A report on

Potential Best Management Practices

Prepared for

The California Urban Water Conservation Council

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Annual Report - Year One

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I. Introduction

General Background

Signatory water suppliers to the *Memorandum of Understanding Regarding Urban Water Conservation in California (MOU)* agree to make good faith efforts to implement 14 urban water conservation Best Management Practices (BMPs). In addition to the current 14 BMPs, Exhibit 1 of the MOU includes a list of 11 potential BMPs (PBMPs)[1]. Under the terms of the MOU, the California Urban Water Conservation Council (Council) is responsible for maintaining a dynamic BMP/PBMP assessment process, which includes the following commitments:

1. The assumptions of reliable savings for BMPs and PBMPs will be updated at least every 3 years.
2. The economic reasonableness of a BMP or PBMP will be assessed by the Council using the economic principles in Sections 3 and 4 of Exhibit 3 of the MOU (see attached Exhibit 3).
3. A PBMP will be moved to the BMP list and assigned a schedule of implementation if, after review of data developed during research and/or demonstration projects, the Council determines that the PBMP is economically reasonable and otherwise conforms to the definition of BMPs.

Project Background

To assist in meeting these commitments, the Council secured a three-year grant from the United States Bureau of Reclamation to evaluate and research PBMPs. Over a three-year period, the Council is required to prepare three annual reports summarizing water savings and cost information for the original PBMPs listed in the MOU as well as for other emerging technologies, products, and practices that might be candidate PBMPs.

The original 11 PBMPs drafted in 1991 and included in the MOU are as follows

(a) Rate structure and other economic incentives and disincentives to encourage water conservation

(b) Efficiency standards for water using appliances and irrigation devices

(c) Replacement of existing water using appliances (except toilets showerheads, and washers which are already addressed by BMPs) and irrigation devices

(d) Retrofit of existing car washes

(e) Graywater use

(f) Distribution system pressure regulation

(g) Water supplier billing records broken down by customer class

[1] Refer to *Summary of Best Management Practices* and list of Potential Best Management Practices from Exhibit 1 of the MOU. A complete copy of the MOU may be found at http://www.cuwcc.org/memorandum.lasso

(h) Swimming pool and spa conservation including covers to reduce evaporation

(i) Restrictions or prohibitions on devices that use evaporation to cool exterior spaces

(j) Point of use water heaters, recirculating hot water systems and hot water pipe insulation

(k) Efficiency standards for new industrial and commercial processes

In January 2003, the Council issued a Request for Proposal (RFP)[2] seeking a consultant to "evaluate potential Best Management Practices for urban water conservation." On May 19, 2003, the Council entered into a contract with Koeller and Company (consultant) to perform the scope of services outlined in the RFP.

[2] Request for Proposals by the California Urban Water Conservation Council, January 2003.

II. Selection of Candidates for Evaluation in Year One

Existing PBMPs

A early task of the consultant was to address the existing list of 11 PBMPs to identify which-

(a) Should be removed from the list without further research

(b) Should be refined and made more specific in scope and objective

(c) Should undergo an assessment of water savings and economic potential

At the same time, the Council's Project Advisory Committee (PAC) also assessed the current viability of the existing PBMPs. The result of those independent assessments is displayed in Table 1.

Of the 11 existing PBMPs, four were recommended by the consultant and the PAC for removal from the PBMP list. Decisions as to the further disposition of these four PBMPs (or any others subsequently considered for removal) rests with the Council. The consultant had no further involvement in Year One with those recommended for removal.

The remaining seven PBMPs were determined by the PAC to be worthy of further consideration, of which three were considered as candidates for evaluation in Year One of the project. Those three existing PBMPs were –

(a) PBMP No. 2 - Efficiency standards for water-using appliances and irrigation devices

(b) PBMP No. 4 - Retrofit of existing car washes

(c) PBMP No. 10 - Point of use water heaters, recirculating hot water systems and hot water pipe insulation

New Candidate PBMPs

Additionally, an extensive list of new candidate PBMPs was jointly developed by the PAC and the consultant at the outset of the project. This list included –

Year One candidates

(a) High-efficiency toilets
(b) Zero water consumption urinals
(c) Weather-based irrigation controllers
(d) Pre-rinse spray valves for the food service industry
(e) Ice making machines
(f) X-ray film processor recycling units
(g) Steam sterilizer retrofits (autoclaves)
(h) Commercial laundry systems – rinse water recycling

Future evaluation candidates

(i) Leak detection at a water system level
(j) Commercial dishwashers
(k) Boilerless steamers for the food service industry
(l) Plan review for new commercial, industrial, and institutional projects
(m) High-efficiency clothes washer technology improvements
(n) Monthly vs. bi-monthly customer billing
(o) Automated meter reading
(p) Metering and submetering

<u>Ranking of Candidates for Evaluation in Year One</u>

Combining the three existing PBMPs with the new candidates resulted in a final list for Year One consideration and selection as follows:

(a) Efficiency standards for water-using appliances and irrigation devices
(b) Retrofit of existing car washes
(c) Point of use water heaters, recirculating hot water systems & hot water pipe insulation
(d) Weather-based irrigation controllers (including ET controllers)
(e) Pre-rinse spray valves for food service
(f) Ice-making machines
(g) Commercial laundry systems – rinse water recycling
(h) X-ray film processor recycling units (medical industry)
(i) Steam sterilizer retrofits (medical industry)
(j) Dual-flush and other high-efficiency toilets
(k) Zero-consumption urinals

The consultant next performed a simple assessment of each of the above candidates in each of three areas-

(a) Availability of the data necessary to evaluate as a PBMP
(b) Magnitude and coverage of potential water savings that could result from the practice if implemented
(c) Marketability to the end-user/customer and ease of implementation

Point ratings were assigned to each candidate in each of the three areas. The results of this assessment are displayed in Table 2. From this assessment and in consultation with the PAC, four candidates were ultimately selected for the Year One evaluation:

(a) Weather-based irrigation controllers (including ET controllers)
(b) Pre-rinse spray valves for food service
(c) X-ray film processor recycling units
(d) Steam sterilizer retrofits (medical industry)

The results of those evaluations are included in Section 3 through 8 of this report.

Table 1. Assessment of Existing PBMPs

Existing PBMP	Assessment By Consultant	Assessment By PBMP PAC
1-Rate Structure & Other Economic Incentives & Disincentives to Encourage Water Conservation	Retain & consider	Retain & consider – future year
2-Efficiency Standards for Water-Using Appliances & Irrigation Devices	Retain & consider	Retain & consider – 1st year
3-Replacement of Existing Water Using Appliances & Irrigation Devices (Except toilets & showerheads whose replacements are incorporated as BMPs)	Remove from consideration	Remove from consideration
4-Retrofit of Existing Car Washes	Retain & consider	Retain & consider – 1st year
5-Graywater Use	Remove from consideration	Remove from consideration
6-Distribution System Pressure Regulation	Retain & consider – year 2 or 3	Retain & consider – future year
7-Water Supplier Billing Records Broken Down by Customer Class	Remove from consideration	Retain & consider – future year (possible combine with #1)
8-Swimming Pool & Spa Conservation Including Covers to Reduce Evaporation	Remove from consideration	Remove from consideration
9-Restrictions or Prohibitions on Devices that use Evaporation to Cool Exterior Spaces	Remove from consideration	Remove from consideration
10-Point of Use Water Heaters, Recirculating Hot Water Systems and Hot Water Pipe Insulation	Retain & consider	Retain & consider – 1st year
11-Efficiency Standards for New Industrial and Commercial Processes	Retain & consider	Retain & consider – future year

Table 2. Consultant's Rating of Year One Candidates for PBMP Evaluation

Year 1 PBMP Candidate	Existing PBMP No.	Criteria Rating (0 to 5, 5 being best)			Summary Rating Result
		Data Available (a)	Savings Potential (b)	Marketability & Implementability (c)	
1) Efficiency standards for water-using appliances and irrigation devices	2	2.0	2.0	1.5	1.8
2) Retrofit of existing car washes	4	3.0	3.8	3.5	3.5
3) Point of use water heaters, recirculating hot water systems and hot water pipe insulation	10	3.3	2.3	2.8	2.7
4) Weather-based irrigation controllers (ET controllers & others)		**3.8**	**3.8**	**3.3**	**3.6**
5) Pre-rinse spray valves for food service		**4.7**	**4.0**	**4.7**	**4.4**
6) Ice-making machines		3.7	2.7	3.3	3.1
7) Commercial laundry systems – rinse water recycling		3.7	3.3	3.3	3.4
8) X-ray film processor recycling units		**4.3**	**4.3**	**4.3**	**4.3**
9) Steam sterilizers (medical industry)		**3.0**	**3.3**	**4.0**	**3.5**
10) Dual-flush and other high-efficiency toilets		4.0	3.3	2.8	3.2
11) Zero-consumption urinals		4.0	3.5	2.5	3.2

	Data Available (a)	Savings Potential (b)	Marketability & Implementability (c)	Total
Relative Importance of Evaluation Criteria	24%	39%	37%	100%

Candidates selected for Year One evaluation are shown in **bold**.

