasing occupancy. However, the conclusion is that based on available data there is no correlation between water use and occupancy.

Additional Information

Table 13: Detailed Hotel Information

MEASURE AND FACILITY DESCRIPTIONS							
Site ID	P01	P07	P09	P15	P16	P17	P18
Washer specs (machine #)							
1	Milnor	Washex 46/57FLA-P2	Milnor E-P Plus, 30026V5J AAJ (left)	UniMac (UniMat 80)	UniMac (Raytheon) UW50PVQU20001	UniMac UF 50, UF50PVOU30001	Milnor 30022M5J
2	Milnor	Washex 46/57FLA-P2	Milnor E-P Plus, 36026V5J AAJ (center)	UniMac	UniMac (Raytheon) UW50PVQU20001	UniMac UF 50, UF50PVOU30001	Milnor 30022M5J
3	Milnor	Washex 46/39FLA-P2	Milnor E-P Express, 30022T5X AAD (right)	-	UniMac (Raytheon) UW60PVQU60001	-	Milnor 30022M5J
4	Unimac	PSO 455	-	-	-	-	Milnor 30022M5J
5	Unimac	-	-	-	-	-	-
Rated lbs (machine #)							
1	165	350	95	80	50	50	55
2	165	350	95	100	50	50	55
3	135	240	55	-	60	-	55
4	50	100	-	-	-	-	55
5	50	-	-	-	-	-	-
Total installed capacity	**565**	**1,040**	**245**	**180**	**160**	**100**	**220**
Lbs/room	2.5	1.3	1.3	1.0	0.9	0.9	1.0
Laundry operating hours	Year-round, from 7AM to 7 PM daily	7AM - 8 PM daily, sometimes only until 5 PM, sometimes 24 hours	8AM-4:30 PM, 7 days (March-October); 3 days (winter)	6AM - 9PM; 7AM-5 PM Sundays	8:30AM - 7 PM, plus second shift when high occupancy, until about 11 PM	8:30AM - 5 PM 7 days, year-round	11 AM - 7:30 PM, 7 days
Average daily laundry production (estimated), lbs/day	1,500	10,000	18-42 loads/day, lbs. not known. Linens, towels, duvets (not napkins or anything else from kitchen).	Robes, blankets, rags, linens, towels (not kitchen). See "Sunnyvale Sheraton laundry log.pdf"	Linens, towels, duvets (no napkins). No other info.	Linens, towels, blankets, duvets; kitchen tablecloths, towels, napkins. No other info.	Bedspreads, blankets, linens, towels; nothing from kitchen. No other info.
Schedule variability	Typically, the hotel's busiest months are June-October, and its quietest months are November-March. April-May is the shoulder season.	OK	More occupancy from tourism and business in summer.	No	Second shift in summer (May-October).	No	No
Water agency	Sonoma Valley Water District (wholesaler; VOMWD is retailer)	City of San Jose (Santa Clara Valley Water District is wholesaler)	City of Petaluma (Sonoma County Water Agency is wholesaler)	Santa Clara Valley Water District (wholesale & retail?)	City of Santa Rosa (Sonoma County Water Agency is wholesaler)	Marin Municipal Water District #2 (Sonoma County Water Agency is wholesaler)	East Bay Municipal Utility District (wholesale and retail)
Number of guestrooms	226	775	183	173	170	110	230

Appendix 3: PG&E High-Efficiency Toilets Pilot Program

3.1 M&V Plan

Site-Specific Measurement and Verification

PG&E High-Efficiency Toilets

April 10, 2009

Summary Information

PROJECT

Program Name	*PG&E High Efficiency Toilet Replacement Program*
Measure Type	*High Efficiency Toilet*
Customer Name	*Various (random selection of approximately 30 homes)*
Site Name	*Various (random selection of approximately 30 homes)*
Site Address	*Various (throughout Santa Clara County)*

PRINCIPAL SITE CONTACT

Name	*Various (random selection of approximately 30 homes)*	**Telephone**	*Various (random selection of approximately 30 homes)*
E-mail	*Various (random selection of approximately 30 homes)*	**Title**	*N/A*

INVESTOR-OWNED UTILITY MANAGER

Name		**Telephone**	
E-mail		**Company**	

WATER AGENCY

Name		**Telephone**	
E-mail		**Company**	*Wholesaler: Santa Clara Valley Water District* *Retailers: Campbell, Cupertino, Gilroy, Los Altos, Los Altos Hills, Los Gatos. Milpites, Monte Sereno, Morgan Hill, Mountain View Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale*

SITE LEAD

Name		**Telephone**	
E-mail		**Company**	

Background

The PG&E High Efficiency Toilet (HET) pilot program is co-sponsored by PG&E and the Santa Clara Valley Water District (wholesaler). The program involves the installation of about 900 HETs in single-family homes throughout Santa Clara County. The toilets are being installed by a contractor selected by PG&E. Program participants will be recruited from lists of low-income homes that are pre-qualified for the program by PG&E. The program will replace one or more inefficient toilets—defined as more than 3.5 gallons per flush (gpf)—in a recruited home, as desired by the participant. The program will install the toilets at no cost to the participant.

We will select a sample of approximately 30 participant households for inclusion in this evaluation. The following M&V plan documents our planned evaluation approach. It is based upon the best information currently available, and is subject to change as the project proceeds.

Measure Description

Efficiency Improvement

Replace one or more existing toilets per household with 1.28 gallons per flush (gpf) high efficiency toilets, in the homes of approximately 900 participants. PG&E will provide a list of candidate households for recruitment by the installation contractor.

Pre-retrofit Equipment and Operation

Participants' existing toilets that are eligible for the program are expected to have a rated flush volume of at least 3.5 gpf.

Post-retrofit Equipment and Operation

The program will replace each qualifying existing toilet with a Vortens Loretto RF (model 3213-3475) 1.28 gpf HET. Refer to Figure 1 at the end of this document for a photo of this model. We will administer a characteristics survey to each sampled participant to collect information about changes in toilet use and occupancy between the pre- and post-retrofit periods.

Variability in Schedule

The characteristics survey will collect information necessary to assess seasonal and usage-related variation in the operation of the existing and new toilets.

Algorithms for Estimating Water Savings

Utility Algorithms

Not applicable. To date, the water and energy utilities associated with this project have not prepared an ex ante savings estimate.

Evaluation Algorithms – Water Savings

To estimate average daily water savings from this measure, we will use the following algorithm to estimate savings from the data we collect:

Average daily water savings (in gallon per day) = Average flushes/day,post × (gallons/flush, pre – gallons/flush,post)

Our analysis will control for effects on savings unrelated to the measure, such as vacations or changes in occupancy. Conversely, we will include the effects of measure-related behavioral changes. For instance, this algorithm currently assumes that replacing the toilets does not fundamentally change the number of flushes per day per person. If our data reveal, for instance, that the HETs required occupants to flush more frequently to eliminate waste, then we would adjust the algorithm to reflect the fact that the average flushes/day changed from pre to post.

In addition to calculating the average daily water savings, we will also analyze the flush event time-of-use data and occupant interview information we collect to estimate when these savings occur over given hours, days, and months. These profiles will support the CPUC avoided cost calculator[4]. Key inputs to this calculator include:

- Daily water savings profile: accounts for differences in water savings between hours of the day.
- Day type multiplier: accounts for differences in water savings between weekdays and weekends.
- Monthly multiplier: accounts for differences in water savings between months of the year.

Data Collection

We will randomly select from the population an M&V sample of 30 toilets (in up to 30 homes). During our initial scheduling conversation with each sampled household, we will probe to see if they expect major occupancy changes during the metering period that could compromise our ability to discern differences in pre/post usage. If so, we will find a replacement household.

For each affected toilet among qualifying households in this sample, we will collect the data elements shown in Table 1.

[4] This is a MS Excel spreadsheet tool (WaterMeasures-AvoidedCostCalcs-v__.xls) developed by J.J. Hirsch and Associates to assess the avoided energy costs that water efficiency projects yield.

Table 1: Evaluation Measurements

Description	Evaluation
Equipment monitored	*1. Toilet cold water supply line* *2. Toilet water tank*
Parameter measured	*1. Total gallons* *2a. Flush volume* *2b. Flush events (time of use)*
Measurement equipment	*1. In-line turbine-type totalizing water meter* *2a. Calibrated bucket* *2b. Custom-designed float switch (registers change in circuit status each time water level falls) with Hobo event logger.*
Installation method	*1. Plumbed into toilet water supply line.* *2b. Hooked inside tank.*
Observation frequency	*1.Continuously throughout pre and post metering periods.* *2b. Each time toilet is flushed (can record 8,000 events)*
Measurement duration	*1, 2b. At least one month before and after HETs are installed.* *2a. Tank flush volumes will be measured twice—at the beginning and end of metering for each toilet.*

In addition, we will administer a characteristics survey to each sampled participant to collect information about changes to toilet use patterns (s) during the pre- and post-retrofit periods. Important topics will include items that we can observe directly, such as:

- Pre toilet fixture characteristics (manufacturer, model, date of manufacturer).
- Evidence of leaks (if so, we will attempt to quantify them).

In addition, we will ask participants about indirect factors that could affect our measured results, such as:

- Number and rough ages (infant, child, adult) of occupants.
- Changes to occupancy (e.g., someone moving out of the house) or occupant distribution (e.g., a teen moving from an upstairs shared bathroom to a downstairs bedroom with dedicated bathroom).
- Temporary events that could affect usage (e.g., plumbing malfunctions, vacations, drought-related water restrictions).
- Satisfaction (e.g., reliability, susceptibility to clogging, need for double-flushing).

Sampling Strategy

Our sample size of 30 toilets was selected to be a reasonable compromise between evaluation cost, statistical precision, and uncertainties about how many participants the program will have, and variability in toilet usage. All eligible toilets in each sampled home will be evaluated.

Schedule

We will establish a schedule after the installation contractor has been selected and is under contract. Sample selection is expected to begin in April of 2009.

Data Products

We will produce the following data products as part of the evaluation:

1. Pre and post water usage data, including flush counts, flush volumes, and toilet characteristics.
2. Excel workbook containing calculations of evaluated average daily water savings.
3. Embedded Energy Calculator with annual water savings and corresponding energy savings profiles.

Supporting Information

LORETTO RF

Model 3213-3475

Round Front
High-Efficiency Toilet

Features

- 2-1/8" Fully Glazed Trapway – Passes a 2" Ball
- High-Efficiency Toilet (HET) with Powerful 1.28 gpf /4.8 lpf Flush
- Powered by the 3" HydroSurge™ Flushing System
- Flushes 700 grams of solids
- 8" x 7" Water Surface
- Lifetime Warranty on Vitreous China
- High-Gloss Vitreous China – Durable, Nonporous

Specifications

3213	Round Front Bowl	55 Lbs.
3475	12" Rough-In Tank	30 Lbs.

Meets ANSI / ASME A112.19.2-2003

Meets Canadian Standards Association General Requirements for Ceramic Plumbing Fixtures B45.0-02

Seat Not Included

Vortens
ALL PERFORMANCE.
NO PROBLEMS.

3.2 Summary Metering Data

Table 1 below contains summarized meter data from all HETs in the evaluation sample.

Table 1: Site Logging Dates

Site	Pre Start Date	Pre End Date	Post Start Date	Post End Date	Number of Occupants	Pre gallons	Pre days	Post gallons	Post days	Pre gpf	Post gpf
8	4/21/09	5/28/09	5/28/09	7/14/09	3	458	37	288	47	3.50	1.34
28	4/22/09	5/28/09	5/28/09	7/14/09	8	902	36	598	47	3.65	1.21
80	8/28/09	9/23/09	9/23/09	11/21/09	8	721	25	683	60	1.98	1.64
80	8/28/09	9/23/09	9/23/09	11/21/09		287	25	490	60	3.14	1.68
81	8/28/09	9/29/09	9/29/09	11/22/09	4	1,127	31	1,017	55	2.47	1.76
81	8/28/09	9/29/09	9/29/09	11/22/09		615	31	720	55	2.42	1.61
81	8/28/09	9/29/09	9/29/09	11/22/09		711	31	744	55	2.86	1.59
84	8/21/09	9/23/09	9/23/09	11/21/09	5	1,030	33	1,679	60	4.25	1.67
84	8/21/09	9/23/09	9/23/09	11/21/09		5,325	33	2,323	60	6.10	1.63
84	8/21/09	9/23/09	9/23/09	11/21/09		2,222	33	1,004	60	4.29	1.64
91	10/9/09	12/2/09	12/2/09	1/20/10	3	10,188	54	891	49	3.23	1.19
91	10/9/09	12/2/09	12/2/09	1/20/10		2,530	54	220	49	5.63	1.27
92	10/24/09	12/2/09	12/2/09	1/18/10	1	1,228	39	648	47	3.75	1.19
96	10/26/09	12/10/09	12/10/09	1/19/10	3	3,097	45	762	40	3.65	1.23
98	10/26/09	2/8/10	2/8/10	2/25/10	3	5,313	105	21,325	17	2.87	1.36
98	10/26/09	2/8/10	2/8/10	2/25/10		2,480	105	51,418	17	2.54	1.23
99	10/9/09	12/15/09	12/15/09	1/19/10	3	882	67	161	35	3.58	1.28
99	10/9/09	12/15/09	12/15/09	1/19/10		873	67	233	35	3.14	1.39
100	10/9/09	12/9/09	12/9/09	1/18/10	7	39,859	61	6,694	40	4.33	1.29
100	10/9/09	12/9/09	12/9/09	1/18/10		3,934	61	1,195	40	3.34	1.29
102	10/24/09	12/9/09	12/9/09	1/17/10	6	2,323	46	1,364	39	3.50	1.36
105	10/25/09	12/10/09	12/10/09	1/18/10	5						
105	10/25/09	12/10/09	12/10/09	1/18/10		988	45	287	40	4.02	1.30
112	10/26/09	12/3/09	12/3/09	1/18/10	4	4,308	38	1,324	46	3.90	1.28
114	10/26/09	12/3/09	12/3/09	1/17/10	4						
114	10/26/09	12/3/09	12/3/09	1/17/10		2,302	37	2,624	46	2.11	1.41
116	10/24/09	12/2/09	12/2/09	1/18/10	4	1,370	38	558	48	3.69	1.28
120	10/26/09	12/29/09	12/29/09	2/25/10	2						
120	10/26/09	12/29/09	12/29/09	2/25/10		7,114	63	1,822	59	2.71	1.29
121	10/25/09	1/26/10	1/26/10	2/25/10	9	2,655	92	522	31	2.13	1.36
121	10/25/09	1/26/10	1/26/10	2/25/10		4,473	92	4,836	31	4.64	1.35
123	10/24/09	12/2/09	12/2/09	1/19/10	2						
123	10/24/09	12/2/09	12/2/09	1/19/10		1,114	39	1,768	48	3.94	1.32

Site	Pre Start Date	Pre End Date	Post Start Date	Post End Date	Number of Occupants	Pre gallons	Pre days	Post gallons	Post days	Pre gpf	Post gpf
130	10/24/09	11/29/09	12/16/09	1/20/10	5	16,694	36	685	48	6.23	1.31
132	10/25/09	12/4/09	12/4/09	1/19/10	5	1,852	39	723	47	2.72	1.34
132	10/25/09	12/4/09	12/4/09	1/19/10		1,624	39	783	47	3.41	1.28
138	10/26/09	12/3/09	12/3/09	1/18/10	1	2,351	37	2,162	47	3.13	1.23
140	10/26/09	12/10/09	12/10/09	1/20/10	8	4,996	45	1,972	41	2.99	1.24
140	10/26/09	12/10/09	12/10/09	1/20/10		1,722	45	905	41	4.09	1.16
143	10/27/09	12/10/09	12/10/09	1/18/10	7						
143	10/27/09	12/10/09	12/10/09	1/18/10		8,273	43	736	39	4.38	1.29
166	12/17/09	1/25/10	1/25/10	2/25/10	5	4,095	39	1,334	32	3.92	1.33
166	12/17/09	1/25/10	1/25/10	2/25/10		1,357	39	339	32	3.50	1.45
169	11/22/09	1/12/10	1/12/10	2/24/10	12	6,117	50	2,965	44	3.40	1.80
181	11/22/09	1/12/10	1/12/10	2/25/10	4	878	51	340	44	3.38	1.42

3.3 Examples of Leaks Data

The study found two types of leaks: constant and periodic. Figure 1 shows an example of a constant leak. Note how there is a high baseline value that does not change much based on the time of day. If this were data from a toilet that was not leaking, there would be some times where no or little use was registered.

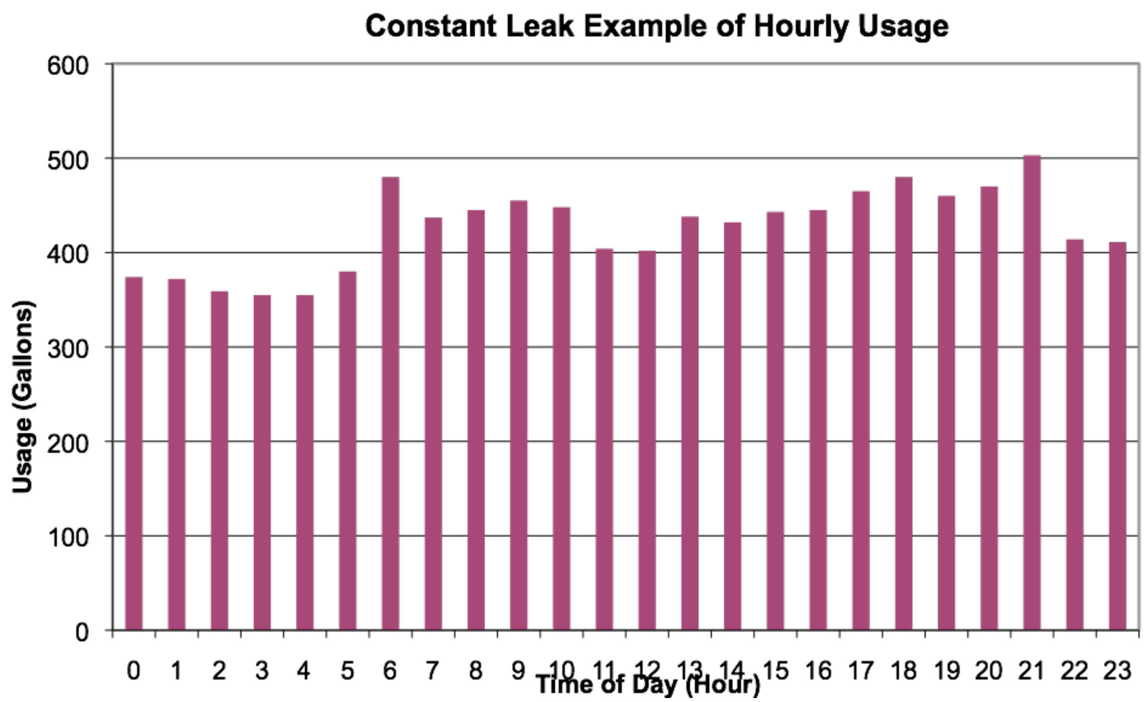


Figure 1: Constant leak from site HO91_1_46

In contrast, with a periodic leak there is an unusual peak in usage while the unit is leaking. An example of summarized data from a periodic leak is shown in Figure 2.

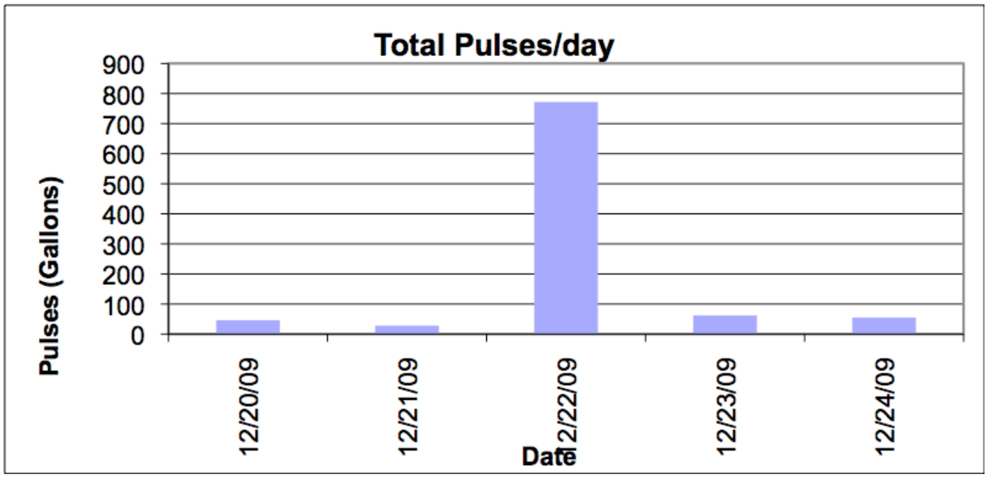


Figure 2: Periodic leak from site H114_2_71

It is evident from looking at the raw data when there is a leak. Table 2 shows normal flush data. There are a few pulses registered, then a span of time until the next flush. Table 3 shows a leak in progress. There are multiple pulses registered each minute for many minutes indicating that the toilet is flowing constantly.

Table 2: Example of normal flush data

Event #	Date	Sensor State
6655	12/21/2009 14:16	0
6656	12/21/2009 14:16	1
6657	12/21/2009 14:16	0
6658	12/21/2009 18:48	1
6659	12/21/2009 18:48	0
6660	12/21/2009 19:08	1
6661	12/21/2009 19:08	0
6662	12/21/2009 23:32	1
6663	12/21/2009 23:32	0
6664	12/21/2009 23:33	1
6665	12/21/2009 23:33	0

Table 3: Example of leak flush data

Event #	Date	Sensor State
6716	12/22/2009 9:53	1
6717	12/22/2009 9:53	0
6718	12/22/2009 9:53	1
6719	12/22/2009 9:53	0
6720	12/22/2009 9:53	1
6721	12/22/2009 9:53	0
6722	12/22/2009 9:54	1
6723	12/22/2009 9:54	0
6724	12/22/2009 9:54	1
6725	12/22/2009 9:54	0
6726	12/22/2009 9:54	1
6727	12/22/2009 9:54	0
6728	12/22/2009 9:54	1
6729	12/22/2009 9:54	0
6730	12/22/2009 9:55	1
6731	12/22/2009 9:55	0
6732	12/22/2009 9:55	1
6733	12/22/2009 9:55	0
6734	12/22/2009 9:55	1
6735	12/22/2009 9:55	0
6736	12/22/2009 9:55	1
6737	12/22/2009 9:55	0
6738	12/22/2009 9:56	1
6739	12/22/2009 9:56	0
6740	12/22/2009 9:56	1
6741	12/22/2009 9:56	0
6742	12/22/2009 9:56	1
6743	12/22/2009 9:56	0
6744	12/22/2009 9:57	1
6745	12/22/2009 9:57	0
6746	12/22/2009 9:57	1
6747	12/22/2009 9:57	0
6748	12/22/2009 9:57	1
6749	12/22/2009 9:57	0
6750	12/22/2009 9:57	1
6751	12/22/2009 9:57	0
6752	12/22/2009 9:58	1
6753	12/22/2009 9:58	0
6754	12/22/2009 9:58	1
6755	12/22/2009 9:58	0
6756	12/22/2009 9:58	1
6757	12/22/2009 9:58	0
6758	12/22/2009 9:59	1
6759	12/22/2009 9:59	0
6760	12/22/2009 9:59	1
6761	12/22/2009 9:59	0

Event #	Date	Sensor State
6762	12/22/2009 9:59	1
6763	12/22/2009 9:59	0
6764	12/22/2009 9:59	1
6765	12/22/2009 9:59	0
6766	12/22/2009 10:00	1
6767	12/22/2009 10:00	0
6768	12/22/2009 10:00	1
6769	12/22/2009 10:00	0
6770	12/22/2009 10:00	1
6771	12/22/2009 10:00	0
6772	12/22/2009 10:00	1
6773	12/22/2009 10:01	0
6774	12/22/2009 10:01	1
6775	12/22/2009 10:01	0
6776	12/22/2009 10:01	1
6777	12/22/2009 10:01	0
6778	12/22/2009 10:01	1
6779	12/22/2009 10:01	0

Appendix 4: PG&E Emerging Technologies Pilot Program

4.1 M&V Plan

East Bay Municipal Utility District SCADA Enhancement M&V Plan

July 2009

Project Description

For this PG&E Emerging Technologies project, the existing SCADA system at East Bay Municipal Utility District (EBMUD) will be enhanced with real-time pump electricity consumption data from four pumping stations, allowing operators to see and analyze pumping system efficiency at these stations and optimize energy use in real-time.[5] As shown in Table 1, all of the project pumping plants have multiple pumps, and each plant pumps into a separate pressure zone, or zones, independent of the other plants.

Table 1: Project Pumping Station Facilities

Pumping Plant (Zones)	Number of Pumps	Capacity (MGD)	2008 kW Consumption
Almond (Almond)	5	15.4	1,772,000
Argyle (Argyle, Verde, Shawn)	3	3.1	673,000
Bayview (Bayview)	4	17.3	45,000
Crocket (Maloney)	4	19.2	759,000

Currently, the SCADA system is configured to monitor the following:

- Pumping plant water *flows* pumped to the pressure zones
- Pumping plant input and discharge *pressures*
- *On/off status* of all plant pumps

The SCADA system does not currently use energy consumption data directly, and a key component of this project is connecting PG&E's revenue meters at these plants to the SCADA system.[6] Each plant has one meter; there is no sub-metering at the pump level. Plants that do not already have a 15-minute interval meter will be upgraded and include a pulse output module that can be read by the SCADA system. The project does not change the basic pump mechanical operations in any way, but rather affects the timing operations.

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[5] In the past, operators have traditionally tried to equalize pump operation hours, so they could be replaced at roughly the same time, although this does not optimize the efficient use of pumping energy.

[6] Some connections will use additional wiring, while others will employ wireless technologies.

After the meter connections were made by EBMUD staff (in June 2009), the SCADA display was re-programmed to show a new energy intensity metric – kWh/million gallons flow – that will allow operators to identify the most efficient pumps/pump combinations at each plant. Plant operators will receive final training in early July, and will be able to utilize the new metric starting July 16.

The objective of the project is to reduce the amount of energy consumed for pumping (as opposed to conserving water). Efficiency gains are possible because water-pumping processes are very dynamic with highly variable efficiency profiles. Each pump/motor combination in a pumping plant has a different efficiency curve (which will slowly change over time as pump components wear out), and it is possible to operate at different points along the curve. The new energy consumption metric will allow the plant operators to determine the optimal pump operations, accounting for other possible system requirements (e.g., limits on nodal pressures, maximum pipe velocities, etc.).

M&V Methodology

For this project we do not expect to use the Embedded Energy Calculator to estimate embedded energy savings, or update the Calculator with pumping plant energy profiles. This project is not designed to conserve water, and instead focuses on reducing the energy required to pump any given amount of water from the project pumping stations. Secondly, unlike other water conservation programs that install more widely applicable measures (e.g., ozone laundry, high-efficiency toilets) across a broader service territory, this Emerging Technologies project focuses narrowly on four specific EBMUD pumping plants and implements a very customized measure (i.e., a new energy consumption metric on the SCADA display). It is unlikely that future energy efficiency programs will affect only the pumping plants included in this SCADA enhancement.

The evaluation will directly measure and document changes in monthly energy used per million gallons of water pumped (i.e. energy intensity) for the four affected pumping stations individually, before and after the SCADA metric is implemented. Three years of pre-project data (2006 – 2008, June – December) will soon be provided by EBMUD to Global Energy Partners (GEP). (Some flows/energy data will be in 15-minute increments, while other data will monthly.) The project team will then collect post installation energy consumption and flows data (July through October 2009) for each pumping plant and compare them to the historical data. The team will utilize aggregate level pump flow and energy consumption data that are logged in the SCADA system and extracted by EBMUD. The data will come from the same meters and employ the same monitoring protocols that have been used historically to ensure consistency.[7]

For the report, the team will analyze monthly pre/post water flow and energy usage data to determine how the implementation of the metric is affecting energy intensity at the four pumping plants. This evaluation does not require any additional direct metering of water usage at the water agency sites.

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[7] EBMUD performs an annual review of energy use for distribution pumping, water treatment plant operation and raw water pumping for purposes of energy cost budgeting. In the summer months (May 1 - October 31) they monitor the Peak Period (noon till 6 PM) pumping operation of distribution pumping plants to ensure minimal use of peak period energy.

Addendum December 2009

The evaluation team will also analyze the pre-installation and post-installation pumping volume data in addition to examining the estimated changes in energy intensity. This step is being done to account for the possibility that there is fixed as well as variable energy usage at the water agencies. With the fixed energy consumption component, observed decreases in energy intensity may be the result of increases in water pumping volume rather than a decrease in energy use. We will examine the overall change in usage and attempt to identify this effect to the extent possible given available data. We will also interview the pump operators and other staff at the water agency to identify any changes in energy consumption and the overall pumping system that may have resulted in changes in energy use that occurred independently of the measures installed as part of the Water Pilot. After examining the changes in pre/post usage and energy intensity, the evaluation team will provide a recommendation on which is the most appropriate metric for measuring impacts.

4.2 Calculations for Data Screening

$\eta_{\textbf{Pump Listed}}$: Pump Efficiency obtained from GEP draft report (Listed for each station in Appendix 4.3)

$\eta_{\textbf{Motor}}$: Pump Motor Efficiency, estimated value of 0.94 applied

(Estimation considered value reasonable for data screening application with tolerance of +-30%)

Pump kW $_{\textbf{Calculated}}$: Tabulated Pump kW using actual interval data

Formula A.1 [1]: $HP_{PumpHydraulic}$ = Flow [gpm] x ($P_{Discharge}$ – $P_{Suction}$) [psi] / 1714
Formula A.2: $kW_{PumpHydrauilic}$ = 0.3021 x Flow [mgd] x ($P_{Discharge}$ - $P_{Suction}$) [psi]
Formula A.3: Pump $kW_{Calculated}$ = $kW_{PumpHydrauilic}$ / ($\eta_{Pump\ Listed}$ x η_{Motor})
Formula A.4: Pump kW_{Pump} = $kW_{PumpHydrauilic}$ / ($\eta_{Pump\ Listed}$)
Ref [1]: Mechanical Engineering reference Manual 11th Edition - Table 18-2
Pump $kW_{Calculated}$ is equivalent to the pump **kW** demand at the pump motor input.
Pump kW_{Pump} is equivalent to the pump **kW** demand at the pump input.

Pump $kW_{\textbf{Expected}}$: Estimated Pump kW based on sample measured interval data of applicable pump configurations.

Formula A.5 (Sample Crockett): Pump $kW_{Expected}$ = IF((K3+L3+M3+N3)=4,150*4, IF((K3+L3+M3+N3)=5,150*3,IF((K3+L3+M3+N3)=6,150*2, IF((K3+L3+M3+N3)=7,150*1,IF((K3+L3+M3+N3)=8, 0

Where K, L, M, N are Pumps On/Off Indicator Flags; "2" is Off, "1" is On
K=Pump-1, L=Pump-2, M=Pump-3, N=Pump-4
Pump-1, Pump-2, Pump-3 & Pump-4 are 150 HP each.

$\eta_{\textbf{Pump Tabulated}}$: Tabulated Pump Efficiency using actual interval data
Formula A.6 [2]: $\eta_{\textbf{Pump Tabulated}}$ = Flow [mgd] x ($P_{Discharge}$ - $P_{Suction}$) [psi] / PG&E Interval kW

Reference [2] : Derived Combining Formula A2 and Formula A3. Tabulated efficiency accounts both pump and motor efficiency

Formula A.7: Expected Flow Max $_{\textbf{Calculated}}$: Tabulated Pump kW using actual interval data

Expected Flow Max [mgd] = Max-kW_{PGE} x ($\eta_{Pump\ Listed}$ x η_{Motor}) /(0.3021 x Estim Min ($P_{Discharge}$ - $P_{Suction}$) [psi])

4.3 Pump Combinations Efficiencies

Table B.1: Argyle, Almond and Crockett Pump Stations Pump Listed Efficiency ($\eta_{Pump\ Listed}$)

Obtained from GEP draft project report. Used for general pump interval data screening (+-30% range) except Almond baseline.

ARGYLE		CROCKETT		ALMOND			
PUMP CONFIG	PUMP EFFICIENCY	PUMP CONFIG	PUMP EFFICIENCY	PUMP CONFIG	PUMP EFFICIENCY	PUMP CONFIG	PUMP EFFICIENCY
1	0.770	1	0.782	1	0.585	124	0.687
2	0.748	2	0.747	2	0.409	125	0.681
3	0.740	3	0.772	3	0.572	134	0.745
12	0.764	4	0.656	4	0.661	135	0.732
13	0.766	12	0.819	5	0.668	145	0.742
23	0.748	13	0.832	12	0.495	234	0.731
123	0.755	14	0.804	13	0.625	235	0.718
		23	0.834	14	0.667	245	0.722
		24	0.851	15	0.667	345	0.757
		34	0.803	23	0.656	1234	0.713
		123	0.856	24	0.682	1235	0.690
		124	0.792	25	0.688	1245	0.701
		134	0.824 [1]	34	0.767	1345	0.733
		234	0.843	35	0.753	2345	0.716
		1234	0.824 [1]	45	0.762	12345	0.690
				123	0.649		

[1] Crockett Pump Station configuration for pump 123 and 1234 are estimated as average of configuration 123 & 124 since values were missing in GEP draft project report

4.4 EBMUD Operator Feedback Questionnaire

Electric Submetering Demonstration at Almond, Argyle, and Crocket Pumping Plants

1. **Technical**
   i. What techniques did you explore to optimize the pumping plant energy efficiency and energy intensity metrics at the each pumping plant?
2. **Pump Combinations**
   i. How did you decide which was the least energy intensive pump combinations"?
   ii. What challenges did you face while trying to select the optimum pump combination? Were you always able to select the "desired" pump?
   iii. What trends did you notice regarding various pump combinations? Like certain pumps combination performed better than others during certain situations.
3. **Other Parameters**
   i. Besides the displayed energy efficiency/energy intensity metric, what other factors did you consider before adjusting the pump combinations? How did the "other factors" affect your decision making?
   ii. How did other system parameters, perhaps beyond your control, affect the energy intensity for the pumping plants? What were those parameters?
   iii. What suggestions do you have for lowering the energy intensity numbers at the pumping plants?
   ii. How often did you check the SCADA screen to observe the readings of *pumping efficiency* metric which was implemented in July 2009?
   iii. After July 2009, which tool did you utilize most to optimize energy consumption – the real time SCADA displays or the static pump-combo efficiency table that was also developed? Why?
   iv. Have you changed your operational procedures or decision making in any way since the implementation of the *energy intensity* (kWh/MG) metric into the SCADA in December 2009? If so, how?
   v. Were the pumping operations at the pumping plants during the project (July 2009- April 2010) similar to previous years (like 2007,2008)? Have there been any major distribution issues or problems that prevented "normal" pumping operations?
   vi. What are the most critical variables that as an operator you have to consider in making pumping decisions?
4. **Process Related**
   i. Describe your level of comfort and understanding of the objectives of the demonstration project.
   ii. How were you trained for the project?
   iii. What resources/tools were made available to you for the project?
   iv. Was the demonstration project valuable from your perspective? Why or why not?
   v. How could the project have been improved?

Appendix 5: SCE High-Efficiency Toilet Pilot Program

5.1 M&V Plan

Pilot Project Name:
SCE Low Income Direct Install
High Efficiency Toilet Program (Multi-family)

Prepared by

Aquacraft Inc.

For the

California Public Utilities Commission

May 29, 2009

MEASURE DESCRIPTION

Efficiency Improvement

SCE will replace up to 550 standard toilets, with flush rates of 3.5 gpf or greater, with new toilets meeting the HET standard of 1.28 gpf or less. Originally these were to be installed on large projects in which a single water meter served many apartment units. This plan has been revised significantly in that the toilet replacements are now contemplated on individually metered multi-family units in the service area of the Irvine Ranch Water District. The individual water meters are believed by the agency to provide water to a single multi-family unit and serve only indoor water demands.

The plan is to install loggers on 60 water meters with the goal of obtaining at least 50 good data files. A data file can be invalidated if there is a failure of the water meter, the sensor or the data logger, or if the unit is occupied too few days during the logging period.

It is understood that *all* toilets in the units will be replaced as part of this project, and no straggler toilets will be left. It is also assumed that all of the replacement toilets will be the same make and model, and that they will be properly installed and adjusted to the correct flush volumes by the installers.

We suggest that the best way to obtain customer consent to participate in the study is to inform all of the customers who will be receiving the free toilets - obtaining their consent *a priori* - that a random group of them will be selected to have a data logger installed on their water meter. It should be made clear that no one will be entering their homes to collect the data, and that all results will be kept confidential. The customers will not know if they are being logged, or, if so, when the loggers may be installed so there is virtually no chance that the data collection process will interfere with their behavior.

On one hand the use of individually metered units complicates the M&V program in that it requires more individual measurements, but it simplifies the program in several ways:

1. It will not be necessary to install additional water meters since the existing utility meters can be equipped with data loggers (which we already own) which will provide the needed flow trace data.
2. It will not be necessary to install the data acquisition and transmission devices that were intended (in the original Impact Evaluation Plan) to collect data from the larger single metered buildings. But it will be necessary to visit the sites to install data loggers and remove them from each water meter.
3. Having one meter per unit will allow a much more accurate and detailed analysis of the water use in the units. Individual fixtures and appliances can be identified and water use disaggregated according to end-use, just as it is for single-family homes.
4. Individual toilet flushes will be seen on the flow trace so that the volume and time of each flush will be recorded by the loggers.
5. Changes in both toilet use and other uses can be analyzed so that the net impact of the retrofits can be determined. This gives a more complete and reliable picture of the impacts of the retrofits on water use.