Notes:

(a) Is sufficient information available to estimate water savings?

(b) Does the savings potential exist on a regional or larger geographic basis (i.e., savings not applicable to only a small geographic area). Are potential savings of a sufficient magnitude (regionally or statewide) to warrant consideration as a PBMP or BMP? Would savings be "reliable" over the long term?

(c) Would there be "demand" for the measure? Is it marketable to the target customers? Can such a measure be implemented effectively and economically?

III. Summary of Evaluation Results

Descriptions of each of the four selected PBMP candidates, together with analyses of the water savings potential and other factors, are included within the following four sections of this report. The essential findings are summarized in Table 3.

Table 3. Summary of Year One PBMP Characteristics and Results of Evaluations

	Weather-based Irrigation Controllers	Pre-Rinse Spray Valves	X-Ray Film Processor Recycling Units	Steam Sterilizer Retrofits
Gross water savings potential for California (acre-feet)	114,000 (in SF residences, other sectors not included)	61,800 (a)	18,200 (b)	75,000 to 560,000 (c)
Readily feasible for state regulation?	Possibly	Yes - Calif Energy Commission	No – fading technology	No
Projected cost of water saved under the measure	$270-$810	$195	$195	$63 to $215 (d)
Applicable customer class(es)	All classes – outdoor	Commercial & Institutional – Indoor	Institutional & Industrial – Indoor	Institutional & Industrial - Indoor
Type of water use reductions	Average and peak period	Average and peak period	Average and peak period	Average and peak period
Ancillary benefits of the measure	Reduced runoff, better plant health, customer convenience	Significant energy use reduction (gas & electricity); wastewater reduction	Wastewater reduction	Wastewater reduction
Cost-effective scale of measure implementation by water utilities	Targeting of customers with high outdoor water use is necessary	Cost-effective to pursue all types of food service applications through the food service industry and valve mfrs.	Marginally cost-effective due to the uncertain future of radiology operations	Cost-effective only for the high-use applications with frequent equipt. cycling
Barriers to implementation	Relies upon system and operator integrity to achieve savings; requires much education of disparate stakeholders	None of significance	Film tech-nology being replaced by digital imaging; space limita-tions; Limited capital avail-able to medical industry for new equipment	Limited capital available to medical indus-try for new equipment
Technical skills required of water agency conservat'n coordinator (e)	3	2	3	4
Viable candidate for PBMP status? (f)	Yes	Yes	No	Yes

Notes:

(a) Over the five(5) year useful life of the typical pre-rinse spray valve.

(b) Because the X-ray film processor technology has a limited future life span (due to competing technology), the water savings potential in California is estimated to only exist for about five years.

(c) Two different technologies were evaluated with overlapping application to sterilizers. The wide range of potential savings (over a 20 year economic life) is due to the lack of reliable information on the types of installed sterilizers that exist in the marketplace AND the frequency of use of those sterilizers. Further investigation is required to gather this important information.

(d) This range of costs applies only to high-volume installations where the sterilizer is used in a 24-hours per day operating room situation or where a high-volume sterilizer is used for at least 10 cycles per day. Other lesser applications would experience a higher "water cost" for the measure.

(e) Some measures require significant technical analysis and assessment at a customer site prior to implementation. Others, such as simple rebate programs, do not. Each measure is subjectively rated on a scale of 1 to 5, with a rating of "5" indicating that specialized technical expertise is required to understand and effectively implement the measure, while a rating of "1" would indicate that little, if any, technical understanding is necessary. On this scale, for example, a showerhead replacement program would be assigned a "1" rating.

(f) Reflects the recommendation of the consultant only.

IV. Pre-Rinse Spray Valves

1. Background

Food Service Application
Food service operations in the commercial sector including restaurants, cafeterias, institutional kitchens and food preparation companies exhibit significant water conservation potential. For example, the dishwashing operation in a typical restaurant consumes over two-thirds of all of the water used by that establishment. In some cases, nearly one-half of the water used in dishwashing is consumed by a pre-rinse spray valve (PRSV) used to remove food from dishware, utensils, and pans prior to placing them in the dishwasher.

Differences and Options for the Food Service Operator

Pre-rinse spray valves can be purchased with a variety of rated flow rates: up to 1.6-gallons per minute (gpm) for the water- and energy-efficient units and over 3.0-gpm for the most common non-efficient units. With completion of the Council's Phase 1 PRSV Replacement Program, we estimate that about 80 percent of the currently installed valves in California remain of the non-efficient type.

Because most operational uses of these valves involve pre-rinsing with heated water, any reduction in flow rates and water usage has the potential to reduce energy consumption as well.

Design differences between the non-efficient and efficient valves also contribute to operating efficiencies. The older non-efficient valves employ a traditional "showerhead" type of spray pattern. That is, water flows through multiple small orifices in a wide spray pattern (similar to a residential showerhead) that is used to remove food residue from dishware and other items to be cleaned. Over time, these orifices tend to become restricted due to mineral buildup or other material in the supply water (including residue from the hot water heater). Thus, the effectiveness of the spray in rinsing or cleaning dishes can deteriorate significantly over the life of the unit.

On the other hand, the new efficient valves employ a different type of head, which does not use multiple orifices. Instead, the head design provides a "knife-like" continuous spray pattern that is much more efficient in removing food from dishware, utensils and other items, and is not subject to the effects of mineral buildup that occur with the "showerhead" design. Therefore, the valve can perform the cleaning task more effectively. Informal studies by the Food Service Technology Center (FSTC) in San Ramon, CA have shown that operators are able to reduce the time required to pre-rinse or clean dishes as a result of changing out the valve.

Currently, there is no maximum flow rate established for these units in any codes or standards; the food service operator has the choice, when replacing a valve, between an inefficient and an efficient unit. Further confusing the matter (for the operator) is the fact that some manufacturers label their valve products as "low-flow" or "water-efficient" or "energy-efficient" when, in fact, the valves are only marginally more efficient than the valves they are replacing[3].

[3] For example, pre-rinse spray valves that flow at 1.9 to 2.5-gpm are "efficient" when compared with those that flow at 3.0-gpm and above. In the absence of an accepted benchmark definition of "water-efficient", the manufacturers are thus able to freely label their products with an efficient designation.

Performance Requirements and Specifications

With the creation and implementation (in 2002) of the Council's Pre-Rinse Spray Valve Replacement Program[4] (Program), it became necessary to create a threshold definition of "water-efficiency" and a performance specification to determine which valves meet this definition. Product performance tests were conducted at the FSTC to determine what flow-rate threshold would yield cleaning performance equal or superior to existing non-efficient valves. As a result of that research, the maximum flow rate of the efficient pre-rinse spray valves specified for this California Program was established at 1.6 gpm. In addition, the specification requires that the cleaning performance of the valve meet certain criteria as well[5]. These requirements, along with the Standard Test Method by which compliance is determined, are detailed in the Program's valve specification[6], which can be downloaded from the Council website:

http://www.cuwcc.org/Uploads/product/Pre_Rinse_Valve_Spec.pdf

Only valves that comply with the stringent criteria described within the specification are qualified for installation through the Council's Program. As of this date, three firms have submitted valves for qualification; two valves have met the requirements of the specification.

Useful Life

A major manufacturer of pre-rinse spray valves indicates that the typical life expectancy of these units is about five (5) years. The return rate for pre-rinse valves that fail within the normal one-year warranty period is less than 15 per 50,000 valves shipped[7]. Unless the unit is of substandard manufacture, is improperly installed, is abused, or is installed in a facility with very poor water quality, there is no reason to believe that a typical pre-rinse spray valve would last less then the expected five years.

[4] The Phase 1 Program was implemented by the Council in 2002 and 2003; 16,896 existing pre-rinse spray valves in hot water applications were replaced in California; that Program was funded by (1) the California Public Utilities Commission (CPUC) with funds from the public goods charge levied on natural gas customers and (2) participating water providers. The existing Program consists of direct installation of the efficient valve in all applications where hot water is used (with certain limitations imposed by the CPUC). The inefficient valve is removed from the premises of the establishment so that it cannot be re-installed by the operator.

[5] Generally speaking, the minimum cleaning performance defined within the specification is equal to or better than the cleaning performance of the typical high-flow 2.65- to 4.0-gpm unit.

[6] Specification developed by the Food Service Technology Center, working in conjunction with the Council.

[7] Personal communication, Ray Fisher, President, Fisher Manufacturing Company.

2. Water Savings Estimates

Although other entities outside of California are beginning to implement PRSV replacement programs, the acknowledged pioneer in such an undertaking is the Council. As such, the documentation of water savings associated with valve replacements has progressed beyond the "estimate" stage. In 2003, the Council commissioned SBW Consulting Inc., Bellevue WA, to measure and evaluate the effectiveness of actual PRSV installations through the Program. By the end of Phase 1 of the Program, 19 such field measurement projects had been completed. These served as a basis for the water savings estimates for the Phase 1 Program and are further described below.

The measurement of water consumption consisted of individually metering water use by each PRSV for 30 days both before and after retrofit. Additionally, water temperatures were measured and hours of actual spray valve use determined. Finally, flow rates of the old inefficient valves and the new efficient valves were measured by the FSTC at various water pressure levels. The difference in flow rates between the inefficient and efficient valves remains relatively constant from 30 to 60 pounds per square inch of water pressure. Thus, the water savings to be achieved through valve replacement at any given establishment can be assumed to be nearly the same regardless of the establishment's line pressure.

Some water agencies outside of California have chosen to set their efficiency standard at 1.8-gpm rather than the 1.6-gpm called for in the Council's Program in order to qualify more valve models for their particular programs[8].

Water and energy savings per valve were measured at the 19 metered sites[9] and extrapolated to the universe of installations under the Phase 1 Program[10]. The majority of restaurants used water heated with gas, although an unexpectedly significant portion of California installations use electric water heating (determined by SBW as approximately 27 percent, based upon data from the Pacific Gas and Electric Company). Phase 1 Program results were as follows:

Water Savings		
CCF[11]/year	Gallons/year	Acre-Feet/year
66.4	50,000	0.153

Energy Savings – method of water heating	
Natural Gas	Electricity
335 therms/year	7,634 kWh/year

[8] Personal communication, Al Dietemann, Seattle Public Utilities.
[9] Other than an Applebee's Restaurant, all of the other sites were small individually owned restaurants.
[10] SBW Consulting, 2004. *Evaluation, Measurement & Verification Report for the CUWCC Pre-Rinse Spray Head Distribution Program.* May 2, 2004
[11] CCF: hundred cubic feet of water, equivalent to 748 gallons and a common volume of measurement used by water utilities.

It must be noted that the above water and energy savings estimates are based predominantly upon field measurements within small establishments[12]. It is very likely that future outreach into food service chains and larger volume establishments will yield savings estimates that are much higher, due to the more intense use of the PRSV in the restaurant dish room. For example, prior to start-up of the Phase 1 Program, laboratory estimates indicated that water savings across all types of food service establishments would average approximately 73,000 gallons per year. This figure was never achieved due to the types of restrictions placed upon the Program[12]. As such, documented savings data for the higher volume installations is not available.

4. Product and Program Cost

The current cost of the PRSV ranges from approximately $30 to $60 each, depending upon the quantities purchased and the sources through which the product is obtained. There is no substantial difference in cost between an efficient PRSV that meets the requirements of the Program and a typical non-efficient PRSV.

For the Council's Program, total cost of implementation is approximately $181, divided as follows:

	Unit Cost
Valve Purchase, Warehousing, Distribution	$ 50
Field Marketing and Installation	100
Evaluation, Measurement, and Verification (EM&V by SBW)	5
Technical and Laboratory Support (by FSTC and others)	7
Program/Contract Administration (by the Council)	19
Total cost (16,896 installations)	$ 181

Other standard vehicles exist for outreach into the food service sector and accomplishing pre-rinse spray valve replacements. Most, if not all, would never achieve the volumes that can be attained through a massive direct install effort such as demonstrated by the Council's Program. Examples of other implementation vehicles are:

- Rebate or voucher program[13]
- Dealer/distributor incentive program
- Food service commercial audit program

5. Cost Effectiveness

With an estimated water savings of approximately 50,000 gallons per year and a physical (useful) life of 5 years, aggregated savings would amount to about 250,000 gallons per valve

[12] Due to conditions imposed by the California Public Utilities Commission (CPUC), the Council's Phase 1 Pre-Rinse Spray Valve Program was focused primarily upon very small, small and "hard-to-reach" customers of the Investor Owned Utilities.

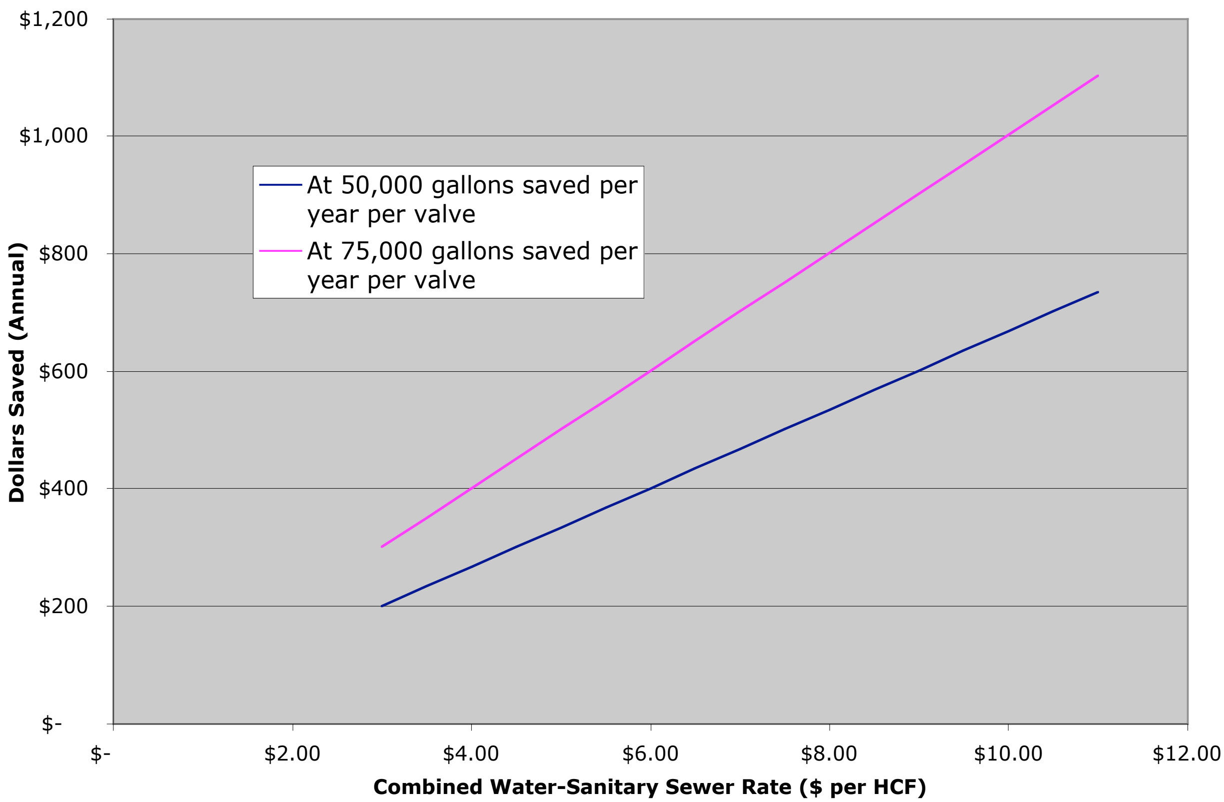
[13] A $50 rebate for PRSVs was implemented by the Metropolitan Water District of Southern California in the late 1990s in connection with its Regionwide Commercial Rebate Program. Few rebates have been provided by their program, even with the active promotion by a manufacturer to potential customers for a replacement valve. For example, the manufacturer pre-packaged rebate forms with the valves at their point-of-sale in order to stimulate purchases of the efficient product, yet customers did not respond and rebates were few.