Pre-retrofit Equipment and Operation

Prior to the HET retrofits, each of the water meters feeding the units selected for measurement will be visited and a data logger will be installed for a two-week period. The logger will be retrieved and the flow trace will be analyzed. Water use in the unit will be broken down into gallons per day per unit for each end use normally found in domestic units: toilets, showers, dish washers, clothes washers, baths, miscellaneous faucets, and leaks. The resulting database will contain one record for each observed water use event. For each event the following information will be generated from the trace: start time, duration, type of use, total volume of use, peak flow rate, mode flow rate. These events are contained in a database format that can be analyzed however best meets the needs of the evaluation.

The information needed from the project implementer at this stage is a list of all of the low-income units that are participating in the HET retrofit program, including their address and unit number. Once we have a complete list of the participating units a logging sample of 60 units can be selected. Aquacraft will then obtain the serial number of the meter register and the location of the water meter from the participating water utility for the sample group.

Post Retrofit Equipment and Operation

After the pre-retrofit data are collected and the toilets retrofit, Aquacraft personnel will return to the sample units and re-log their water meters for another 2-week period. The post retrofit data will be analyzed in the same manner as the pre-retrofit data.

The essential data that are needed from the project implementers consists of the make and model of each toilet removed and the make and model of each toilet installed, and the unit address. Aquacraft does not need flush volume measurements since these will be obtained from the flow traces. The number of bathrooms in each unit will be known from the number of toilets replaced. If the installers are able to tell Aquacraft personnel the number of residents in each unit and the number of bedrooms, that would be interesting information, but not essential to the fundamental task, which is to measure the water use savings per unit retrofit and per toilet.

Variability in Schedule

There is no reason to expect any kind of seasonal variability in the water use for toilets in housing that is occupied on a year-round basis. We will be able to generate tables of hourly water use from the data, which will be one of the key outputs of the study.

Ex Ante Savings Estimate

The actual savings expressed on an annual basis will be compared to the ex ante estimate used for project design.

APPROACH FOR ESTIMATING SAVINGS

The savings will be estimated using the paired, pre and post retrofit data, for the following parameters obtained from the flow trace analysis.

- Average gallons per day of total domestic use per unit
- Average gallons per day for toilet flushing per unit
- Average number of flushes per unit per day

- Average leakage rates per unit per day

All of these values will be tabulated and paired t-tests will be run to determine if there are statistically significant changes (95% confidence level). Changes in mean daily toilet water use (as well as for other categories) will be determined. Interactions among the data will be evaluated, such as increases in flushes per day offsetting changes in gallons per flush, or impacts of changes in leakage that could be due to the retrofits replacing leaking toilets.

In addition to the statistical analysis the data will be analyzed using regression techniques to determine the impacts of the number of toilets replaced per unit and the pre-retrofit flush volumes. It is assumed that all of the replacement toilets are identical, which will simplify the analysis by eliminating the post retrofit flush volume as a variable.

The hourly water use data for the sample will be tabulated and a comparison will be made between pre and post water use on an hourly basis. Both total water use and toilet use will be analyzed. Changes in hourly average water use will be checked for at a 95% confidence level.

Because there will be a relatively short interval between the pre and post data collection periods we believe that the assumption that there will not be a drastic change in occupancy rates for the units is valid. The other assumption that is being made is that the units included in this sample are typical of the low-income multi-family units in the general population. If Aquacraft can obtain the number of occupants per unit from the installers it will be possible to test this assumption with respect to the number of residents per unit.

DATA COLLECTION

Site Specific Input Parameters

As discussed above the following specific parameters will be collected at each site:

- Address of unit
- Serial number of utility water meter
- Make, model and size of water meter
- Date and time for logger installation and removal
- Beginning and ending water meter readings over logging period
- Serial number of data logger
- Number of toilets replaced in unit (obtained by installers)
- Make and model of toilets replaced (obtained by installers)
- Number of bedrooms (obtained from property managers)
- Number of occupants of unit (obtained from property managers)
- Make and model of toilets used for replacement (obtained by installers)

Data Collection Method

- Data on the addresses of the customers will be obtained from the IOU or project sub-contractor;
- Data on the water meter serial numbers will be obtained from the water utility;

- Data on the logger serial numbers, water meter readings at the installations and pick ups will be obtained from Aquacraft field personnel;
- Data on the numbers and types of toilets will be obtained from the installers of the toilets
- Data on the number of bedrooms and occupants will be obtained from the sub-contractor.
- No new or special water meter installation will be required

Appendix A shows the anticipated interactions between contractors, sub-contractors and the HET installer. Appendix B provides the data logging spreadsheets that will be used for both pre and post-retrofit data collection, and summary results.

Sampling Strategy

A systematic random sample of 60 homes will be chosen from the 500 units receiving new toilets using the techniques developed by the M&V team. ECONorthwest will perform the systematic random sampling method using interval sampling.

Data Products

The following data products will be generated by this study:

- Copies of reports from the installation crew for each unit showing the numbers and types of toilets, the numbers of bedrooms and the number of occupants for each unit.
- The water event database showing all pre and post water events logged during the two 14 day logging periods.
- Excel spreadsheets showing the statistical analyses of pre-post water use and regression analysis.

Schedule

Once authorization to proceed is given by CPUC and ECONorthwest, Aquacraft personnel will proceed in implementing this Revised M&V Plan. The following milestones are identified for this project:

- Receive list of low-income apartments that will be participating in study. (Out of our control: Day 1)
- Choose sample (Day 10)
- Complete initial site visit (Day 20)
- Retrieve data loggers (Day 40)
- Complete retrofits (out of our control: Day N)
- Receive data requested from installers (Day N+1)
- Complete second site visit (Day N+20)
- Retrieve second set of loggers (Day N+40)
- Complete Data analysis and report (Day N + 90)

Appendix A

SCE Multi-family HET pilot program: EM&V Steps

Step	Responsible Party*	Task	Completion dates
1	IC	Generates list of ~500 low-income qualified multi-family units	
2	EcoNW	Randomly select sample of 60 multi-family units from IC list of low-income qualified units	
3	EcoNW	Send sample list to Installer and EM&V contractor	
4	Aquacraft	Acquire individual meter numbers from water agency	
5	Aquacraft	Pre-retrofit site visit to install data loggers onto individual water meters - loggers collect flow trace data for two weeks	
6	Aquacraft	Site visit to retrieve data loggers from individual water meters	
7	Aquacraft	Inform Installer when it is OK to proceed with HET retrofits	
8	BL	Retrofit sample units with HET	
9	BL	Inform Aquacraft of retrofit completion and provide field information collect by installers	
10	Aquacraft	Post-retrofit site visit to install data loggers onto individual water meters - loggers collect flow trace data for two weeks	
11	Aquacraft	Site visit to retrieve data loggers from individual water meters	
12	Aquacraft	Pre and Post-retrofit data analysis and computation of impacts	

**Key to responsible parties*

EM&V prime contractor	*EcoNW*	*EcoNorthwest*
EM&V contractor	*Aquacraft*	*Aquacraft Inc.*
EM&V field subcontractor	*IC*	*Irvine Company*
Installer	*BL*	*Bottom Line*

Appendix B

Site information sheet

Aquacraft	Irvine Company									Bottom Line			
Aquacraft Keycode #	Meter Make	Meter Model	Meter Size	Water Agency account Number	Register Number	Site Address	Unit #	Persons per Home	Toilets per Home	# of Toilets Retrofit	Make & Model of Old Toilet	Make & Model of New Toilet	Comments

Data sheet used to record pre and post-retrofit field data

Aquacraft logger install data sheet														
			Install			Pcik-up		Calculated Info.						
Aquacraft Keycode #	Register Number	Aquacraft Field Technician	Logger #	Install Date and Time	Meter Reading at Install (cf)	Pick-up Date and Time	Meter Reading at Pick-up	Length of Trace (days)	Register Volume (cf)	Register Vol (gal)	Logged Volume (gal)	Correction Factor (?)	Comments	

Data sheet used to record summary results

Aquacraft									
	Pre-retrofit			Post-retrofit			Change in Use		
Aquacraft Keycode #	Average GPD for Toilet flushing	Average Flushes per Day	Average Flush Volume	Average GPD for Toilet flushing	Average Flushes per Day	Average Flush Volume	Daily use (gpd)	Flushes per Day	Gal/Flush
						Average Change			
						Number of Observations			
						Std Dev			
						95% CI			

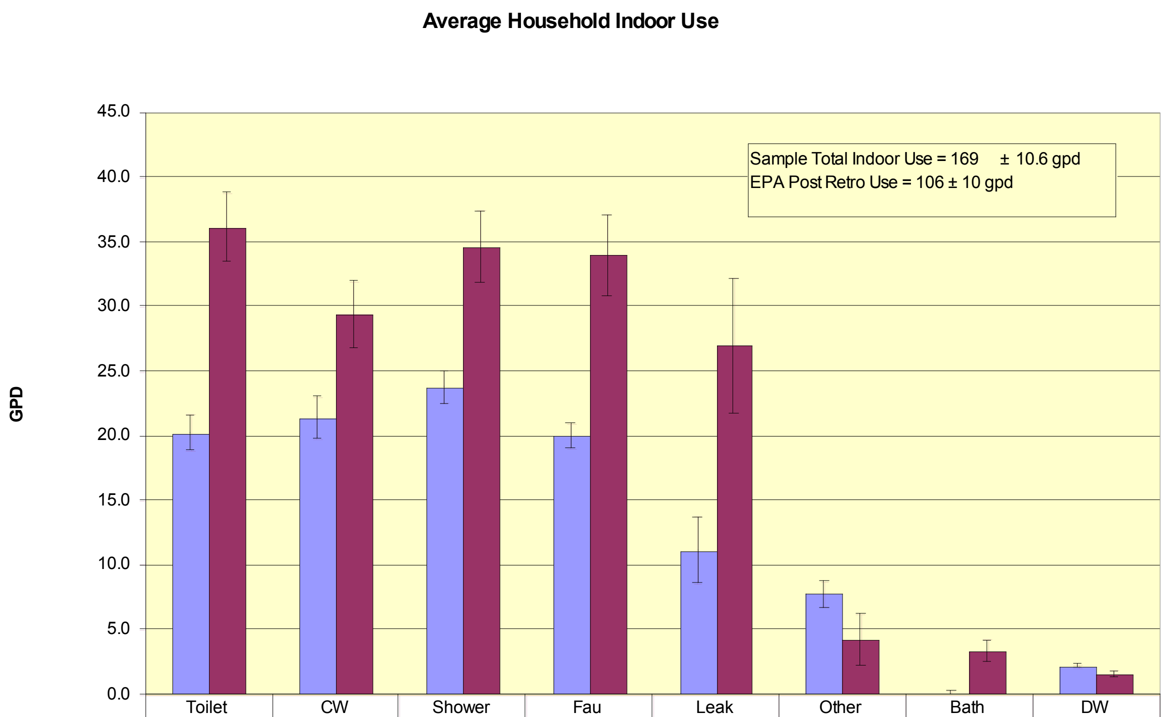
5.2 Flow Trace Method and Trace Wizard Software

The purpose of flow trace analysis is to obtain precise information about water use patterns: Where, when, and how much water is used by a variety of devices including toilets, showers, baths, faucets, clothes washers, dishwashers, hand-held and automatic irrigation systems, evaporative coolers, home water treatment systems, leaks, and more. The collected data are precise enough that individual water use events such as a toilet flush or a clothes washer cycle or miscellaneous tap use can be isolated, quantified and then identified. This technique makes it possible to disaggregate most of the water use in a residential home and to quantify the effect of many conservation measures, from toilet and faucet retrofit programs to behavior modification efforts. It is also possible to disaggregate water use into more coarse categories. For example, the changes in water use from much larger end user categories with large meters (i.e. industrial facilities) can be to measured by demand profile changes in domestic/indoor, process and other category water uses.

The flow trace methodology is based on the fact that there is consistency in the flow trace patterns of most water uses. For example, a specific toilet will generally flush with the same volume and flow rate day in and day out. A specific dishwasher exhibits the same series of flow patterns every time it is run. The same is true for clothes washers, showers, irrigation systems, etc. By recording flow data at 10-second intervals, a rate determined by Aquacraft to optimize accuracy and logger memory, the resulting flow trace is accurate enough to quantify and categorize almost all individual water uses in each study home.

Trace Wizard is a software package developed by Aquacraft Inc., specifically for the purpose of analyzing flow trace data. Trace Wizard provides the analyst with powerful signal processing tools and a library of flow trace patterns for recognizing a variety of residential fixtures. Any consistent flow pattern can be isolated, quantified, and categorized using Trace Wizard including leaks, evaporative coolers, humidifiers, and swimming pools. Once all the water use events have been isolated and quantified and statistics generated, Trace Wizard implements a user defined set of parameters developed for each individual study residence to categorize the water use events and assign a specific fixture designation to each event.

Figure 1shows a typical analysis that can be performed on household flow traces with Trace Wizard software. In this example of a sample of single-family homes, the average baseline water demand profile for each of the domestic categories is shown. These baseline data results are compared against a test group of homes in which the fixtures and appliances (minus the dish washers) were retrofit to best available technology (circa 2000). This provides a clear comparison of the performance of the sample water demand profile against a known benchmark group.



	Toilet	CW	Shower	Fau	Leak	Other	Bath	DW
Post Retro	20.2	21.4	23.8	20.0	11.2	7.8	0.0	2.2
Sample	36.1	29.4	34.7	34.0	27.0	4.2	3.3	1.6

Figure 1 Example of water use analysis with flow trace data disaggregated by Trace Wizard

The hourly water demand profiles that are generated in this study for the six categories of end uses may reliably be used as benchmarks to predict how much, when and where water is being used.

The flow trace analysis technique and the Trace Wizard software have been used as the fundamental analytic tool in a number of residential, commercial, industrial and institutional water use studies both in the U.S. and worldwide including:

- Heatherwood Residential End-use and Retrofit Studies – 1995-96, Aquacraft
- Westminster Water Use Study – 1998, Aquacraft
- Perth Residential End Uses of Water Study – 1999, Australia
- Residential End Uses of Water – 1999, AWWA
- Commercial and Institutional End Uses of Water – 2000, AWWA
- Pinellas County Utilities Water Conservation Opportunities Study – 2002, Aquacraft
- Seattle Market Penetration Study – 2003, Aquacraft
- Yarra Valley Water District Residential End-use Study – 2003, Australia
- EPA Residential Retrofit Studies (Seattle, EBMUD, Tampa) – 2004, Aquacraft
- Water Efficiency Opportunities in California Supermarkets – 2004, Aquacraft
- Monterey Pre-Rinse Spray Valve Study – 2005, Quantec
- Regional Water Authority of Sacramento CII Studies – 2005, Aquacraft

- Santa Paula Residential End-use Study – 2006, RBF Consulting
- New Zealand Residential Demand Study – 2007, Branz
- Lathrop and American Canyon, CA End-use Studies – 2008, RBF Consulting
- California (CALFED) Residential End-use Baseline Study – 2009, Aquacraft
- Gold Coast Water Residential End-use Study – 2009, Australia

Validation studies have confirmed the repeatability and reliability of the flow trace methodology. Figure 2 shows the most recent validation study of the flow trace analysis methodology. The National Renewable Energy Lab (NREL) compared end-use disaggregation using flow trace analysis to measurements based in in-line meters installed on individual water supply lines inside specifically equipped test homes in Boulder, CO (Magnusson, L., 2009).

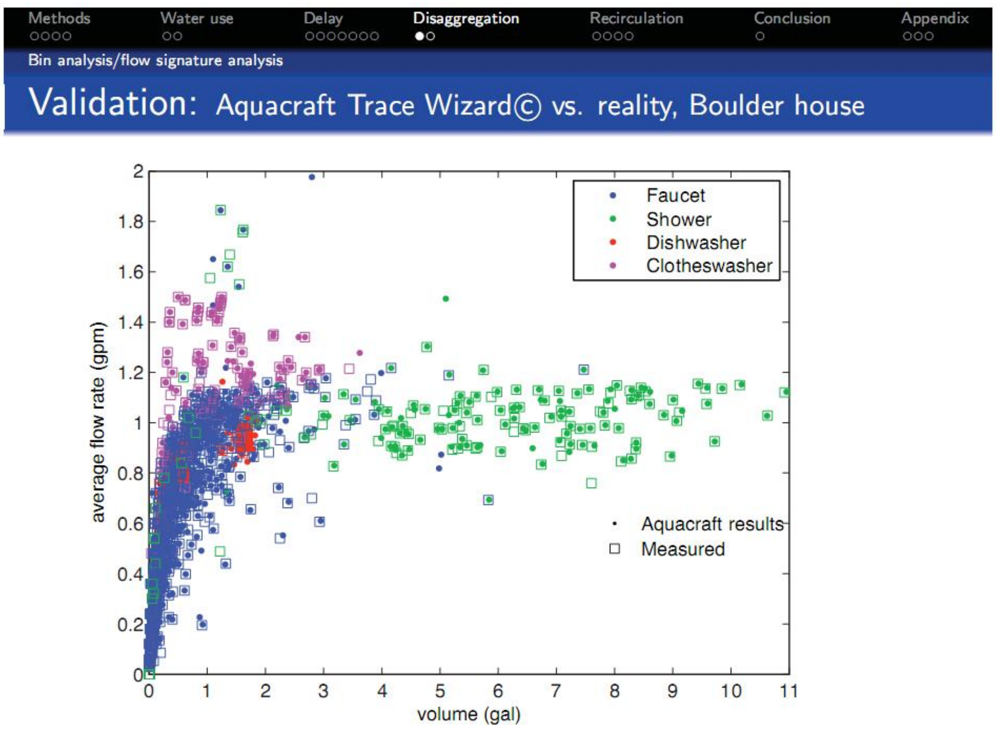


Figure 2 Comparison of flow trace analysis results to sub-meter measurements (Magnusson, L., 2009)

The Aquacraft Inc. results are based on flow trace analysis of a single meter supplying hot water to all of the fixtures in the homes. Individual faucet, shower, dishwasher and clothes washer events have been sorted by flow rate and volume for both sets of measurements. Where ever the two points coincide there is agreement. These appear as boxes with dots in them. As can be seen from Figure 3, there is excellent agreement between the flow trace and sub-meter measurements. When the measured water usage of faucet, shower, dishwasher, and clothes washer events are combined in the NREL study, Trace Wizard analysis and the in-line water meter data are 88% in agreement.

5.3 Regression Analysis Modeled Variables

Keycode	PreretroIndoorGPD	PostretroIndoorGPD	Indoor Change	PreretroToiletgpd	PostretroToiletgpd	ToiletChange	NumRetro	PersonsperHome
09M201	579	404	-175	97	54	-43	3	6
09M202	162	235	73	44	9	-35	1	3
09M204	256	199	-57	104	33	-71	3	4
09M205	266	82	-185	117	9	-108	2	3
09M207	142	108	-34	58	16	-42	3	3
09M208	166	143	-23	82	39	-43	1	2
09M210	179	79	-100	115	38	-77	2	2
09M214	144	126	-17	39	13	-26	1	1
09M215	53	35	-18	28	10	-18	1	1
09M216	17	32	15	4	6	2	1	2
09M217	125	49	-76	40	4	-36	1	1
09M219	128	91	-37	73	32	-40	2	3
09M220	116	88	-28	40	11	-28	1	3
09M221	153	106	-47	85	26	-60	2	2
09M222	236	31	-204	68	3	-65	1	3
09M223	91	44	-46	53	12	-42	2	2
09M224	260	244	-16	80	52	-27	1	2
09M225	75	70	-5	19	8	-10	2	2
09M226	308	162	-146	40	16	-25	2	4
09M227	96	157	62	34	7	-27	2	2
09M228	71	65	-5	31	36	5	1	1
09M229	131	228	97	40	62	22	1	1
09M232	29	73	44	7	15	7	1	4
09M233	132	461	328	63	43	-21	2	2
09M234	145	87	-58	64	16	-48	2	4
09M237	195	125	-71	69	37	-32	1	5
09M238	158	82	-76	61	17	-44	1	3
09M239	179	89	-90	96	18	-78	2	4
09M240	74	48	-26	20	6	-13	2	2
09M241	113	101	-12	38	17	-21	2	3
09M242	39	55	16	23	21	-2	1	2
09M243	129	120	-8	56	14	-42	1	2
09M245	83	53	-31	48	12	-36	1	2
09M251	103	0	-103	55	0	-55	2	3
09M250	59	47	-12	25	9	-16	1	1
09M252	180	176	-4	65	39	-26	1	5
09M253	93	135	42	48	23	-25	2	5
09M254	23	45	22	7	5	-2	2	2
09M255	81	65	-16	38	15	-23	1	2
09M256	6	224	219	2	26	24	2	3
09M257	98	73	-25	59	23	-36	2	2
Average	138.28	118	-20.3	52	21	-31	1.6	2.7
Std Dev	99.81	94.30	94.05	29.31	15.14	26.80	0.63	1.24
Count	41	41	41	41	41	41	41	41
95%CI	30.55	28.87	28.79	8.97	4.63	8.20	0.19	0.38
90% CI	25.64	24.23	24.16	7.53	3.89	6.88	0.16	0.32

5.4 Completed Data Logging Sheets

The following four tables show the data sheets used for the pre and post retrofit installations of the HETs.

Aquacraft	IRWD & Irvine Company						Bottom Line			
Keycode	Meter Make	Meter Model	Meter Size	Register Number -OR- Meter Serial Number	Persons per Home	Toilets per Home	# of Toilets Retrofit	Make & Model of Old Toilet	Make & Model of New Toilet	Comments
09M201	Neptune	T10	5/8	46512156	6	3	3	Briggs	Caroma Sydney 305	
09M202	Neptune	T10	5/8	77959550	3	1	1	Briggs	Caroma Sydney 305	
09M203	Neptune	T10	5/8	77959593	1	2	2	Briggs	Caroma Sydney 305	
09M204	Neptune	T10	5/8	77959603	4	3	3	Briggs	Caroma Sydney 305	
09M205	Neptune	T10	5/8	78823976	3	2	2	Briggs	Caroma Sydney 305	
09M206	Neptune	T10	5/8	78823997	4	3	3	Briggs	Caroma Sydney 305	
09M207	Neptune	T10	5/8	78823998	3	3	3	Briggs	Caroma Sydney 305	
09M208	Neptune	T10	5/8	78824004	2	2	1	Briggs	Caroma Sydney 305	
09M209	Neptune	T10	5/8	78823968	1	1	0	Briggs	Caroma Sydney 305	
09M210	Neptune	T10	5/8	85375685	2	2	2	Briggs	Caroma Sydney 305	
09M211	Neptune	T10	5/8	78823964	3	1	0	Briggs	Caroma Sydney 305	
09M212	Neptune	T10	5/8	78823965	1	1	0	Briggs	Caroma Sydney 305	
09M213	Neptune	T10	5/8	78823949	1	1	0	Briggs	Caroma Sydney 305	
09M214	Neptune	T10	5/8	78823950	1	1	1	Briggs	Caroma Sydney 305	
09M215	Neptune	T10	5/8	78823921	1	1	1	Briggs	Caroma Sydney 305	
09M216	Neptune	T10	5/8	78824497	2	1	1	Briggs	Caroma Sydney 305	
09M217	Badger	?	5/8	16173142	1	1	1	Briggs	Caroma Sydney 305	
09M218	Neptune	T10	5/8	78823929	3	3	0	Briggs	Caroma Sydney 305	
09M219	Neptune	T10	5/8	78823930	3	3	2	Briggs	Caroma Sydney 305	
09M220	Neptune	T10	5/8	78823898	3	1	1	Briggs	Caroma Sydney 305	
09M221	Neptune	T10	5/8	78823905	2	2	2	Briggs	Caroma Sydney 305	
09M222	Neptune	T10	5/8	78823903	3	2	1	Briggs	Caroma Sydney 305	
09M223	Neptune	T10	5/8	78823877	2	2	2	Briggs	Caroma Sydney 305	
09M224	Rockwell	?	5/8	78823908	2	2	1	Briggs	Caroma Sydney 305	
09M225	Neptune	T10	5/8	78823894	2	2	2	Briggs	Caroma Sydney 305	
09M226	Neptune	T10	5/8	78823816	4	2	2	Briggs	Caroma Sydney 305	
09M227	Neptune	T10	5/8	78823819	2	2	2	Briggs	Caroma Sydney 305	
09M228	Neptune	T10	5/8	78823875	1	1	1	Briggs	Caroma Sydney 305	
09M229	Neptune	T10	5/8	78823833	1	2	1	Briggs	Caroma Sydney 305	
09M230	Neptune	T10	5/8	78823828	1	1	1	Briggs	Caroma Sydney 305	
09M231	Neptune	T10	5/8	78823835	3	1	0	Briggs	Caroma Sydney 305	
09M232	Neptune	T10	5/8	78823836	4	2	1	Briggs	Caroma Sydney 305	
09M233	Neptune	T10	5/8	79770530	2	3	2	Briggs	Caroma Sydney 305	
09M234	Neptune	T10	5/8	79770536	4	2	2	Briggs	Caroma Sydney 305	
09M235	Neptune	T10	5/8	79770521	3	2	0	Briggs	Caroma Sydney 305	
09M236	Neptune	T10	5/8	37739924	2	1	1	Briggs	Caroma Sydney 305	
09M237	Neptune	T10	5/8	79770503	5	3	1	Briggs	Caroma Sydney 305	
09M238	Neptune	T10	5/8	79770481	3	1	1	Briggs	Caroma Sydney 305	
09M239	Neptune	T10	5/8	79770543	4	2	2	Briggs	Caroma Sydney 305	
09M240	Neptune	T10	5/8	79770456	2	2	2	Briggs	Caroma Sydney 305	
09M241	Neptune	T10	5/8	79770432	3	2	2	Briggs	Caroma Sydney 305	
09M242	Neptune	T10	5/8	79771985	2	1	1	Briggs	Caroma Sydney 305	
09M243	Neptune	T10	5/8	79770443	2	1	1	Briggs	Caroma Sydney 305	
09M244	Neptune	T10	5/8	79770446	1	1	0	Briggs	Caroma Sydney 305	
09M245	Neptune	T10	5/8	79770407	2	1	1	Briggs	Caroma Sydney 305	
09M246	Neptune	T10	5/8	79770412	1	1	0	Briggs	Caroma Sydney 305	
09M247	Neptune	T10	5/8	79771988	4	2	0	Briggs	Caroma Sydney 305	
09M248	Neptune	T10	5/8	79771983	3	2	1	Briggs	Caroma Sydney 305	
09M249	Neptune	T10	5/8	79770421	1	1	1	Briggs	Caroma Sydney 305	
09M250	Neptune	T10	5/8	79770422	1	1	1	Briggs	Caroma Sydney 305	
09M251	Neptune	T10	5/8	77407926	3	2	2	Briggs	Caroma Sydney 305	
09M252	Neptune	T10	5/8	77408011	5	2	1	Briggs	Caroma Sydney 305	
09M253	Neptune	T10	5/8	77407981	5	2	2	Briggs	Caroma Sydney 305	
09M254	Neptune	T10	5/8	77407964	2	2	2	Briggs	Caroma Sydney 305	
09M255	Neptune	T10	5/8	77407995	2	1	1	Briggs	Caroma Sydney 305	
09M256	Neptune	T10	5/8	77408027	3	2	2	Briggs	Caroma Sydney 305	
09M257	Neptune	T10	5/8	84597679	2	2	2	Briggs	Caroma Sydney 305	
09M258	Neptune	T10	5/8	77408041	3	2	0	Briggs	Caroma Sydney 305	
09M259	Neptune	T10	5/8	77408080	3	2	0	Briggs	Caroma Sydney 305	
09M260	Neptune	T10	5/8	77407694	2	2	2	Briggs	Caroma Sydney 305	[8]

[8] Homes with '0' toilets replaced were excluded from the impact analysis.

Aquacraft pre-retrofit data logging sheet												
Install									Pick-up			
Aquacraft Keycode #	Logger #	Register Number -OR- Meter Serial Number	Meter Size	Meter Make & Model	Meter Model	Aquacraft Field Technician	Install Date and Time	Meter Reading at Install (cf)	Aquacraft Field Technician	Pick-up Date and Time	Meter Reading at Pick-up
09M201	12608	46512156	5/8	Neptune	T10	MKD	6/29/2009 15:47	119934	MKD	7/13/09 18:50	121041
09M202	12598	77959550	5/8	Neptune	T10	MKD	6/29/2009 15:46	56797	MKD	7/13/09 18:50	57083
09M203	12613	77959593	5/8	Neptune	T10	MKD	6/29/2009 15:45	30175	MKD	7/13/09 18:50	30177
09M204	12590	77959603	5/8	Neptune	T10	MKD	6/29/2009 15:44	38686	MKD	7/13/09 18:50	39165
09M205	12580	78823976	5/8	Neptune	T10	MKD	6/29/2009 15:25	45631	MKD	7/13/09 18:45	46137
09M206	12607	78823997	5/8	Neptune	T10	MKD	6/29/2009 15:24	54141	MKD	7/13/09 18:30	54768
09M207	11370	78823998	5/8	Neptune	T10	MKD	6/29/2009 15:23	44086	MKD	7/13/09 18:30	44356
09M208	12586	78824004	5/8	Neptune	T10	MKD	6/29/2009 15:22	51364	MKD	7/13/09 18:30	51680
09M209	12617	78823968	5/8	Neptune	T10	MKD	6/29/2009 15:01	10404	MKD	7/13/09 18:30	10529
09M210	12566	85375685	5/8	Neptune	T10	MKD	6/29/2009 12:07	9156	MKD	7/13/09 18:00	9499
09M211	12587	78823964	5/8	Neptune	T10	MKD	6/29/2009 14:56	24287	MKD	7/13/09 18:15	24663
09M212	12592	78823965	5/8	Neptune	T10	MKD	6/29/2009 14:56	16177	MKD	7/13/09 18:15	16282
09M213	12566	78823949	5/8	Neptune	T10	MKD	6/29/2009 12:58	10803	MKD	7/13/09 17:20	10958
09M214	12611	78823950	5/8	Neptune	T10	MKD	6/29/2009 12:57	28930	MKD	7/13/09 17:20	29241
09M215	11321	78823921	5/8	Neptune	T10	MKD	6/29/2009 12:55	14917	MKD	7/13/09 17:20	15013
09M216	12606	78824497	5/8	Neptune	T10	MKD	6/29/2009 14:34	21801	MKD	7/13/09 18:15	21837
09M217	12577	16173142	5/8	Badger	?	MKD	6/29/2009 14:54	55755	MKD	7/13/09 18:00	56016
09M218	12619	78823929	5/8	Neptune	T10	MKD	6/29/09 12:55	29753	MKD	7/13/09 17:20	30049
09M219	12605	78823930	5/8	Neptune	T10	MKD	6/29/2009 12:53	29067	MKD	7/13/09 17:20	29311
09M220	12585	78823898	5/8	Neptune	T10	MKD	6/29/2009 14:53	28251	MKD	7/13/09 18:00	28471
09M221	12615	78823905	5/8	Neptune	T10	MKD	6/29/2009 12:52	34799	MKD	7/13/09 17:40	35078
09M222	12582	78823903	5/8	Neptune	T10	MKD	6/29/2009 14:53	38436	MKD	7/13/09 18:00	38875
09M223	11349	78823877	5/8	Neptune	T10	MKD	6/29/2009 14:52	39047	MKD	7/13/09 18:00	39215
09M224	12597	78823908	5/8	Rockwell	?	MKD	6/29/2009 12:50	27588	MKD	7/13/09 17:40	28068
09M225	11314	78823894	5/8	Neptune	T10	MKD	6/29/2009 11:40	31859	MKD	7/13/09 16:56	32000
09M226	12579	78823816	5/8	Neptune	T10	MKD	6/29/2009 11:32	62406	MKD	7/13/09 16:37	62996
09M227	11329	78823819	5/8	Neptune	T10	MKD	6/29/2009 11:31	32336	MKD	7/13/09 16:40	32700
09M228	11372	78823875	5/8	Neptune	T10	MKD	6/29/2009 11:56	26160	MKD	7/13/09 16:20	26291
09M229	11386	78823833	5/8	Neptune	T10	MKD	6/29/09 11:18	50375	MKD	7/13/09 16:45	50724
09M230	12612	78823828	5/8	Neptune	T10	MKD	6/29/09 11:55	15953	MKD	7/13/09 16:20	16098
09M231	12583	78823835	5/8	Neptune	T10	MKD	6/29/2009 11:07	29286	MKD	7/13/09 16:20	29467
09M232	11319	78823836	5/8	Neptune	T10	MKD	6/29/09 11:30	37856	MKD	7/13/09 16:45	37912
09M233	12565	79770530	5/8	Neptune	T10	MKD	6/29/09 11:00	35904	MKD	7/13/09 16:20	36157
09M234	11297	79770536	5/8	Neptune	T10	MKD	6/29/09 10:59	41348	MKD	7/13/09 16:20	41649
09M235	11364	79770521	5/8	Neptune	T10	MKD	6/29/09 10:58	26369	MKD	7/13/09 16:20	26542
09M236	12620	37739924	5/8	Neptune	T10	MKD	6/29/09 10:57	89293	MKD	7/13/09 16:20	89477
09M237	11377	79770503	5/8	Neptune	T10	MKD	6/29/09 9:55	39982	MKD	7/13/09 15:15	40350
09M238	11312	79770481	5/8	Neptune	T10	MKD	6/29/09 9:55	20068	MKD	7/13/09 15:15	20353
09M239	12564	79770543	5/8	Neptune	T10	MKD	6/29/09 10:18	37602	MKD	7/13/09 15:24	37941
09M240	11373	79770456	5/8	Neptune	T10	MKD	6/29/09 9:36	52552	MKD	7/13/09 15:15	52696
09M241	11375	79770432	5/8	Neptune	T10	MKD	6/29/09 9:30	33054	MKD	7/13/09 15:15	33273
09M242	11356	79771985	5/8	Neptune	T10	MKD	6/29/09 10:29	16012	MKD	7/13/09 15:40	16088
09M243	11398	79770443	5/8	Neptune	T10	MKD	6/29/2009 9:24	23960	MKD	7/13/09 15:15	24203
09M244	11302	79770446	5/8	Neptune	T10	MKD	6/29/2009 9:12	19193	MKD	7/13/09 13:50	19392
09M245	12574	79770407	5/8	Neptune	T10	MKD	6/29/2009 9:12	17235	MKD	7/13/09 13:50	17340
09M246	11393	79770412	5/8	Neptune	T10	MKD	6/29/2009 9:09	8491	MKD	7/13/09 13:50	8534
09M247	12568	79771988	5/8	Neptune	T10	MKD	6/29/2009 8:50	35675	MKD	7/13/09 12:51	35952
09M248	11376	79771983	5/8	Neptune	T10	MKD	6/29/2009 8:42	49977	MKD	7/13/09 11:33	50445
09M249	11303	79770421	5/8	Neptune	T10	MKD	6/29/2009 10:09	12255	MKD	7/13/09 14:36	12372
09M250	11383	79770422	5/8	Neptune	T10	MKD	6/29/2009 10:09	11518	MKD	7/13/09 14:53	11626
09M251	11294	77407926	5/8	Neptune	T10	MKD	6/29/09 16:06	40347	MKD	7/13/09 20:20	40513
09M252	11397	77408011	5/8	Neptune	T10	MKD	6/29/09 16:26	46102	MKD	7/13/09 20:15	46445
09M253	12563	77407981	5/8	Neptune	T10	MKD	6/29/09 16:33	56061	MKD	7/13/09 20:15	56242
09M254	11307	77407964	5/8	Neptune	T10	MKD	6/29/09 16:01	35852	MKD	7/13/09 20:10	35903
09M255	11401	77407995	5/8	Neptune	T10	MKD	6/29/09 16:38	28042	MKD	7/13/09 20:00	28195
09M256	11385	77408027	5/8	Neptune	T10	MKD	6/29/09 16:59	68470	MKD	7/13/09 19:45	68479
09M257	11309	84597679	5/8	Neptune	T10	MKD	6/29/09 17:01	5533	MKD	7/13/09 19:30	5719
09M258	12562	77408041	5/8	Neptune	T10	MKD	6/29/09 17:16	37861	MKD	7/13/09 19:30	38007
09M259	11390	77408080	5/8	Neptune	T10	MKD	6/29/09 16:58	24754	MKD	7/13/09 19:30	24878
09M260	11311	77407694	5/8	Neptune	T10	MKD	6/29/09 17:18	48040	MKD	7/13/09 19:30	48218