(0.767 acre-feet) when installed in a very small or small establishment. If a statewide retrofit program was to be implemented throughout California in a structure similar to the Council's Phase 1 Program[14], water savings could therefore be expected to be achieved at a cost of about $196 per acre-foot[15].

From the viewpoint of the customer or end-user, the water savings achieved through the installation of an efficient valve in a typical food service application yields two significant benefits (in addition to energy use reductions): reduced water consumption and reduced flows to the sanitary sewer. Depending upon the specific application (breakfast, lunch, and/or dinner operations by the restaurant), peak flows would likely be reduced as well.

Because water and sewer rates vary significantly throughout the state, the economic benefits will likewise vary. Over a small range of rates, however, benefits to the food service operator would be as follows:

Figure 1. Water & Sewer Cost Savings from PRSV at Various Combined Water-Sewer Rates



[14] The Council's Phase 1 Pre-Rinse Spray Valve Replacement Program was a full-service direct-install program that cost approximately $181 per installed valve as noted above. Of this cost, approximately $31 could be attributed to the very strict regulatory and administrative requirements of the CPUC. As such, a similar program implemented exclusively by the water industry (without CPUC participation, funding, and conditions) could therefore be expected to cost about $150 per installed valve.

[15] Calculated as follows: $150 divided by 0.767 acre-feet of water = $196 per acre-foot

6. California Potential

As of 2002, the California State Board of Equalization had issued sales tax permits to 77,916 restaurants and similar food establishments in the state[16]. This figure does not include food service operations within a larger commercial or industrial entity (such as company cafeterias or within hospitals or schools, for example), firms whose business is to manufacture and/or prepare food for sale by others[17], and other similar operations. On the other hand, this figure does include very small restaurants and bars that do not use a PRSV.

With very limited information on the current number of installed PRSVs in California, the above inventory information was coupled with the experience[18] gained through the Council's Phase 1 Program to arrive at an estimate of approximately 102,000 installed hot water valves in California, with a range between 90,000 and 110,000. Additional valves are also installed on cold-water applications[19], but the number is exceedingly small.

Through implementation of the Council's Program, it was discovered that approximately four (4) percent of the food service sites visited were already equipped with water-efficient PRSVs. The Program resulted in another 17 percent of the inventory being converted to water-efficient units, for an estimated saturation rate (as of 2003) of approximately 21 percent.

We estimate the potential water-savings benefit of replacing the remaining 79 percent of the 102,000 valves in California to be as follows:

79% x 102,000 valves x 0.767 acre-feet = 61,800 acre-feet
Or approximately 12,400 acre-feet per year

This figure assumes that the water savings documented through the Council's Phase 1 Program would prevail for the entire state, although we expect that this would be a very conservative estimate if all sizes of food service establishments were to be included in a program outreach.

Based upon the very successful market penetration of Phase 1 of the Program, we estimate that at least 80 percent of these potential savings is "capturable" through initiatives and cost-effective incentives by the water industry. Phase 2 of the Council's Program is targeted to replace another 24,700 valves in California in 2004 and 2005. This phase will likely yield additional market and technical information that will permit a better assessment of the installed inventory and replacement potential.

[16] California State Board of Equalization, *Taxable Sales in California (Sales & Use Tax), 2002 Fourth Quarter*, no date.
[17] Food product processors and manufacturers, catering firms, etc.
[18] The Phase 1 Program's average replacement rate was 1.3 PRSVs per establishment.
[19] An on-premises survey of 89 food service operations was conducted by the Council in connection with the EM&V task for the Program. Within these 89 facilities, the Program installed 124 new pre-rinse spray valves. The survey found that only one of the 124 valves was being used in a cold-water application.

IV. X-Ray Film Processor Retrofits

1. Background

Processing Film

Large-scale X-ray film processing (developing) with current technologies uses large amounts of water to rinse chemicals from the film and to cool the processing equipment[20]. X-ray film processing in medical applications represents a significant opportunity for new technologies to reduce or eliminate water use. One of those technologies is the application of water recycling to the process equipment.

Medical Applications

X-ray film processors are used throughout the medical industry by doctors, hospitals, imaging centers, health and medical clinics, chiropractors and veterinarians. Processing equipment comes in a variety of sizes to suit the individual needs of the practitioners.

The largest user of processors is hospitals. Most hospitals in the U.S. have a number of medical x-ray film processors operating 24 hours per day, 365 days per year. The larger hospitals may possess over a dozen of these units. Processors generally use a constant flow of water to cool the machine and develop the film. Published flow rates for this equipment range from as little as 0.25 to as high as 2.5-gallons per minute (gpm)[21] of fresh water, all of which is directed to drain.

Most smaller facilities (such as those found in doctors' offices) use processors that do not operate in a constant flow mode, use very small amounts of water, and are not considered within this analysis.

In the mid-1990s, C&A X-Ray developed a water recycling process and system that captured the water in the larger processors and recirculated it back through the unit. Consisting of a small reservoir, a pump, and an algaecide dispenser, the Water Saver/Plus (patented by C&A X-Ray) is being marketed entirely to the medical sector, although other industrial x-ray applications do exist.

Conversion to Digital Technology

The use of film processors in the medical sector is gradually declining, as new digital imaging technology for radiography becomes cost-effective and gains presence in the market. Digital technology will eventually provide better images at lower cost than X-ray films.

[20] Irvine Ranch Water District, Dale Lessick, *Converting X-Ray Machines from Water Pass-Through to Recirculating*, no date.
[21] C&A X-Ray, *Published Water Flow Rates for Medical X-Ray Processors, Revised December 8, 2000*, found on the website: www.caxray.com/flow_rates.html

The investment required to convert to the newer digital technology is significant and comes at a time when the entire medical sector is experiencing severe constraints on capital and operating costs. Furthermore, new seismic requirements in California are forcing a large number of hospitals to perform major facility retrofits or abandon their existing facilities and construct new ones. Seismic retrofits and new hospital construction are allowing hospitals to install the necessary wireless and other systems that enable the use of digital technology. This may speed the elimination of conventional film processing in many hospitals.

Within 10 years, many expect that digital imaging will prevail in all of the larger medical facilities in California, potentially meaning that the Water Saver/ Plus and similar technologies will have a shrinking customer base.

<u>Other Non-Medical Film Processing Applications</u>

Other possible applications for the recycling units, such as Water Saver/ Plus, include industries of metal plating, fabrication and assembly; defense and aerospace manufacturing; medical and scientific research; electronics; commercial graphics operations; and other similar sectors employing film processors for their work.

<u>Useful Life</u>

Authoritative data does not currently exist on the expected useful life of the Water Saver/ Plus unit, although the water agencies currently underwriting incentives for this equipment have assumed lifetimes of between 5 and 20 years. With the conversion of facilities to digital radiography, however, the real economic life (and the accrued water savings) should probably be limited to a maximum of five years.

2. Water Savings Estimates and Projections

Over a period of approximately three years, water agencies have conducted a number of independent analyses of the water-saving benefit of the Water Saver/ Plus technology. In particular, three separate sets of investigation reveal valuable information:

<u>Metropolitan Water District (MWD) Innovative Conservation Program (ICP)</u>

The ICP included the field measurement of water use at eight Water Saver/ Plus installations in three hospitals in the region. The savings measured over the study period for these installations were as follows[22]:

[22] Metropolitan Water District of Southern California, *Innovative Conservation Program, Water Saver/Plus Recycling System, Final Report*, September 18, 2001.

Hospital/Medical Facility	No. of Film Proces-sing Units Metered & Retrofitted	No. of Licensed Beds[23]	Metered Savings/Unit (per week)	Estimated Annual Savings/ Unit (acre-feet)
Pacific Alliance Medical Center, Los Angeles	3	138	20,175 gallons	3.22
California Hospital Medical Center, Los Angeles	4	313	21,085 gallons	3.36
Irvine Regional Medical Center, Irvine	1	176	19,270 gallons	3.07

The result of the ICP study of X-ray film processing installations resulted in MWD offering a $2,000 rebate within its regionwide commercial-institutional program for retrofits in larger hospitals.

Los Angeles Department of Water and Power (LADWP)

The LADWP has encouraged the installation of the water-saving technology in a large number of installations in the city; to date, 70 Water Saver/ Plus units have been incented in the City of Los Angeles. In some cases, LADWP has added additional incentives to the $2,000 MWD rebate for specific retrofit installations where water savings are high. Following are those 30 installations (out of the total of 70) within the City of Los Angeles where actual water use data was gathered by LADWP[24]:

Hospital/Medical Facility	No. of Film Proces-sing Units Metered & Retrofitted	No. of Licen-sed Beds[23]	Metered Savings/ Unit (per week)	Estimated Annual Savings/Unit (acre-feet)
Good Samaritan Hospital	14	408	14,658	2.34
Encino-Tarzana Regional Medical Center	2	387	30,947	4.94
Los Angeles County USC Medical Center	14	1,417	10,207	1.63

[23] Office of Statewide Health Planning and Development (OSHPD), *Summary of Hospital Seismic Performance Ratings*, April 2001.

[24] Notes supplied by Mark Gentili, LADWP.

Irvine Ranch Water District, East Bay Municipal Utility District (EBMUD), and Upper San Gabriel Valley Municipal Water District

The three agencies jointly conducted a CalFed study in 2001 and 2002 that encompassed the measurement of water use at seven installations in northern and southern California[25]. Results reported by Irvine Ranch Water District (the lead agency) were as follows:

Hospital/Medical Facility	No. of Film Proces-sing Units Metered & Retrofitted	No. of Licen-sed Beds[23]	Metered Savings/ Unit (per week)	Estimated Annual Savings/ Unit (acre-feet)
Eden Township Hospital, Castro Valley	1	214	20,042	3.20
Childrens Hospital Medical Center, Oakland	1	205	15,289	2.44
San Leandro Hospital	1	122	20,861	3.33
Irvine Regional Medical Center[26]	1	176	14,996	2.39
Greater El Monte Community Hospital	1	117	31,426	5.01
San Gabriel Valley Medical Center, San Gabriel	1	274	25,780	4.11
Queen of the Valley Hospital, West Covina	1	Not avail	23,514	3.75

The overall weighted average for all 45 hospital installations in the preceding three tables was 2.57 acre-feet of annual savings for each metered retrofit.

Metering projects to date have been focused entirely on larger hospitals with high film processing throughput. It is these facility categories that represent the largest opportunities for water efficiency. Other opportunities may exist at smaller, less-active medical establishments, such as emergency care facilities, medical clinics, doctors' offices, and the like. However, no studies of film processor retrofits at these facilities have yet surfaced.

Most of the film processing units that are being retrofitted with the Water Saver/ Plus already contain automatic shut-offs that would terminate the flow of water when the unit is not operating. However, these shut-off switches rarely work due to age or lack of proper maintenance, thereby creating the retrofit opportunity for the Water Saver/ Plus. As such, properly maintained film processors would normally function at lesser flow rates than those experienced in the metering projects itemized above. Consequently, water savings would be less than that shown.[27]

Finally, the Water Saver/ Plus manufacturer calls for certain periodic maintenance of the system over and above that normally required for the film processor itself. It is critical that operators rigorously follow the periodic maintenance schedule in order to assure that the water

[25] Irvine Ranch Water District (lead agency), *Quarterly Progress Report #3, Contract No. 460000-1587*, dated July 2002 (Note: This report was deemed to be the final report by the other participating water agencies.)
[26] This is the second of two units installed at the Irvine Regional Medical Center, the first being under the MWD Innovative Conservation Program.
[27] Personal communication, Mark Gentili, LADWP.

savings are sustained throughout the unit's assumed economic life. That schedule requires cleaning the unit every two weeks, which includes replacement of the algaecide within the holding tank. Without maintenance, the unit will likely fail. With declining staff at many hospitals, maintenance priorities can change and, as a result, the maintenance of the Water Saver/ Plus could suffer.

3. Product and Program Cost

The Water Saver/ Plus costs from $4,000 to $5,000, including tax and installation. As reported in the Council's Cost and Savings Update Draft[28], costs to operate and maintain the unit are approximately $1,300 per year[29]. Maintenance is a service offered by C&A X-Ray.

Program costs to reach end-users[30] vary according to the incentives offered and the type of program undertaken. Individualized outreach to hospital facilities administrator (or the radiography department) by the vendor, when in partnership with water agency personnel and their associated financial incentives, has proven successful for some of the larger water agencies such as LADWP, EBMUD, and MWD.

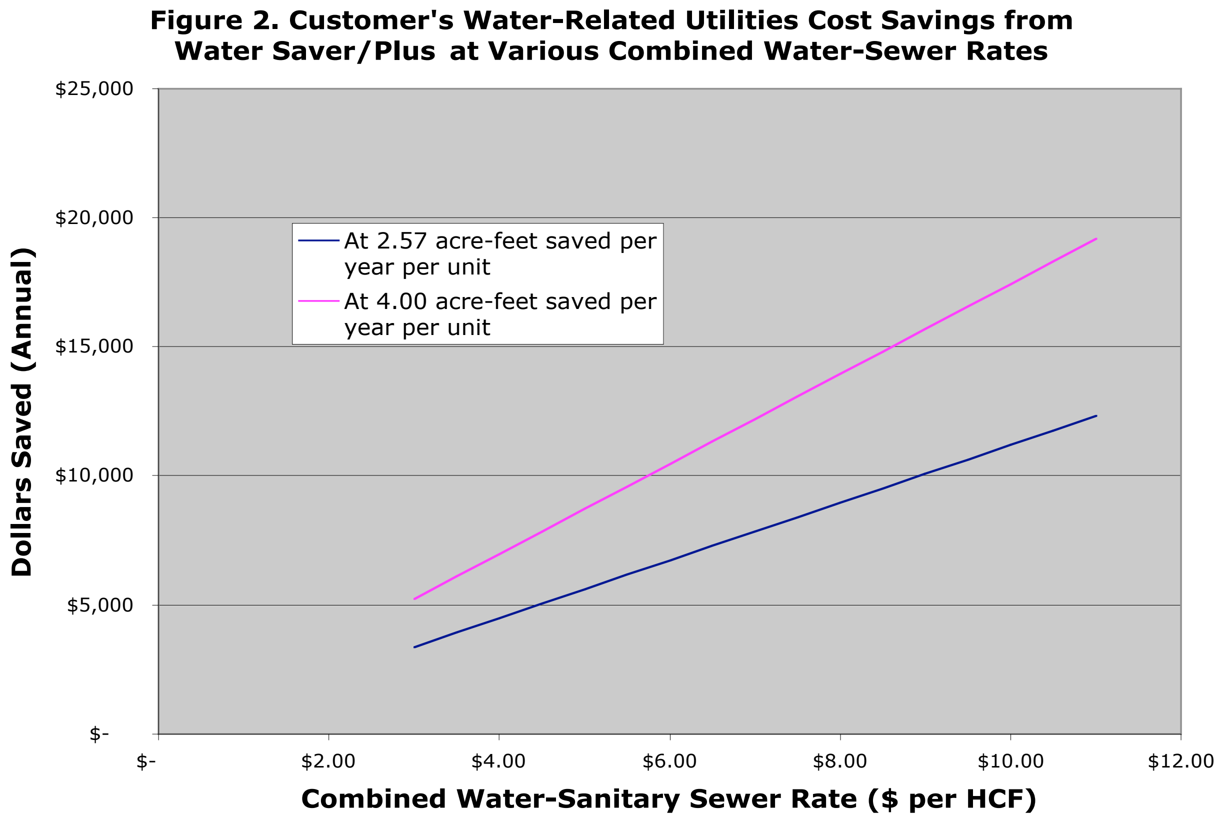
4. Cost Effectiveness

With an estimated water savings in large medical facilities of approximately 2.57 acre-feet of water per year and a physical (useful) life of 10 years, aggregated savings would amount to about 25 acre-feet per installed unit. However, with the likely replacement of existing high volume film processors with digital radiography, an economic life of no more than 5 years should be assumed. Accrued savings over 5 years, then, would average around 13 acre-feet. At an assumed program cost of $2,500 per retrofit (typical of the MWD regionwide program[31]), water savings can be expected to be achieved by the water agency at a cost of about $195 per acre-foot, generally below the cost of new supply.

From the viewpoint of the end-user, the water savings achieved through the installation of the Water Saver/ Plus in a large medical facility potentially yields two significant benefits: reduced water consumption and reduced flows to the sanitary sewer. Depending upon the frequency and timing of film processor use, peak flows could be reduced as well.