Aquacraft post-retrofit data logging sheet												
Install										Pick-up		
Aquacraft Keycode #	Logger #	Register Number -OR- Meter Serial Number	Meter Size	Meter Make & Model	Meter Model	Aquacraft Field Technician	Install Date and Time	Install Time	Meter Reading at Install (cf)	Aquacraft Field Technician	Pick-up Date	Meter Reading at Pick-up
09M201a2	12586	46512156	5/8	Neptune	T10	MKD	9/29/2009	11:08	125911	MH	10/13/2009	126673
09M202a2	11307	77959550	5/8	Neptune	T10	MKD	9/29/2009	11:18	58949	MH	10/13/2009	59383
09M203a2	11386	77959593	5/8	Neptune	T10	MKD	9/29/2009	11:12	30193	MH	10/13/2009	30195
09M204a2	11294	77959603	5/8	Neptune	T10	MKD	9/29/2009	11:16	41514	MH	10/13/2009	41865
09M205a2	12590	78823976	5/8	Neptune	T10	MKD	9/29/2009	11:56	52309	MH	10/13/2009	52455
09M206a2	12618	78823997	5/8	Neptune	T10	MKD	9/29/2009	11:39	57549	MH	10/13/2009	58082
09M207a2	11385	78823998	5/8	Neptune	T10	MKD	9/29/2009	11:44	45696	MH	10/13/2009	45892
09M208a2	11349	78824004	5/8	Neptune	T10	MKD	9/29/2009	11:37	52906	MH	10/13/2009	53171
09M209a2		78823968	5/8	Neptune	T10							
09M210a2	11309	85375685	5/8	Neptune	T10	MKD	9/29/2009	12:19	10774	MH	10/13/2009	10924
09M211a2		78823964	5/8	Neptune	T10							
09M212a2		78823965	5/8	Neptune	T10							
09M213a2		78823949	5/8	Neptune	T10							
09M214a2	12607	78823950	5/8	Neptune	T10	MKD	9/29/2009	12:34	31852	MH	10/13/2009	32100
09M215a2	12594	78823921	5/8	Neptune	T10	MKD	9/29/2009	12:44	15521	MH	10/13/2009	15585
09M216a2	11312	78824497	5/8	Neptune	T10	MKD	9/29/2009	14:18	22077	MH	10/13/2009	22135
09M217a2	12620	16173142	5/8	Badger	?	MKD	9/29/2009	14:27	57161	MH	10/13/2009	57257
09M218a2		78823929	5/8	Neptune	T10							
09M219a2	11298	78823930	5/8	Neptune	T10	MKD	9/29/2009	12:37	30804	MH	10/13/2009	30964
09M220a2	12579	78823898	5/8	Neptune	T10	MKD	9/29/2009	14:09	29435	MH	10/13/2009	29595
09M221a2	12564	78823905	5/8	Neptune	T10	MKD	9/29/2009	12:57	35825	MH	10/13/2009	36037
09M222a2	11306	78823903	5/8	Neptune	T10	MKD	9/29/2009	14:06	40682	MH	10/13/2009	40736
09M223a2	12598	78823877	5/8	Neptune	T10	MKD	9/29/2009	14:03	39945	MH	10/13/2009	40027
09M224a2	11311	78823908	5/8	Rockwell	?	MKD	9/29/2009	12:54	31121	MH	10/13/2009	31592
09M225a2	11397	78823894	5/8	Neptune	T10	MKD	9/29/2009	14:46	32807	MH	10/13/2009	32942
09M226a2	11329	78823816	5/8	Neptune	T10	MKD	9/29/2009	15:01	66191	MH	10/13/2009	66736
09M227a2	12616	78823819	5/8	Neptune	T10	MKD	9/29/2009	15:03	34751	MH	10/13/2009	35076
09M228a2	11314	78823875	5/8	Neptune	T10	MKD	9/29/2009	15:22	27041	MH	10/13/2009	27166
09M229a2	12587	78823833	5/8	Neptune	T10	MKD	9/29/2009	15:08	53454	MH	10/13/2009	53874
09M230a2	12566	78823828	5/8	Neptune	T10	MKD	9/29/2009	15:24	16748			
09M231a2		78823835	5/8	Neptune	T10							
09M232a2	11383	78823836	5/8	Neptune	T10	MKD	9/29/2009	15:13	37941	MH	10/13/2009	38076
09M233a2	12562	79770530	5/8	Neptune	T10	MKD	9/29/2009	16:06	37354	MH	10/13/2009	38191
09M234a2	12582	79770536	5/8	Neptune	T10	MKD	9/29/2009	16:02	42973	MH	10/13/2009	43137
09M235a2		79770521	5/8	Neptune	T10							
09M236a2	12585	37739924	5/8	Neptune	T10	MKD	9/29/2009	16:24	90244	MH	10/13/2009	90351
09M237a2	12603	79770503	5/8	Neptune	T10	MKD	9/29/2009	16:30	42111	MH	10/13/2009	42346
09M238a2	12615	79770481	5/8	Neptune	T10	MKD	9/29/2009	16:34	21263	MH	10/13/2009	21412
09M239a2	11376	79770543	5/8	Neptune	T10	MKD	9/29/2009	17:44	39206	MH	10/13/2009	39370
09M240a3	12617	79770456	5/8	Neptune	T10	MKD	9/29/2009	17:36	53543	MH	10/13/2009	53628
09M241a2	12577	79770432	5/8	Neptune	T10	MKD	9/29/2009	17:40	34490	MH	10/13/2009	34630
09M242a2	11393	79771985	5/8	Neptune	T10	MKD	9/29/2009	16:42	16924	MH	10/13/2009	17026
09M243a2	12597	79770443	5/8	Neptune	T10	MKD	9/29/2009	17:25	25374	MH	10/13/2009	25596
09M244a2		79770446	5/8	Neptune	T10							
09M245a2	12613	79770407	5/8	Neptune	T10	MKD	9/29/2009	17:20	18245	MH	10/13/2009	18350
09M246a2		79770412	5/8	Neptune	T10							
09M247a2		79771988	5/8	Neptune	T10							
09M248a2	12606	79771983	5/8	Neptune	T10	MKD	9/29/2009	18:01	52491	MH	10/13/2009	52908
09M249a2	11401	79770421	5/8	Neptune	T10	MKD	9/29/2009	17:02	12741	MH	10/13/2009	12748
09M250a2	11319	79770422	5/8	Neptune	T10	MKD	9/29/2009	17:00	12220	MH	10/13/2009	12267
09M251a2	11372	77407926	5/8	Neptune	T10	MKD	9/30/2009	9:08	40749	MH	10/13/2009	40749
09M252a2	11346	77408011	5/8	Neptune	T10	MKD	9/30/2009	9:26	48447	MH	10/13/2009	48756
09M253a2	12565	77407981	5/8	Neptune	T10	MKD	9/30/2009	9:32	57735	MH	10/13/2009	57977
09M254a2	12583	77407964	5/8	Neptune	T10	MKD	9/30/2009	10:12	36341	MH	10/13/2009	36415
09M255a2	12612	77407995	5/8	Neptune	T10	MKD	9/30/2009	10:05	28877	MH	10/13/2009	28992
09M256a2	11297	77408027	5/8	Neptune	T10	MKD	9/30/2009	9:45	70601	MH	10/13/2009	71005
09M257a2	12563	84597679	5/8	Neptune	T10	MKD	9/30/2009	9:59	6569	MH	10/13/2009	6700
09M258a2		77408041	5/8	Neptune	T10							
09M259a2		77408080	5/8	Neptune	T10							
09M260a2	11390	77407694	5/8	Neptune	T10	MKD	9/30/2009	9:53	48957			

5.5 Pre-Post Water Use Tables

The following tables show the key toilet data collected per home. The first table represents the Pre Retrofit data and the second table the Post Retrofit data.

Pre retrofit data

Keycode	Total Volume (gal)	Trace (days)	Total GPD	Toilet Events	Toilet Total (gal)	Toilet (gpd)	Average Flush Volume (gal)	Leak Total (gal
09M201	7522.04	13	578.62	373	1258.10	96.78	3.27	520.24
09M202	2100.26	13	161.56	166	578.21	44.48	3.48	285.78
09M204	3327.85	13	255.99	322	1348.02	103.69	4.16	37.42
09M205	3464.08	13	266.47	421	1520.41	116.95	3.61	35.13
09M207	1848.91	13	142.22	200	756.69	58.21	3.78	253.12
09M208	2157.18	13	165.94	316	1062.99	81.77	2.94	40.10
09M210	2328.22	13	179.09	362	1496.84	115.14	4.13	16.91
09M214	1868.25	13	143.71	25	509.45	39.19	3.18	671.13
09M215	689.29	13	53.02	82	363.87	27.99	4.44	34.98
09M216	167.61	10	16.76	10	35.89	3.59	3.59	15.57
09M217	1621.51	13	124.73	129	518.99	39.92	3.93	43.24
09M219	1658.13	13	127.55	163	947.49	72.88	5.81	35.07
09M220	1511.42	13	116.26	131	515.76	39.67	3.74	15.32
09M221	1986.18	13	152.78	266	1106.57	85.12	4.16	46.91
09M222	3064.33	13	235.72	245	884.19	68.01	3.54	240.36
09M223	1177.88	13	90.61	156	695.18	53.48	4.37	22.08
09M224	3382.64	13	260.20	241	1038.29	79.87	4.29	11.23
09M225	969.64	13	74.59	58	241.71	18.59	4.17	49.73
09M226	4006.69	13	308.21	138	521.28	40.10	3.78	9.68
09M227	1501.30	13	115.48	81	443.29	34.10	5.47	82.64
09M228	919.70	13	70.75	92	397.82	30.60	4.14	21.81
09M229	44981.58	13	3460.12	158	522.16	40.17	3.30	34.78
09M232	300.76	10	30.08	30	73.97	7.40	2.47	2.63
09M233	1721.57	13	132.43	205	821.29	63.18	3.89	20.77
09M234	1319.61	9	146.62	128	579.93	64.44	4.50	16.72
09M237	2541.27	13	195.48	281	898.03	69.08	3.18	53.03
09M238	2050.15	13	157.70	190	790.22	60.79	4.05	15.72
09M239	2323.32	13	178.72	315	1245.46	95.80	3.84	208.51
09M240	959.51	13	73.81	69	253.84	19.53	3.68	36.43
09M241	1464.97	13	112.69	142	499.24	38.40	3.35	142.17
09M242	511.48	13	39.34	94	298.82	22.99	3.18	8.56
09M243	1671.89	13	128.61	183	732.96	56.38	4.01	8.09
09M245	1084.61	13	83.43	144	628.56	48.35	4.37	14.39
09M250	763.67	13	58.74	81	323.57	24.89	3.99	22.73
09M251	1336.53	13	102.81	165	717.65	55.20	4.35	154.15
09M252	2342.08	13	180.16	388	838.65	64.51	2.14	28.47
09M253	1208.59	13	92.97	139	618.30	47.56	4.42	21.47
09M254	297.94	13	22.92	22	87.02	6.69	3.96	0.29
09M255	1057.05	13	81.31	120	496.06	38.16	4.13	55.44
09M256	72.98	13	5.61	8	27.35	2.10	3.42	4.29
09M257	1268.10	13	97.55	243	766.32	58.95	3.05	30.87

Post retrofit data

Keycode	Total Volume (gal)	Trace (days)	Total GPD	Toilet Events	Toilet Total (gal)	Toilet (gpd)	Average Flush Volume (gal)	Leak Total (gal)
09M201A2	5245.58	13	403.51	299	696.58	53.58	2.33	1005.35
09M202A2	3057.45	13	235.19	117	122.33	9.41	1.05	1473.44
09M204A2	2581.42	13	198.57	310	425.88	32.76	1.37	212.38
09M205A2	1059.72	13	81.52	116	117.60	9.05	1.01	7.91
09M207A2	1406.66	13	108.20	238	213.00	16.38	0.89	279.69
09M208A2	1872.24	13	144.02	482	510.36	39.26	1.06	40.24
09M210A2	1031.78	13	79.37	351	496.62	38.20	1.41	20.62
09M214A2	1644.13	13	126.47	176	171.47	13.19	0.97	48.29
09M215A2	459.96	13	35.38	123	135.84	10.45	1.10	9.59
09M216A2	416.82	13	32.06	71	72.45	5.57	1.02	16.75
09M217A2	636.67	13	48.97	49	55.35	4.26	1.13	71.69
09M219A2	1179.01	13	90.69	136	421.29	32.41	3.10	82.36
09M220A2	1151.44	13	88.57	118	145.34	11.18	1.23	58.95
09M221A2	1393.33	13	107.18	251	332.95	25.61	1.33	42.95
09M222A2	405.90	13	31.22	23	37.84	2.91	1.65	93.58
09M223A2	577.23	13	44.40	131	149.96	11.54	1.14	34.99
09M224A2	3171.53	13	243.96	260	681.90	52.45	2.62	28.87
09M225A2	909.85	13	69.99	89	107.28	8.25	1.21	7.68
09M226A2	2168.22	13	166.79	66	201.91	15.53	3.06	24.78
09M227A2	2046.97	13	157.46	84	97.47	7.50	1.16	109.27
09M228A2	848.38	13	65.26	103	468.42	36.03	4.55	22.97
09M229A2	2968.93	13	228.38	203	806.67	62.05	3.90	209.59
09M232A2	942.62	13	72.51	161	192.97	14.84	1.20	21.13
09M233A2	5989.60	13	460.74	224	554.34	42.64	2.47	4463.16
09M234A2	1129.19	13	86.86	152	212.49	16.35	1.40	31.06
09M237A2	1632.90	13	125.61	230	480.62	36.97	2.09	30.62
09M238A2	1061.02	13	81.62	167	221.83	17.06	1.33	13.81
09M239A2	1152.96	13	88.69	205	228.80	17.60	1.12	11.08
09M240A3	618.70	13	47.59	59	78.84	6.06	1.34	9.36
09M241A2	1329.55	13	102.27	185	225.21	17.32	1.22	98.55
09M242A2	720.78	13	55.44	197	273.25	21.02	1.39	39.41
09M243A2	1562.15	13	120.17	141	184.18	14.17	1.31	79.30
09M245A2	587.78	11	53.43	136	131.65	11.97	0.97	12.29
09M250A2	282.69	6	47.11	64	54.42	9.07	0.85	20.89
09M251A2	8.07	8	1.01			0.00		8.07
09M252A2	2116.45	12	176.37	298	467.99	39.00	1.57	34.40
09M253A2	1619.42	12	134.95	238	272.34	22.70	1.14	28.50
09M254A2	552.13	12	46.01	37	60.83	5.07	1.64	17.86
09M255A2	778.05	12	64.84	134	175.95	14.66	1.31	27.55
09M256A2	2693.25	12	224.44	264	317.21	26.43	1.20	45.90
09M257A2	875.31	12	72.94	224	279.87	23.32	1.25	27.87

5.6 References

Funk, A., Mayer, P. & Luettgen, M., 2010. Dual Flush Savings - An Analysis of Field Data. *Water Efficiency Journal for Water Resource Management*, 1:5:44.

HHS, 2008. The poverty guidelines updated periodically in the Federal Register by the U.S. Department of Health and Human Services under the authority of 42 U.S.C. 9902(2).

Magnusson, L., 2009. Methods and Results for Measuring Hot Water Use at the Fixture.

Appendix 6: SCE Express Water Efficiency Pilot Program

6.1 M&V Plan

Pilot Project Name: SCE Express Water Efficiency: pH Controllers

Site Information Table:

SITE INFORMATION	
Business Name:	
Business NAICS Code:	
Site Street Address/ Zip Code:	
Contact Name, Title:	
Contact Phone Number:	
Contact Email:	
OTHER CONTACTS	
IOU Representative:	
IOU Contact Phone:	
IOU Email:	
Other Contact Name/Title:	
Other Contact Phone:	
Other Contact Email:	
AQUACRAFT CONTACTS	
Project Manager:	
PM Phone	
Field Tech Name:	
Field Tech Phone:	

MEASURE DESCRIPTION

Efficiency Improvement

SCE has obtained the participation from ABC to install pH Controllers on three of their cooling towers. The general approach to the M&V for this program was described in the Final Embedded Energy Evaluation Plan, dated June 16, 2008, section 6.2.4 for pH Controllers. The purpose of the site specific plan is to provide the specifics of how the Final M&V plan from June will be applied to the site reference in this document.

The essence of the evaluation plan, as spelled out in the June 2008 document was as follows:

> *Modeling pre and post water demand regimes in cooling towers requires data on inflow water, concentration ratios, heat loadings deduced from temperature or operating hours, and leakage rates. These will be collected before and after the change to the pH controller and used to verify that measured water savings*

are the result of cooling tower system conversion and not due to ambient temperature changes or other changes not related to the bleed control.

For evaluation purposes, we propose to use the units of gallons per ton-day as the normalized expression for water use. This will correct for both the size of the cooling tower (in Tons of capacity) and the actual heat loading to the system measured in days (or fractions of days) of operation.

In a cooling tower with a constant heat load and minimal leakage the only way to save water is by reducing the amount of bleed water drained from the system. Assuming that leakage from the tower is kept to a minimal level, and that drift from the tower is negligible, the only places where water can go from a cooling tower is into the atmosphere through evaporation or down a drain line as bleed.

Evaporation is unavoidable from a cooling tower since this is how the heat escapes from the system and the water is cooled. By definition, a 1-ton of cooling tower capacity equals 360,000 BTU per day. A series of simple calculations show that a 100-ton cooling tower requires approximately 4000 gallons per day of evaporation.[9] This means that a 100 T tower running for 24 hours will evaporate 4000 gallons of water. That is equivalent to 4 gallons of water per T-day of cooling. There is nothing that can be done about this given the physics of heat transfer.

Note that a chiller ton of cooling is 12,000 BTU/hr or 288,000 BTU/day. Due to the inefficiency in the transfer from the chiller to the cooling tower in order to provide 1 ton of chiller capacity requires 1.25 tons of cooling tower capacity. Hence there are definitions for both chiller capacity and cooling tower capacity, as described below.

Chiller Refrigeration Tons

A chiller refrigeration ton is defined as:

1 refrigeration ton = 12,000 Btu/h = 3,025.9 k Calories/h

A ton is the amount of heat removed by an air conditioning system that would melt *1 ton* of ice in *24 hours*.

Cooling Tower Tons

A cooling tower ton is defined as:

1 cooling tower ton = 15,000 Btu/h = 3,782 k Calories/h

[9] Aquacraft. (2003). "Demonstration of Water Conservation Opportunities in Urban Supermarkets." California Department of Water Resources/U.S. Bureau of Reclamation, CalFed Bay-Delta Program, Boulder.

Heat Load and Water Flow

A water systems heat load in *Btu/h* can be simplified to:

h = cp ρ q dt

= (1 Btu/lbm oF) (8.33 lbm/gal) q (60 min/h) dt

= 500 q dt (1)

where

h = heat load (Btu/h)

cp = 1 (Btu/lbm oF) for water

ρ = 8.33 (lbm/gal) for water

q = water volume flow rate (gal/min)

dt = temperature difference (oF)

Example - Water Chiller Cooling

Water flows with *1 gal/min* and *10^{o}F* temperature difference. The ton of cooling load can be calculated as:

Cooling load = 500 (1 gal/min) (10^{o}F) / 12,000

= 0.42 ton

Bleed water use, however, can be modified by improved water treatment methods. The concentration ratio of a cooling tower can be expressed as the ration of the volume of make-up water (M) entering the system to the volume of bleed water (B) being flushed out, or:

CR = M/B ……………………. (1)

This can be re-arranged as:

B = M/CR …………………….. (2)

At this site we will be obtaining direct measurements of the M, CR and hours of operation, and we will obtain the rated capacity of the tower from the owner. This will be done both before and after the pH controller retrofit for a period of ~30 days each session. The data will be collected using data loggers, which will show the water use on an hourly basis. This will also show the hours of operation since when the system is turned off the water us drops and this can be seen in the data. The concentration ratios will be obtained weekly from the water treatment company (Apollo Technologies). The assumption will be that this does not vary significantly between reading days. From these data we will be able to calculate the daily total water use and bleed use per hour of operation and ton of cooling.

The daily data will be averaged and 95% confidence intervals determined. Changes in mean bleed water use will be determined for each of the three towers. Table 1 shows an example of the analysis that will be done for this and similar sites. Of the 15 columns in the sheet only data from columns 2,5,9 and 12 are input from data obtained in the field; the rest are calculated. Columns

2 and 9 are the cumulative make-up water use (M) for the cooling system. These are obtained from the pulse counting data loggers we will be installing on the inflow line water meters. Columns 5 and 12 are the concentration ratios, which will be obtained from the water treatment contractor's weekly readings, and confirmed by us when we make field visits to the site. The dates for which actual CR readings are obtained should be shaded.

This analysis assumes that the weather patterns during the pre and post retrofit period are fairly constant. In order to check for this, a temperature/relative humidity logger with radiation shield should be installed at a spot on the plant site that is in an open area that is exposed to direct sunlight and not subject to accidental disturbance or tampering. Use the Hobo U-23-002 logger. If the temperature and relative humidity are significantly different during the two periods we will apply a suitable correction factor.

Table 1: Cooling tower evaluation sheet (with example data)

COOLING TOWER WATER SAVINGS EVALUATION SHEET (PRE-POST ANALYSIS)														
Pre- Retrofit							Post- Retrofit							Savings
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Day	M Cum	M Daily	Hours	CR	B	B Norm	Day	M Cum	M Daily	Hours	CR	B	B Norm	
	(Gal)	(Gal)	(hrs)		(Gal)	(Gal/T-day)		(Gal)	(Gal)	(hrs)		(Gal)	(Gal/T-day)	(Gal/T-day)
1	6000	6000	24	3	2000	20.00	1	4000	4000	24	6	667	6.67	13.33
2	12500	6500	24	3	2167	21.67	2	8000	4000	24	6	667	6.67	15.00
3	19250	6750	24	3	2250	22.50	3	12000	4000	24	6	667	6.67	15.83
4	25500	6250	24	3	2083	20.83	4	16000	4000	24	6	667	6.67	14.17
5	31600	6100	24	3	2033	20.33	5	20000	4000	24	6	667	6.67	13.67
6	34600	3000	12	3	1000	20.00	6	22000	2000	12	6	333	6.67	13.33
7	38100	3500	12	3	1167	23.33	7	24100	2100	12	6	350	7.00	16.33
8	44601	6501	24	2.8	2322	23.22	8	28100	4000	24	6	667	6.67	16.55
9	51601	7000	24	2.8	2500	25.00	9	32100	4000	24	6	667	6.67	18.33
10	59101	7500	24	2.8	2679	26.79	10	36100	4000	24	6	667	6.67	20.12
11	65601	6500	24	2.8	2321	23.21	11	40100	4000	24	6	667	6.67	16.55
12	71851	6250	24	2.8	2232	22.32	12	44100	4000	24	6	667	6.67	15.65
13	75351	3500	12	2.8	1250	25.00	13	46100	2000	12	6	333	6.67	18.33
14	78801	3450	12	2.8	1232	24.64	14	48200	2100	12	6	350	7.00	17.64
15	85601	6800	24	3.1	2194	21.94	15	52200	4000	24	6	667	6.67	15.27
16	92101	6500	24	3.1	2097	20.97	16	56200	4000	24	6	667	6.67	14.30
17	98101	6000	24	3.1	1935	19.35	17	60200	4000	24	6	667	6.67	12.69
18	104001	5900	24	3.1	1903	19.03	18	64200	4000	24	6	667	6.67	12.37
19	110251	6250	24	3.1	2016	20.16	19	68200	4000	24	6	667	6.67	13.49
20	113251	3000	12	3.1	968	19.35	20	70200	2000	12	6	333	6.67	12.69
21	116351	3100	12	3.1	1000	20.00	21	72300	2100	12	6	350	7.00	13.00
22	123351	7000	24	3.2	2188	21.88	22	76300	4000	24	6	667	6.67	15.21
23	130851	7500	24	3.2	2344	23.44	23	80300	4000	24	6	667	6.67	16.77
24	137351	6500	24	3.2	2031	20.31	24	84300	4000	24	6	667	6.67	13.65
25	143601	6250	24	3.2	1953	19.53	25	88300	4000	24	6	667	6.67	12.86
26	150351	6750	24	3.2	2109	21.09	26	92300	4000	24	6	667	6.67	14.43
27	153351	3000	12	3.2	938	18.75	27	94300	2000	12	6	333	6.67	12.08
28	156451	3100	12	3.2	969	19.38	28	96400	2100	12	6	350	7.00	12.38
29	162951	6500	24	2.5	2600	26.00	29	100400	4000	24	6	667	6.67	19.33
30	168951	6000	24	2.5	2400	24.00	30	104400	4000	24	6	667	6.67	17.33
Average		5632	21	3	1896.01	21.80	Average		3480	21	6	580.00	6.71	15.09
StDev		1540			544.52	2.23	StDev		877			146.24	0.12	2.24
N		30			30.00	30.00	N		30		4	30.00	30.00	30.00
95% CI		551			194.85	0.80	95% CI		314			52.33	0.04	0.80

Table 2: Definitions of Data for pH Controller Table

Column	Name	Units	Source
1	Day -Pre	Day	Day of pre-retrofit logging interval
2	M-Cum	Gal	Cumulative make up water use from start of logging
3	M-Daily	Gal	Daily increment of water use
4	Hours	Hrs	Hours of operation of the tower (from logger).
5	CR	Unit-less	Ratio of conductivity of circulating water to make-up water.
6	B	Gal	Volume of bleed water = daily make up water (Col 3) divided by CR (Col 5)
7	B Norm	Gal/Ton-day	Normalized bleed use = B (Col 6)/Tower Capacity / Hours (Col 4) x 24
8-14	Same as 1-7		Same data, but based on *post*-retrofit operation
15	Savings	Gal/Ton-day	Pre-retrofit water use minus post-retrofit use (Col7 – Col 14)

The impacts of the pH retrofit will be based on the average daily savings in gallons per ton of capacity per day of operation. The 95% confidence interval will be determined. If the mean savings plus or minus the 95% CI does not include zero then the system will be judged as having saved a measurable amount of water during its operation period.

The test results will be summarized as shown in Table 3.

Table 3: Summary of water use impacts for pH controllers at ABC

Site Name	ABC	ABC	ABC
Tower Name	#1	#2	#3
Tower Location			
Tower Capacity			
Pre-retrofit Dates			
Ave CR Pre-retrofit			
Ave CR Post-retrofit			
Ave Pre-retro B ± 95% CI			
Ave Post-retro B ± 95% CI			
Ave Daily Savings ± 95% CI			

Data Collection Instructions

The following are the data that must be collected as this site both prior to and after the pH controller is installed.

1. Cumulative make up water use. Obtained from Hobo event logger attached to the SeaMetrics pulse generating water meter installed on the inflow line.
2. The Concentration ratio of the tank. When the logger is installed and removed obtain a water sample of both the make-up water (from a tap) and the circulating water or bleed water leaving the tank. Test both of these samples for conductivity and pH three times using the Myron-L conductivity/pH meter, following the Myron-L protocol. Enter the three readings on the data sheet and average them. Give a portion of these samples to the water quality vendor technologies tech and have them test it. Obtain a copy of their results for comparison. If they are not comparable have them check their calibration and re-check. Fill in all direct measurements of CR in the appropriate rows for the table and shade them so we can tell which are direct and which are interpolated.
3. Test both the inflow and circulating water for chlorides, using the Taylor test kit. The instructions for the test are located on a card inside the test kit. Write down the test results on the data sheet.
4. Intermediate CR data. This will be obtained from the weekly tests done on the system by Apollo Technologies. Arrange with the water quality vendor tech to have copies of his weekly test results faxed or emailed to you. Fill in all CR test data into Table 2 in the appropriate space.
5. Use the appropriate data collection sheet depending on whether you are installing or picking-up loggers. Examples are provided.
6. In order to correct for major changes in weather conditions during the pre and post logging periods install a temperature/relative humidity data logger on site in an accessible and appropriate location.

pH CONTROLLER DATA COLLECTION SHEET			
Name of Site	PepsiCo	Address	
Contact Person		Phone	
Date of Visit		Email	
Technician		Type:	pH Controllers on cooling towers
Purpose of Trip	Installation of data loggers on inflow meters		

Tower #1		Inflow Meter Make	
Location		Inflow Meter Number	
Tons Cap		Inflow Meter Reading	
		Inflow Meter Units	

	1	2	3	Average	pH	Cl-	
Inflow Water Cond. (uMhos)							
Circ Water Cond. (uMhos)							
Hobo Logger SN:							
Logger Launch Date/time							
Logger Battery Availability							
Logger Memory Availability							
logger Status Check							
Comments:							

Tower #2		Inflow Meter Make	
Location		Inflow Meter Number	
Tons Cap		Inflow Meter Reading	
		Inflow Meter Units	

	1	2	3	Average	pH	Cl-	
Inflow Water Cond. (uMhos)							
Circ Water Cond. (uMhos)							
Hobo Logger SN:							
Logger Launch Date/time							
Logger Battery Availability							
Logger Memory Availability							
logger Status Check							
Comments:							

Tower #3		Inflow Meter Make	
Location		Inflow Meter Number	
Tons Cap		Inflow Meter Reading	
		Inflow Meter Units	

	1	2	3	Average	pH	Cl-	
Inflow Water Cond. (uMhos)							
Circ Water Cond. (uMhos)							
Hobo Logger SN:							
Logger Launch Date/time							
Logger Battery Availability							
Logger Memory Availability							
logger Status Check							
Comments:							

pH CONTROLLER DATA COLLECTION SHEET							
Name of Site	PepsiCo		Address				
Contact Person			Phone				
Date of Visit			Email				
Technician			Type:	pH Controllers on cooling towers			
Purpose of Trip	Retrieval of data loggers from inflow lines						
Tower #1		Current meter read					
Location		Previous meter read					
Tons Cap		Total Meter Use					
		Logged Use					
	1	2	3	Average	pH	Cl-	
Inflow Water Cond. (uMhos)							
Circ Water Cond. (uMhos)							
Hobo Logger SN:							
Logger Download Date/time							
Logger Battery Availability							
Logger Memory Availability							
Data File Name							
Comments:							
Tower #2		Current meter read					
Location		Previous meter read					
Tons Cap		Total Meter Use					
		Logged Use					
	1	2	3	Average	pH	Cl-	
Inflow Water Cond. (uMhos)							
Circ Water Cond. (uMhos)							
Hobo Logger SN:							
Logger Download Date/time							
Logger Battery Availability							
Logger Memory Availability							
Data File Name							
Comments:							
Tower #3		Current meter read					
Location		Previous meter read					
Tons Cap		Total Meter Use					
		Logged Use					
	1	2	3	Average	pH	Cl-	
Inflow Water Cond. (uMhos)							
Circ Water Cond. (uMhos)							
Hobo Logger SN:							
Logger Download Date/time							
Logger Battery Availability							
Logger Memory Availability							
Data File Name							
Comments:							

6.2 Completed Data Logging Sheets

The following four tables show the data sheets for the pre and post retrofit installations. The first two are from the beginning and end of the pre-retrofit period and the second two are from the beginning and end of post-retrofit period.

pH CONTROLLER DATA COLLECTION SHEET								
Name of Site				Address				
Contact Person				Phone				
Date of Visit	8/6/2009			Email				
Technician	DeOreo, Hayden			Type:	pH Controllers on cooling towers			
Purpose of Trip	Installation of data loggers on inflow meters, temp/RH logger in Parking lot							
Tower #1	EC-1		Inflow Meter Make		Seametrics			
Location	East tank on front of bldg.		Inflow Meter Number					
Tons Cap	305		Inflow Meter Reading		145,099			
			Units		Gal			
		1	2	3	Average	pH	Cl-	
Inflow Water TDS (ppm)		549	450	460	486.3	6.2	90	
Circ Water TDS (ppm)		500	480	560	513.3	7.2	100	
Hobo Logger SN:	212			CR=	1.06		1.11	1.08
Logger Launch Date/time		8/6/09:10:00						
Logger Battery Availability		100						
Logger Memory Availability		100						
logger Status Check	OK							
Comments:	conductivity controller on tank is malfunctioning. Manual Bleed.							
Installed motot logger on circulation pump on this unit.								
Tower #2	EC-2		Inflow Meter Make		Seametrics			
Location	West tank on front of bldg.		Inflow Meter Number					
Tons Cap	305		Inflow Meter Reading		125,329			
			Units		Gal			
		1	2	3	Average	pH	Cl-	
Inflow Water TDS (ppm)		450	460	549	486.3	6.2	90	
Circ Water TDS (ppm)		500	480	567	515.7	7.2	100	
Hobo Logger SN:	215			CR=	1.06		1.11	1.09
Logger Launch Date/time		8/6/2009:11:00						
Logger Battery Availability		100						
Logger Memory Availability		100						
logger Status Check	ok							
Comments:	Tank conductivity controller OTL							
Tower #3	EC-3		Inflow Meter Make		Seametrics			
Location	In yard by compressors		Inflow Meter Number					
Tons Cap			Inflow Meter Reading		80,700			
			Units		Gal			
		1	2	3	Average	pH	Cl-	
Inflow Water TDS (ppm)		450	460	549	486	6.2	90	
Circ Water TDS (ppm)		1290	1250	990	1177	7.5	210	
Hobo Logger SN:				CR=	2.42		2.33	2.38
Logger Launch Date/time		8/6/09:11:30						
Logger Battery Availability		100						
Logger Memory Availability		100						
logger Status Check	ok							
Comments:	conductivity controller working. Set pont 2000 ppm							

pH CONTROLLER DATA COLLECTION SHEET									
Name of Site					Address				
Contact Person					Phone				
Date of Visit		9/9/2009			Email				
Technician		mh			Type:	pH Controllers on cooling towers			
Purpose of Trip		Retrieval of data loggers from inflow lines							
Tower #1	EC-1			Current meter read		506,739			
Location	East tank on front of bldg.			Previous meter read		145,099			
Tons Cap	305			Total Meter Use		361,640			
				Logged Use		331,800			
			1	2	3	Average	pH	Cl-	
Inflow Water TDS (ppm)			399	444	434	426		65	
Circ Water TDS (ppm)			623	622	623	622		130	
Hobo Logger SN:		221	212		CR=	1.46		2.00	1.73
Logger Download Date/time			9/6/2009 11:00						
Logger Battery Availability			96						
Logger Memory Availability			41%						
Data File Name									
Comments: Cl- titration: 1 d S, 13 d Ag									
pH probe uncalibrated on site. Samples returned to Aquacraft for further testing. This applies to all 3 towers.									
Tower #2	EC-2			Current meter read		343053			
Location	West tank on front of bldg.			Previous meter read		125,329			
Tons Cap	305			Total Meter Use		217,724			
				Logged Use		201500			
			1	2	3	Average	pH	Cl-	
Inflow Water TDS (ppm)			399	444	434	426		65	
Circ Water TDS (ppm)			640	640	642	640	6.74	130	
Hobo Logger SN:		231	215		CR=	1.50		2.00	1.75
Logger Download Date/time			9/6/2009 11:00						
Logger Battery Availability			90						
Logger Memory Availability			45%						
Data File Name									
Comments: Cl- titration: 1 d S, 13 d Ag									
Tower #3	EC-3			Current meter read		212606			
Location	In yard by compressors			Previous meter read		80,700			
Tons Cap	0			Total Meter Use		131,906			
				Logged Use		134200			
			1	2	3	Average	pH	Cl-	
Inflow Water TDS (ppm)			399	444	434	426		65	
Circ Water TDS (ppm)			1159	1170		1165		230	
Hobo Logger SN:		nn	nn		CR=	2.74		3.54	3.14
Logger Download Date/time			9/6/2009 10:00						
Logger Battery Availability			100						
Logger Memory Availability			0%						
Data File Name									
Comments: 0 d S, 23 d Ag									
Noise on signal line is possibly a defect within meter. While other loggers show compatibility with loggers									
this meter inconsistently registers several pulses per 100 gal. Data reported have been corrected.									

pH CONTROLLER DATA COLLECTION SHEET								
Name of Site				Address				
Contact Person				Phone				
Date of Visit	10/15/2009			Email				
Technician	mh			Type:	pH Controllers on cooling towers			
Purpose of Trip	Reset data loggers after retrofit							
Tower #1	EC-1		Inflow Meter Make		Seametrics			
Location	West tank on front of bldg.		Inflow Meter Number					
Tons Cap	305		Inflow Meter Reading		736,300			
			Units		Gal			
		1	2	3	Average	pH	Cl-	Controller
Inflow Water TDS (ppm)		581.2	581.5	584.7	582.5	7.22	87.5	
Circ Water TDS (ppm)		2260	2267		2263.5	6.92	340	
Hobo Logger SN:	212			CR=	3.89		3.89	3.89
Logger Launch Date/time		10/14/2009 10:00						
Logger Battery Availability		96%						
Logger Memory Availability								
logger Status Check	OK							
Comments:								
Tower #2	EC-2		Inflow Meter Make		Seametrics			
Location	East tank on front of bldg.		Inflow Meter Number					
Tons Cap	305		Inflow Meter Reading		490,733			
			Units		Gal			
		1	2	3	Average	pH	Cl-	
Inflow Water TDS (ppm)		581.2	581.5	584.7	582.5	7.22	87.5	
Circ Water TDS (ppm)		2209	2216		2212.5	7.1	345	
Hobo Logger SN:	215			CR=	3.80		3.94	3.87
Logger Launch Date/time		10/15/2009						
Logger Battery Availability		96%						
Logger Memory Availability		83%						
logger Status Check	ok							
Comments:								
Tower #3	EC-3		Inflow Meter Make		Seametrics			
Location	In yard by compressors		Inflow Meter Number					
Tons Cap			Inflow Meter Reading		321,040			
			Units		Gal			
		1	2	3	Average	pH	Cl-	
Inflow Water TDS (ppm)		581.2	581.5	584.7	582	7.22	87.5	
Circ Water TDS (ppm)		2005	2050		2028	7.31	335	
Hobo Logger SN:	204			CR=	3.48		3.83	3.65
Logger Launch Date/time								
Logger Battery Availability		90%						
Logger Memory Availability		Full						
logger Status Check	ok							
Comments:	Controller read between 3750 and 3340 umho							

pH CONTROLLER DATA COLLECTION SHEET

Name of Site		Address	
Contact Person		Phone	
Date of Visit	11/13/2009	Email	
Technician	WBD	Type:	pH Controllers on cooling towers
Purpose of Trip	Pick up of post retrofit data		

Tower #1	EC1	Current meter read		781600			
Location		Previous meter read		736,300			
Tons Cap		Total Meter Use		45,300			
		Logged Use		45400			
	1	2	3	Average	pH	Cl-	
Inflow Water Cond. (uMhos)	840	838	838	858	7	80	
Circ Water Cond. (uMhos)	3782	3785	3788	3872	6.9	410	
Hobo Logger SN:		CR=		4.5		5.1	4.8
Logger Download Date/time	11/13/2009						
Logger Battery Availability	76%. 2.9V						
Logger Memory Availability	98%						
Data File Name							
Comments: pH controller model 2412, display: pH=8.04. cond = 4600							

Tower #2		Current meter read		528,900			
Location		Previous meter read		490,733			
Tons Cap		Total Meter Use		38,167			
		Logged Use		38,400			
	1	2	3	Average	pH	Cl-	
Inflow Water Cond. (uMhos)				858	7	80	
Circ Water Cond. (uMhos)	3489	3488	3486	3568	6.9	350	
Hobo Logger SN:		CR=		4.2		4.38	4.3
Logger Download Date/time	11/13/2009						
Logger Battery Availability	90%, 3V						
Logger Memory Availability	98%						
Data File Name							
Comments: pH controller display: pH=8.05, Cond = 4450							

Tower #3		Current meter read		378500			
Location		Previous meter read		321,040			
Tons Cap		Total Meter Use		57,460			
		Logged Use		626,800			
	1	2	3	Average	pH	Cl-	
Inflow Water Cond. (uMhos)				858		80	
Circ Water Cond. (uMhos)	2100	2100	2095	2147		220	
Hobo Logger SN:		CR=		2.5		2.75	2.63
Logger Download Date/time	11/13/2009						
Logger Battery Availability	90%, 3V						
Logger Memory Availability	83%						
Data File Name							
Comments:							
Conductivity meter tested against standard after readings: Standard = 2060, meter = 2013; cf=1.023 applied							

6.3 Pre-Post Water Use Tables

The following three tables show the daily water use calculations for each of the three towers during the pre and post retrofit periods. Columns on the left side of the table are from the pre-retrofit period and the columns on the right side are from the post retrofit period. During the post retrofit period the daily water use was calculated externally to the table and imported, which is why columns 9 is blank in the tables. Columns 3 and 10 were obtained from the data loggers after verifying that the logger volumes matched the register volumes. These values matched very closely for towers 1 and 2. The water meter at tower 3, however, gave more than one pulse per 100 gallons (it was defective). However, it appeared to be consistent in its error, so we applied a scaling factor to generate the daily flows that matched the register volume.