Because water and sewer rates vary significantly throughout the state, the economic benefits would likewise vary. Over a range of rates, however, the assumed costs of retrofit ($2,500) could reasonably be shown to be recovered within one year, as seen in Figure 2.

[28] Draft of December 2003.
[29] These costs are in addition to the normal maintenance costs associated with the film processor itself.
[30] In reality, the end-users, and frequently the decision-makers in the medical facility, are the managers of the radiology operations, not necessarily the hospital facility administrator. Because of the very specialized interests of this group, program outreach can be somewhat more difficult and less effective.
[31] Personal communication, Bill McDonnell, Metropolitan Water District.



5. California Potential

The distributor of the Water Saver/ Plus, C&A X-Ray, has prepared very rough estimates of the number of film processors that would represent retrofit candidates. For example, 14 California hospitals[32] under the auspices of Catholic Healthcare were identified by C&A as having a total of 70 heavily used processors that could yield water savings averaging 2.42 acre-feet per year per retrofit[33].

California's OSHPD licenses slightly in excess of 2,500 hospitals in the state; those hospitals contain approximately 90,000 licensed beds[23]. Assuming that the distribution of film processors in California is generally proportionate to licensed bed count, and that the distribution found in the 14 Catholic Healthcare facilities is representative, the total number of film processors as candidates for retrofit in California would approximate 1,400.

Completion of these 1,400 retrofits could be expected to yield about 3,500 acre-feet of water savings annually[34].

[32] The 14 hospitals were situated throughout the state and ranged in licensed capacity from 76 beds (one installed film processor) to 531 beds (9 installed film processors). Total licensed capacity for all 14 facilities was 4,438 beds. These inventory of installed processors includes only those that were retrofit candidates. Of the 70 processors, 28 had already been installed at the time of the assessment.

[33] C&A X-Ray, *Grand Totals – Projected Annual Water and Cost Savings, Catholic Healthcare*, August 14, 2003.

[34] Based upon the range of 2.42 to 2.57 acre-feet of water savings per retrofit.

It must be noted that these water savings are achievable only if the Water Saver/ Plus unit is rigorously maintained. In addition, the reluctance of some radiology departments to invest in a disappearing technology (i.e., film processors), coupled with space limitations in the typical radiology facility, may make the achievement of these water savings somewhat unrealistic.

In conclusion, the short “opportunity window” of five to 10 years before a water-efficient technology takes over makes X-ray film processor retrofits an unlikely candidate for full BMP status. As such, we do not recommend that they be included within the PBMP list.

VI. Steam Sterilizer Retrofits

1. Background

Steam sterilizers, a subcategory of autoclaves, are utilized in three major applications: hospitals, pharmaceutical manufacturers, and research institutions. They are used to disinfect (1) surgical instruments in hospitals and (2) instruments and apparatus used in the research and manufacture of products where sterilization is essential. The purpose of sterilization is to destroy all living microorganisms that include spores, viruses and bacteria including those that cause infection or disease (pathogens). Although other types of sterilizers exist, including dry heat, ethylene oxide, and radiation, steam sterilizers are by a large margin the most widely used form of sterilization. Sterilizers present a major opportunity for water conservation because water is used in these units when they are in operation and when they are at idle.

Water is used in sterilizers in two main areas: jacket and chamber trap cooling and in the ejector, which is used to create the vacuum. Depending upon the unit's usage pattern and size, water and sewer rates, operator practices, and other factors, trapway cooling and/or ejector vacuum water usage may be a candidate for water efficiency.

Sterilizer Classifications

Sterilizers are divided into two major categories: *tabletop,* which are small and do not represent viable water conservation candidates and the *freestanding type,* which are much larger, use large quantities of water in many installations, and where conservation opportunities exist. *Freestanding* sterilizers are further broken down into the *vacuum type*, where the chamber is subjected to a vacuum during the drying phase and the *gravity type,* where filtered air is drawn through the chamber during the drying phase. Air is removed from vacuum units to avoid stratification and coincident cold spots created by the presence of air in the chamber. Vacuum units sterilize much quicker than gravity units and are generally found in applications such as operating rooms where time is essential. Sterilizers generally range in standard size from about 3.8 cubic feet to 71 cubic feet; however, custom "walk-in" designs are as large as 2800 cubic feet.

Manufacturers

Two manufacturers lead the market in the United States and California in the sale of freestanding steam sterilizers: Amsco (Sterris) Corporation and Getinge-Castle. A third firm, ARS, builds customized sterilizers and ancillary systems for sterilizers. ARS is not a nationally distributed product but is a regional participant in Southern California.

All manufacturers utilize the same basic technologies to accomplish the sterilization task. First, inject low-pressure steam into the chamber when the sterilization process is taking place and, second, create a vacuum in the sterilization chamber during the dry phase cycle. Most all sterilization processes take place with temperatures ranging from 212º F on the low side up to about 275º F for certain load applications. Additionally, all manufacturers pass some steam into the chamber when the unit is in the standby mode in order to keep the unit ready to activate at a moment's notice.

Amsco (Sterris), the largest and most commonly found of the manufacturers, has the largest sterilizer product line. Sterris has approximately 4,700 units installed in California. Their approach to water efficiency is the retrofit of a vacuum pump[35] to eliminate the ejector and all ejector water consumption together with a control/solenoid valve arrangement for condensate trap cooling[36]. Both of these elements have added maintenance requirements and are considered unreliable and, thus, will not be discussed in this analysis.

Following are brief summaries of the two equipment approaches to water-efficiency analyzed in this report. More detailed descriptions may be found in Section 2.

Jacket and Chamber Condensate Drain Water Modification

Continental Equipment Company is not a manufacturer of sterilization equipment but manufactures a water-efficient technology, the Water Mizer [37] that can be retrofitted onto almost any sterilizer for jacket and chamber condensate cooling. This technology reduces condensate cooling water flow by approximately 90 percent and is similar to the technology offered by ARS mentioned below.

Ejector Water Modification

Getinge-Castle, the second largest manufacturer in terms of market share with approximately 3,100 units installed in California, is more innovative in their approach to water efficiency. They offer their MP-129 Modernization Package[38] which lowers ejector water consumption by approximately 75 percent. Getinge-Castle does not offer a technology that addresses condensate trap cooling.

ARS, the smallest manufacturer, with about 600 units installed in Southern California, primarily builds highly customized sterilizers. However, ARS also offers the most flexible and comprehensive array of water-efficiency packages, including trap cooling and ejector packages as well as one package that completely eliminates all water consumption.

Sterilizer Operation

Sterilizer operation is broken down into two modes or cycles of operation: *ready (standby)* and *active (sterilization)* mode.

Ready (Standby) Mode

Depending upon the application and the operator, many units will be turned off at night and other periods of time when no sterilization activity is anticipated. When these units are reactivated, they are run through a "flash cycle" which brings the unit up to temperature and sterilizes the internals of the unit. Most units are kept in a ready mode

[35] Sterris Corporation, document number M1408.980529 Water Conservation Kit/Vacuum Pump Modification

[36] Sterris Corporation, document number M1407.011115 Rev. C Water Conservation Kit/Trap Cooling Modification.

[37] Continental Equipment Company brochure dated 2002.

[38] Getinge-Castle MP 129 Water saver Modification Package, Dated 1993.

during the day so that when multiple sterilization runs are required, the unit will not have to go through repeated “flash cycles” before it can be used for sterilization. Many units are kept in the standby mode 24 hours a day and therefore do not require a flash cycle during start-up.

To keep the unit in the standby mode, small amounts of low-pressure steam are passed into the chamber to maintain a specific temperature in the chamber to keep it sterile. As this steam condenses, it is bled off to a floor drain where it mixes with municipal water to cool it below 140º F before it goes into the sanitary sewer lines

Steam is also fed into the chamber jacket to keep it hot. By keeping the sterilizer jacket hot, less steam condenses in the chamber during the standby and sterilization modes. Additionally, when steam is now injected into the chamber it has a greater ability to sterilize rather than being consumed as waste by condensing on the chamber walls, thus partially defeating the sterilization process and lengthening the time needed for sterilization. By keeping the walls of the chamber hot, any potential condensation is nearly eliminated and, thus, less steam is required in the chamber. This steam eventually condenses in the jacket, similar to the steam in the chamber, and it is led to a trapway below the unit where it is also cooled below 140º F.

Code prohibits temperatures of water discharged to the sewer exceeding 140º F. To lower the temperature of the condensate leaving the two trapways, cold potable water is mixed with the condensate to lower the temperature to comply with code. Standby condition flow rates range from 0.5-gallons per minute (gpm) to as much as 6.0-gpm (or more) in this mode. The flow rate is a function of the size of the chamber and how well the needle valve is maintained and adjusted. In the vast majority of applications visited, trapway flow rates range between 0.5 and 2.5-gpm. However, the needle valves employed on many units are either not maintained or are set improperly and they therefore pass more water to drain than is necessary.

Active (Sterilization) Mode

This mode of operation occurs when the unit is actively sterilizing a load. Although there are several different types of loads, each with different temperatures and durations, the series of operational phases is the same for each:

(1) Ready Phase: Unit is up to temperature and is ready for automatic processing.

(2) Conditioning Phase: Steam enters the chamber and conditions the load. Air is removed from the chamber.

(3) Exposure Phase: Steam processes the load at a selected temperature and pressure.

(4) Exhaust Phase: Steam is removed from the chamber. The load is dried for a drying time selected by the operator.

(5) Complete: Control panel indicates that the processing cycles are complete.

Water is used extensively in the conditioning phase to remove air from the chamber and again in the exhaust phase to remove the steam and dry the load. This water passes through the ejector and goes directly to drain. Some water use occurs as the steam enters the unit and condenses, although the amount is very small.

The largest consumer of water in this mode is the ejector or venturi device which passes cold potable water through it to draw a vacuum in the chamber as seen in the figure which follows. The high velocity of water through the ejector creates a vacuum (low pressure) at that point, which is connected through a vent line to the chamber. Ejectors use approximately 5 to 6-gpm on small units and 10 to 15-gpm on the largest units. The initial conditioning phase (where a vacuum is drawn) lasts for about 2-3 minutes. The exhaust phase, again where the ejector is activated, can last anywhere from 12 minutes up to 2 hours depending upon load and operator discretion. The most common loads take about 24-30 minutes in the exhaust phase.

2. Water-Efficiency Measures

Jacket and Chamber Condensate Cooling Modification

This measure is designed to reduce the water consumed during "ready" or "standby" mode discussed earlier. This is the state during which the sterilizer operates most of the time. During standby mode, the sterilizer is kept at an elevated temperature by periodically introducing steam into the chamber to keep it sterile so that it can be utilized at a moment's notice without having to go through a "flash" cycle. The steam that is introduced eventually condenses and flows to the trap drain located beneath the sterilizer. The chamber jacket must be continuously heated to prevent cooling of the chamber walls and subsequent problems in the sterilizer when called upon. To prevent water at a temperature above 140º F from entering the sanitary sewer, water in the jacket and chamber traps is cooled by potable water. This water runs 24 hours a day at the flow rates set during start up by the adjustment of a needle valve. Needle valves should be changed out approximately once a year because of wear. Generally, replacement is not performed and most units flow cooling water at rates two to four times the manufacturer's recommended set point. Flow rates exceeding ten times the manufacturer's recommended set point have been observed in isolated cases. As mentioned earlier, recommended flow rates range from 0.5 to 3-gpm on most units but may range up to 5-gpm on units not maintained.

The condensate drain modification consists of a small tank and a thermostatically actuated valve. This is a simple technology that intercepts all the condensate from the chamber and jacket before it has a chance to go to drain. The tank is uninsulated and will transfer most of the excessive heat to (room) ambient atmosphere, which is kept, between 60º and 70º in most operating rooms. The quantities of water coming from the chamber and the jacket are relatively small so the tank will have enough time to cool the condensate well below the 140º F level before any cooling water must be added. No attempt is made to save the condensate. However, if the temperature does occasionally elevate above 140º F, the thermostatic valve will open and allow potable water to flow into the tank, thereby lowering its temperature below 140°F. The system operation is simple and easy to maintain. There is no electrical power needed. Most other technologies employ a logic controller and temperature sensors which can be complicated for service personnel and are sometimes unreliable, especially when the sensors fail or do not read the temperature of the water in the trap correctly.

The equipment associated with this technology is relatively small in size, consisting of a small tank and external thermostatic valve. The length is 12 inches, width is 7-1/2 inches, and height is 10 inches. The unit is small enough to fit beneath most sterilizer units or it can be mounted next to the support structure of the sterilizer if needed. Space constraints are not a major obstacle to the installation of this technology.

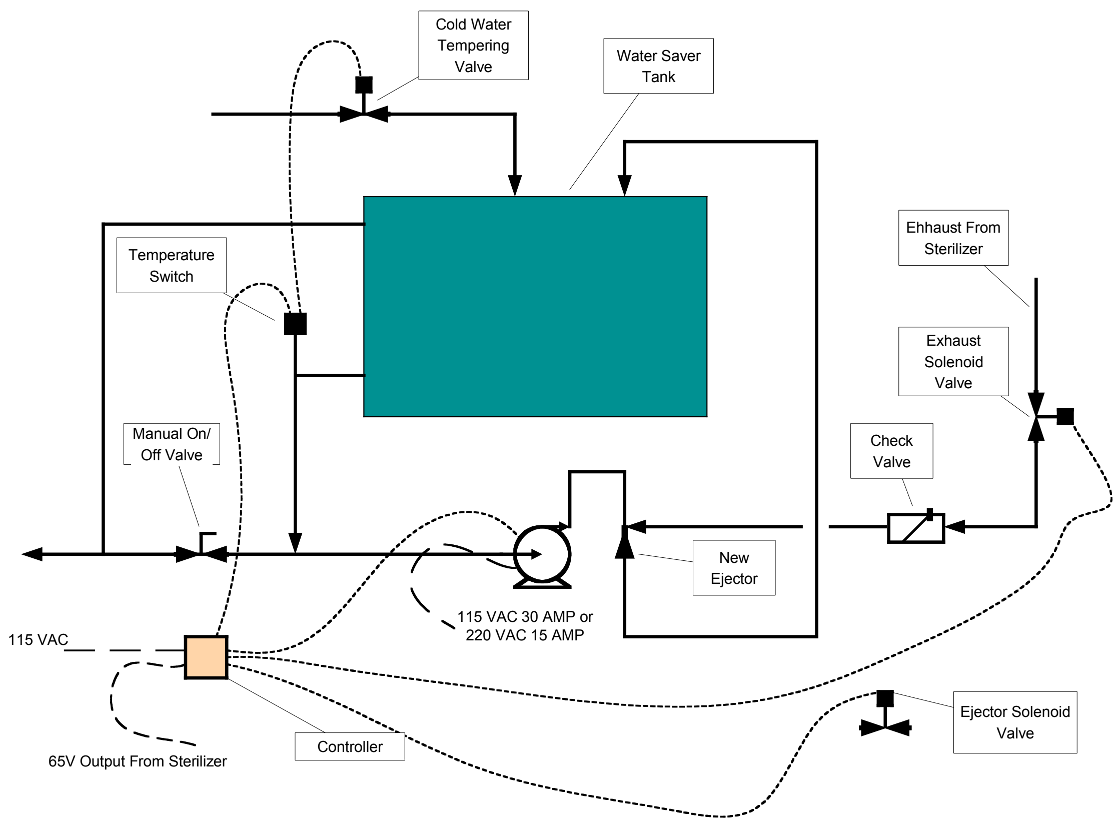
Ejector Water Modification

Vacuum units contain a device called an ejector that is used to create the vacuum in the sterilization chamber. Ejectors work on a venturi principle where potable water is passed through a narrowing in the ejector and the velocity of the water is greatly increased. A vacuum is created at this point by the high velocity water drawing off air.

Gravity (atmospheric) units also use this same ejector device to draw atmospheric air into the chamber after passing through HEPA filters. Drying times are lengthened when gravity units are used because of the presence of air. Therefore, on those units that are subjected to frequent use in the active sterilization mode, it is worthwhile to investigate opportunities to employ the more heavily engineered solution by modifying the water controls and piping being supplied to the ejector.

In either case, water passes through the ejector venturi one time and then flows to drain. The simple modification for single sterilizer applications takes a portion (50 to 75 percent) of the water flowing through the ejector and channels it into a small tank located under or behind the unit. The water cools in the tank due to the localized flow of ambient air (at 60º-70ºF) around the unit. On those sterilizers that see limited usage, the ambient air may provide all necessary cooling before the next sterilization cycle is called for. This modification is shown in the Figure 3.