EC-1: pH Control Evaluation normalized on Actual Heat Loading													
Pre- Retrofit							Post- Retrofit						
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Day	M Cum (Gal)	Aug7-Sep5 (GPD)	CR	B (GPD)	E (GPD)	Heat Load (C.T. Tons)	Day	M Cum (Gal)	Oct15-Nov1: (GPD)	CR	B (GPD)	E (GPD)	Heat Load (C.T. Tons)
7-Aug	18100	11900	1.40	8530	3370	84	10/15/2009		2548	4.35	586	1962	49.04
8-Aug	27200	9100	1.40	6523	2577	64	10/16/2009		588	4.35	135	453	11.32
9-Aug	36100	8900	1.40	6380	2520	63	10/17/2009		0	4.35	0	0	0.00
10-Aug	47400	11300	1.40	8100	3200	80	10/18/2009		0	4.35	0	0	0.00
11-Aug	58500	11100	1.40	7957	3143	79	10/19/2009		0	4.35	0	0	0.00
12-Aug	70200	11700	1.40	8387	3313	83	10/20/2009		2646	4.35	609	2037	50.93
13-Aug	80400	10200	1.40	7312	2888	72	10/21/2009		3038	4.35	699	2339	58.47
14-Aug	92600	12200	1.40	8746	3454	86	10/22/2009		1568	4.35	361	1207	30.18
15-Aug	104500	11900	1.40	8530	3370	84	10/23/2009		3430	4.35	789	2641	66.01
16-Aug	115200	10700	1.40	7670	3030	76	10/24/2009		0	4.35	0	0	0.00
17-Aug	127200	12000	1.40	8602	3398	85	10/25/2009		0	4.35	0	0	0.00
18-Aug	137000	9800	1.40	7025	2775	69	10/26/2009		98	4.35	23	75	1.89
19-Aug	147300	10300	1.40	7384	2916	73	10/27/2009		1372	4.35	316	1056	26.41
20-Aug	158600	11300	1.40	8100	3200	80	10/28/2009		1862	4.35	429	1433	35.84
21-Aug	170600	12000	1.40	8602	3398	85	10/29/2009		2450	4.35	564	1886	47.15
22-Aug	180800	10200	1.40	7312	2888	72	10/30/2009		4312	4.35	992	3320	82.99
23-Aug	189800	9000	1.40	6452	2548	64	10/31/2009		0	4.35	0	0	0.00
24-Aug	200900	11100	1.40	7957	3143	79	11/1/2009		0	4.35	0	0	0.00
25-Aug	210500	9600	1.40	6882	2718	68	11/2/2009		1862	4.35	429	1433	35.84
26-Aug	221300	10800	1.40	7742	3058	76	11/3/2009		1862	4.35	429	1433	35.84
27-Aug	232200	10900	1.40	7814	3086	77	11/4/2009		2254	4.35	519	1735	43.38
28-Aug	243100	10900	1.40	7814	3086	77	11/5/2009		3234	4.35	744	2490	62.24
29-Aug	252900	9800	1.40	7025	2775	69	11/6/2009		4802	4.35	1105	3697	92.42
30-Aug	262000	9100	1.40	6523	2577	64	11/7/2009		294	4.35	68	226	5.66
31-Aug	273400	11400	1.40	8172	3228	81	11/8/2009		0	4.35	0	0	0.00
1-Sep	284800	11400	1.40	8172	3228	81	11/9/2009		1666	4.35	383	1283	32.06
2-Sep	297500	12700	1.40	9104	3596	90	11/10/2009		1078	4.35	248	830	20.75
3-Sep	308200	10700	1.40	7670	3030	76	11/11/2009		196	4.35	45	151	3.77
4-Sep	320300	12100	1.40	8674	3426	86	11/12/2009		2254	4.35	519	1735	43.38
5-Sep	331800	11500	1.40	8244	3256	81	11/13/2009		1666	4.35	383	1283	32.06
Mean		10853	1.40	7780	3073	76.83	Average		1503	4.35	345.84	1156.83	28.92
StDev		1055	0.00	756	299	7.47	StDev		1401		322.54	1078.91	26.97
N		30	30	30	30	30.00	N		30	4	30.00	30.00	30.00
95% CI		377	0.00	271	107	2.67	95% CI		501		115.42	386.08	9.65
Bleed Use (gpd/Ton Heat Load)				101.27							11.96		
Change in Bleed (pre to post) (gpd/Ton)											-89.31		

EC-2: pH Control Evaluation normalized on Actual Heat Loading													
Pre- Retrofit							Post- Retrofit						
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Day	M Cum	Aug7-Sep5	CR	B	E	Heat Load	Day	M Cum	Oct15-Nov1:	CR	B	E	Heat Load
	(Gal)	(Gal)		(Gal)	(Gal)	(Tons)		(Gal)	(Gal)		(Gal)	(Gal)	(Tons)
7-Aug	10100	6800	1.42	4789	2011	50	10/15/2009		2268.322	4.09	555	1713	42.83
8-Aug	14400	4300	1.42	3028	1272	32	10/16/2009		493.1135	4.09	121	372	9.31
9-Aug	18700	4300	1.42	3028	1272	32	10/17/2009		98.6227	4.09	24	74	1.86
10-Aug	25200	6500	1.42	4577	1923	48	10/18/2009		0	4.09	0	0	0.00
11-Aug	31300	6100	1.42	4296	1804	45	10/19/2009		0	4.09	0	0	0.00
12-Aug	37900	6600	1.42	4648	1952	49	10/20/2009		2169.699	4.09	531	1639	40.96
13-Aug	43000	5100	1.42	3592	1508	38	10/21/2009		2564.19	4.09	628	1936	48.41
14-Aug	50100	7100	1.42	5000	2100	53	10/22/2009		1479.341	4.09	362	1117	27.93
15-Aug	56900	6800	1.42	4789	2011	50	10/23/2009		2860.058	4.09	700	2160	54.00
16-Aug	62700	5800	1.42	4085	1715	43	10/24/2009		0	4.09	0	0	0.00
17-Aug	69500	6800	1.42	4789	2011	50	10/25/2009		0	4.09	0	0	0.00
18-Aug	74600	5100	1.42	3592	1508	38	10/26/2009		197.2454	4.09	48	149	3.72
19-Aug	80800	6200	1.42	4366	1834	46	10/27/2009		1084.85	4.09	266	819	20.48
20-Aug	88700	7900	1.42	5563	2337	58	10/28/2009		1577.963	4.09	386	1192	29.79
21-Aug	98100	9400	1.42	6620	2780	70	10/29/2009		1972.454	4.09	483	1490	37.24
22-Aug	104200	6100	1.42	4296	1804	45	10/30/2009		3747.663	4.09	917	2830	70.76
23-Aug	108500	4300	1.42	3028	1272	32	10/31/2009		0	4.09	0	0	0.00
24-Aug	116000	7500	1.42	5282	2218	55	11/1/2009		0	4.09	0	0	0.00
25-Aug	121400	5400	1.42	3803	1597	40	11/2/2009		1380.718	4.09	338	1043	26.07
26-Aug	128100	6700	1.42	4718	1982	50	11/3/2009		1577.963	4.09	386	1192	29.79
27-Aug	135200	7100	1.42	5000	2100	53	11/4/2009		1972.454	4.09	483	1490	37.24
28-Aug	142500	7300	1.42	5141	2159	54	11/5/2009		2860.058	4.09	700	2160	54.00
29-Aug	148100	5600	1.42	3944	1656	41	11/6/2009		4142.153	4.09	1014	3128	78.20
30-Aug	152400	4300	1.42	3028	1272	32	11/7/2009		394.4908	4.09	97	298	7.45
31-Aug	160200	7800	1.42	5493	2307	58	11/8/2009		0	4.09	0	0	0.00
1-Sep	168300	8100	1.42	5704	2396	60	11/9/2009		1282.095	4.09	314	968	24.21
2-Sep	176700	8400	1.42	5915	2485	62	11/10/2009		690.3589	4.09	169	521	13.03
3-Sep	183900	7200	1.42	5070	2130	53	11/11/2009		197.2454	4.09	48	149	3.72
4-Sep	193200	9300	1.42	6549	2751	69	11/12/2009		1972.454	4.09	483	1490	37.24
5-Sep	201500	8300	1.42	5845	2455	61	11/13/2009		1183.472	4.09	290	894	22.34
Mean		6607	1.42	4652.58	1954.08	48.85	Average		1272	4.09	311.44	960.79	24.02
StDev		1418	0.00	998.83	419.51	10.49	StDev		1194		292.36	901.93	22.55
N		30	30.00	30.00	30.00	30.00	N		30		30.00	30.00	30.00
95% CI		508	0.00	357.42	150.12	3.75	95% CI		427		104.62	322.75	8.07
Bleed Use (gal/Ton Heat Load)				95.24							12.97		
Change in Bleed (pre to post) (gal/Ton)											-82.27		

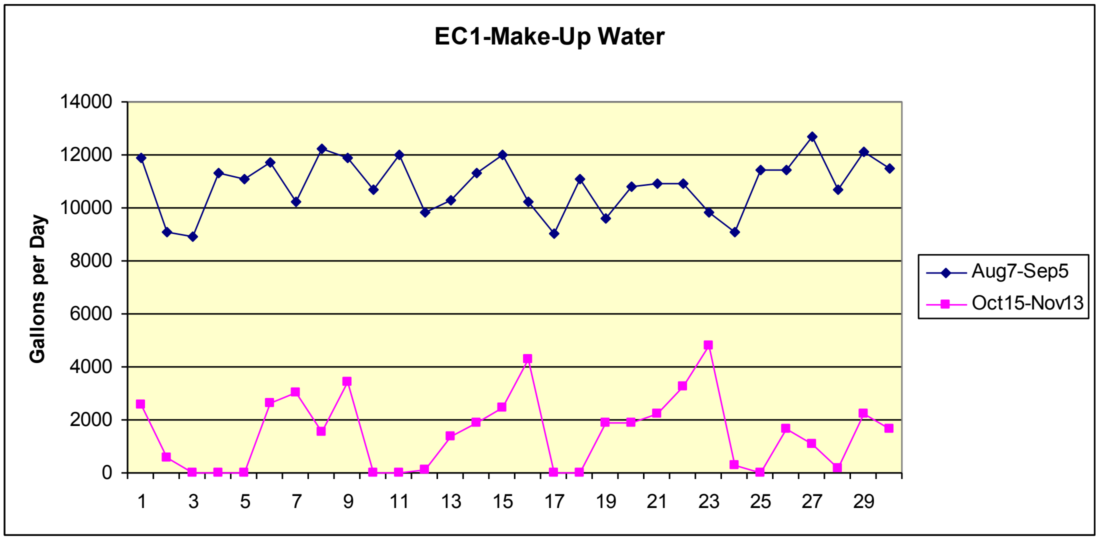
EC-3: pH Control Evaluation normalized on Actual Heat Loading

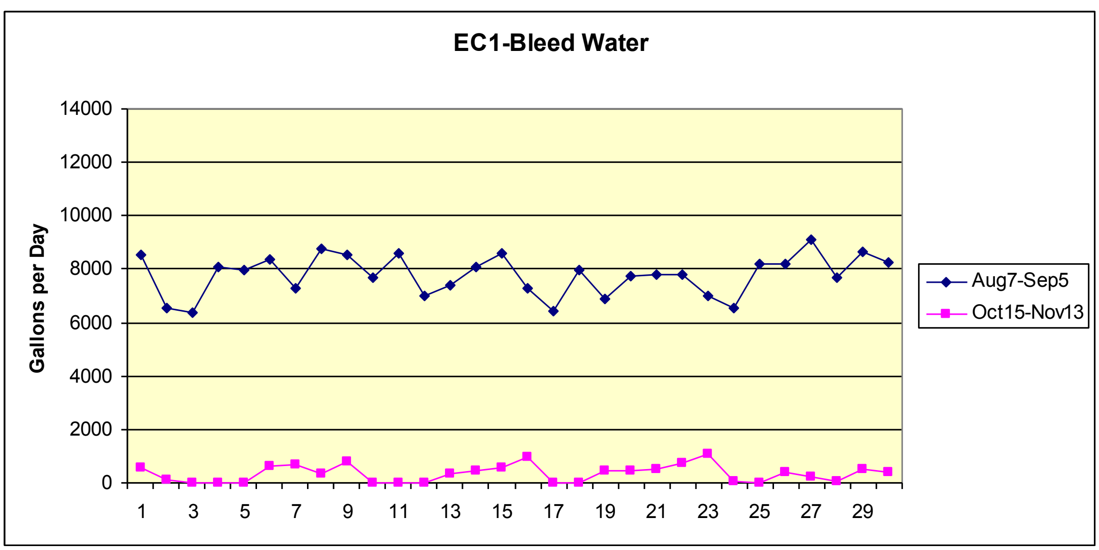
Pre- Retrofit							Post- Retrofit						
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Day	Make-up	Aug7-Sept 5	CR	B	E	Heat Load	Day	M Cum	Oct15-Nov13	CR	B	E	Heat Load
	(Gal)	(GPD)		(GPD)	(GPD)	(Tons)		(Gal)	(GPD)		(GPD)	(GPD)	(Tons)
7-Aug	7600	4600	2.76	1667	2933	73	10/15/2009		1157	3.14	369	789	19.71
8-Aug	11900	4300	2.76	1558	2742	69	10/16/2009		2785	3.14	887	1898	47.44
9-Aug	16100	4200	2.76	1522	2678	67	10/17/2009		1674	3.14	533	1141	28.53
10-Aug	19400	3300	2.76	1196	2104	53	10/18/2009		2832	3.14	902	1930	48.25
11-Aug	23800	4400	2.76	1594	2806	70	10/19/2009		2766	3.14	881	1885	47.12
12-Aug	28400	4600	2.76	1667	2933	73	10/20/2009		2371	3.14	755	1616	40.39
13-Aug	32800	4400	2.76	1594	2806	70	10/21/2009		2201	3.14	701	1500	37.51
14-Aug	37600	4800	2.76	1739	3061	77	10/22/2009		1787	3.14	569	1218	30.45
15-Aug	42500	4900	2.76	1775	3125	78	10/23/2009		2098	3.14	668	1430	35.74
16-Aug	46800	4300	2.76	1558	2742	69	10/24/2009		1891	3.14	602	1289	32.22
17-Aug	50300	3500	2.76	1268	2232	56	10/25/2009		1035	3.14	330	705	17.63
18-Aug	55300	5000	2.76	1812	3188	80	10/26/2009		2465	3.14	785	1680	41.99
19-Aug	60000	4700	2.76	1703	2997	75	10/27/2009		1618	3.14	515	1103	27.57
20-Aug	64500	4500	2.76	1630	2870	72	10/28/2009		3706	3.14	1180	2526	63.15
21-Aug	68400	3900	2.76	1413	2487	62	10/29/2009		2342	3.14	746	1596	39.91
22-Aug	73000	4600	2.76	1667	2933	73	10/30/2009		2408	3.14	767	1641	41.03
23-Aug	76000	3000	2.76	1087	1913	48	10/31/2009		1533	3.14	488	1045	26.13
24-Aug	78600	2600	2.76	942	1658	41	11/1/2009		1110	3.14	354	757	18.91
25-Aug	82900	4300	2.76	1558	2742	69	11/2/2009		1806	3.14	575	1231	30.77
26-Aug	87500	4600	2.76	1667	2933	73	11/3/2009		2051	3.14	653	1398	34.94
27-Aug	92000	4500	2.76	1630	2870	72	11/4/2009		1712	3.14	545	1167	29.17
28-Aug	96600	4600	2.76	1667	2933	73	11/5/2009		1646	3.14	524	1122	28.05
29-Aug	100500	3900	2.76	1413	2487	62	11/6/2009		1684	3.14	536	1148	28.69
30-Aug	104700	4200	2.76	1522	2678	67	11/7/2009		894	3.14	285	609	15.23
31-Aug	108500	3800	2.76	1377	2423	61	11/8/2009		1355	3.14	431	923	23.08
1-Sep	113600	5100	2.76	1848	3252	81	11/9/2009		1900	3.14	605	1295	32.38
2-Sep	118800	5200	2.76	1884	3316	83	11/10/2009		2813	3.14	896	1917	47.92
3-Sep	123900	5100	2.76	1848	3252	81	11/11/2009		1853	3.14	590	1263	31.58
4-Sep	129300	5400	2.76	1957	3443	86	11/12/2009		1769	3.14	563	1205	30.13
5-Sep	134200	4900	2.76	1775	3125	78	11/13/2009		1731	3.14	551	1180	29.49
Mean		4373	2.76	1584.54	2788.79	69.72	Average		1966	3.14	626.25	1340.18	33.50
StDev		646	0.00	234.22	412.22	10.31	StDev		622		198.15	424.04	10.60
N		30	30	30	30	30.00	N		30	30	30.00	30.00	30.00
95% CI		231		83.81	147.51	3.69	95% CI		223		70.91	151.74	3.79
Bleed Use (gal/Ton Heat Load)				22.73							18.69		
Change in Bleed (pre to post) (gal/Ton)											-4.04		

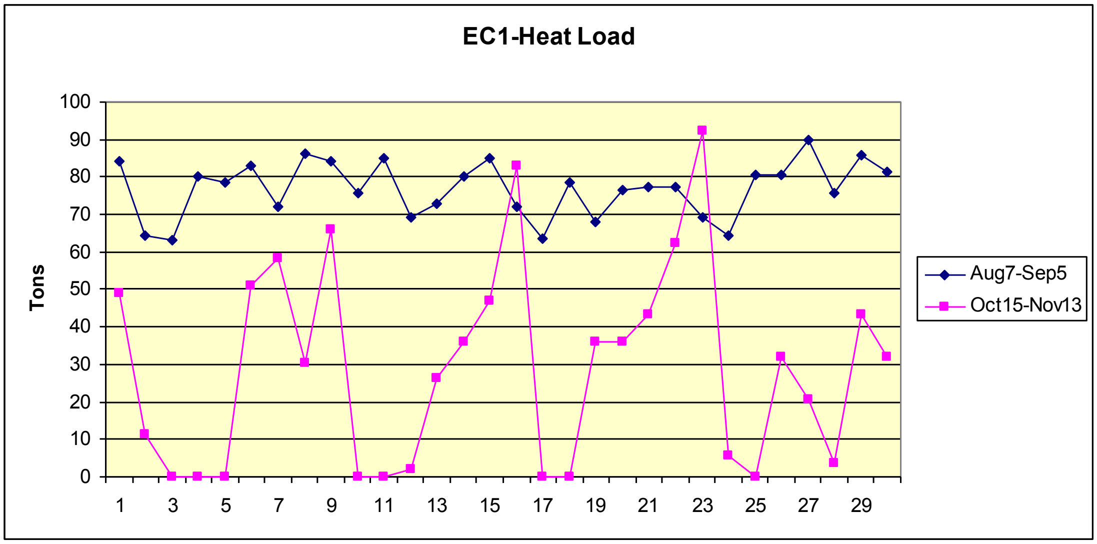
Daily data for each tower

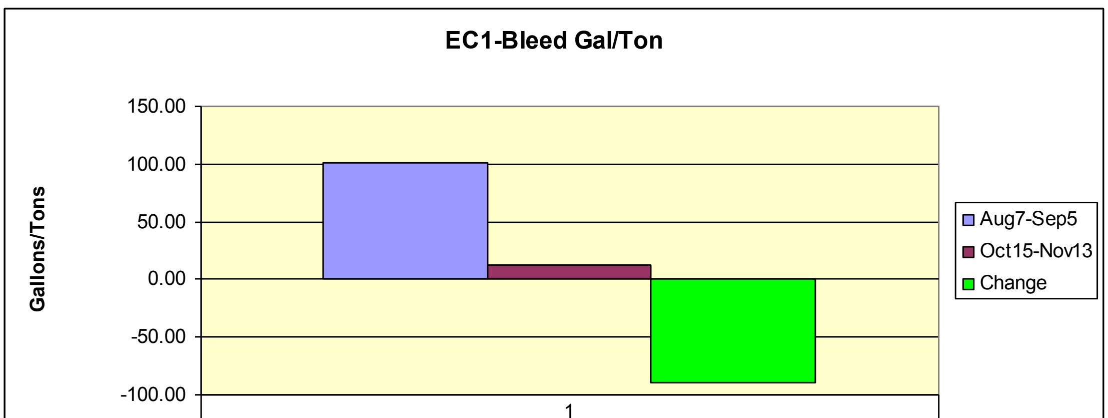
The following graphs provide the pre and post data for make-up water, bleed water, heat loading and normalized bleed use for each tower in the pre and post logging periods. These data were derived from the previous pre-post water use tables.

Tower EC1



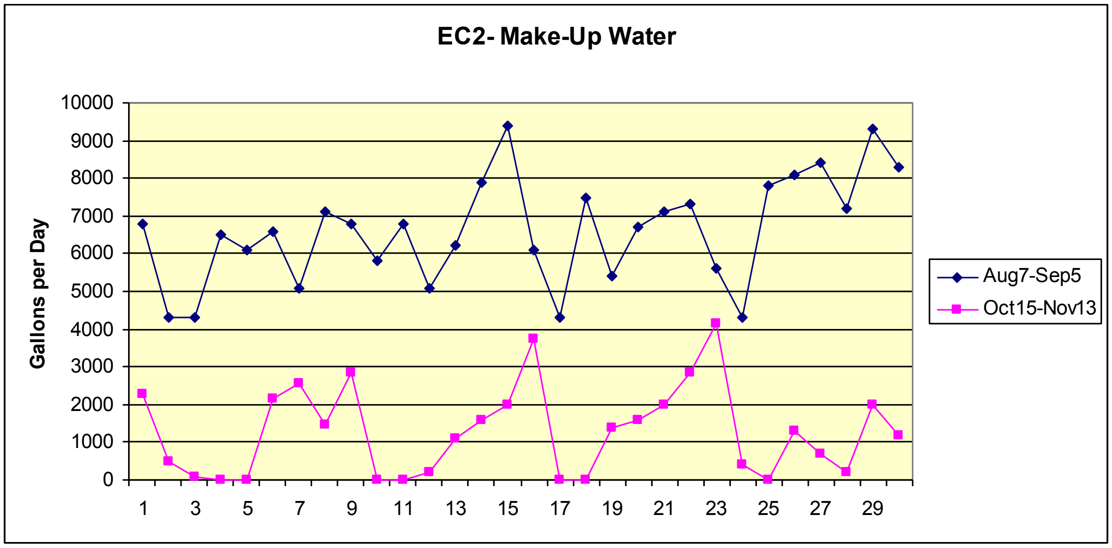


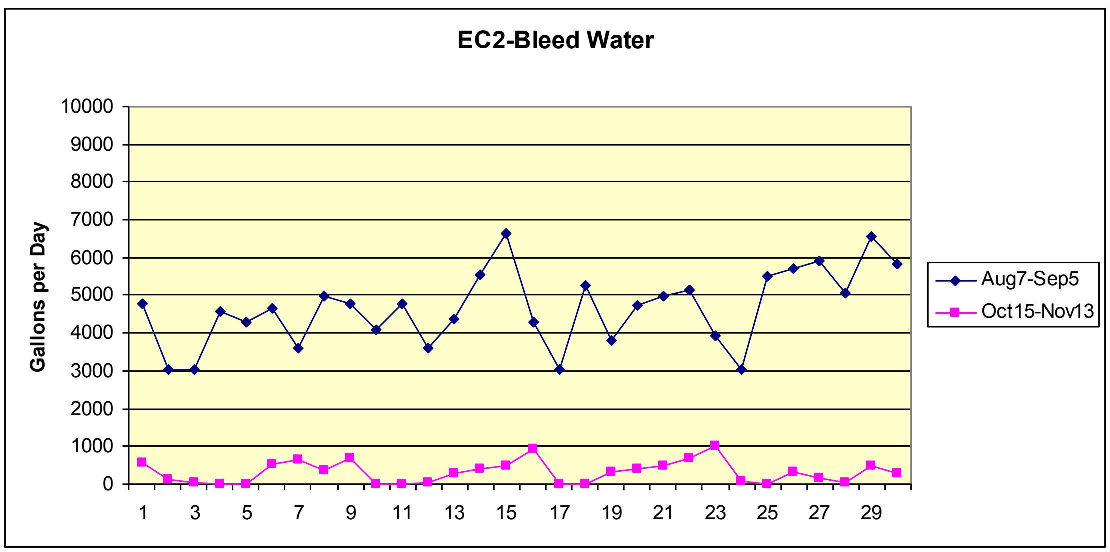


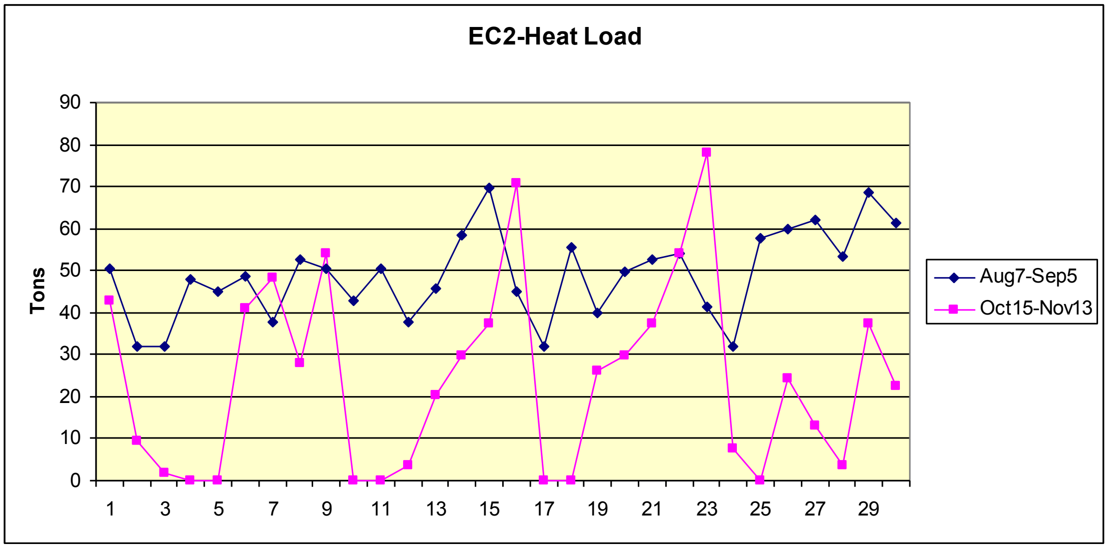


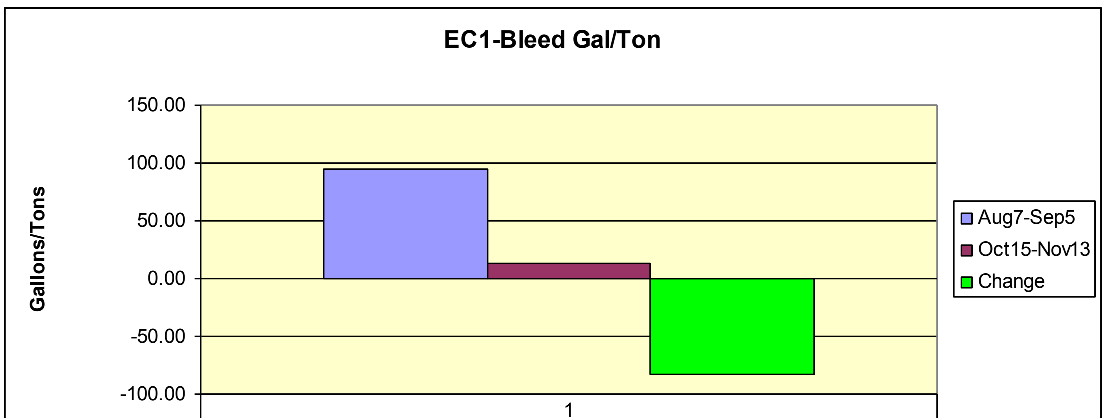
	1
Aug7-Sep5	101.27
Oct15-Nov13	11.96
Change	-89.31

Tower EC2


EC2- Make-Up Water
Gallons per Day
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
Aug7-Sep5
Oct15-Nov13

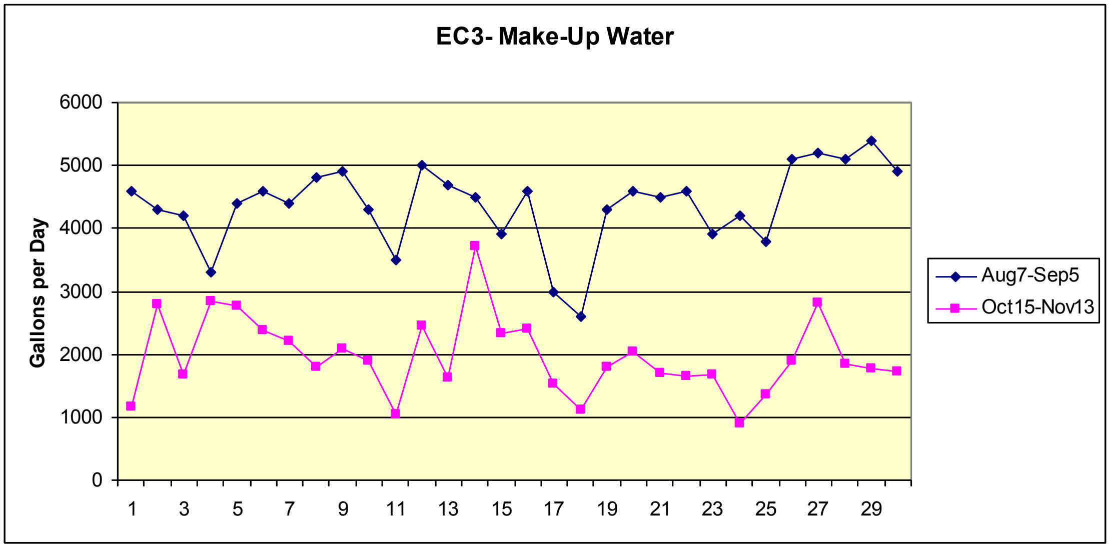

EC2-Bleed Water
Gallons per Day
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
Aug7-Sep5
Oct15-Nov13

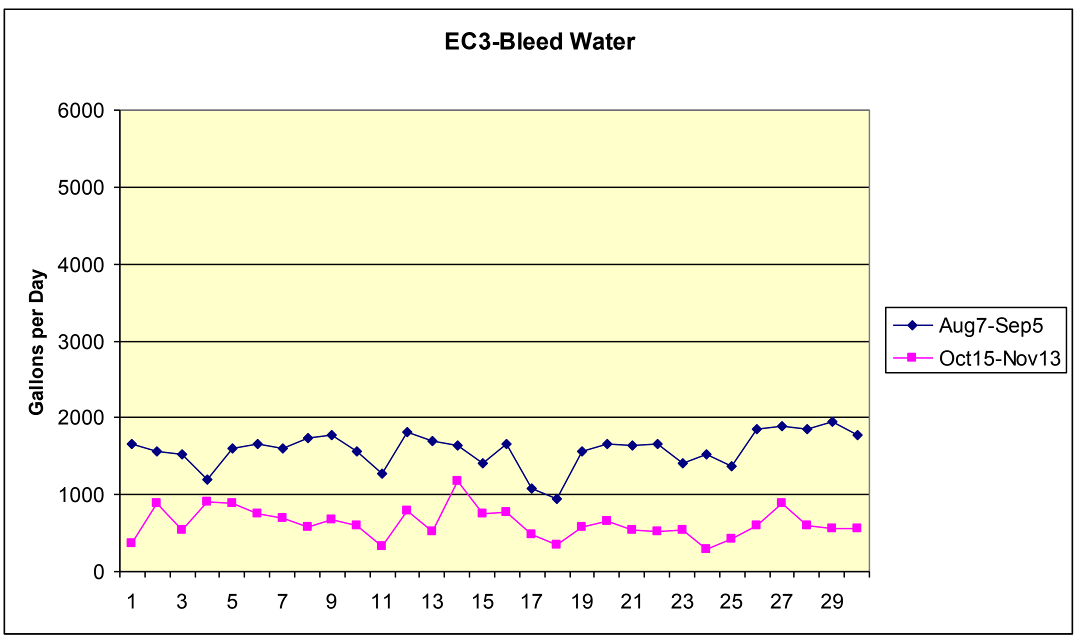


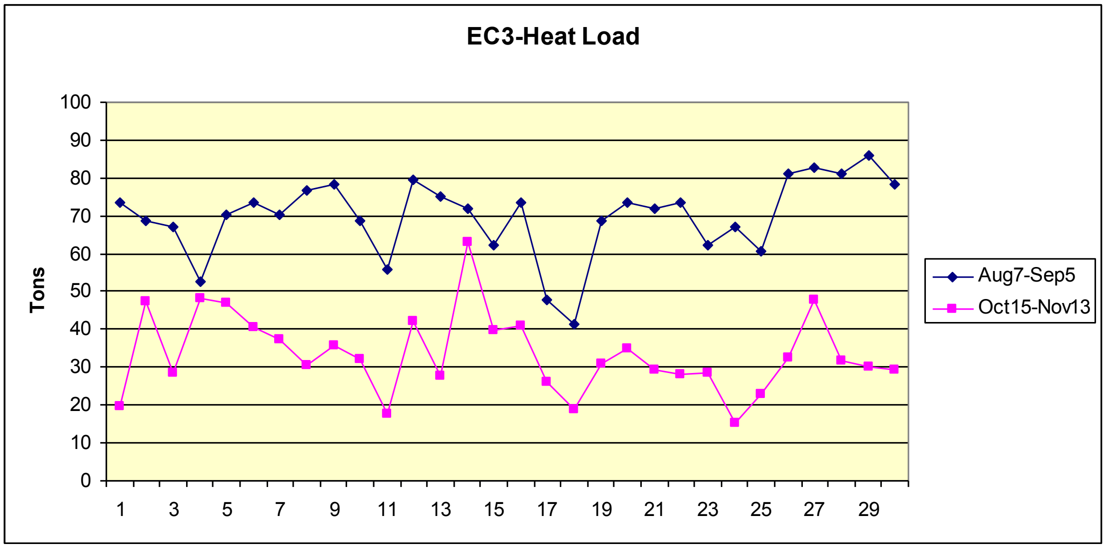


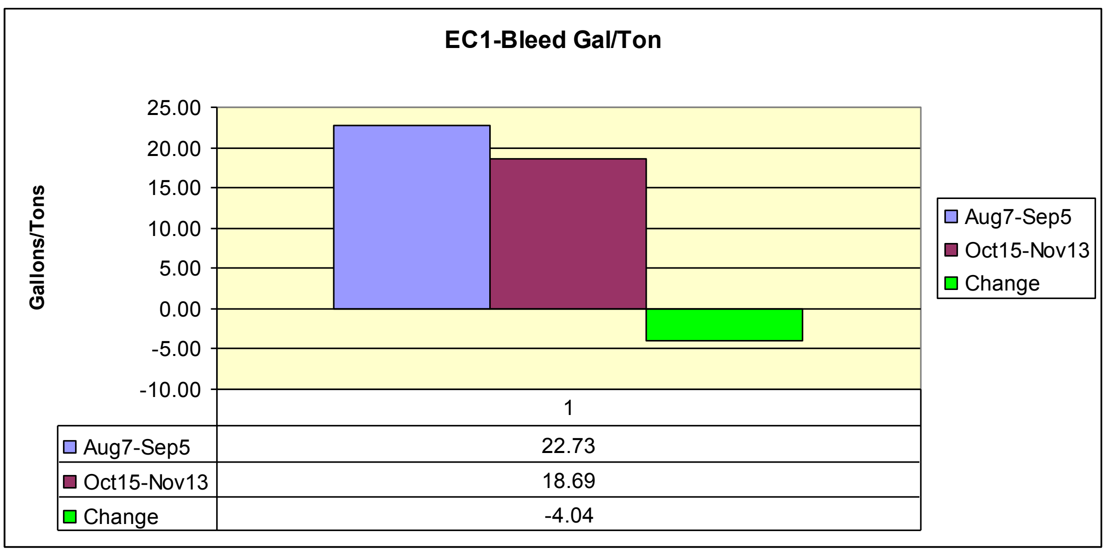
	1
Aug7-Sep5	95.24
Oct15-Nov13	12.97
Change	-82.27

Tower EC3


EC3- Make-Up Water
Gallons per Day
6000
5000
4000
3000
2000
1000
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
Aug7-Sep5
Oct15-Nov13


EC3-Bleed Water
Gallons per Day
6000
5000
4000
3000
2000
1000
0
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
Aug7-Sep5
Oct15-Nov13





6.4 References

ETB, 2009. Calculating Cooling Loads, http://www.engineeringtoolbox.com/cooling-loads-d_665.html.

Appendix 7: SCE Leak Detection Pilot Program

7.1 M&V Plan

November 2008

Program Summary

For SCE's Leak Detection Program, water audits that comply with International Water Association (IWA) and American Water Works Association (AWWA) protocols will be conducted for the Las Virgenes Municipal Water District and Apple Valley Ranchos Water Company. The audits will identify both real water losses and apparent water losses. Real water losses occur due to physical leaks while apparent losses are caused by meter malfunctions, data transcription errors, and unauthorized consumption. Only real losses affect the amount of being supplied, therefore the M&V effort will focus on real water losses rather than apparent losses.

Regarding real water losses, the study will identify and fix or manage unreported breaks and leaks, which are typically hidden from above ground view, have moderate flow rates and longer run times. These are located through active leak detection. Background leakage - the collective weeps and seeps in pipe connections that are too small to be detected by conventional acoustic equipment - will be estimated by the contractor, although no interventions are planned as part of this Pilot.

The implementation contractor will employ an Economic Evaluation of Leakage (ELL) model to identify the appropriate type and level of intervention (e.g., survey/repair work) to minimize total costs (i.e., annual cost of leakage control + annual cost of lost water).[10] A prioritized list of intervention strategies will be prepared based on economic viability for each utility.

For each water utility, a discrete area will be selected and field leakage measurements and interventions (leak repairs and/or pressure management) will be conducted. Leakage volumes will be quantified before and after the interventions using a District Metered Area (DMA) approach.

M&V Approach

Both water utilities are expected to approve the implementation contractor's final work scope in October 2008. This M&V approach is based on the contractor's initial implementation plan and will be updated as needed when the final work implementation plan is approved and conversations are conducted with the implementation contractor.

During the intervention phase of the program, the evaluation team will do on-site visits and work with the implementation contractor to confirm the amount and volume of leaks that are reduced by the program intervention. We will rely on the leak detection contractor to do the metering but will inspect the metering and monitoring devices and processes used to make sure that they are

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[10] Intervention strategies can include the speed and quality of leak repair, pressure management, active leakage control and infrastructure management.

adequate for evaluation purposes and provide the detailed information needed to calculate the embedded energy savings.

The contractor will be measuring leakage volumes before and after the interventions, and then quantifying water savings. Based on past projects of a similar nature, it is likely that the contractor will do hourly or more frequent measurement of leakage volumes – this will be confirmed with the implementation contractor to determine what data will be available.

We will collect the data on leak repair savings for each of the individual interventions and compile these data to show an overall daily profile of the water saved through the leak detection and repair activities. Once these savings profiles are created, they will be incorporated into the Embedded Energy Calculator. This will require that additional information be collected from the Las Virgenes Municipal Water District and Apple Valley Ranchos Water Company (pumping schedules, energy use data, water supply data, etc.) as part of the evaluation in order that these water agencies can profiled in the Calculator.

Additional information regarding the metering equipment to be studied, data to be collected, data collection period, repair sites and analysis techniques will be provided in this plan as more becomes known about the actual implementation of this particular program. In particular, we will review the contractor's detailed work scope to confirm the nature and timing of water savings estimates and coordinate as necessary.

Appendix 8: SDG&E Large Customer Audits Pilot Program

8.1 Detention Center (S1) M&V Plan

SITE-SPECIFIC MEASUREMENT AND VERIFICATION PLAN

SDG&E LARGE CUSTOMER AUDITS PROGRAM – SITE S1, AAA AND BBB DETENTION FACILITIES

June 11, 2009

SUMMARY INFORMATION

PROJECT

Program Name	SDG&E Large Customer Audit Program
Measure Type	Efficient Toilets, Urinals, Aerators and Showerheads
Customer Name	
Site Name	Site S1, AAA and BBB Detention Facilities
Site Address	

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

INVESTOR-OWNED UTILITY MANAGER

Name		**Telephone**	
E-mail		**Company**	

WATER AGENCY

Name		**Telephone**	
E-mail		**Company**	

SITE LEAD

Name		**Telephone**	
E-mail		**Company**	

Background

SDG&E's Water-Energy Pilot Large Customer Program offers financial incentives to help offset the cost of customer water efficiency improvements. One avenue that SDG&E uses to develop projects for this program is to work with partner water utilities, such as the San Diego County Water Authority, to identify promising water-saving projects. This partnership was used to develop a water efficiency improvement project that includes the replacement of toilets, urinals, faucet aerators and showerheads at a detention center in San Diego. The S1 detention center includes the adjacent AAA and BBB facilities.

The following M&V plan documents our planned approach for evaluating water savings. It is based upon the best information currently available, and is subject to change as the project proceeds.

Measure Description

Measure 1 – Wall Hung Toilet Valve/China Replacements

This measure represents 2.4% of expected savings, and includes the replacement of 32 toilets at the BBB facility. The existing, 3.5 gpf flushometer valve toilets will be replaced with 1.28 gpf toilets.

Pre-retrofit Equipment and Operation

The 32 existing flushometer toilets are various models manufactured by Kohler and American Standard. They are wall mounted china toilets that are rated at between 1.6 and 3.5 gallons per flush. All appear to be flushing with 3.5 gpf or more. They are located in dorm units 1-8. The audit savings calculation assumed a usage of 30 flushes per toilet per day at 3.5gpf, every day of the year.

Post-retrofit Equipment and Operation

The 32 new flushometer toilets are manufactured by Zurn (model 5615). They are wall mounted china toilets that are rated at 1.28 gallons per flush. The audit savings calculation assumed the same daily usage as the existing toilets (30 flushes per day).

Variability in Schedule

The BBB facility is operated on a daily schedule that does not vary across the months of the year.

Annual Ex Ante Measure Savings

In the audit and subsequent analysis of water savings, the utilities produced an estimate of water savings for the flushometer toilets of 583,416 gallons per year. The ex ante estimate was based on 24 flushometer toilets.

Measure 2 – Tank Toilet Replacements

This measure represents 1.6% of expected savings, and includes the replacement of 8 existing 3.5 gpf tank toilets will be replaced with 0.8/1.28 gpf dual flush tank toilets.

Pre-retrofit Equipment and Operation

There are reported to be 16 existing tank toilets in the BBB facility Staff/Visitor areas, of which 8 will be replaced. The 16 existing toilets are manufactured by Kohler, American Standard and Water Management. Some are rated at 1.6 gpf and some are unmarked and assumed to be 3.5 gpf. For the 8 to be replaced, the audit savings calculation assumed a usage of 30 flushes per toilet per day at 3.5 gpf, every day of the year.

Post-retrofit Equipment and Operation

The 8 new tank toilets are manufactured by Caroma. They are dual flush toilets rated at 0.8 gallons per flush for the lower volume option and 1.28 gallons per flush for the higher volume flush. The audit savings calculation assumed the same daily usage as the existing toilets (30 flushes per day), at 1.28 gpf.

Variability in Schedule

The BBB facility is operated on a daily schedule that does not vary across the months of the year.

Annual Ex Ante Measure Savings

In the audit and subsequent analysis of water savings, the utilities produced an estimate of water savings for the tank toilets of 388,944 gallons per year. The ex ante estimate was based on 16 tank toilets.

Measure 3 – Urinal and Urinal Valve Replacements

This measure represents 3.0% of expected savings, and includes the replacement of 24 urinal valves at the AAA facility and 25 urinals (china and valves) at the BBB facility.

Pre-retrofit Equipment and Operation

The 24 existing urinal valves at the BBB facility are china washdown units manufactured by Kohler. They are located in housing units 1 and 2. There are no markings on the existing urinals indicating rated flush volume. The existing exposed manual flush valves have been rendered non-operable and they are flushed using a continuous flow of water, estimated at approximately 0.5 gpm per fixture.

The 25 existing urinals at the AAA facility are stainless steel washdown units (except for one in the staff/visitor area which is china). All but this one of the urinals is located in dorm units 1&2. There are no markings on the existing urinals indicated rated flush volume. The 24 urinals in the dorm units are flushed with a continuous flow of water, estimated at approximately 0.5 gpm per fixture. The existing concealed push button flush valves have been rendered non-operational.

Post-retrofit Equipment and Operation

The 24 new valves for the stainless steel urinals at the AAA facility are rated at 1.0 gallons per flush. The 25 new china urinals (valve and china) at the BBB facility (and one at the AAA facility) are rated at 0.125 gallons per flush. The audit savings calculation assumed the same daily usage as the existing urinals (30 flushes per day) for both urinal types.

Variability in Schedule

Both facilities are operated on a daily schedule that does not vary across the months of the year.

Annual Ex Ante Measure Savings

In the audit and subsequent analysis of water savings, the utilities produced an estimate of water savings for the urinal measure of 737,756 gallons per year. The audit savings calculation assumed a usage of 30 flushes per urinal per day. The flush volume for the existing urinals was assumed to be 1.5 gpf. The flush volume for all new urinals was assumed to be 0.125 gallons per flush.

Measure 4 – Aerator Replacements

This measure represents 1.8% of expected savings, and includes the replacement of 51 faucet aerators at the BBB facility. Existing 2.2 gpm aerators will be replaced by 1.0 gpm aerators.

Pre-retrofit Equipment and Operation

The 51 existing aerators are to be replaced. 48 aerators are located in dorm units 1-8. The remaining 3 aerators are located in the staff and visitor area. The audit savings calculation assumed that each aerator was on at full throttle at 2.2 gpm for 20 minutes per day, every day of the year.

Post-retrofit Equipment and Operation

The 51 new aerators are rated at 1.0 gallon per minute. The audit savings calculation assumed the same daily usage as the existing aerators (20 minutes per day).

Variability in Schedule

The BBB facility is operated on a daily schedule that does not vary across the months of the year.

Annual Ex Ante Measure Savings

The audit and subsequent analysis of water savings the utilities produced an estimate of water savings for the aerators of 446,760 gallons per year.

Measure 5 – Detention Toilet Flush Valve Replacements

This measure represents 90.9% of expected savings, and includes the replacement of 565 toilet flush valves in the detention area of the AAA facility. Mechanical 3.5 gpf flush valves will be replaced with electronic 1.6 gpf valves, which have the capability of being limited to a maximum number of flushes per hour.

Pre-retrofit Equipment and Operation

The 565 existing toilet flush valves in the detention area are manufactured by Delaney. They are mechanical flushometer valves rated at 3.5 gallons per flush. 500 of the toilets are stainless steel combi-units located in housing units 3,4,5,6 and 8. Each housing unit has 100 toilets (one unit serving two inmates per cell). An additional 48 stainless steel wall mount toilets are located in housing units 1 and 2. In addition, 17 toilets are located in the intake area. The audit savings calculation assumed a usage of 40 flushes per toilet per day, every day of the year.

Post-retrofit Equipment and Operation

The new flush valves are manufactured by Icon. They are electronic valves rated at 1.6 gallons per flush. The audit savings calculation assumed a usage of 20 flushes per toilet per day, every day of the year. This usage is half of the existing condition.

Variability in Schedule

The AAA facility is operated on a daily schedule that does not vary across the months of the year.

Annual Ex Ante Measure Savings

In the audit and subsequent analysis of water savings, the utilities produced an estimate of water savings for the valve replacement of 22,272,300 gallons per year.

Measure 6 – Showerhead Replacements

This measure represents 0.3% of expected savings, and includes the replacement of 6 showerheads at the BBB facility. Existing 3.0 gpm showerheads aerators will be replaced by 1.5 gpm showerheads.

Pre-retrofit Equipment and Operation

The 6 existing showerheads are located in the staff and visitor area. The audit savings calculation assumed that each showerhead was on at full throttle at 3.0 gpm for 30 minutes per day, every day of the year.

Post-retrofit Equipment and Operation

The 6 new showerheads are rated at 1.5 gallons per minute. The audit savings calculation assumed the same daily usage as the existing showerheads (30 minutes per day).

Variability in Schedule

The BBB facility is operated on a daily schedule that does not vary across the months of the year.

Annual Ex Ante Measure Savings

In the audit and subsequent analysis of water savings, the utilities produced an estimate of water savings for the showerheads of 65,700 gallons per year.

Algorithms for Estimating Water Savings

Utility Algorithms

The energy audit estimated water savings through simple spreadsheet calculations. The basic algorithm is as follows:

$$\textit{Water use} = \textit{Nominal water userate} \times \textit{Annual usage}$$

Where:

- *Nominal water userate* was expressed as gallons per flush for the toilets and urinals; and gallons per minute for the aerators and showerheads.

- *Annual usage* was expressed as number of flushes for the toilets and urinals; and minutes for the aerators and showerheads.

Water savings equaled the difference between calculated annual pre-installation water use and annual post-installation water use.

Evaluation Algorithms – Water Savings

The evaluation team will estimate verified water savings through pre and post measurement and logging of water consumption and flow rates for typical building units and/or sets of fixtures for which measures are being implemented.

The basic algorithm will be as follows:

Water use per measure = Water use by logged building unit per day x % of logged usage attributed to that measure x Number of building units affected x 365

Where:

Logged Building Unit is a discrete building or portion of a building with an accessible water line suitable for ultrasonic metering, supplying a known quantity and type of fixtures, including those to be upgraded. A minimum number of building units will be logged to ensure each distinct unit type for which a significant number of fixtures is being upgraded is logged.

For measures for which it may not be practical to conduct a submetering analysis, including tank toilets, showers, and aerators, individual flow rates (for showers and aerators), gallons per flush (for tank toilets), and gallons (or flushes) per day (where possible) will be measured for a representative sample using graduated containers, flush sensors, and/or in-line flow meters as appropriate. No measuring devices will be left unattended in areas accessible by inmates.

In these cases the basic algorithm will be:

Water use per measure = Measured flowrate x Calculated annual usage

Where:

Measured flowrate is measured gpm or gpf for the representative sample, and calculated annual usage is based on flush sensor data or best engineering estimate, as appropriate.

We will then input our evaluated average daily water savings into the Energy Savings and Avoided Costs Calculator prepared by Jeff Hirsch (Embedded Energy Calculator) to compute annual water savings. The Embedded Energy calculator requires four input parameters to compute annual water savings – daily water savings profile, day type multiplier, monthly multiplier, and average savings per day. An additional input parameter, measure life, is then used to compute lifetime savings. The input data for the Embedded Energy calculator are described below.

- Daily water savings profile: accounts for differences in water savings between hours of the day.
- Day type multiplier: accounts for differences in water savings between weekdays and weekends.

- Monthly multiplier: accounts for differences in water savings between months of the year.
- Measure Life (yrs): accounts for the life of the equipment; we will apply the measure life used by the IOU for this technology. .

Data Collection

Data collection is addressed by building type. There are (4) building types for which conservation measures are to be implemented. Some building types may have more than one measure being implemented. The (4) primarily affected building types include the (4) BBB Dorms, the BBB Admin Bldg., the (2) AAA Facility Dorms (Buildings 1&2), and the (5) AAA Facility Cell Blocks (Buildings 3, 4, 5, 6, & 8). Additionally, there is to be (1) urinal replacement in the AAA Facility Admin Building, but this is expected to have minimum impact on overall savings.

Data will be collected for both the pre-installation and post-installation periods. Overall a one-month data collection period is desired. The length of the pre-installation period will be limited for some measures by the aggressive installation schedule. Some of the measures (particularly the Icon controls in the cell blocks) will require a significant commissioning period where the performance of the measure is adjusted to meet the needs of the prison and the inmates. Data collected during this period are of no value to the evaluation. For these measures, the start of the post-installation data collection period will be delayed until commissioning is completed.

Building Type 1 (BBB Dorms): Measures 1, 3, & 4– Toilet,Urinal, and Aerator Replacements

These measures cover the existing wall hung china toilets and urinals and all associated flush valves in Buildings “A”, “B”, “C”, and “D” of the BBB facility, as well as the lavatory faucet aerators. SBW will install a logging ultrasonic flowmeter on the 2” cold water line feeding (8) toilets and (6) urinals in back to back restrooms on the ground floor in (1) of the above buildings, as selected by BBB Facilities personnel, in which an electrical outlet has been made available. Flow traces will be completed over minimum one-month (3 month max) period covering both pre and post-installation, with both instantaneous gpm and total gallons being logged every 12 minutes. Two separate channels will be simultaneously utilized, one logging at a point on the line serving both the toilets and urinals, and one at a point further down the line serving only the urinals. Before and after flow volumes (gpm) for the individual lavatory faucets in the two metered restrooms will also be measured, but due to low projected savings for this measure, logging of total hot and cold water used for the lavatories will not be conducted. [Note: If lavatory faucet usage were to be logged, it would require an additional 2 channel ultrasonic meter.]

Site Data Collection Method

The following information will be collected at the site.

1. Pre and post-installation log of flow rate and total gallons for selected toilets and urinals.
2. Pre and post-installation measurements of flow rate for selected lavatory faucets
3. Number of inmates currently in areas being served by the restrooms being logged.

The table below provides additional information concerning these measurements.

Table 1: Evaluation Measurements

Description	Evaluation
Equipment monitored	2" CW line in plumbing chase leading to ground floor toilets and urinals
Parameter measured	GPM, Total Gallons
Measurement equipment	Panametrics ultrasonic flowmeter (2 channels)
Installation method	Clamp-on
Observation frequency	12 minute
Measurement duration	One month

Sampling Strategy

Toilet and urinal water usage logged will be for (8) toilets and (6) urinals in (2) restrooms of (1) building. There are (4) buildings with (2) restrooms each with (4) toilets per restroom (32 toilets total). Therefore, the sample represents 25% of the total toilets and urinals replaced under this measure.

A proposed sampling strategy for this building is to reserve one of the buildings for baseline metering. Dorm building "A" was observed during the initial site visit, but his building did not have a 110 V power receptacle available in the main mechanical room. It was suggested by XYZ that perhaps one of the other dorm buildings there may already have power available, and if not, then power could be made available by Facilities staff. We will request that Facilities staff determine if one of these buildings has power in the mechanical room, and if so reserve that building. If not, we will identify which building they would like to bring power to (such as Bldg. A), and hold off on work on that building.

Schedule

Program pre-retrofit metering will begin in June 2009. The measures are expected to be installed in the summer of 2009. Metering will continue through installation to cover a minimum of two weeks post-installation.

Data Products

The following data products will be generated during the evaluation.

1. Excel analysis spreadsheet used to compute pre and post water consumption by all buildings affected by these two measures, normalized to average inmate population. Spreadsheet will also include trace data.
2. A copy of the Embedded Energy Calculator to compute annual water savings and provide an energy savings profile.

Building Type 2 (BBB Admin Bldg): Measures 2, 4, & 6 – Toilet Replacements (tank), Aerator Replacement, Shower Replacement

These measures cover (8) of the existing (16) existing tank toilets, (6) showerheads, and (3) of the (16) existing lavatory faucet aerators in Staff/Visitor areas of the BBB facility. SBW will measure individual flush volumes and total gallons used over the pre and post installation period for at least 37% (3) of these toilets and associated lavatories. Flush volume will be measured by marking actual tank water level, turning off the water supply to the toilet, flushing the toilet, and using a calibrated measuring device to refill the tank to the original level. Water for bowl refill will be separately captured and measured. Total gallons (pre and post installation) used by sampled toilets and lavatories will be measured using in-tank flush counters and/or in-line water meters with pulse output for every 10 (or 100) gallons connected to an event logger. In-line counters or meters will not be left in any areas to which inmates have accesses. In addition, pre and post instantaneous flow rates (gpm) will be taken for individual showerheads and faucets to be replaced. Due to the minimal savings projected for the showerheads (180 GPD, or 0.3% of total projected savings), totalizing meters will not be installed for the showerheads.

Site Data Collection Method

The following information will be collected at the site (both pre and post-installation)

1. Pre and post gallons per flush and gallons (or flushes) per day for at least 25% of toilets to be replaced.
2. Pre and post flow rates of all showerheads
3. Pre and post gallons per day for at least 25% of lavatories with aerators to be replaced
4. Number of staff currently in areas being served by the toilets being metered.

The table below provides additional information concerning these measurements.

Table 1: Evaluation Measurements

Description	Evaluation
Equipment monitored	Existing tank toilets, showers, lavatories
Parameter measured	Toilet Gallons per flush, Total gallons (or flushes) per day for toilets and lavatories, Shower and Aerator GPM
Measurement equipment	Calibrated container, in-line water meters with pulse outputs and battery operated event loggers, in-tank flush sensors with event loggers
Installation method	In-line meters installed between wall stop and fixture, flush counters installed inside tank
Observation frequency	Records pulse every 10 or 100 gallons used. Records each flush event
Measurement duration	One month

Sampling Strategy

Toilet usage logged will be for a minimum of (3) toilets in the Staff/Visitor areas. There are (8) existing toilets to be replaced. Therefore, the sample represents 37% of the total toilets replaced under this measure. Toilets to be metered will be chosen depending upon how representative they appear to be (including both men's and women's) and security from inmates. Pre and post gpm measurements will be made for all lavatories associated with measured toilets. All (6) showerheads will have low rates measured both pre and post installation. In-line water meters and/or in-tank flush counters with pulse output connected to event loggers will installed at the wall stop (or inside the tank for flush counters) for each subject toilet and on hot and cold lines leading to each subject lavatory.

A proposed sampling strategy for this building is to identify exactly which toilets are to be changed out, but do not begin the change out of toilets or showerheads until baseline metering has been completed.

Schedule

Program pre-retrofit metering will occur in June 2009. The measures are expected to be installed in the summer of 2009. Post-retrofit metering will begin soon after the measures are installed.

Data Products

The following data products will be generated during the evaluation.

1. Excel analysis spreadsheet used to compute pre and post water consumption for these measures.
2. A copy of the Embedded Energy Calculator to compute annual water savings and provide an energy savings profile.

Building Type 3 - AAA Facility Dorms (Units 1&2): Measures 3 & 5– Urinal and Toilet Flush Valve Replacement

These measures cover the toilets and the existing continuously flowing urinals in Housing Units 1&2 in the AAA Facility. The AAA urinals are stainless steel and only the valves will be replaced with 1.0 gpf manual units. The AAA toilets are also stainless steel and will have only the flush valves replaced with 1.6 gpf with an electronic control system to prevent excessive flushing.

SBW will install a logging ultrasonic flowmeter at two points on the cold water line in one of the pipe chases serving (4) toilets and (2) urinals in AAA Facility Housing Unit 1 or 2. Logging interval for gpm and total gallons will be every 12 minutes for a period of time covering both pre and post installation. One location will record flow to both toilets and urinals, and one location will record urinal usage only. For urinals, the minimum baseline flow recorded will be assumed to represent the continuous flowing urinals. Continuous baseline flow will also be measured in two additional pipe chases in the same AAA Facility Housing Unit, representing baseline flow to a total of (6) AAA urinals, or 25% of the continuous flowing urinals in this building. Savings for the (1) additional urinal, which does not have a continuous flow, will not be independently measured but will be calculated using the original algorithm. Additionally, an ultrasonic flowmeter will be placed on the main cold water feed in the main mechanical room of either Housing Unit 1 or 2, which will measure baseline flow for the entire building, as well as pre and post water consumption for the entire building. This flowmeter will be set to log gpm and total gallons every 12 minutes for the entire pre and post installation period, in order to document overall savings for the entire building.

Site Data Collection Method

The following information will be collected at the site.

1. Pre-installation baseline flow (gpm) for (6) urinals in AAA (25% of continuous flowing urinals).
2. Number of inmates currently in areas being served by the restrooms being logged.
3. Pre and post-installation log of water usage for (2) urinals and (4) toilets in AAA.
4. Log of pre and post installation total cold water usage for AAA Housing Unit 1 or 2.

The table below provides additional information concerning these measurements.

Table 1: Evaluation Measurements

Description	Evaluation
Equipment monitored	CW lines in restroom plumbing chases toilets and urinals, Total building cold water usage
Parameter measured	GPM & Total Gallons
Measurement equipment	Panametrics ultrasonic flowmeters (3 channels measured)
Installation method	Clamp-on
Observation frequency	12 minute
Measurement duration	One month

Sampling Strategy

Total water usage logged for one building (50% of this type), and separate toilet and urinal usage will be measured for (2) urinals and (4) toilets in (2) restrooms, representing 12.5% of the toilets and urinals in that building. There are (2) buildings of this building types with (48) continuous flowing urinals. The separate toilet and urinal logs will be used to allocate overall measured savings for the building between the toilet and urinal measures. Savings for the second building will be assumed to be the same as the first building, adjusted for inmate count. One additional urinal, which was not continuously flowing, will not be independently measured, as its savings potential will be much less significant.

A proposed sampling strategy for this building is to begin implementation of measures (Icon controllers for toilets and urinals) with the Housing Unit #1 Building. Hold off on work on the Housing Unit #2 Building until baseline metering has been in place for at least 1 week. (It could be done the other way around, i.e. Unit #2 first, except that the mechanical room in #2 was observed during the initial site visit.)

Schedule

Program pre and poet-retrofit metering will begin in June 2009. The measures are expected to be installed in the summer of 2009. Post-retrofit metering will continue for a minimum of two weeks after the measures are installed.

Data Products

The following data products will be generated during the evaluation.

1. Excel analysis spreadsheet used to compute pre and post water consumption by all buildings affected by this measure, normalized to average inmate population. Spreadsheet will also include log data.

2. A copy of the Embedded Energy Calculator to compute annual water savings and provide an energy savings profile

Building Type 4 - AAA Cell Blocks (Housing Units 3, 4, 5, 6, & 8): -Measure 5 – Detention Toilet Flush Valve Replacement

These measures covers the flush valves for the combination toilet/lavatory units Housing Units 3, 4, 5, 6, & 8 in the AAA Facility. The AAA combination units are stainless steel and only the valves will be replaced with 1.6 gpf units with electronic controls to prevent excessive flushing.

SBW will install a logging ultrasonic flowmeter on the main cold water feed in the main mechanical room of one representative housing unit, which will measure pre and post water consumption for the entire building. As this is the only measure being evaluated in this building, all savings will be allocated to this measure. Since these combi-units are spread throughout the building, there is no place to conduct submetering of a statistically significant sample. This flowmeter will be set to log gpm and total gallons every 12 minutes for the entire pre and post installation period, in order to document overall savings for the entire building.

Site Data Collection Method

The following information will be collected at the site (both pre and post-installation)

1. Flow rate and total gallons logged every 12 minutes for one building.

2. Number of staff and inmates currently in building being served by the toilets being metered.

The table below provides additional information concerning these measurements.

Table 1: Evaluation Measurements

Description	Evaluation
Equipment monitored	Combination toilet/lavatory Fixtures
Parameter measured	Total gallons per minute flow, Total gallons
Measurement equipment	Ultrasonic flowmeter (1 channel)
Installation method	Strap on
Observation frequency	12 minutes
Measurement duration	One month

Sampling Strategy

Total water usage will be logged for one building for a period covering both pre and post installation. Similar savings, adjusted for inmate population, will be assumed for the other (5) building of this type.

A proposed sampling strategy for this building is to reserve Housing Unit #3 (which was visited earlier) until baseline metering is completed. Begin work on Units 4, 5, 6, & 8 (Icon controllers for combi-units).

No metering will occur on the 17 combi-units in the intake area so work can be completed in this area at any time.

Schedule

Program pre-retrofit metering will begin in June 2009. The measures are expected to be installed in the summer of 2009. Post-retrofit metering will continue for at least two weeks after the measures are installed.

Data Products

The following data products will be generated during the evaluation.

1. Excel analysis spreadsheet used to compute pre and post water consumption for this measure.

2. A copy of the Embedded Energy Calculator to compute annual water savings and provide an energy savings profile

8.2 Research/Production Facility (S2) M&V Plan

SITE-SPECIFIC MEASUREMENT AND VERIFICATION PLAN

SDG&E/SCDWA LARGE CUSTOMER AUDIT PROGRAM

RESEARCH/PRODUCTION FACILITY S2

August 19, 2009

SUMMARY INFORMATION

PROJECT

Program Name	SDG&E/SCDWA Large Customer Audit Program
Measure Type	Autoclave Water Conserving Trap Cooling Kits, Pure Water System Efficiency Upgrades
Customer Name	
Site Name	S2
Site Address	

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

INVESTOR-OWNED UTILITY MANAGER

Name		**Telephone**	
E-mail		**Company**	

WATER AGENCY

Name		**Telephone**	
E-mail		**Company**	

SITE LEAD

Name		**Telephone**	
E-mail		**Company**	

Background

SDG&E and SCDWA's Large Customer Audits for Energy and Water Conservation Program (Audit Program) offers assistance to customers for identification and implementation of water efficiency improvements.

An audit of the S2 Facility identified two measures, autoclave trap cooling water conservation kit installations and pure water system upgrades that the customer chose to implement immediately.

The following M&V plan documents our planned approach for evaluating water savings from these measures. It is based upon the best information currently available, and is subject to change as the project proceeds.

Measure Description

Measure 1 – Autoclave Trap Cooling Water Conservation Kits

This measure involves installation of trap cooling water conservation kits on autoclaves to eliminate the continuous use of potable water for trap cooling.

Pre-retrofit Equipment and Operation

The water audit identified three similar sized autoclaves for installation of water conservation trap cooling kits. Each of these autoclaves was observed to have a continuous flow of potable water for trap cooling during operation. Cooling water use for one of the three autoclaves was measured by the auditor using a transit time flowmeter at approximately 6 gpm, which was assumed as typical for all three. Hours of operation were reported by facility personnel to be 6 AM to 10 PM for all three units.

Post-Retrofit Equipment and Operation

Kits to be installed are manufactured by Steris. The description of the kit provided by Steris is as follows: "*Constant water flow used for chamber and jacket trap cooling is eliminated with this modification. A solenoid valve replaces the needle valves and a controller with temperature sensors operate the solenoid to flow cooling water only as required to keep average drain effluent temperature below 140F. A fixed orifice is used to limit overall flow when the system is in operation. The original sterilizer vacuum breaker is replaced with a backflow preventer.*" Operation if the kit is automatic. No change in user operation is required.

Variability in Schedule

There was reportedly no variation in schedule from week to week. No change in hours of operation is being proposed. Data showing seasonal variability will be collected from the operator log sheet.

Annual Ex Ante Measure Savings

Estimated water savings computed in the water audit was 3,594,240 gal/yr. This assumed three (3) sterilizers, each flowing at 6.0 gpm, 16 hours/day, five days/week, 52 wk/yr, with an 80% savings.

Measure 2 – Pure Water System Efficiency Upgrades

This measure involves installation of a second stage to both of the pure water systems in the Reverse Osmosis/Deionization (RO/DI) Room to increase the efficiency of pure water production. More efficient production results in less water waste.

Pre-Retrofit Equipment and Operation

There are two separate RO units at the facility, one supplying the Gel DI (de-ionized water) System, and the other supplying both the Kit DI System and the Kit UP (ultrapure water) System. These two RO units each have their own makeup water meter and independent storage tank. In addition, the Gel system has a single product water meter from the storage tank, and the Kit system has two separate product water meters, one for the Kit DI system and one for the Kit UP system. There are hour meters and GPM meters for permeate and concentrate on both units. In addition, there is a makeup meter for the water softening system situated upstream of the RO units, but this also supplies softened water to other processes, in addition to the RO units, so readings from this meter do not provide useful information with regard to RO unit water usage. Both units discharge concentrate directly, with visible air gap, to separate floor drains.

Monthly logs are kept for both units, showing among other things, makeup meter gallon readings, hour meter readings, permeate gpm, and concentrate gpm. In the water audit it was noted that each unit operated at approximately 19.5 gpm, including approximately 10.5 gpm concentrate flow and approximately 9 gpm permeate flow.

Post-Retrofit Equipment and Operation

In the water audit it was proposed that improvements to each system would include 1) upgrading from a single stage system to a two stage system, 2) adding an anti-scaling feed system for each system, and 3) adding a static mixer upstream of each RO feed line. By implementing these modifications it was estimated that the recovery rate could be increased from a current 46% to a target 75%.

Variability in Schedule

In the water audit no variability was assumed in flow.

Annual Ex Ante Measure Savings

Estimated water savings computed in the water audit was 784,045 gal/yr (2151 GPD), based on assumed current consumption of 2,038,516 gal/yr (5585 GPD). This was computed assuming a pre-installation requirement of 19.5 gpm to produce 9 gpm per product (46% recovery rate), and a post-installation requirement of only 12 gpm to produce the same 9 gpm of product (75% recovery rate, or 50% recovery per stage), resulting in a 38.5% water savings.

Algorithms for Estimating Water Savings

Measure 1 – Autoclave Trap Cooling Water Conservation Kits

Utility Algorithms

The water audit estimated water savings through simple spreadsheet calculations. The basic algorithm is as follows:

Water savings = Number of autoclaves × Flow rate × Annual hours of use × % Savings potential

Where:

- *Number of autoclaves* to be retrofitted was 3.
- *Flow rate* was assumed to be 6.0 gpm (both pre and post install).
- *Annual hours of use* was based on 18 hrs/day x 5 days/wk x 52 wks/yr.
- *% Savings potential* was 80%, representing post-installation flow (still at 6 gpm) for 1 minute out of every 5 minutes, as opposed to a pre-installation continuous flow.

Evaluation Algorithms

The evaluation team will estimate verified water savings through simple spreadsheet calculations. Savings for each of the autoclaves being retrofitted will be separately calculated and then added together for the total measure savings. The basic algorithm for each autoclave will be as follows:

Average annual water savings = (Pre-install flowrate – Post-install flowrate) × Annual hours of use

Where:

- *Pre-install flowrates* will be gallon/minute measurements x 60, as determined from short-term flow measurement at each autoclave.
- *Post-install flowrate* will be average gallons/hour during hours of operation, as determined from long term logging of one retrofitted unit.
- *Annual hours of use* will be the best estimate of hours based on logging data and/or staff interviews, and will be computed by multiplying (operational hours/day x operational days/wk x 52 weeks/year).

We will then input our evaluated average daily water savings into the Energy Savings and Avoided Costs Calculator prepared by Jeff Hirsch (Embedded Energy Calculator) to compute annual water savings. The Embedded Energy calculator requires four input parameters to compute annual water savings – daily water savings profile, day type multiplier, monthly multiplier, and average savings per day. An additional input parameter, measure life, is then used to compute lifetime savings. The input data for the Embedded Energy calculator are described below.

- Daily water savings profile: accounts for differences in water savings between hours of the day.
- Day type multiplier: accounts for differences in water savings between weekdays and weekends.
- Monthly multiplier: accounts for differences in water savings between months of the year.

- Measure Life (yrs): accounts for the life of the equipment; we will apply the measure life used by the IOU for this technology.

Measure 2 – Pure Water System Efficiency Upgrades

Utility Algorithms

The vendor water audit estimated water savings through simple spreadsheet calculations. The basic algorithm is as follows:

Water savings = Pre-install annual consumption × (Typical pre-install potable flowrate – Target post-install potable flowrate) / *(Typical pre-install potable flowrate)*

Where:

- *Pre-install annual consumption* as extrapolated from operational logsheet is 2,038,516 gallons per year.
- *Typical pre-install potable flowrate* is taken as 19.5 gpm (9 gpm permeate + 10.5 gpm concentrate), from operational logsheet.
- *Target post-install potable flowrate* is projected as 12 gpm (9 gpm permeate / 75% target recovery rate).

Evaluation Algorithms

The evaluation team will estimate verified water savings through simple spreadsheet calculations. Savings for each of the two systems will be computed separately and then added together. The basic algorithm will be as follows:

Projected annual water savings = Average daily pre-install water consumption × Pre-install recovery rate × (Pre-install reject ratio – Post-install reject ratio) × *Days per year*

Where:

- *Average daily pre-install pure water consumption* will be computed from the "Gallonage Meter Reading" entries recorded monthly on the operator log for each system and will cover the period from Nov 13, 2008 up until the last record before installation.
- *Pre-install recovery rate* will be the average "RO Permeate Flow" divided by the average ("RO Permeate Flow" plus "RO Concentrate Flow") for the pre-install time period, as recorded on the monthly operator log.
- *Pre-install reject ratio* will be the average "RO Concentrate Flow" divided by the average "RO Permeate Flow" for the pre-install time period, as recorded on the monthly operator log.

- *Post-install reject ratio* will be the average "RO Concentrate Flow" divided by the average "RO Permeate Flow" for the post-install time period, as recorded on the monthly operator log.
- *Days per year = 365.*

We will then input our evaluated average daily water savings into the Energy Savings and Avoided Costs Calculator prepared by Jeff Hirsch (Embedded Energy Calculator) to compute annual water savings. The Embedded Energy calculator requires four input parameters to compute annual water savings – daily water savings profile, day type multiplier, monthly multiplier, and average savings per day. An additional input parameter, measure life, is then used to compute lifetime savings. The input data for the Embedded Energy calculator are described below.

- *Daily water savings profile: accounts for differences in water savings between hours of the day.*
- *Day type multiplier: accounts for differences in water savings between weekdays and weekends.*
- *Monthly multiplier: accounts for differences in water savings between months of the year.*
- *Measure Life (yrs): accounts for the life of the equipment; we will apply the measure life used by the IOU for this technology.*

Data Collection

The table below describes the parameters that will be monitored. Note that the pre-installation data collection has already begun, in advance of the approval of this plan. We started this process early with the consent of the CPUC evaluation manager, because the opportunity for collecting suitable pre data was going to end soon.

Table 14: Evaluation Measurements - Autoclaves

Equipment monitored	Autoclaves (4)
Parameter measured	1. Pre-install continuous flowrate for each subject autoclave. 2. Autoclave operating ("on") hours. 3. Typical post-install flowrate.
Measurement equipment	1. Panametrics PT868 ultrasonic flowmeter (preferred) or graduated plastic flow bag. 2. Dent Instruments SmartLogger time-of-use motor logger. 3. Panametrics PT868 ultrasonic flowmeter

Installation method	1. Sensors strapped onto water pipes temporarily for each autoclave, or bag held under discharge 5 seconds if piping prohibits use of flowmeter. 2. Strapped to ON/OFF solenoid for typical units. 3. Sensors strapped onto water inlet pipe of one typical autoclave.
Observation frequency	1. Once. 2. Every change of state (on/off event). 3. Every 6 minutes
Measurement duration	1. Instantaneous measurement. 2. Minimum two weeks pre-installation and two weeks post-installation. 3. Logged over a one week pre-installation period and again over a one week post-installation period.

Table 2: Evaluation Measurements – RO/DI

Equipment monitored	Ultra-filtration units (2)
Parameter measured	1. Average daily water use. 2. Average RO Permeate flow. 3. Average RO Concentrate Flow 4. Time of use profile
Measurement equipment	1. Permanent in-line water meter on input lines. Log sheet with monthly readings will be provided by customer. 2. Permanent flowmeter in equipment control panel. Log sheet with monthly readings will be provided by customer. 3. Permanent flowmeter in equipment control panel. Log sheet with monthly readings will be provided by customer. 4. Electronic motor logger
Installation method	1. NA - previously installed by customer 2. NA – integral to control panel. 3. NA – integral to control panel. 4. Strapped to RO unit pump as appropriate
Observation frequency	1. Logged monthly by customer 2. Logged monthly by customer 3. Logged monthly by customer 4. Every state change (on or off) for a minimum of one week
Measurement duration	1. Pre-installation: Nov. 13, 2008 until one month prior to when new installation is begun. 2. Post-installation: Beginning with first log after installation has been completed, with monthly readings taken at least two more times.

Sampling Strategy

No sampling will be required for this effort.

Schedule

The autoclave kits for Measure 1 were installed in late May 2009. The schedule for making the RO/DI modifications for Measure 2 is unknown at this time, but is expected to occur in the summer or fall of 2009. The post-retrofit period will begin with the first monthly log entry after the new stages have been installed and will continue for at least two months.

Data Products

We will produce the following data products as part of the evaluation:

1. Pre and post water usage data, including both time-of-use and cumulative volumes.
2. Excel workbook containing calculations of evaluated average daily water savings.
3. Embedded Energy Calculator with annual water savings and corresponding energy savings profiles.

8.3 Research/Production Facility (S3) M&V Plan

SITE-SPECIFIC MEASUREMENT AND VERIFICATION PLAN

SDG&E/SCDWA LARGE CUSTOMER AUDIT PROGRAM RESEARCH/PRODUCTION FACILITY S3

September 18, 2009

SUMMARY INFORMATION

PROJECT

Program Name	SDG&E/SCDWA Large Customer Audit Program
Measure Type	Convey clean wastewater to boilers
Customer Name	
Site Name	S3
Site Address	

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

INVESTOR-OWNED UTILITY MANAGER

Name		**Telephone**	
E-mail		**Company**	

WATER AGENCY

Name		**Telephone**	
E-mail		**Company**	

SITE LEAD

Name		**Telephone**	
E-mail		**Company**	

Background

SDG&E and SCDWA's Large Customer Audits for Energy and Water Conservation Program (Audit Program) offers assistance to customers for identification and implementation of water efficiency improvements.

An audit of the S3 production facility identified potential water reuse opportunities in which wastewater from high-quality discharge streams could be rerouted to supply boiler makeup water.

The following M&V plan documents our planned approach for evaluating water savings from this measure. It is based upon the best information currently available, and is subject to change as the project proceeds.

Measure Description

Measure – Divert high-quality wastewater to boiler

This measure involves conveying 4 separate high-quality discharge streams to a storage tank for boiler makeup water to displace use of potable water.

Pre-retrofit Equipment and Operation

The water audit identified approximately 52,400 gallons per day of water currently being discharged to wastewater or Brine lines from cleaning, blowdown and clean steam generation processes that exceed minimum quality standards for use as boiler makeup water. The four boilers operate twenty-four hours per day, seven days per week and are supplied with 43,000 to 58,000 gallons per day of treated and softened potable water.

Post-Retrofit Equipment and Operation

The measure requires installation of two new storage tanks, along with collection pipelines, valves and conductivity meters. Discharge from cleaning processes in two separate buildings will be piped to a 6,500 gallon tank while discharge from water-for-injection stills blowdown and clean steam generation located in closer proximity to the boilers will be conveyed to a 1,500 gallon tank. Conductivity meter and valves will divert wastewater discharge to the storage tanks when water quality is adequate for boiler makeup water use.

Variability in Schedule

There was reportedly no variation in schedule from week to week. No change in hours of operation is being proposed.

Annual Ex Ante Measure Savings

Estimated water savings computed in the water audit was 52,400 gallons per day.

Algorithms for Estimating Water Savings

Measure –

Utility Algorithms

The water audit estimated water savings according to the table below.

High-quality discharge stream	Approximate Flow (gal/day)
Warehouse Bldg cleaning process	25,000
Other Bldg cleaning process	12,000
WFI Stills Blowdown	14,000
Clean steam generators	1,4000
Total Recoverable Discharges	**52,400**

Evaluation Algorithms

The evaluation team will estimate verified water savings through simple spreadsheet calculations. The basic algorithm will be as follows:

*Average annual water savings = average daily flow of reclaimed water * 365 days/year*

We will then input our evaluated average daily water savings into the Energy Savings and Avoided Costs Calculator prepared by Jeff Hirsch (Embedded Energy Calculator) to compute annual water savings. The Embedded Energy calculator requires four input parameters to compute annual water savings – daily water savings profile, day type multiplier, monthly multiplier, and average savings per day. An additional input parameter, measure life, is then used to compute lifetime savings. The input data for the Embedded Energy calculator are described below.

- Daily water savings profile: accounts for differences in water savings between hours of the day.
- Day type multiplier: accounts for differences in water savings between weekdays and weekends.
- Monthly multiplier: accounts for differences in water savings between months of the year.
- Measure Life (yrs): accounts for the life of the equipment; we will apply the measure life used by the IOU for this technology.

Data Collection

The table below describes the parameters that will be monitored.

Table 15: Evaluation Measurements – Convey clean wastewater to boilers

Equipment monitored	Piping from reclaimed water storage tank to boilers
Parameter measured	Reclaimed water flow

Measurement equipment	Signet 8550 Flow Transmitter
Installation method	Meter installed on pipeline that conveys reclaimed water to boiler
Observation frequency	15 minute interval
Measurement duration	1 week post-installation

Sampling Strategy

No sampling will be required for this effort.

Schedule

The installation of equipment to convey clean wastewater to the boilers is scheduled to be complete by the end of 2009. Metering will be in place in early 2010 for post-installation data collection.

Data Products

We will produce the following data products as part of the evaluation:

1. Post reclaim water usage data, including both time-of-use and cumulative volumes.
2. Excel workbook containing calculations of evaluated average daily water savings.
3. Embedded Energy Calculator with annual water savings and corresponding energy savings profiles.

8.4 Research/Production Facility (S4) M&V Plan

SITE-SPECIFIC MEASUREMENT AND VERIFICATION PLAN

SDG&E/SCDWA LARGE CUSTOMER AUDIT PROGRAM

RESEARCH/PRODUCTION FACILITY S4

August 20, 2009

SUMMARY INFORMATION

PROJECT

Program Name	SDG&E/SCDWA Large Customer Audit Program
Measure Type	Reverse Osmosis Unit Efficiency Upgrades
Customer Name	
Site Name	S4
Site Address	

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

INVESTOR-OWNED UTILITY MANAGER

Name		**Telephone**	
E-mail		**Company**	

WATER AGENCY

Name		**Telephone**	
E-mail		**Company**	

SITE LEAD

Name		**Telephone**	
E-mail		**Company**	

Background

SDG&E and SCDWA's Large Customer Audits for Energy and Water Conservation Program (Audit Program) offers assistance to customers for identification and implementation of water efficiency improvements.

An audit of the S4 Facility identified two measures, cooling tower improvements and reverse osmosis unit recalibration.

The following M&V plan documents our planned approach for evaluating water savings from the reverse osmosis unit recalibrations only. It is based upon the best information currently available, and is subject to change as the project proceeds. Cooling tower improvements will not be evaluated as part of this plan because installation has already been completed.

Measure Description

Reverse Osmosis Unit Efficiency Upgrades

This measure involves adjustments to reverse osmosis units to increase the efficiency of pure water production. More efficient production results in less water waste.

Pre-Retrofit Equipment and Operation

There are eight (8) separate RO units at the facility located within buildings CB1 through CB7, producing ultra-pure water for lab R&D use. The units operate intermittently and are operated by automatic level controllers located in the storage tanks. There are three units that have a specified product flow rate of 4 gpm, one at 1.5 gpm, and four at 1 gpm. All units are intended to operate at 50% recovery rate. However, based on visual observations as part of the water audit, it was reported that at least the 1.5 gpm unit was operating at approximately a 38% recovery rate. No additional information was provided in the water audit regarding the recovery rate for the other seven units. Regular logs are reportedly kept for most if not all of the units, showing makeup water and reject. However, no copies of the logs were provided with the audit and it is therefore unclear exactly what information will be available from these logs.

Post-Retrofit Equipment and Operation

Each of the units is to be recalibrated as necessary to achieve a target 50% recovery rate.

Variability in Schedule

In the water audit, no variability was assumed in product flow rate over the year. To the extent that logs are available, variability over the year will be verified.

Annual Ex Ante Measure Savings

Estimated water savings computed in the water audit was 27,000 gal/yr (74 GPD), based on assumed current consumption of 108,450 gal/yr (297 GPD), and an estimated future water use of 81,000 gal/yr (222 GPD) as a result of recalibrating the unit. Savings were computed assuming a pre-installation requirement of 100 gallons of makeup water to produce 38 gallons of product (38% recovery rate), and a post-installation requirement of only 76 gallons to produce the same 38 gallons of product (50% recovery rate), resulting in water savings of approximately 25%.

Algorithms for Estimating Water Savings

Utility Algorithms

The vendor water audit estimated water savings through simple spreadsheet calculations. The basic algorithm is as follows:

Water savings = Pre-install annual consumption × (1- (Pre-install recovery rate / Post-install recovery rate))

Where:

- *Pre-install annual consumption,* as estimated by facilities personnel, was taken as 108,450 gallons per year.
- *Pre-install recovery rate (i.e. product flow/makeup flow)* is taken as 38% for all units.
- *Post-install recovery rate* is targeted at 50%.

Evaluation Algorithms

The evaluation team will estimate verified water savings through simple spreadsheet calculations. Savings for each of the eight systems will be computed separately and then added together. The basic algorithm will be as follows:

Projected annual water savings = Average daily pre-install water consumption × (1- (Pre-install recovery rate / Post-install recovery rate)) × *Days per year*

Where:

- *Average daily pre-install water consumption* will be computed from regular log entries of makeup water meter readings if they are available. If unavailable, measured makeup water flow in gpm will be multiplied by average measured run time in minutes per day, times 365 days per year.
- *Pre-install recovery rate* will be the average permeate flow divided by the average makeup water flow for the pre-install time period, either as recorded on the regular operator log or as field measured. As necessary, permeate flow may be either directly measured or computed by subtracting measured reject flow from measured makeup flow.
- *Post-install recovery rate* will be the average permeate flow divided by the average makeup water flow for the post-install time period, either as recorded on the regular operator log or as field measured. As necessary, permeate flow may be either directly measured or computed by subtracting measured reject flow from measured makeup flow.
- *Days per year = 365.*

We will then input our evaluated average daily water savings into the Energy Savings and Avoided Costs Calculator prepared by Jeff Hirsch (Embedded Energy Calculator) to compute annual water savings. The Embedded Energy calculator requires four input parameters to compute annual water savings – daily water savings profile, day type multiplier, monthly multiplier, and average savings per day. An additional input parameter, measure life, is then used to compute life time savings. The input data for the Embedded Energy calculator are described below.

Daily water savings profile: accounts for differences in water savings between hours of the day.

Day type multiplier: accounts for differences in water savings between weekdays and weekends.

Monthly multiplier: accounts for differences in water savings between months of the year.

Measure Life (yrs): accounts for the life of the equipment; we will apply the measure life used by the IOU for this technology.

Data Collection

The table below describes the parameters that will be monitored. To the extent that some of this information may be available from the equipment logs, that information may not need to be measured.

Table 1: Evaluation Measurements

Equipment monitored	Eight (8) Ultra-filtration units
Parameter measured	1. Average daily water use. 2. Average permeate and/or reject flow during operation 3. Average makeup water flow during operation 4. Time of use profile
Measurement equipment	1. Permanent in-line water meter on input lines if existing. Any log sheet with regular readings will be requested from customer. Note: If no makeup meter exists, measured makeup water flow (parameter #3) will be multiplied by logged minutes per day (as determined from parameter #4). 2. Permanent flowmeter in equipment control panel if existing. Any log sheet with regular readings will be requested from customer. If no permanent flowmeter for either permeate or reject flow exists, reject flow will be measured using an ultrasonic meter, a calibrated flow bag, or a temporarily installed in-line flowmeter as appropriate. 3. Permanent flowmeter if existing. Log sheet with regular readings will be provided by customer. Where no makeup flowmeter exists but an in-line makeup meter exists, flow through the existing makeup meter will be recorded over a 60 second interval using an electronic stopwatch. If no makeup water meter exists, flow will be measured using an ultrasonic flowmeter. 4. Time of use profile will be logged using a separate electronic motor logger for each unit.

Installation method	1. NA - previously installed by customer 2. Permanent flowmeter integral to control panel. Ultrasonic meter to be temporarily strapped to permeate or reject flow line as appropriate. Flow bag held under reject outlet in floor drain. Temporary in-line flowmeter temporarily attached to reject outlet at floor drain using rubber hose. 3. Permanent flowmeter integral to control panel. Ultrasonic meter temporarily strapped to makeup water line. 4. Electronic motor logger strapped to RO unit pump as appropriate.
Observation frequency	1. As logged by customer 2. Minimum of one minute 3. Minimum of one minute 4. Every state change (on or off)
Measurement duration	1. Log data for one year if available 2. Minimum of one minute 3. Minimum of one minute 4. Minimum of one week

Sampling Strategy

No sampling will be required for this effort.

Schedule

The RO recalibrations may begin immediately after the initial site visit has been completed. Time of use logging will cover a minimum of one week operation before and/or after recalibration.

Data Products

We will produce the following data products as part of the evaluation:

Pre and post water usage data, including both time-of-use and cumulative volumes.

Excel workbook containing calculations of evaluated average daily water savings.

Embedded Energy Calculator with annual water savings and corresponding energy savings profiles.

Reverse Osmosis Equipment Characteristics Data Sheet

Reverse Osmosis Equipment Characteristics Data Sheet

Date ________________

Job & Location ____________________________________

Data Collected By:________________

1. Equipment Make & Model ____________________
2. Equipment Serial # _______________________
3. Approximate Installation Date if Known _____________________
4. Dedicated Use ________________________
5. Bldg/Room __________________________
6. Nominal Pure Water Flow (gpm) ______________

Associated Meters with Readings:

1. ____
2. ____
3. ____
4. ____
5. ____

Notes:

Ultrasonic Water Metering Protocol and Data Sheet

Protocol for Use of Ultrasonic Water Metering

8/20/09 Draft

1. Check temperature of water pipe and enter on data sheet.

2. Check material, nominal diameter and classification of pipe, and enter on data sheet.

3. For outside dimension and wall thickness, either consult specification tables or measure, using ultrasonic thickness transducer for wall thickness. Enter on data sheet.

4. Install transducers on a section of straight pipe, with a minimum of 10 diameters unimpeded flow upstream and 5 diameters downstream if possible. If not possible, note on data sheet.

5. Check that sound speed and signal strength are within range (no error messages). Enter sound speed and signal strength on data sheet.

6. If logging, enter log begin time and date, programmed log end time and date, and data interval on data sheet, and set forward total to zero.

Ultrasonic Water Metering Data Sheet

Date _________________

Job & Location ______________________________________

Installer:_________________

Meter Make & Model________________

Transducer Model Number _______________

Meter Serial Number _____________________

Transducer Serial Numbers ____________________

1. Pipe Temperature _____________ F
2. Pipe Nominal Diameter _______________
3. Pipe Actual Diameter: Measured, Specified _________________
4. Pipe Wall Thickness: Measured, Specified _________________
5. Pipe Material: Copper, Carbon Steel, Cast Iron, PVC, SS, Other: __________
6. Pipe Classification/Schedule: K, L, DWV, 40, 80, Other: ___________
7. Unimpeded Diameters Upstream/Downstream _______/_________
8. Sound speed _______________
9. Signal Strength _______________
10. Observed Flow Range (gpm) _____________
11. Log Begin Date & Time ______________
12. Programmed Log End Date & Time _________________
13. Logging Interval _________________
14. Data Points Logged __________________
15. Actual Log End Date & Time __________________
16. Ending Total Gallons ____________________

Motor Logger Metering Protocol and Data Sheet

Protocol for Use of Motor Logger

8/20/09 Draft

1. Set the logger's internal clock (this may already have been done in the metering shop).
2. Record the installation date and time on the data sheet.
3. Choose an appropriate location to place the logger and attach it securely.
4. Set the logger's sensitivity level. Verify that the logger symbol is displayed when the monitored device is on, and that the symbol is blank when the monitored device is off.
5. Clear the logger's memory by pushing and holding the RESET switch.
6. Record the logger's location and serial number on a separate piece of paper for easy retrieval.
7. When the monitoring period is done, retrieve the logger. Record the removal date and time on the data sheet.
8. Check with facility personnel whether any unusual or anomalous events that would have affected the logged motor occurred during the metering period.
9. Connect the logger to a computer to retrieve the data.

Motor Logger Metering Data Sheet

Date _________________

Job & Location ______________________________________

Installer:_________________

Logger Make & Model________________

Logger ID Number _____________________

1. Motor/load to be metered _____________

2. Logger installation date and time _____________

3. Logger removal date and time _____________

4. Unusual conditions or events that might have affected metered data (elaborate as necessary):

8.5 Detention Center (S1) Site-Specific Report

SITE-SPECIFIC MEASUREMENT AND VERIFICATION REPORT

SDG&E LARGE CUSTOMER AUDIT PROGRAM: SITE S1, AAA AND BBB DETENTION FACILITIES

July 30, 2010

SUMMARY INFORMATION

PROJECT

Program Name	SDG&E Large Customer Audit Program
Measure Type	Efficient Toilets, Urinals, Aerators and Showerheads
Customer Name	
Site Name	Site S1, AAA and BBB Detention Facilities
Site Address	

PRINCIPAL SITE CONTACT

Name		**Telephone**	
E-mail		**Title**	

INVESTOR-OWNED UTILITY MANAGER

Name		**Telephone**	
E-mail		**Company**	

WATER AGENCY

Name		**Telephone**	
E-mail		**Company**	

SITE LEAD

Name		**Telephone**	
E-mail		**Company**	

Background

SDG&E's Water-Energy Pilot Large Customer Program offered financial incentives to help offset the cost of customer water efficiency improvements. One avenue that SDG&E used to develop projects for this program was to work with partner water utilities, such as the San Diego County Water Authority, to identify promising water-saving projects. This partnership was used to develop a water efficiency improvement project at a detention center in the San Diego area. The detention center includes the AAA and BBB Detention Facilities. The AAA Facility consists of both higher security dormitory style and cell block style housing complexes, while BBB Facility includes four lower security dormitory style buildings.

This M&V report documents the methodology used and findings from an evaluation of the water impacts from measures installed at the detention center.

Description of Building Types and Measures

Measures were implemented in four distinct building types. At the BBB Facility, measures were implemented in four identical dormitory style buildings (A, B, C, and D), as well as in the staff locker rooms. At the AAA Facility, measures were implemented in the two dormitory style structures (Buildings 1 and 2), as well as in the five cell blocks, Buildings 3, 4, 5, 6, and 8.

The following table outlines the four distinct building types monitored and the measures implemented in each building type. In addition to the measures listed below, a number of showerheads and aerators were anticipated in the plan but were not installed by the time metering was completed.

Table 2: Measures Implemented by Building Type

Facility Building Type	Measures Implemented	Fixtures Replaced
1 - BBB Dorms (4 buildings)	▪ High flow toilets & flush valves replaced with 1.28 gpf[11] toilets & Icon push button flush valves. ▪ Constant flow urinals & flush valves replaced with 0.125 gpf urinals & sensor flush valves.	32 toilets & valves 24 urinals & valves
2 - BBB Staff Locker Rooms (1 building)	▪ Existing tank toilets replaced with high efficiency dual flush (1.6/0.8 gpf) toilets.	6 toilets
3 - AAA Dorms (2 buildings)	▪ High flow toilet flush valves replaced with 1.6 gpf Icon push button flush valves. ▪ Constant flow urinal flush valves replaced with automatic timer controlled 0.5 gpf Icon flush valves.	48 toilet valves 24 urinal valves
4 - AAA Cell Blocks (5 buildings)	▪ High flow toilet flush valves replaced with 1.6 gpf Icon push button flush valves programmed to limit maximum number of flushes per hour.	500 toilet valves
ALL		**586 toilets** **48 urinals**

Note that the M&V plan included the replacement of 6 showerheads and 51 faucet aerators in the BBB Facility. However, these measures were not installed.

Separate metering was done to monitor representative water consumption and compute savings associated with each building type. Pre- and post-retrofit equipment and operation, schedule, and the ex ante savings basis for each building type are described below.

BUILDING TYPE 1 – BBB Dorms

The BBB Facility houses approximately 480 inmates in four identical dormitory style buildings. Each dormitory buildings contains two restrooms, each with four wall-hung flush valve toilets and three wall-hung flush valve urinals, for a total of 32 toilets and 24 urinals throughout all four dormitory buildings.

Pre-retrofit Equipment and Operation

The 32 original china flushometer toilets at the BBB dormitories were of various makes and models. In the one restroom visited, three of the existing toilets were labeled 1.6 gpf and one was unlabeled and appeared to be nominally 3.5 gpf. However, all appeared to be flushing at 3.5 gpf or higher. Ultrasonic metering was conducted in the pipe chase of one restroom, which indicated a median flush volume of 3.9 gpf for the existing toilets, based on analysis of a week's worth of data.

[11] gpf = gallons per flush.

The 24 original urinals at the BBB facility were china washdown units. There were no markings on these urinals indicating rated flush volume. The existing flush valves were manual diaphragm type, but had been modified to run continuously rather than manually because of concern that the inmates did not always flush. Ultrasonic metering conducted in two separate pipe chases serving two restrooms (ground floor restrooms of Buildings A and B), showed an average continuous flow to the urinals of approximately 1.12 gpm per restroom, or 0.37 gpm per urinal.

At the time metering was being conducted, it was understood that faucet aerators were not being installed due to concern that the inmates would remove them. For this reason, faucet aerator flow was not measured.

Post-retrofit Equipment and Operation

Dormitory toilet upgrades included replacement of all 32 existing toilet bowls with 1.28 gpf bowls and new Icon push button 1.28 gpf flush valves. The Icon flush valves are solenoid-operated valves that can be locked out by prison staff when necessary.

Dormitory urinal upgrades included replacement of all 24 existing urinals and continuously flowing flush valves with new 0.125 gpf urinals and matching 0.125 gpf sensor-operated flush valves. Installation of the sensor-operated urinal flush valves solved the problem of inmates not flushing.

Installations of toilets and urinals in the BBB Dorms began during June of 2009 and were completed during August 2009.

Variability in Schedule

The BBB facility is operated on a daily schedule that does not vary across the months of the year.

Annual Ex Ante Measure Savings

In the audit and subsequent analysis of water savings, the utilities produced an estimate of water savings for the flushometer toilets of 583,416 gallons per year. The ex ante estimate was based on 24 flushometer toilets.

The utilities produced an estimate of water savings for the urinal measure of 361,344 gallons per year. The audit savings calculation assumed a usage of 30 flushes per urinal per day. The flush volume for the existing urinals was assumed to be 1.5 gallons per flush. The flush volume for all new urinals was assumed to be 0.125 gallons per flush. At the time these estimates were produced, one can assume that the fixtures were not running continuously.

BUILDING TYPE 2 – BBB Locker Rooms

This measure included the replacement of six existing tank toilets located in the staff locker rooms with 0.8/1.28 gpf dual flush tank toilets, and replacement of eight showerheads with new 1.5 gpm showerheads.

Pre-retrofit Equipment and Operation

The flush volume of the existing toilets was listed as 3.5 gpf in the audit report. This could not be verified as replacement of these toilets had already been completed before metering could begin.

However, since it was unclear whether these toilets were actually 1.6 gpf or 3.5 gpf, the audit value of 3.5 gpf is used for savings calculation purposes.

Flow rates for four of the eight existing showerheads were measured, averaging 1.3 gpm, indicating little if any potential savings from replacement of these showerheads. The observed low flow of the existing showerheads appeared to have been caused by calcium buildup in the heads.

Post-retrofit Equipment and Operation

The six replacement tank toilets were manufactured by Caroma. They are dual flush toilets rated at 0.8 gpf for the lower volume option and 1.28 gpf for the higher volume flush. Toilet replacements were completed before metering began in June 2009.

New showerheads were not installed before metering in this building was completed.

Variability in Schedule

The BBB Facility is operated on a daily schedule that does not vary across the months of the year.

Annual Ex Ante Measure Savings

In the audit and subsequent analysis of water savings, the utilities produced an estimate of water savings for the tank toilets of 388,944 gallons per year. The ex ante estimate was based on 16 tank toilets.

BUILDING TYPE 3 – AAA Dorms

This measure included replacement of 3.5 gpf manual flush valves for inmate toilets with 1.6 gpf push-button-operated Icon flush valves, and replacement of constantly flowing urinal flush valves with 0.5 gpf Icon flush valves connected to a timer to automatically flush every five minutes during the day or every ten minutes at night.

Pre-retrofit Equipment and Operation

A total of 48 stainless steel wall mount toilets and 24 stainless steel urinals are located in inmate restrooms for Housing Units 1 and 2. Each of these two buildings contains 12 restrooms, each with two toilets and one urinal.

The 48 toilets in the inmate restrooms in Buildings 1 and 2 are stainless steel wall-mount units. There were no markings on the original toilets that indicated rated flush volume. The manual push button flush valves were 3.5 gpf diaphragm-type valves.

The 24 urinals in the inmate restrooms in Buildings 1 and 2 are stainless steel washdown units. There were no markings on the original urinals indicating rated flush volume. These urinals were being flushed with a continuous flow of water. The original concealed push button flush valves had been rendered non-operational due to concerns around inmates not flushing. Ultrasonic metering of the main cold water line serving Building 1 was conducted and showed a base continuous flow at all times (including the middle of the night) of approximately 20 gpm. Divided among the 12 urinals in the building, this indicated an average continuous flow of 1.67 gpm per urinal.

Post-retrofit Equipment and Operation

A total of 48 new 1.6 gpf Icon valves were installed on the toilets. These are push-button-operated and can also be remotely locked out by prison staff. The toilets themselves (apart from the valves) were not changed out.

A total of 24 new timer-actuated 0.5 gpf Icon valves were installed for the urinals, automatically flushing once every five minutes during the day and every ten minutes during the night. The urinals themselves (apart from the valves) were not changed out.

Installation of toilet and urinal flush valves was completed between September of 2009 and the end of January of 2010.

Variability in Schedule

Both facilities are operated on a daily schedule that does not vary across the months of the year.

Annual Ex Ante Measure Savings

The utilities produced an estimate of water savings for the toilets of 2,562,300 gallons per year. The ex ante savings assume the replacement of 48 toilets. Each toilet was flushed 40 times per day in the pre-retrofit period and 20 times per day in the post-retrofit period. The flush volume was reduced from 3.5 gallons per flush to 1.6 gallons per flush.

The utilities produced an estimate of water savings for the urinals of 376,412 gallons per year. The audit savings assumed the replacement of 25 urinals (including one in a staff restroom), each being flushed 30 times per day. The flush volume for the existing urinals was assumed to be 1.5 gallons per flush. The flush volume for all new urinals was assumed to be 0.125 gallons per flush.

BUILDING TYPE 4 – AAA Cell Blocks

There are five cell block buildings at the AAA Facility—Buildings 3, 4, 5, 6, and 8. Each building contains 100 cells, with each cell housing between one and three inmates and containing one toilet per cell. This measure included the replacement of 100 toilet flush valves in the each of the cell blocks of the AAA facility, for a total of 500 valves. Mechanical 3.5 gpf flush valves were replaced with Icon solenoid-operated 1.6 gpf valves that could be remotely limited to a maximum number of flushes per hour.

Pre-retrofit Equipment and Operation

The 500 original toilet flush valves in the detention area were manufactured by Delaney. They were mechanical diaphragm-type flushometer valves rated at 3.5 gpf. Each of the toilets was stainless steel combi-units (combined toilet/lavatory).

Post-retrofit Equipment and Operation

The new flush valves are manufactured by Icon. They are push button solenoid type valves rated at 1.6 gpf, and can be remotely programmed to limit the maximum number of flushes per hour.

Installation of toilet flush valves was completed between September of 2009 and the end of January of 2010.

Variability in Schedule

The AAA Facility is operated on a daily schedule that does not vary across the months of the year. Inmate population counts provided at the beginning and end of the period being monitored (six months apart) did not show a significant change. Average inmate count for the AAA Facility, not including BBB or Building 8, was 1,636 inmates for the period 7/1/09 – 8/31/09, compared with 1,628 inmates for the period from 1/28/10 – 2/18/10. Comparable counts for BBB and Building 8 were not provided. However, no indication was given that these would not have been similarly stable over the same time period.

Annual Ex Ante Measure Savings

The utilities produced an estimate of water savings for the toilets of 19,710,000 gallons per year. The audit savings assumed the replacement of 500 toilets. Each toilet was flushed 40 times per day in the pre-retrofit period and 20 times per day in the post-retrofit period. The flush volume was reduced from 3.5 gallons per flush to 1.6 gallons per flush.

Algorithms for Estimating Water Savings

Utility Algorithms

The utility audit estimated water savings through simple spreadsheet calculations for each measure proposed. The basic algorithm is as follows:

Water use = Number of fixtures x Nominal water use rate × Daily usage x 365

Where:

- *Nominal water use rate* was expressed as gpf for the toilets and urinals; and gallons per minute for the aerators and showerheads.
- *Daily usage* was expressed as number of flushes for the toilets and urinals; and minutes for the aerators and showerheads.

Water savings equaled the difference between calculated annual pre-installation water use and annual post-installation water use.

The ex ante savings estimate per the M&V Plan for all measures to be implemented was approximately 24.5 MGY (millions of gallons per year). This compares with a potential savings estimate contained in the 2006 "Water Systems Efficiency & Conservation Feasibility Study" for "Inmate Restroom Measures" of approximately 33 MGY.

Evaluation Algorithms

The evaluation team projected actual water savings through pre and post measurement and logging of water consumption and flow rates for typical building units and/or fixtures for which measures were implemented.

The basic algorithm is:

Annual savings = Sum of annual water savings from all four building types

Where:

Annual water savings for each building type = (Average pre-measure daily water use by logged building unit – Average post-measure daily water use by logged building unit) x Number of identical building units x 365

And:

Logged Building Unit is a discrete building or portion of a building with an accessible water line suitable for ultrasonic metering, supplying a known quantity and type of fixtures to be upgraded. One representative building unit of each type was logged.

For measures where it was impractical to conduct a building submetering analysis--such as tank toilets and showers--gallons per flush (for tank toilets), gallons per minute (for showers) and flushes per day (toilets) were measured using graduated containers, or logging in-line flow meters as appropriate.

In these cases the basic algorithm is:

Annual water savings per measure = Measured flowrate x Calculated daily use x 365

Where:

Measured flowrate is measured gpm or gpf for the representative sample, and calculated daily use is average minutes per day or flushes per day, extrapolated from logger data or best engineering estimates, as appropriate.

Data Collection

There were four building types at which conservation measures were implemented and we collected data. We describe the data collection process at each building type below. In general, short-term metering occurred between June 2009 and March 2010. Exact time periods for each metering activity are shown in the accompanying tables below. Printouts on number in inmates per day were also obtained over the logging periods for both AAA and BBB.

To supplement the building-specific data collection, we also obtained billed water usage figures from the San Diego County Sheriff's Department.

Building Type 1 (BBB Dorms)

At BBB an ultrasonic flowmeter was first placed temporarily on the 2" cold water line serving four toilets and three urinals on the ground floor restroom of Building A. The base observed flow was 1.37 gpm, taken to represent continuous flow to the urinals, which had been observed during a walk through at that time. The ultrasonic meter was then installed on the similar line in Building B and left there for over two months, during which time upgrades were completed, logging flow and total gallons once per minute. The baseline flow attributable to continuous flowing urinals in Building B was 0.72 gpm, for an average base flow for the two buildings of 1.12 gpm, or 0.37 gpm per urinal.

Data Collection Method

The following information was collected for this building type.

1. Pre and post-installation log of flow rate and total gallons for one restroom (selected as the only restroom with 110 V electrical outlet in the plumbing chase for long term use by the ultrasonic meter).
2. Pre-installation base flow rate for continuous flowing urinals for two restrooms (one the same as the restroom above plus one in the closest neighboring building).

The table below provides additional information concerning these measurements.

Table 3: Evaluation Measurements for BBB Dorms

Description	Evaluation
Equipment monitored	2" cold water line in plumbing chase leading to ground floor toilets and urinals
Parameter measured	GPM, total gallons
Measurement equipment	Panametrics ultrasonic flowmeter
Installation method	Clamp-on
Observation frequency	1 minute
Measurement duration (Pre)	28 days (6/27/09 – 7/24/09)
(Post)	28 days (8/5/09 – 9/1/09)

Sampling Strategy

Toilet and urinal water usage was logged at one restroom of one building. There are four buildings with two restrooms each with four toilets per restroom (32 toilets total). Therefore, the sample represents 12.5% of the total toilets replaced under this measure. Additionally, the base flow for constantly flowing urinals was measured momentarily in a second restroom, representing a 25% pre-installation sample of the urinals replaced. A higher percentage of urinals was sampled pre-installation because of the substantially higher savings contribution related to elimination of continuously flowing urinals.

Building Type 2 (BBB Staff Locker Rooms)

The toilets previously installed in the staff locker rooms had been observed prior to retrofit but were changed out before metering could be performed.

For the replacement toilets, a mechanical in-line water meter was installed separately on two (33%) of the dual flush Caroma Caravelle toilets that had just been installed in individual staff locker rooms. The first toilet was measured at 0.87 gpf for half flush and 1.36 gpf for full flush. The second toilet was measured at 0.84 gpf for half flush and 1.35 gpf for full flush, for an average of approximately 0.85 gpf for half flush and 1.36 gpf for full flush. The meter was then left in place with logger activated (one pulse per gallon) on the second toilet for approximately two months to document gallons per day and flushes per day.

Flow bag measurements were taken on the four original showerheads in the staff locker rooms, with measurements ranging from 0.4 gpm to 2.1 gpm and averaging 1.3 gpm. No new showerheads were installed before metering was completed.

Data Collection Method

The following information was collected for this building type. Note that toilets were changed out before pre-metering could be done, and showers had not been changed out by the time metering was complete.

1. Post gallons per flush for two toilets (33% of total) and gallons (or flushes) per day for one randomly selected toilet (17% of total).
2. Pre flow rates for four closest showerheads (50% of total)

The table below provides additional information concerning these measurements.

Table 4: Evaluation Measurements for BBB Staff Locker Rooms

Description	Evaluation
Equipment monitored	Existing tank toilets & showers
Parameter measured	Toilet gallons per flush (two toilets) Total gallons (or flushes) per day (one toilet) Shower gallons per minute (four showers)
Measurement equipment	Calibrated flow bag for shower flow, in-line water meter with pulse output and battery operated event logger for toilets
Installation method	In-line meter installed between wall stop and fixture
Observation frequency	Recorded pulse every 1 gallon used.
Measurement duration (Post)	Two months + (6/25/09 – 9/1/09) for toilet log

Sampling Strategy

Gallons per flush (both full flush and half flush) was measured for two toilets (33% of total). A mechanical water meter with pulse output and event logger was installed on one toilet (17% of total) and left in place for approximately two months to document gallons per day and average gallons per flush.

Building Type 3 - AAA Facility Dorms (Bldgs 1&2)

An ultrasonic water meter was installed on the main cold water line just downstream of the takeoff for the water heaters in Building 1 to obtain a pre-measure log, and then reinstalled for two weeks afterwards for a post-measure log.

Data Collection Method

The following information was collected for this building type.

1. Number of inmates currently housed the building being logged.
2. Log of pre and post installation total cold water usage for AAA Housing Unit 1 (closest of the two buildings of this type).

The table below provides additional information concerning these measurements.

Table 5: Evaluation Measurements for AAA Facility Dorms

Description	Evaluation
Equipment monitored	Cold water lines in restroom plumbing chases toilets and urinals Total building cold water usage
Parameter measured	GPM & total gallons
Measurement equipment	Panametrics ultrasonic flowmeter
Installation method	Clamp-on
Observation frequency	12 minute
Measurement duration Pre)	One month (7/1/09 – 7/31/09)
Measurement duration (Post)	One week (1/29/10 – 2/4/10)

Sampling Strategy

Total water usage logged for one building was measured, representing 50% of the toilets and urinals in this building type. Savings for the second building were assumed to be the same as the first building, adjusted for inmate count. Both buildings have identical floor plans and number and type of fixtures.

Building Type 4 - AAA Cell Blocks (Housing Units 3, 4, 5, 6, & 8): Measure 5 – Detention Toilet Flush Valve Replacement

An ultrasonic water meter was installed on the main cold water line just downstream of the takeoff for the water heater in Building 3 to obtain pre-measure logs, and then reinstalled for two weeks afterwards for the post-measure log.

Data Collection Method

The following information was collected for this building type (both pre and post-installation)

1. Flow rate and total gallons logged every 12 minutes for Building 3 (closest of the five buildings of this type).
2. Number of staff and inmates currently in building being metered.

The table below provides additional information concerning these measurements.

Table 6: Evaluation Measurements for AAA Cell Blocks

Description	Evaluation
Equipment monitored	Combination toilet/lavatory fixtures
Parameter measured	Total gallons per minute flow Total gallons
Measurement equipment	Ultrasonic flowmeter
Installation method	Strap on
Observation frequency	12 minutes
Measurement duration (Pre)	One month (7/1/09 – 7/31/09)
Measurement duration (Post)	Three weeks (1/29/10 – 2/19/09)

Sampling Strategy

Total water usage was logged for one building (20% sample size) for a period covering both pre and post installation. Similar savings, adjusted for inmate population, were assumed for the other four buildings of this type. All five buildings have identical floor plans and number and type of fixtures.

Evaluation results

The evaluation found that greater than expected water savings were realized from this project. The four building types and projected savings are given below. See attached summary spreadsheet for detailed calculations for each building type.

Table 7: Summary of Evaluation Results

Building Type	Sample Size	Measures	Fixtures Replaced	Evaluation Savings (GPY)	Adjusted Ex Ante Savings (GPY)	Realization Rate**
BBB Dorms	12.5% (1 of 8 restrooms)	1.28 gpf toilets & valves 0.125 gpf urinals & valves	32 toilets & valves 24 urinals & valves	9,119,160	944,760	9.65
BBB Staff Locker Rooms	16.7% (1 of 6 toilets)	1.6/0.8 gpf dual flush tank toilets	6 toilets	52,998	145,854*	5.05
AAA Dorms	50% (1 of 2 buildings)	1.6 gpf toilet flush valves 0.5 gpf urinal flush valves with timer control	48 toilet valves 24 urinal valves	19,227,497	2,253,516*	8.53
Bailey Cell Blocks	20% (1 of 5 buildings)	1.6 gpf toilet flush valves with limits on flushes/hour	500 toilet valves	42,812,199	19,710,000	2.17
ALL		**ALL**	**586 toilets** **48 urinals**	**71,211,853**	**23,054,130**	**3.09**

* Adjusted to actual fixture count installed.

** Realization rate is calculated as evaluation savings divided by adjusted ex ante savings.

Key Findings

Total evaluated savings for all measures was estimated to be approximately 71.2 MGY. This is substantially greater than the approximate 23.05 MGY adjusted ex ante savings estimate and the 33 MGY savings estimate in the original Feasibility Study, but is consistent with the overall reduction in water use documented by the facility billing history (see discussion and Figure 1 below). This represents a realization rate, compared with the ex ante savings estimate of 3.09.

Much of the high savings can be attributed to the discontinuation of constantly flowing urinals in both the AAA and BBB facilities. We estimate that constantly flowing urinals consumed approximately 25 MGY of water. The balance of the savings can be attributed to better than expected results for the electronic flush valve control systems installed in the cell blocks. This measure not only reduced the gallons per flush, but also reduced the maximum permitted number of flushes per hour per cell, which appears to have substantially reduced both the volume and the frequency of flushes.

The projected savings of around 71.2 MGY (approx. 6,000 KGAL/month) computed in this report agrees best with the documented reduction in billed water use, when one compares November - March 2009-10 (post implementation) with November - March of 2007-08 (see Figure 1). However, when compared with November – March 2008-09, the documented reduction in billed water use is even higher, around 10,000 KGAL per month.

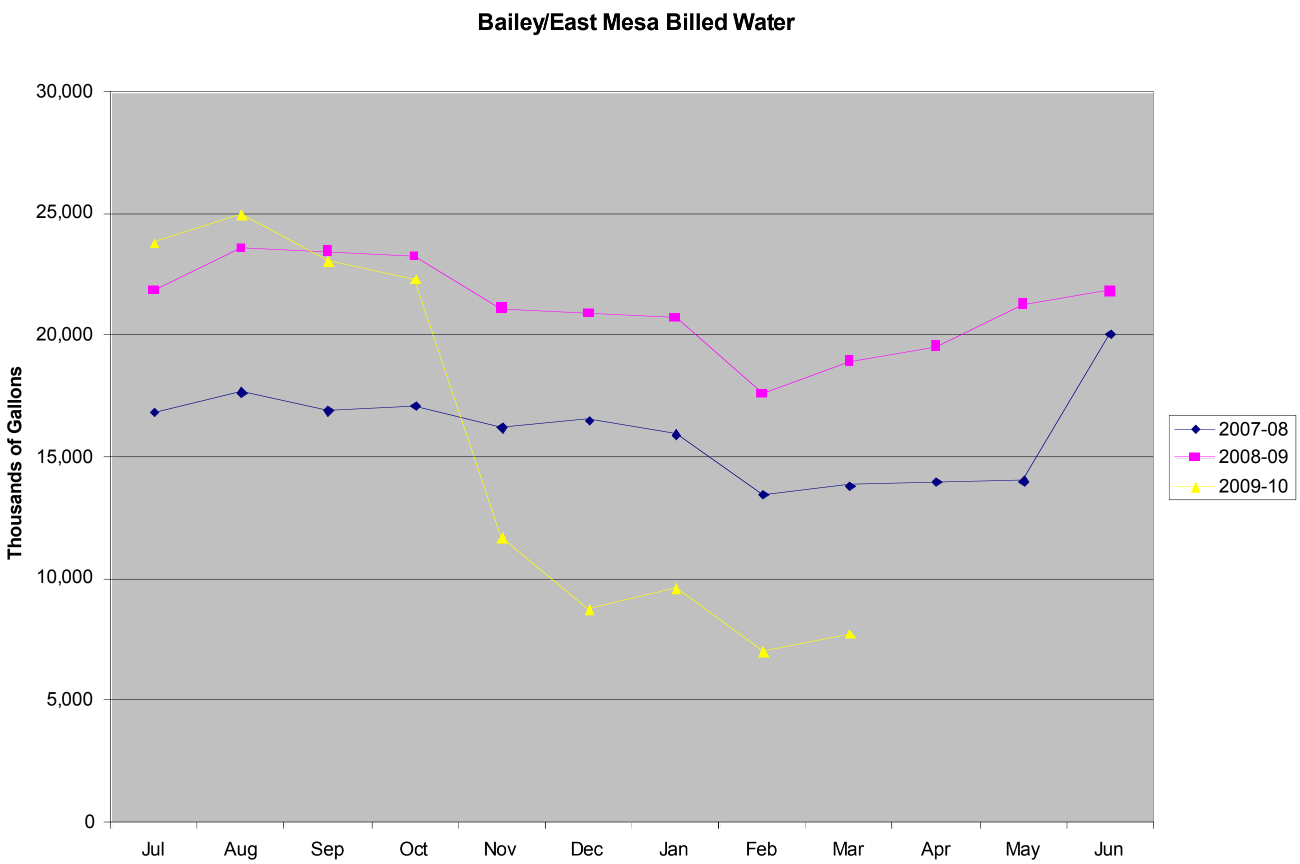


Figure 1: Historical Water Usage.

The proposed explanation for this is that the 2007-08 time period represents the more accurate baseline flow with which to reference savings, while the higher 2008-09 billed water usage represents a somewhat temporary maintenance related increase in one or more of the unmetered buildings. This temporary increase could be related to failing flush valves, implementation of continuously flowing urinals, leakage, or a combination of these and other factors that were resolved during implementation of the water conservation measures. For this reason it is suggested that the comparable 2007-08 time period be used as the baseline for confirming incentivized water savings, rather than the 2008-09 time period, in order to exclude non-incentivized, maintenance related savings.

As shown in Figure 2, calculated daily water consumption per inmate dropped from 81 GPD to 33 GPD for BBB, from 134 GPD to 35 GPD for the AAA dormitories, and from 119 GPD to 25 GPD for the AAA cell blocks.

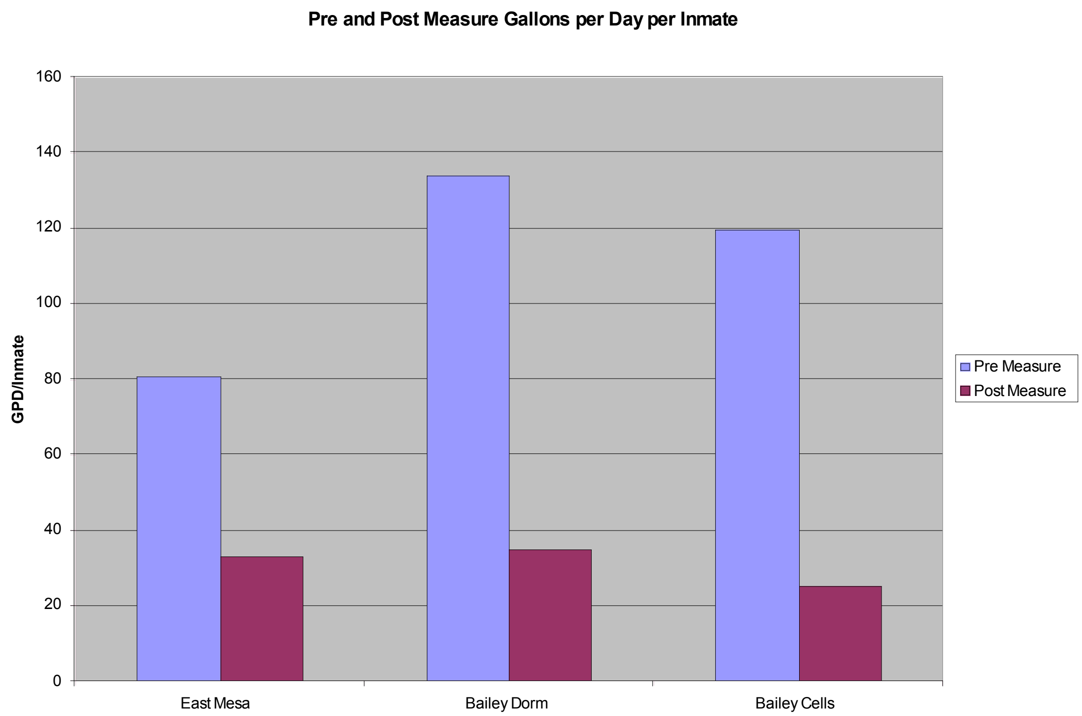


Figure 2: Evaluated Pre-Post Water Usage by Building.

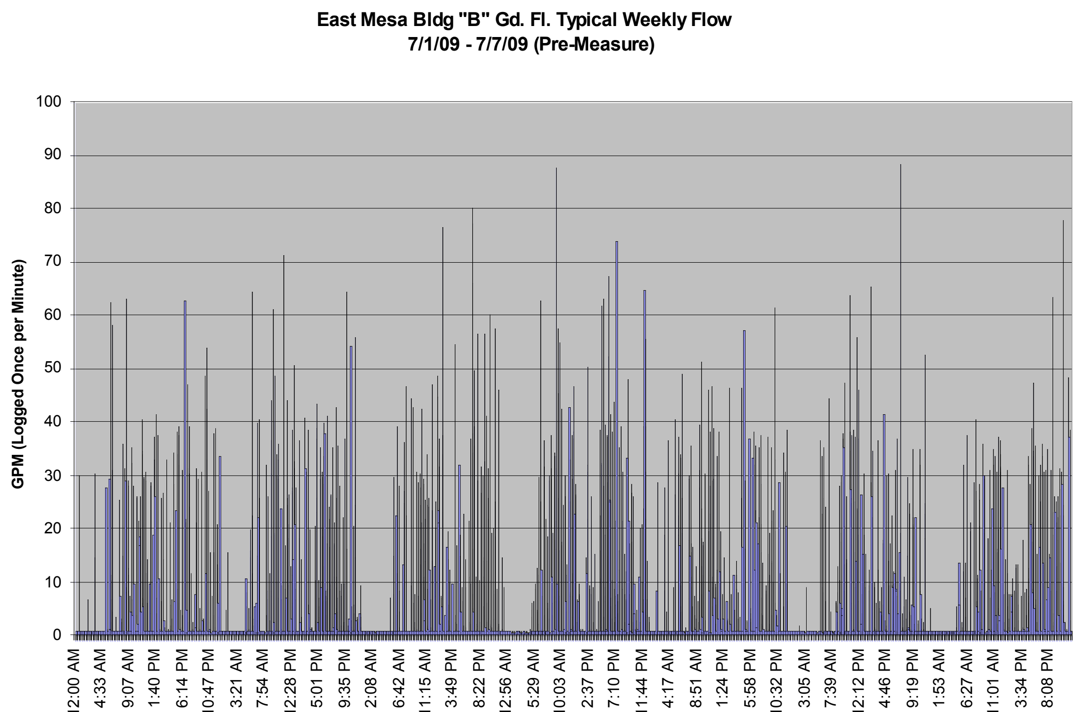
Supporting Analysis

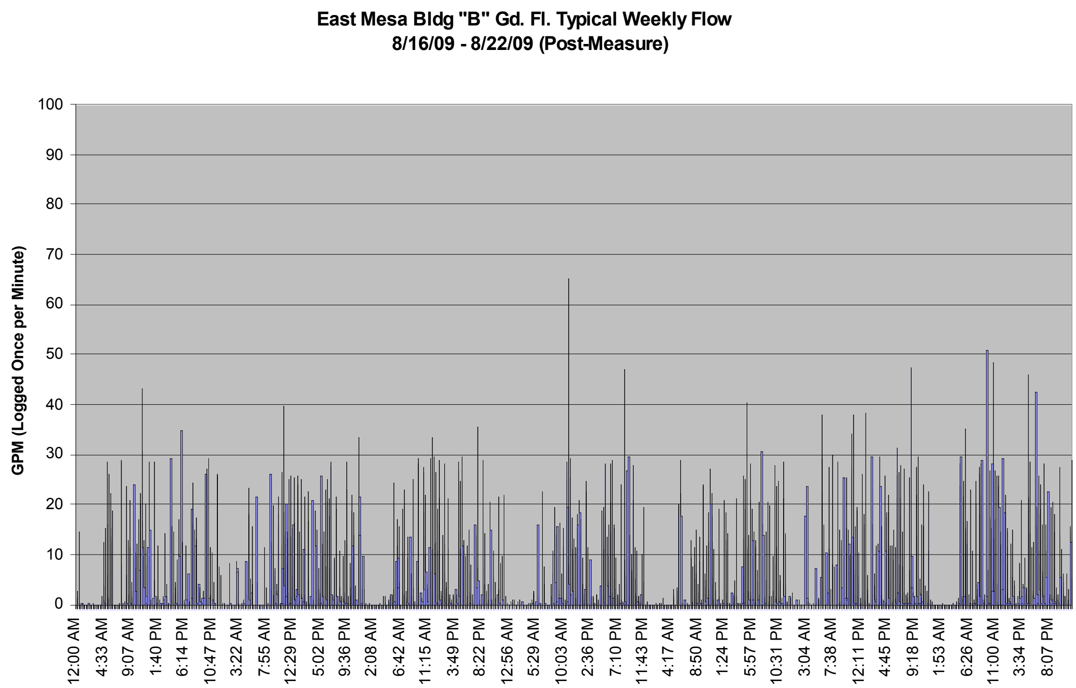
The primary savings calculations, analysis, and data for this project can be found in the workbook "[AAA]SummaryWorksheet(3-25-10).xls".

Additional Information

Graphs of BBB Dorm Restroom, typical weekly water use (Pre and Post)

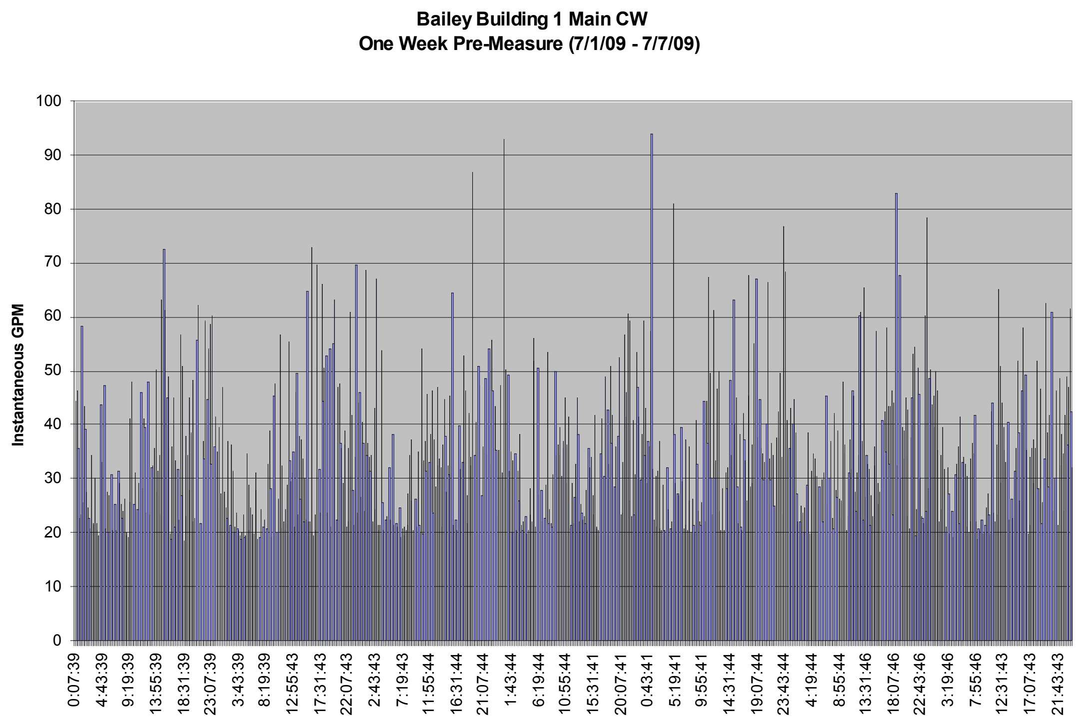
Note higher flow rates pre-measure.





Graphs of AAA Dorm Building, typical weekly water use (Pre and Post)

Note both higher flow rates pre-measure as well as pre-measure 20 gpm base flow from continuously flowing urinals.


Bailey Building 1 Main CW
One Week Pre-Measure (7/1/09 - 7/7/09)
Instantaneous GPM
0
10
20
30
40
50
60
70
80
90
100
0:07:39
4:43:39
9:19:39
13:55:39
18:31:39
23:07:39
3:43:39
8:19:39
12:55:43
17:31:43
22:07:43
2:43:43
7:19:43
11:55:44
16:31:44
21:07:44
1:43:44
6:19:44
10:55:44
15:31:41
20:07:41
0:43:41
5:19:41
9:55:41
14:31:44
19:07:44
23:43:44
4:19:44
8:55:44
13:31:46
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22:43:46
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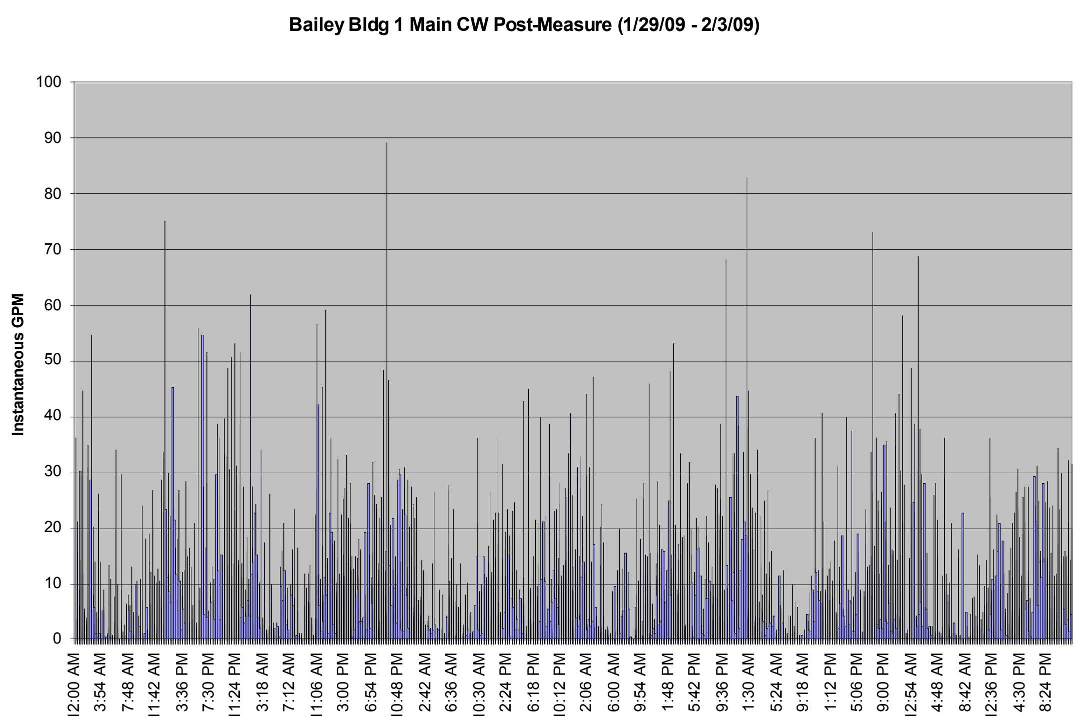
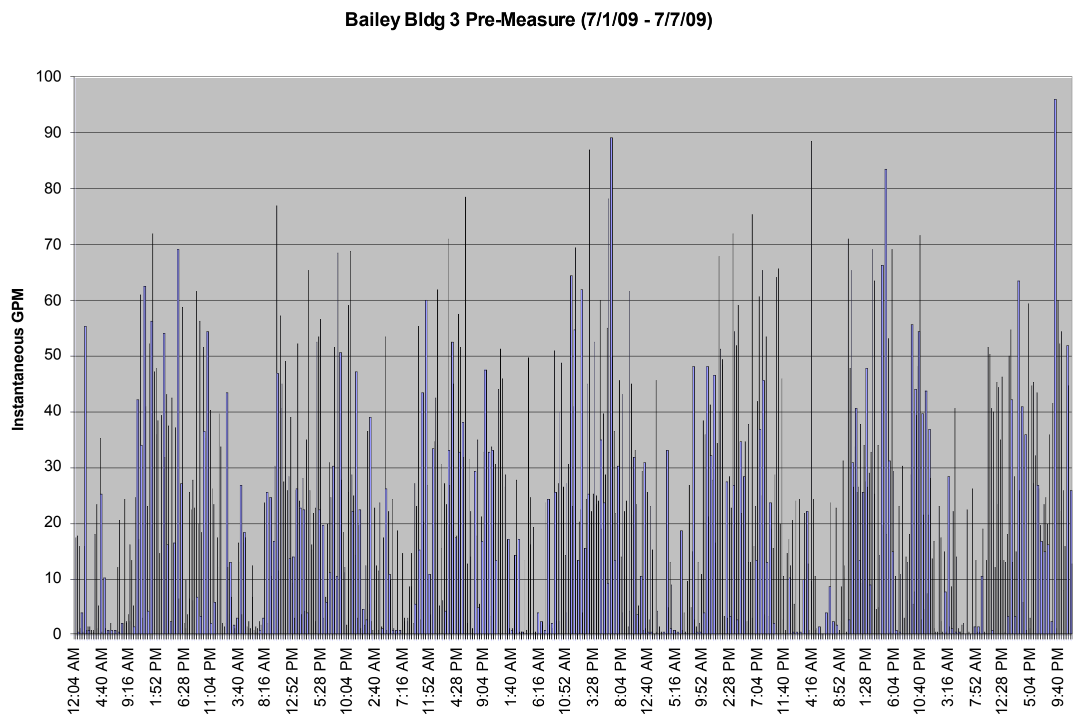
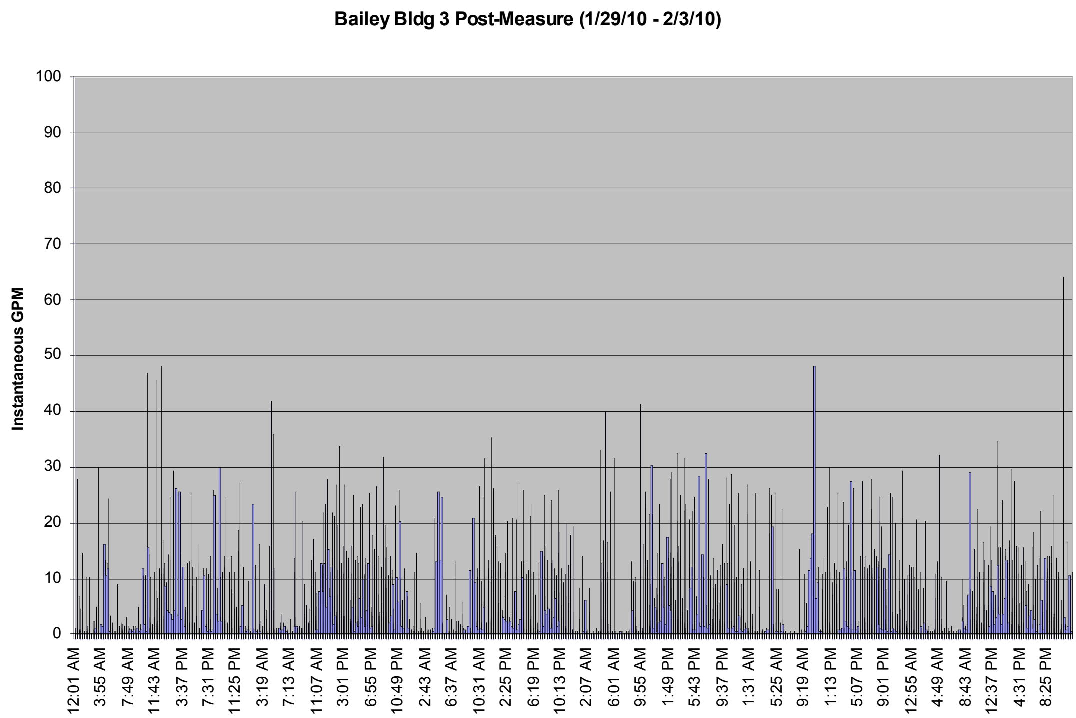
7:55:46
12:31:43
17:07:43
21:43:43


Bailey Bldg 1 Main CW Post-Measure (1/29/09 - 2/3/09)
Instantaneous GPM
0
10
20
30
40
50
60
70
80
90
100
12:00 AM
3:54 AM
7:48 AM
11:42 AM
3:36 PM
7:30 PM
11:24 PM
3:18 AM
7:12 AM
11:06 AM
3:00 PM
6:54 PM
10:48 PM
2:42 AM
6:36 AM
10:30 AM
2:24 PM
6:18 PM
10:12 PM
2:06 AM
6:00 AM
9:54 AM
1:48 PM
5:42 PM
9:36 PM
1:30 AM
5:24 AM
9:18 AM
1:12 PM
5:06 PM
9:00 PM
12:54 AM
4:48 AM
8:42 AM
12:36 PM
4:30 PM
8:24 PM

Graphs of AAA Cell Block Building, typical weekly water use (Pre and Post)

Note much higher flow rates pre-measure.




Bailey Bldg 3 Post-Measure (1/29/10 - 2/3/10)
Instantaneous GPM
100
90
80
70
60
50
40
30
20
10
0
12:01 AM
3:55 AM
7:49 AM
11:43 AM
3:37 PM
7:31 PM
11:25 PM
3:19 AM
7:13 AM
11:07 AM
3:01 PM
6:55 PM
10:49 PM
2:43 AM
6:37 AM
10:31 AM
2:25 PM
6:19 PM
10:13 PM
2:07 AM
6:01 AM
9:55 AM
1:49 PM
5:43 PM
9:37 PM
1:31 AM
5:25 AM
9:19 AM
1:13 PM
5:07 PM
9:01 PM
12:55 AM
4:49 AM
8:43 AM
12:37 PM
4:31 PM
8:25 PM

Appendix 9: SDG&E Recycled Water Pilot Program

9.1 M&V Plan

RECYCLED WATER PILOT PROJECTS MEASUREMENT & EVALUATION PLAN

Introduction

This document is intended to be the Measurement and Evaluation Plan for all six of the recycled water pilot projects. All six projects are very similar. All projects involve sites that currently use potable water for irrigation and will be changing to use of recycled water for irrigation. None of the projects discharge to a wastewater treatment plant.

Summary project information for each of the six sites is provided in Attachment A.

Measure Description

Efficiency Improvement: The Recycled Water Pilot Projects (RWPP) will result in potable water savings by changing from current use of potable water to the use of recycled water for irrigation. Six sites have been selected to participate in the RWPP. The sites in the pilot program are highway and other road right-of-way areas and park areas. Currently, all six sites use potable water for irrigation. By participating in the RWPP, those sites will discontinue using potable water for irrigation and will instead use treated wastewater (recycled water) for irrigation. Recycled water receives conventional wastewater treatment and then is subjected to additional treatment in order to be authorized by the California Dept. of Health Services to be used for irrigation. One of the six sites is located in the City of Carlsbad. The remaining five sites are located in San Diego.

Pre-retrofit Equipment and Operation: At the current time, the potable water used for irrigation is conveyed to the sites and is metered using conventional potable water pipe and utility meters. During the pre-retrofit inspections, the pre-retrofit irrigation equipment, configuration and control system at each site will be investigated and documented. Some control systems may be based solely on a time clock, in which on specified days, at specified times the irrigation system is turned on. Other control systems may incorporate weather information so that the amount of irrigation water used is affected by the evapotranspiration rate. Whether or not there is seasonal variation in the setting of the control systems will also, be investigated. Information describing the irrigation system operation during the previous two years will be obtained for those sites where such information is available.

Post-retrofit Equipment and Operation: Special color-coded (purple) piping and meters are used to identify when such equipment contains recycled water. For each of the six RWPP a connection will be made to the recycled water distribution system and purple piping installed to convey the recycled water to the irrigation site. A purple meter will be installed at each site to measure the amount of recycled water used. No change in the irrigation system configuration is anticipated, except for two sites that will continue to use potable water for specific end uses. One site has a small kitchen and restroom facilities. The second site has sports fields that need to continue to be irrigated with potable water. Appropriately sized potable water lines and meters will be installed at those sites that will continue to use some potable water. Whether or not there will be a change to the operation of the irrigation system as a result of changing to the use of recycled water will be investigated. The customer will be installing the piping at some of the sites. A contractor may be retained to do the installation work at other sites. The operation of the post-retrofit irrigation control system will be described, including seasonal, monthly, day of the week and time of day operation.

Variability to the Irrigation Schedule: Weather data will be obtained for both the pre- and post-retrofit periods for each site. These data will be used to assess seasonality to the control system and to provide information for comparing water use for the same month of different years.

Annual Ex Ante Measure Savings: The amount of annual water savings estimated by the IOU for each site and the basis for that estimate will be obtained. Those savings will be compared to the savings determined by this M&V analysis. If there are any discrepancies, the reason(s) for those differences will be investigated.

Algorithms for Estimating Water Savings for Each Measure

The annual potable water savings achieved by the pilot project during the first year of operation will be evaluated for each site. Both the pre-retrofit and the post-retrofit data will be used in the analysis. Two methodologies will be used for estimating the water savings. One methodology will apply to sites at which no potable water was used after the conversion to recycled water. The methodology for estimating the potable water savings at sites where some potable water use continued after the conversion to recycled water will be similar, but will involve a few additional parameters. Water utility data, both potable water and recycled water use data, will be obtained for both the pre- and post-retrofit periods of data collection. Only post-retrofit data collected through the summer of 2009 will be utilized in order to complete the potable water savings analysis within the project schedule.

Estimating Potable Water Savings for Sites where all Water Use is Changed to Recycled Water: The methodology described below for estimating potable water savings will be repeated for each site of this type. First, 24 months of historical potable water use data will be aggregated by month. Using information obtained during the on-site inspections, from reviewing operations logs, interviewing agency staff, comparing information about weather variation and other factors, differences between the water consumption for the same month of different years will be clarified. Other factors to be investigated to explain difference in water use by month will include both intentional changes in water use, such as a change in the irrigation schedule and un-intentional changes, such as a break in an irrigation line. The results of this effort will produce a baseline 'expectation' of the amount of potable water use that would be expected on the corresponding month after making the switch to use of recycled water for each of the 12 months of the year.

Based on information obtained during the post-retrofit site inspection, reviewing the operations log, interviewing agency staff, comparing weather information and investigating other factors, the difference between the amount of recycled water used will be compared to the baseline 'expectation'. Both intentional and unintentional water use changes will be investigated to explain differences between the baseline 'expectation' and actual recycled water consumption. One intentional change that may occur is a reduction in total gallons of water used for irrigation over a comparable period of time. This could occur because when using recycled water, run-off onto impermeable surfaces is not allowed. Also, irrigating for a period of time such that 'ponding' of recycled water occurs, is not allowed. Due to these and other constraints on the use of recycled water, agency staff may adjust the irrigation control system to reduce slightly the total gallons of water to be used for irrigation after the switch to use of recycled water has been made.

The 'expected' baseline potable water use will be compared to the recycled water use for corresponding months. After differences between the expected baseline water use and recycled water use have been investigated, a correlation will be developed to describe the relationship. That correlation value will be used to estimate recycled water use for the months that metered recycled water use data are not available. Specifically, this information will be needed for all sites where the switch to recycled water provides less than 12 months of data by the summer of 2009. Using the expected baseline potable water use and the correlation developed above, an estimate of the amount of recycled water that would be used will be calculated for those months for which metered data of recycled water use are not available. The sum of the 12 months of recycled water use will be the potable water savings.

Estimating Potable Water Savings for Sites with both Potable and Recycled Water Use: The methodology for estimating the potable water savings for sites with both potable and recycled water use is similar to the methodology above, but is a little more complex. First, the 24 months of historical potable water use data will be aggregated by month. A broad range of factors will be investigated in order to explain any difference in water consumption for each corresponding month. Using information obtained during the on-site inspections, from reviewing operations logs, interviewing agency staff, comparing information about weather variation and other factors, the difference between the water consumption for the same month will be clarified. Factors to be investigated will include both intentional changes in water use, such as a change in the irrigation schedule and un-intentional changes, such a break in an irrigation line. The results of this effort will produce a baseline 'expectation' of the amount of potable water use that would be expected in the corresponding month after making the switch to recycled water for each of the 12 months of the year, except that the baseline 'expectation' needs to be reduced by the amount of potable water that continues to be used after the switch to use of recycled water for irrigation. Consequently, it will be important to collect both historical information about the 'operation' and use of facilities that will continue to use potable water after the post-retrofit has been completed. The post-retrofit potable water consumption that is available at the end of summer 2009 will be obtained. The post-retrofit potable water consumption data, discussions with agency staff and other information will be used to estimate the amount of potable water that would be used in each of the 12 months following the change to recycled water for irrigation. An adjusted, baseline expected potable water consumption will be estimated for each of the 12 months of the pre-retrofit period.

Based on information obtained during the post-retrofit site inspection, reviewing the operations log, interviewing agency staff, comparing weather information and other factors, the difference between the amount of recycled water use will be compared to the adjusted baseline expected potable water use for that month. Both intentional and unintentional water use changes will be investigated to explain differences between the baseline 'expectation' and actual recycled water consumption. As described previously, both intentional and unintentional water use changes will be investigated to explain differences between the adjusted, baseline expected water use and the actual amount of recycled water used.

The adjusted, baseline expected water use will be compared to the recycled water use for corresponding months. After differences between the adjusted, baseline expected water use and actual recycled water use have been investigated, a correlation will be developed to describe the relationship. That correlation value will be used to estimate recycled water use for the months that metered recycled water use data are not available. Specifically, this information will be needed for all sites where the switch to recycled water provides less than 12 months of data by the summer of 2009. Using the adjusted, baseline expected water use and the correlation developed above, an estimate of the amount of recycled water that would be used will be calculated for those months for which metered data of recycled water use are not available. The sum of the 12 months of recycled water use will be the potable water savings for the first post-retrofit year.

Note on Embedded Energy Impacts

It is important to note there is an additional embedded energy component to the production of recycled water that does not apply to the other pilot projects, such as the Large Customer Audits. The additional embedded energy component results from the fact that the recycled water must undergo additional wastewater treatment as compared to 'normal/conventional' wastewater treatment. Recycled water undergoes several additional treatment processes before it can be recycled. There are significant energy requirements in providing that additional treatment. While recycled water has this additional embedded energy requirement, it also has one less embedded energy component compared to other pilot projects, there is no energy input to make potable water from the source water. It is unlikely this energy savings is as great as the energy use for the additional treatment prior to use as recycled water. In addition, the embedded energy in conveyance of the water is very different for the recycled water projects then the other pilot projects.

Data Collection

Site Specific Input Information: The following information will be obtained for each site for the pre-retrofit period:

- Monthly potable water use for the 24 months prior to the post-retrofit
- Seasonal, weekly and daily irrigation schedule during the 24 months
- Description of control system settings and operation
- Documentation of the baseline irrigation system configuration
- Description of intentional changes to the irrigation schedule over the 24 months
- Description of un-intentional changes to the irrigation system during the previous 24 months
- Changes to the grounds/plantings irrigated during the 24 month period
- Operations logs (to be reviewed)
- Manufacturer and model number of the potable water meter
- A map of the area irrigated with potable water
- Description of facilities that will continue to be supplied with potable water after the conversion to use of recycled water for irrigation, if any
- Description of any other changes to the irrigation system or grounds to be irrigated during the 12 months after the retrofit

The following information will be obtained for each site for the post-retrofit period:

- Monthly recycled water (RW) use
- Monthly potable water use, if any
- Documentation of the post-retrofit irrigation configuration
- Description of control system settings and operation

- Description of intentional changes to the irrigation schedule
- Description of un-intended changes to the irrigation system
- Changes to the grounds/plantings
- Operations logs (to be reviewed)
- Manufacturer and model number of the RW meter and potable water meter, if any
- A map of the area irrigated with RW
- Description of facilities that were supplied with potable water, if any
- Description of potable water system controls, if any

Data Collection Method: The above data and information will be obtained via several methods. A pre-retrofit site inspection will be conducted for as many sites as possible to observe baseline conditions for important aspects of the affected irrigation system and its operation. All relevant agency staff members will be interviewed, some during the site inspection and others via telephone. Email, fax and postal services will be used for conveying additional information. Other sources of information that will be used as appropriate include: operations logs, utility billing records, construction plans, and manufacturers' literature. At this time, it appears that no additional metering beyond the metering that will be installed by the customer and the utility will be needed. However, if additional water metering is needed, such meters will be installed. The on-site data collection form for the pre-retrofit inspection is provided in Attachment B.

A post-retrofit site inspection will be conducted at all sites to observe port-retrofit conditions for important aspects of the affected irrigation system and its operation. All relevant agency staff members will be interviewed, some during the site inspection and others via telephone. Other sources of information that will be used to collect post-retrofit information include: operations logs, utility billing records, as-built construction plans, and manufacturers' literature.

Sampling Strategy: At this time it is anticipated that a census of the RWPP will be conducted. Therefore, no sampling strategy applies to this evaluation.

Data Products

The following products will be produced during this evaluation for each site:

- Aggregated and unaggregated 24 months of historical potable water use
- Irrigation system discription and control schedule
- Potable and recycled water meter manufacturer and model number
- Map of the area irrigated with potable water (as available)
- Map of the area irrigated with recycled water (as available)
- Photographs of the site
- Weather data, if applicable
- Post-retrofit monthly recycled water use, by month
- Post-retrofit potable water use, if any, by month
- Correlation factor for potable water to recycled water
- Chronology of intentional and unintentional events affecting water use for the 24 months of pre-retrofit period and the post-retrofit period through summer 2009
- Estimated annual potable water savings by month

Schedule

Activity	Completion Date
Submit M&V plan	September 22, 2008
Conduct pre-retrofit site inspections	September 30, 2008
Obtain and aggregate historical water use data	March 2009
Obtain post-retrofit water use data	September 2009
Develop correlation factor for potable to recycled water	October 2009
Estimate annual potable water savings by month	October 2009

Attachment A:

Summary Project Information (Deleted to maintain customer confidentiality)

Attachment B:

Pre-Retrofit Site Inspection Questionnaire

Site: ______________________________ Date: ___________________________

Contact Name: _____________________ Contact Phone: __________________

1. Over the past 2 years has there been:

   A. Intentional change in the amount of irrigation water used due to change in:

   - Policy that changed hours of irrigation
   - Spray-head or distribution equipment
   - Planting changes or die-off so that more/less water is needed
   - Area served by the water meter
   - Maintenance program
   - Other reasons ____

   When did the change(s) occur, what was the duration and likely impact on potable water use?

   ____

   B. Other factors that potentially affected amount of irrigation water usage:

   - Does your control irrigation control system account for precipitation in the control scheme? (such as use of CIMIS/NWS information?)
   - Water use restrictions imposed by other agencies
   - Change in system water pressure
   - Other reason ____

   When did the change(s) occur, what was the duration and likely impact on potable water use?

   ____

2. What plans or potential changes could affect the amount of recycled water that will be used for irrigating the area over the next year? Do you plan to use more or less recycled water than the amount of potable water that was used? If so, why?

____

____

3. Who is the supplier of potable water? Agency: ______________________________

Please provide the name and phone of a contact at the Agency: ________________

____

4. Who will be the supplier of recycled water? Agency/ Plant: ___________________

Please provide the name and phone of a contact at the Agency/ Plant: ___________

____

5. Please provide the following items:
- A map of the area that will be irrigated with recycled water for this project.
- A map of the area that is irrigated using the potable water for this project.
- Identify any current end uses (restrooms, fountains, etc.) of potable water that will continue to receive potable after the change to use of recycled water is made, if any.

  ____
- Is any information available to quantify the historical potable water use that will remain potable water use? If so, please quantify the potable water use. If not, are there any reasons to think the amount of that potable water use will change?

  ____
- The amount of potable water usage, by month for the previous 24 months, for irrigating the area that will be irrigated with recycled water.
- Will there be any difference in the acreage irrigated by the recycled water than is being irrigated with the potable water? If so, please describe: _______________

  ____

6. Please provide the manufacturer and model number of the potable water meter used to provide the historical water use information. _________________________________

7. Please describe how the irrigation control system is programmed currently, including: hours/day of irrigation; schedule for each day of the week; if the control system has seasonal or other variation; whether, and if so how precipitation affects the irrigation schedule.

____

____

____

Thank you for your time.

Addendum

Please provide:

- Documentation/map of the pre-retrofit irrigation system.
- Is there an operations log for each site? May I review/obtain a copy of that log?
- Are any other changes planned or considered for the irrigation system or grounds/plantings after the retrofit? If so, please describe.

Items that will be requested towards the end of the pilot test period:

- Amount of recycled water use by month
- Amount of potable water use by month
- Map of the post-retrofit irrigation system
- Description of the control system settings and operation
- Description of intentional changes made to the irrigation system and operation
- Description of un-intentional changes to the irrigation system and operation
- Changes to the grounds and/or plantings
- Operations log
- Manufacturer and model number of recycled water meter(s) and potable water meter(s)
- Description of facilities that were supplied with potable water, if any
- Description of potable water system controls

Appendix 10: SDG&E Managed Landscapes Pilot Program

10.1 M&V Plan

Introduction

This document is intended to be the Measurement and Evaluation Plan for all of the Managed Landscapes Pilot Projects (MLPP). It is estimated that the MLPPs will involve up to approximinately 20 sites. Participants will include multifamily apartment complexes, condominiums, office parks, commercial properties, homeowner associations, and potentially estate properties. Project sites will be property with a minimum of four irrigated acres and five or less existing irrigation systems. All projects will be similar in that they will involve converting an irrigation controller that does not utilize daily evapotranspiration (ET)/weather data into a controller that does utilize daily ET/weather information to control the amount of water used for irrigation.

The projects may differ by the end-uses served by the utility water meter. Some projects will have all metered water used for irrigation. Other projects may have some water going to irrigation and some water going to another end-use such as restroom, pool or laundry area. The former type of project is referred to as having a dedicated end-use meter. The later type of project is referred to as having a mixed end-use meter. The evaluation approach is different for projects with a mixed end-use meter, as explained later. The water savings achieved by the use of Water2Save's (W2S) technology is indifferent to the type of end-use metered project since the water savings are only on the irrigation systems. However, due to the substantially greater cost to evaluate a project with a mixed end-use meter, we recommend that only sites with a dedicated end-use meter be sampled for this evaluation. For a similar reason, we recommend sampling only irrigation systems in which all controllers supplied by a single meter are up-graded with the W2S's remotely managed, ET/weather based irrigation control system. Due to the nature of the projects in the MLPP, limiting the sampled systems to those with a dedicated end-use meter and all controllers supplied by the meter up-graded with W2S's control system will not result in any bias in the results of the evaluation.

All of the projects in the MLPP will involve the installation of Water2Save's (W2S) irrigation control system on a managed landscape. Because all of the projects will involve implementing this same water saving measure, this evaluation plan is intended to serve as the plan for evaluating all the sampled projects.

Measure Description

Efficiency Improvement: The MLPP will save water by installing a remotely managed, ET/weather based control system that makes a daily adjustment to the watering schedule of irrigation controllers to minimize water consumption. Many managed landscape services adjust their irrigation control systems on a monthly or seasonal basis. Those services do not automatically adjust their irrigation contoller schedules to account for daily changes in the ET rate. As a result, many managed landscape areas are overwatered. Water2Save's remotely managed, ET/weather based control system is expected to reduce overwatering and thus reduce water consumption while maintaining sufficient watering for the health of the flora.

For this evaluation, a sampled meter and the associated controllers will be referred to as a sampled irrigation system.

Pre-retrofit Equipment and Operation: As described previously, there may be two types of sampled meters in the MLPP, sites with a dedicated end-use meter and sites with a mixed end-use meter. No pre-installation site inspection will be conducted on sampled irrigation systems with a dedicated end-use meter. A post-installation inspection will be conducted to verify and further document the installation of the control equipment.. However, SBW will conduct both a pre- and post-installation inspection if a sampled irrigation system has a mixed end-use meter. SBW will measure and record pre-installation water use for one month and will measure post-installation water use for several months for a sampled system with a mixed end-use meter. Information on pre-retrofit irrigation equipment, configuration and control system at each site will be obtained from W2S, the facility manager and the landscape contractor. Information describing the irrigation system and its operation during the previous three years will be obtained for those sites where such information is available.

Post-retrofit Equipment and Operation: For each affected irrigation system, W2S will recommend a baseline (maximum) watering schedule of daily runtimes and frequencies, which will be input to the irrigation controllers by the landscape contractor. The new baseline schedule will ensure that the landscape is always watered between 8 p.m. and 6 a.m., in accordance with the ordinance established by the Metropolitan Water District of Southern California (MWD). In addition, W2S will obtain daily local ET rate and weather forecast information, such as precipitation, wind and sunshine from either the California Irrigation Management Information System (CIMIS) or the National Weather Service (NWS). W2S uses the current ET value in a ratio with the baseline (peak) ET value to calculate an adjustment factor. This adjustment factor is used to revise the irrigation schedule. SBW will obtain additional information about any changes to the irrigation system, the landscape design, and/or the irrigated area by interviewing the facility manager and the landscape contractor immediately after installation of W2S's control system and near the end of the evaluation period.

Variability to the Irrigation Schedule: ET data and water use data will be obtained for both the pre- and post-retrofit periods for each sampled system. These data will be used to assess seasonality to the water usage and to provide information for comparing water use for the same month of different years.

Annual Ex Ante Measure Savings: The amount of annual water savings estimated by W2S for each sampled system and the basis for that estimate will be obtained. Those savings will be compared to the savings determined by this M&V analysis. Reasons for variation between the estimated savings will be discussed.

Methodology for Estimating Water Savings

The amount of water savings at each sampled site will be estimated by two calculation methods, an unadjusted and an adjusted method. The unadjusted water savings will be calculated by subtracting the post-installation water usage from the pre-installation water usage, on a monthly basis. The adjusted water savings will be calculated after making adjusting the water usage by key factors, as described bellow:

Landscape design (plant type): For each sampled site, SBW will use several sources of information to determine whether an adjustment to water usage is needed to account for a change in plant type, low, medium or high water use. Sources of information will this analysis will include the interviews of the landscape contractor and the facility manager. Also, Geographic Information System (GIS) information for both pre- and post-installation will be used if available. It is not clear at the current time whether SBW will have direct access to the GIS information, whether SBW can rely on other members of the project team to provide that information or whether another source, such as Google Earth can provide the desired information. The available information will be used to determine the amount of irrigated area by each plant type. The area of the sampled system will be categorized for both pre- and post- measure installation. We will then adjust the post-installation water use to reflect changes, if any, in the area of each plant type.

Irrigated area (sf): For each sampled system, SBW will normalize pre- and post-installation irrigation water use data by the area served by each system. Results will be expressed in units such as inches (or gallons) of water per sqaure foot. This will remove any impact on water savings due to an increase or decrease in irrigated area from the pre- to the post-installation period.

Evapotranspiration rate (ET): Finally, for each sampled system, SBW will plot the adjusted pre- and post-implementation water usage as a function of ET rate. Plotting water usage as a function of ET rate will minimze the impact of extremely dry or wet weather from adversely impacting the analysis of the water savings. From the graph of water usage as a function of the ET rate, we will produce two curves; one curve for the pre- installation water usage and one curve for the post-implementation water usage. The graph will also be used to extrapolate the post-implementation water use for ET rates not observed during the post-implementation period, if needed (for example, if the post-implementation data collection period does not include data from all four seasons). The difference between the water usage rate between the pre- and post-implementation curve for the same ET rate will be the basis for estimating the water savings.

Comparison of Water Savings Between Sites: The amount of water savings achieved by implementation of W2S's control system can be affected by several factors such as soil type, topography and the level of effort applied by the landscape contractor to minimize irrigation. However, the impact of these factors is difficult to quantify. SBW will endeavor to collect qualitative information about the items identified below during site inspections and interviews. SBW will attempt to incorporate adjustments to the water savings analysis in recognition of its findings.

Type of soil and surface conditions: Different soils and mulching practices can affect water retention and hence, watering needs. Thus, water use and hence water savings could vary as a result of differing soils and landscaping practices.

Topography: A sloped area may require more rigorous control of irrigation frequency and duration than more level areas. Consequently, these sites may have less water savings by W2S's control system if the landscape contractor is already diligent in controlling irrigation.

Landscape Contractor's Diligence: The level of effort applied by the landscape contractor to conserve water prior to the installation of W2S's control system may differ between sites. Thus, the amount of water savings achieved by W2S's control system may differ between sites that otherwise would have the same level of water savings.

Data Collection

A pre-installation site inspection will not be conducted at sites where the sampled system has a dedicated end-use meter. SBW will conduct a post-installation site inspection for all sampled sites to verify installation and interview the landscape and facility staff. Both a pre- and post-installation inspection would be conducted for any sampled system that has a mixed end-use meter. The data collection effort required for a sampled system that has a mixed end-use meter is described in greater detail at the end of this section.

Site Specific Input Information: The following information will be obtained for each sampled irrigation system for the pre-retrofit period.

- Monthly potable water use for the previous 36 months prior to installation. This information will be obtained from W2S since W2S is required to get this information and it is very laborious and time consuming to obtain a second copy of this data. Since our data source will be the project implementer, a paper or digital copy of the bill for randomly selected months will also be obtained in order to verify accuracy of the water use data from W2S.

- Utility meter number and piping diagram if a mixed end-use irrigation system is sampled.

- Area in square feet served by the irrigation system.

- Controller manufacturer, model number and type for each controller.

- Changes to the irrigation system as reported by the landscaper and property manager for the previous 36 months prior to installation of the W2S control system.

- Irrigation schedule for the pre- condition in addition to information regarding the irrigation schedule during the previous year.

- Changes to the landscape design (ground cover), for the previous 36 months prior to installation. SBW will seek this information from the landscaper, the property manager and if possible, from the Geographical Information System (GIS).

- Historic California Irrigation Management Information System (CIMIS) or National Weather Service (NWS) data for the previous 36 months prior to irrigation control system installation.

SBW will attempt to collect all historic information described above for a period of 36 months prior to W2S control system installation. However, we may reduce the time period over which to base pre-installation water use calculations if major landscape or irrigation design changes were made during that time period and the impact of these changes on the irrigation water use cannot be assessed.

If mixed end-use meters are selected for sampling, the data collection effort will be considerably more intensive. In addition to conducting the data collection described above, sub-metering of the water use will be necessary. First, it will be necessary to understand the distribution of the water, including at what locations water is distributed to non-irrigation uses. Depending on the design, it may be less costly (require fewer meters and recorders) to submeter either the non-irrigation uses or the irrigation uses. Submetering should occur for a minimum of 1 month prior to the installation of the W2S control system in order to obtain some knowledge of 'pre-installation' water use for irrigation. The metering and recording of water use should continue through the balance of the pilot test period. Clearly, this level of data collection would involve two trips to each site and installing metering and recording equipment for as many measurement locations as needed by each distribution system. These activities would add significantly to the cost to evaluate mixed end-use metered sites but provide no benefit to assessing the water savings by the W2S system in comparison to the evaluation of irrigation systems with dedicated end-use meters. In fact, due to the very limited historical data available for systems with a mixed end-use meter, the savings analysis would be less reliable then the analysis of a system with a dedicated meter.

Time-of-use energy savings is important information to the evaluation of avoided cost analysis. However, time-of-use metering will not be conducted for the MLPPs. There are two main facilities that time-of-use metering might apply, wastewater treatment and water treatment. For the MLPPs, there is no wastewater that goes to a wastewater treatment plant. SBW staff conducted a brief investigation of water treatment plants that supply potable water in the SDG&E service territory. The results of the investigation were that there is no direct time correlation between the time the irrigation water is used (or would be saved) and the time the source water is provided to the water treatment plant nor to the time the water is treated at the treatment plant. Briefly, the MWD has adopted ordinances that identify the allowable time periods for irrigation of lawns and landscapes. Those time periods are from 5 p.m. to 8 a.m. during November through April and 8 p.m. to 6 a.m. during May through October. However, water treatment plants are typically operated at a single through-put rate for a 24-hour period. Coordination amongst the water treatment plants is such that there are 3 times throughout a day at which plants may change throughput rates if necessary. Based on interviews with water treatment plant personnel, such changes in throughput during a 24-hour period are rare. Based on this information, it was concluded that there is no direct correlation between the time water is used for irrigation – hence, the time water savings would occur from the implementation of the W2S irrigation control system - and the time energy is used to provide or treat the water. The memorandum describing the results from the investigation is provided in Attachment B. Since there is no direct correlation between the time of water savings and the time of energy used to provide the water, there is no justification for conducting time-of-use water metering for the MLPPs.

The following information will be obtained for each sampled system for the post-retrofit period:

- Monthly potable water use for as many months as allowed by the project schedule up to 12-months.
- Paper or digital copies of billing information for randomly selected months, as selected by SBW.
- Description of changes to the irrigation system.
- Description of changes to the landscape design (ground cover), including irrigated area.
- The irrigation schedule.
- Hours per month of irrigation time.
- CIMIS or NWS ET data.

Data Collection Method: The above data and information will be obtained from the following sources:

- Pre- and post-installation water use data will be provided by W2S, which they obtained from paper copies of billing information from the water utility. W2S will also provide digital/paper copies of the utility bills for a random sample of months as selected by SBW. SBW will use these bills to verify the billing summaries prepared by W2S.
- Utility meter number will be obtained from the W2S application to the MWD.
- Pre- and post-installation irrigated area served by each meter will be estimated by various sources, including interviewing the landcape contractor,and/or the facility manager. Also, W2S and/or the GIS system may provide useful information.
- Controller manufacturer and model number will be provided by W2S.
- Description of controller system settings will be obtained by interviewing the landscape contractor.
- W2S will provide a description of the existing irrigation system. SBW will interview the landscape contractor and the facility manager to understand historic and post-installation changes to the irrigation system.

- Pre- and post-installation changes to the landscape design will be obtained by interviewing the landscape contractor and the facility manager. Also, SBW will seek to access pre- and post-installation GIS information.

- W2S will provide SBW with ET data.

Sampling Strategy: It is estimated that the MLPP could involve up to 20 sites. The MLPP may include sites with dedicated end-use meters and mixed end-use meters. For the reasons discuss previously, it is recommended that only systems with a dedicated end-use meter be sampled. Further, in order to include more sites in the sample, it is recommended that only one irrigation system (1 meter and the associated controllers) be sampled at each site. The number of irrigation systems to be sampled will depend on the budget available, and the decisions regarding whether to include mixed end-use metered systems and the number of systems sampled at each site.

Data Products

The following products will be produced for each sample irrigation system:

- Description of the irrigation system – including type of meter, type of controller(s), initial control schedule, post-installation control schedule and map of the system.

- Chronology of intentional and unintentional events affecting water use for the 36 months of pre-retrofit period and the post-retrofit period through summer 2009, as available.

- An Excel workbook with the following information as needed by the Water-Energy Savings and Avoided Cost Model:

    - Name of investor owned utility in which the project is located.
    - Climate zone in which the project is located
    - Measure description
    - Number of units rebated and/or installed per measure
    - Type of measure savings
    - Water savings per day per measure both adjusted and unadjusted
    - Values needed by the Model to produce an 8,760 values water savings profile
    - Measure life

Schedule

Activity	Completion Date
Submit M&V plan	November 2008
Obtain and aggregate historical water use data	As sampled sites identified
Obtain post-retrofit water use data	September 2009
Estimate annual potable water savings	December 2009
Provide all other data products	December 2009

Attachment A: Summary Project Information - Example

SAMPLE SITE 1

Program Name: **Managed Landscape Pilot Project**

Customer Name:

Site Name:

Site Address:

Principal Site Contact Name:	**Telephone:**
	E-mail:
IOU Manager Name:	**Telephone:**
	E-mail:
Water Agency Manager Name:	**Telephone:**
	E-mail:
Wastewater Agency Manager Name:	**Telephone:**
	E-mail:
Assigned Lead Engineer:	**Telephone:**
	Email:

Appendix 11: Responses to Draft Report Comments

Date	Author	Subject	Response:	Change?
1/14/11	**david morse**	**Comments on behalf of San Jose Water Company**		
Comment:		**General**: San Jose Water Company (SJWC) is an investor owned water company serving one million people in the San Jose area. Unlike the municipal water utilities that have participated in the Water Pilot Programs, SJWC's rates and terms of service are regulated by the California Public Utilities Commission. Thus the assumption noted in the report Abstract: "the CPUC required the IOU energy utilities to partner with water providers to implement jointly funded programs…" is not true. Without CPUC approval for water utilities to partner with the program, utilities such as SJWC are unequal partners: one funded and one not. The CPUC granted full funding and rate relief to the IOU energy utilities and their consultants, while the IOU water companies were not given rate relief for the expenses incurred for their participation in the study. Please see the attached 3 page PDF which has specific comments and suggested language.	Comment noted. The citation in the abstract is from the Oct. 16, 2006 ACR, which did not distinguish between regulated and non-regulated water agencies. Whether or not the regulated water agencies should be reimbursed by the CPUC or other parties is a policy matter that was not in the scope of this evaluation.	None
		Page viii, **Line 1:** The report notes that the timeline was too short for SJWC to implement the recommendations from BASE Engineering before the project closeout. Furthermore as noted in the opening comment above, SJWC must request authorization to incorporate the implementation	Comment noted. Implementation authorization requirements for regulated water utilities are beyond the scope of this evaluation, which focused on program impacts.	None

	costs of automatic pumping control algorithms. SJWC may do so as a part of SJWC's 2012 general rate case application.		
	Page x, Overarching Recommendation #1: SJWC provided energy data. However, in the future, water utilities regulated by the CPUC will need authorization from the CPUC to recover in rates the incremental costs of providing embedded energy data. For the pilots, SJWC received no compensation for its costs for materials and labor.	Comment noted, and we appreciate that SJWC provided energy data to EEW Study 2 that we could utilize.	None
	Page xii, Item #4: Improvement of emerging technology programs is not merely a matter of changing operator behavior as the report suggests. Programs must clearly articulate program scope, objectives and performance expectations. For example, SJWC was neither asked nor did it commit to implement any pilot recommendations. SJWC was interested to learn if kWh data could be brought into the SJWC's SCADA from PG&E meters. The recommendations from the PG&E consultant, BASE Engineering, came at the end of the project. The BASE Engineering recommendation was presented, as what appeared to be, a marketing proposal from BASE Engineering.	The evaluation team agrees that clear communication of performance expectations and program requirements when participation is being solicited are good practice and should be incorporated into future programs. However, we note that this is largely a program implementation comment.	None
	Page 39, first full paragraph: There was no agreement between PG&E and SJWC on a key goal "to develop and program a new pumping algorithm into the SCADA system..." SJWC's goal was to do on-line pump efficiency testing with the kWh data. Subsequently, BASE	Comment noted. The evaluation team was informed that a project goal was to implement an algorithm to actually save energy during the program period (similar to the EBMUD project, which installed an efficiency metric and not an algorithm). As we note above, it is beyond the	None

		Engineering's surfaced the idea to implement pumping algorithms at the end of the project.	scope of this evaluation to comment on project communication and implementation issues.	
		Page 52, Item #3: Performance bonuses to employees are not necessary for privately owned water utilities such as SJWC to implement programs authorized by the CPUC. Item 3 should note that water utilities regulated by the CPUC would need authorization to share implementation costs.	Comment noted. This comment was developed to address the EBMUD project, since the SJWC project was not evaluated.	We will add a note that the privately owned water utilities would need CPUC authorization to share implementation costs.
		Page 142, Item 12.2.3: The report incorrectly makes the conclusion that SF Bay Area water agencies are unwilling or unable to fine-tune their pumping operations to save energy. As previously noted, SJWC must request authorization to incorporate the implementation costs of automatic pumping control algorithms. SJWC may do so as a part of SJWC's 2012 general rate case.	Comment noted. See change.	We will make the following change: "*While these strategies may have resulted in energy savings in other places, this was not observed during the Pilots period.*"
1/14/11	**Paul**	**Free ridership claim**		

	Thomas			
	Comment	**Page x of Executive Summary - Overarching Recommendations #2:** In reference to page x of Executive Summary: "Overarching Recommendations" - #2, phrase (and where similar phrases exist): "These projects have a relatively high potential for free ridership…" If the economics of recycled water are convincing then the report should discuss reasons why market transformation is not occurring and/or suggest studies that investigate these barriers.	The report notes that customer costs for recycled water, relative to potable water, will vary across the state, and thus the cost effectiveness of recycled water (to the customer) will vary too. It was beyond the scope of this study to collect comprehensive data on recycled water costs, or to assess the degree of statewide market transformation.	None
		Metrics used for Program Comparisons need revision		
	Comment:	**Table ES-1 of p. vi:** In reference to page vi of the Executive Summary: Table ES-1: It should be noted clearly that the metrics used to evaluate the programs are not optimal for cross-program comparisons. This evaluation uses absolute measurements of energy and water savings when the programs were operating at different scales and proportions. Budgets and scope were not equal, implementation success varied between programs, and program durations varied. Therefore, when measured in this way comparing between programs can result in specious conclusions. A relative measurement (i.e., kWh/gal H2o saved/yr) would level the playing field somewhat, but not entirely. If this measure is used then the Leak Detection Program is a mediocre-performing program and the SCE Low Income HET was a superior-performing program, out of all embedded energy pilots.	The evaluation did not include an evaluation of cost effectiveness, which would help to understand the findings. We have tried to make this clear throughout the report. In introducing the summary table, page iv of the Executive Summary notes that "cost-effectiveness was not assessed." The CPUC may assess cost effectiveness using information developed in this study and other information (e.g., actual program spending, measure lifetimes, water agency electricity costs, etc.)	None

	Suggestions for Table ES-1		
Comment:	**Table ES-1 of p. vi:** In reference to page vi of the Executive Summary: Table ES-1, and where mentioned elsewhere in the report. We recommend the following bullets be considered: • True-up budgets; • Provide degree of confidence metric to all water and energy savings values presented in the table; • Provide a range of energy and water savings values where possible; • Include "at least" or "better than" when stating under-estimated energy and water saving values where appropriate; • Provide alternative means to describe the energy impacts of the PG&E Emerging Technologies Program, as "not applicable" and "0" do not provide helpful information • Add column of for "Total Energy Savings"	We appreciate the comments, but do not believe changes are needed for the following reasons. We have noted that actual program spending should be considered in cost effectiveness. Each chapter also provides text about water savings measurement uncertainty; this is sometimes possible (e.g., water utility meter inaccuracy) but was not assessed by the study team. In general, we did not develop ranges of water savings, as water savings could be measured fairly precisely via direct metering or bill analysis. The energy savings are based on the actual average energy intensities for the relevant water agencies, which is a common industry metric. We did not develop ranges or make assumptions about water agencies that did not provide data. Lastly, the Emerging Technologies Program was not designed or necessarily expected to save water, which is why we use "not applicable". This program was designed to save energy directly, and we determined that no energy savings could be attributed to the program.	None
	Cost Effectiveness		
Comment:	**Executive Summary - Summary Findings: p. v "Objective #4":** In reference to page v of the Executive Summary: "Summary of Key Findings" – "Objective #4," phrase (and where similar phrases exist): "The other programs do not initially appear to be cost effective." Without proper analysis this statement is only conjecture.	Comment noted. We will amend the text so as not to allude to a comprehensive cost effectiveness analysis, which was not done.	We will note that *"the program costs are likely to exceed the energy*

			benefits."
	Program continuation		
Comment:	**Executive Summary - Summary Findings: p. v:** In reference to page v of Executive Summary: "Summary of Key Findings" – Paragraph 1, phrase (and where similar phrases exist): "In general, most of the program evaluations provided useful information about embedded energy savings to inform future analyses of cost-effectiveness and program continuation…" The findings of this impact evaluation bring us modestly closer towards the goal of incorporating water conservation programs into IOU energy efficiency portfolios as currently structured. Despite this progress, they do not provide actionable information for determining the cost-effectiveness of the water pilot programs and are inadequate to make a determination on program continuation. Any ex post study using this data would still likely have variance too large for proper decision-making.	This evaluation has developed functional data on actual water savings and estimated energy savings for a wide variety of projects. In addition, these data can be supplemented with actual program expenditure data from the IOUs, energy load shapes from EEW Study 2, and other data to develop reasonable estimates of cost effectiveness. The task of assessing cost-effectiveness was beyond the scope of this study, which was to determine the Pilots' energy saving impacts and develop a methodology for doing so. We cannot comment about the validity of future, potential studies.	None
	Accounting for inconclusiveness of findings / **SCE Express Water Efficiency Pilot**		
Comment:	In the SCE Express Water Efficiency Pilot presents theoretical water impacts that are used as the basis of further estimates. The word "theoretical" should be attached to the description of every single estimate that is based upon the theoretical water impacts, e.g. "Table 36 also shows the THEORETICAL wastewater energy savings..." and "the THEORETICAL energy	For all the other evaluations we were able to use actual, measured water savings data, and thus there was no need to label them as "theoretical". Only for this specific program evaluation did we include theoretical water savings in addition to the actual, measured water savings, which were inflated due to improper equipment maintenance.	None

	savings are 9,385 kWh..." Dropping the label "theoretical" may mislead a reader who is casually skimming the report to think that the estimates are more accurate than they really are.		
	Description and clarification of statistical terms		
Comment:	**SCE's HET Program:** For SCE's HET pilot program, the evaluation report should clearly explain to the layperson what an R squared of .13 really means. It means that Model 3 (that uses # of toilets and # of people in the household) only predicts 13% of the water usage reduction. Presenting the following explanation would make the consequences of using Model 3 clearer: If you just use # of toilets and # of people in the household to model water reduction as suggested in the report, you would not be able to explain 87% of any reduction in water usage.	Good comment.	We have added text on page 71 that helps the reader understand the R^2 value.
	Table clarification		
Comment:	**Table ES-1 of p. vi**: Table should indicate more clearly which numbers are "inconclusive" or "theoretical". While the current table has indexes by the pilot program names that refer to footnotes that sometimes mention data uncertainty, those indexes should be moved to the last column, where people will naturally look first.	We have used a conventional table/notes format that most readers should be familiar with. This format is also recommended to keep the table on one page, to facilitate readability and presentations. As noted above, the report clearly notes that the documented energy savings are estimates based on actual production and energy data from the water agencies.	None
	General		
Comment:	Please see attached document for SCE's general comments.		
	1) Data needed to calculate embedded energy cannot be obtained reliably. This issue affects the	We agree that data on embedded energy is *hard to obtain* for a variety of reasons (water agency	None

	evaluability of any embedded energy program, and could likely be improved if some data standards were defined prior to further efforts to calculate embedded energy.	staff constraints, competing priorities, etc.), and future studies should consider this. But we do not think the data we actually obtained are unreliable. The energy use data were provided by the IOUs, and we believe the "flows" data from the water agencies are accurate, as in many cases they came from regular reporting documents. We were also careful to omit energy obviously used for administrative or ancillary uses.	
	2) Better coordination is needed between water agencies and energy utilities. The Water Pilot programs have provided an invaluable service in beginning to acquaint the water agencies and energy utilities with the complexities of partnering to offer programs, and the challenges of evaluating these joint programs. But this is just a beginning of a relationship that needs further development. We at SCE have some ideas for furthering the development of these relationships that we will be happy to discuss with the CPUC and the water agencies at the appropriate forum.	Thank you for your comment.	None
	3) Both metering and statistical tools for conducting evaluations in this field are still being refined. Real-world situations have presented challenges to the evaluation. The evaluators' heroic efforts at imputing missing data have allowed some estimates of savings to be produced, but their data analysis difficulties should be highlighted in the report and used to guide the improvements in program design to support future data collection. Instead, Table ES-1's presentation of inconclusive data and "theoretical" savings seems to focus on numbers that may be	We are grateful for the reviewer's appreciation of our data collection efforts. As noted previously, each report chapter does note any data collection issues, so that future evaluations can potentially be improved. Regarding the summary tables with program level water and energy savings, we agree that there are data gaps, and these are fully disclosed. That said, there is value in presenting summary findings in this manner to give an overall picture of what was learned. The full Executive Summary section does note some of the key data collection issues,	None

		meaningless, instead of clearly communicating data analysis problems that make the reader fully aware of the uncertainty inherent in the final figures.	which are detailed in full in each program chapter.	
		4) The inconclusive findings of the analysis do not support IOU decision-making needs about the future of the embedded energy programs. For example, the finding that SCE's HET program performance could be modeled with a weak R^2 of 0.13 means that any extrapolations of these estimated savings to a larger program would only mean that more taxpayer money would be thrown at a program that has a weak assurance of effectiveness.	We have acknowledged that there is a "weak" statistical relationship for program performance of this measure, and expect that CPUC will consider these findings accordingly. In most cases (e.g., SCE HETs), we have recommended additional data collection (e.g., occupancy changes) that could potentially improve the estimates.	None
1/14/11	**Brenda Gettig**	**Recommendations**		
Comment:		**Section 12.4.2 pages 146-147:** Would like to see some specific modification recommendations for the SDG&E pilots.	We have added a recommendation for the Managed Landscapes program. There were no important data collection issues for the Large Audits Pilots, and the key Recycled Water program issues are covered in the Overarching recommendations.	For Managed Landscapes, on page 148 and in the Executive Summary we discuss the value of further researching the vendor's technology to understand when/why

				the control algorithms are overwritten. This could help refine future estimates of expected water savings, as SBW found some unexpected changes in pre/post soil moisture correlations and the vendor may make future adjustments.
1/13/11	**Lynne Galal**	**Cost effectiveness**		
Comment:		**General**: The draft report provides new insights into the extremely complex relationship between water and energy consumption in California. However, it does not conclusively resolve whether water conservation programs and/or measures should be added to the energy IOU's energy efficiency portfolios since cost-effectiveness is not directly addressed in the report. Table ES-1 indicates that the costs associated with embedded	These are good points, and the report does note that analyses of cost effectiveness are needed before final determinations are made on whether these Pilots should become regular, full-scale efficiency programs in the IOUs' portfolios. To facilitate these analyses, we have disaggregated the estimates of IOU and non-IOU energy savings.	None

		energy programs could be prohibitive, and further analysis is required to draw conclusions about the feasibility of adding embedded energy programs to the energy IOUs portfolios. Any evaluation of the cost-effectiveness of a potential embedded energy program should address cost savings associated with IOU provided energy versus non-IOU provided energy. Page 119 of the companion Embedded Energy in Water Study 1, Statewide and Regional Water-Energy Relationship, states that "Significant amounts of the energy used by the participating nine large water agencies is self produced and supplemented by purchases from the wholesale power market. Only small quantities of energy are provided by the state's investor-owned utilities (IOUs). The only wholesaler identified in this study that purchases retail energy from an IOU was the SCVWD who purchases approximately 15 percent of the energy use for one of its smaller pumping plants from PG&E."		
1/3/11	**Lon House**	**General**		
Comment:		Key findings in Executive Summary are good, but I would expand a bit. Key finding 1 (pg.iv), I would expand to recommend that additional programs that directly impact water system operations be developed and evaluated for cost effectiveness in future programs (they are probably more likely to be cost effective that joint programs with water customers). I would also note that this analysis was part of the picture and if total energy savings are included more of these types of programs would be cost effective.	It was beyond the scope of this evaluation to recommend if and what types of future programs should be developed; the IOUs and CPUC will need to address this issue. We agree and have noted that total energy savings may affect these decisions, and have included non-IOU energy savings using secondary data sources documented in the Appendices (e.g., EEW Study 1).	None

	Summary - Cost data. Table ES-1 add a column $/kWh saved.	We have not done this because it could imply that a detailed cost effectiveness analysis was completed, and it was not. Such an analysis would include actual program spending (i.e., not budget amounts), installed measure lifetimes, etc.	None
	Program life - it was difficult to find expected program life (duration of savings). You will need this for each program to determine cost effectiveness.	We agree that measure lifetime data should be considered in future analyses of cost effectiveness.	None
	Statistical analysis. This is my professor voice talking, but you cannot use parametric statistical analysis (that relies upon normal [Bell shaped] data when you have skewed data (which almost all of this data is - e.g. see Fig 14). If I was reviewing this for publication I would reject it for that reason. Now, as I anticipate your eye rolling, the issue is what difference does it make? In actuality, I have found only a few instances over the years in which it makes a difference what statistical analysis you use. I'd just recommend a note (footnote) acknowledging this issue.		We have added a note acknowledg -ing this issue.
	Data anomalies. It is obvious that real data was used, because there are some observations that cry for explanations. HET Table 10 - who flushes the toilet 130 times a day? Savings range from a negative 115 gpd to almost 400 gpd! HET - Table 25 lists average savings of about 20 gpd but Figure 8 says it is closer 30 gpd savings for toilets. SCADA - the energy intensity depends upon where the pumps are operating on their pump curve (which pumps are providing how much	We agree that there are some unusual real-world data results, and we have noted known or potential causes. Due to budget constraints we could not investigate every possible data anomaly and have retained data where an obvious problem could not be identified. Regarding the PG&E SCADA project at EBMUD, you raise a good point about pump curves and energy efficiency. The regression analysis was used for our own analysis – the	None

	water). While the regression equation is interesting, what you really want to do is to provide operators with a matrix table that lists the most efficient combination of pumps to provide a given quantity of water, information that they can use to most efficiently provide the necessary water.	operators were in fact given efficiency matrix tables to utilize (see Appendix) and also a real-time kWh/Mgals metric on the SCADA display.	