Figure 3. Ejector Water Modification Schematic



The system incorporates a new water ejector with a pump and a water reservoir to recirculate a portion of the water that passes through the system. The system cannot be used on any sterilizer with a sealing flange, nor can it be installed on equipment that may process Bio Hazard material or Bio-contaminated waste.

When this ejector modification is employed, the system will determine whether the new or the standard ejector in the sterilizer provides the vacuum. A 115v, 30-amp or 220v, 15-amp pump is employed to circulate water through the ejector and into the new tank and then back to the suction side of the pump. This process repeats itself until the water reaches 120º F, at which point the temperature sensor activates the cold water tempering valve to open and allow cool potable water in the tank to reduce the temperature below 120º F. Excess water overflows through the drain connection on the upper side of the tank. The exhaust line from the chamber is retrofitted with a second line leading to the new ejector complete with it's own solenoid that is activated when the new system is energized and a check valve to prohibit water from being forced back into the chamber. The existing ejector solenoid valve is de-energized when the new system is in operation. A manual valve can be closed to allow maintenance or repair to the new system components, which allows normal (pre-modification) sterilizer operation when needed.

Space is a consideration in the implementation of this measure. The tank is physically larger than the Water Mizer mentioned earlier. More planning and effort must be given to the mounting of these systems and must be performed by experienced technicians familiar with the sterilizer technology. These units, which are specifically designed for the Getinge-Castle units, can also be adapted for use on Amsco sterilizers. They are often mounted to the support structure behind or next to the unit, rather than directly beneath the sterilizer.

On those applications (primarily hospitals) with "central sterilization" or "central processing" centers, another strategy can be employed where all of the ejector and trapway water is fed back to a central tank and stored. Heat is removed from this water via a cooling coil with chilled water supplied from the building's central chilled water system, located in the tank. Because of the expense of these systems, complexity of their design and installation challenges, these should only be considered on multiple unit installations. Space is at a premium in many hospital applications. This system requires about 6-8 square feet for skid-mounted components, electric power for a small recirculation pump, and a piping connection into the central chilled water system. The system is simple and reliable and is engineered to switch back to potable water in case of system failure.

The benefits of this approach are that 100 percent of the ejector and trapway water is saved. The first cost to retrofit several units in this manner (one system) may have a lower first cost than multiple installations of the previous technology discussed.

Performance Requirements and Specifications

At this time there is no governing authority that sets the standards for sterilizer performance or efficiency. Personnel working in "central sterilization", laboratory and R&D departments, and industrial production departments are generally trained in the field of sterilization and infectious disease control. Therefore, sterilization effectiveness is largely up to the operating personnel and the accuracy of information gained from the sterilizer control/feedback system. Sterilizer operational efficiency is left to the maintenance personnel of the facility and service contractors.

Useful Life

Sterilizers last up to 20 years with proper maintenance and repair. Of course, this figure varies greatly depending upon the time in use, operator practices, maintenance and repair practices, water conditions, steam quality, and atmospheric conditions in the sterilizer room. We have chosen conservation strategies partly based upon the maintainability and reliability of the product. Most of the strategies discussed have minimal control devices or moving parts that would otherwise be the components that would cause problems on any piece of machinery. Therefore, it is reasonable to expect that the water-efficiency strategies discussed in this report will remain operational (with reasonable maintenance and occasional service) with the same life expectancy as the sterilizers that they are serving.

3. Water Savings Estimates

Jacket and Chamber Condensate Cooling Modification

The calculations below assume the unit is retrofitted with the Continental Water Mizer. The effectiveness of this water-efficiency measure is entirely dependent upon the time that the unit sits in the ready or standby mode. Standby time can generally be divided into three use classifications for analytical purposes :

- unit is turned on 12 hours a day.
- unit is turned on 18 hours a day.
- unit is never turned off.

Also, when the unit is going through a sterilization cycle, this time must be deducted from the standby time.

According to the only third party study done on the performance of the Water Mizer technology, the average idle flow for trapway cooling was 2.4 gpm. It was decided to use the data as presented from this study as the basis for our analysis because it is the best qualitative study containing useful information available[39]. Table 3 shows the spectrum of savings relating to hours of usage and sterilization time per day for one sterilizer.

[39] Ibid.

Table 3. Savings: Jacket and Chamber Condensate Cooling Modification (Water Mizer)

Hours of Operation per Day	Average Cooling Water Flow (gpm)	Condensate Cooling Water Consumption (gpd - 4 hours per day of sterilization)	Days of Operation per Year	Pre-Retrofit Consumption (gpy)	Post-Retrofit Consumption (gpy)	Savings (gpy)
12	2.4	1,152	250	288,000	28,800	259,200
18	2.4	2,016	250	504,000	50,400	453,600
24	2.4	2,880	250	720,000	72,000	648,000

gpm – gallons per minute
gpd – gallons per day
gpy – gallons per year
Pre-retrofit consumption = (hours per day – hours per day of sterilization) x average flow of 2.4-gpm x days of operation per year
Post-retrofit consumption = Pre-retrofit consumption x. 0.10 (representing a 90% reduction in consumption)
Savings = Pre-retrofit consumption – post-retrofit consumption

Ejector Water Modification

This water-efficiency measure is entirely dependent upon the time that the unit is running in the sterilization mode and, more specifically, how much time the unit is programmed to spend in the conditioning and exhaust phases. The calculations below assume Getinge-Castle units of varying sizes with actual ejector flow rates and average conditioning and exhaust phase times set at 3 minutes and 30 minutes, respectively. Table 4 shows savings based upon 4 and then 10 sterilization runs per day, a critical factor in defining the return on initial investment for this measure.

Table 4. Savings: Ejector Water Modification – 4 and 10 Sterilizing Runs Per Day

Model Number	Flow Rate (gpm)	Water Consump-tion – Conditioning Phase (gpc)	Water Consumptio n – Exhaust Phase (gpc)	Total Pre-Retrofit Consump-tion (gpc)	Machine Uses per Day	Days per Year	Pre-Retrofit Consum p- tion (gpy)	Post-Retrofit Consum p- tion (gpy)	Water Savings (gpy)
3533	6	18	180	198	4	250	198,000	49,500	148,500
3633	11	33	330	363	4	250	363,000	90,750	272,250
4233	18	54	540	594	4	250	594,000	148,500	445,500

Model Number	Flow Rate (gpm)	Water Consump-tion – Conditioning Phase (gpc)	Water Consumptio n – Exhaust Phase (gpc)	Total Pre-Retrofit Consump-tion (gpc)	Machine Uses per Day	Days per Year	Pre-Retrofit Consump - tion (gpy)	Post-Retrofit Consump - tion (gpy)	Water Savings (gpy)
3533	6	18	180	198	10	250	495,000	123,750	371,250
3633	11	33	330	363	10	250	907,500	226,875	680,625
4233	18	54	540	594	10	250	1485,000	371,250	1113,750

gpm – gallons per minute
gpc – gallons per cycle
gpy – gallons per year
Savings = Pre-retrofit consumption – post-retrofit consumption

4. Product Cost

Jacket and Chamber Condensate Cooling Modification

The estimated cost of the Water Mizer device, including installation, is shown below. It takes approximately 8 hours to install.

Continental Water Mizer	$1,850
Installation Labor	$600
Miscellaneous Parts	$50
Total Installed Cost	$2,500

Ejector Water Modification

The estimate below is based upon the Getinge-Castle MP129 Water Saver Modernization Package.

Getinge-Castle MP129	$13,500
Installation Labor	$1,200
Total Installed Cost	$14,700

5. Cost Effectiveness

Jacket and Chamber Condensate Cooling Modification

At the low range of water savings of approximately 259,000 gallons per year and a physical (useful) life of 20 years, aggregated savings would amount to about 5,180,000 gallons per installed Water Mizer (15.9 acre-feet). Assuming implementation through a direct install program (installation included), the undiscounted cost per acre-foot of water saved is approximately $157 per acre-foot.

At the high range of savings of 648,000 gallons per year, aggregate savings over a 20-year life would amount to about 40 acre-feet of water, yielding an undiscounted value of approximately $63 per acre-foot.

Ejector Water Modification

At the low range of water savings estimated at approximately 148,500 gallons per year, together with a physical (useful) life of 20 years, aggregated savings would amount to about 2,970,000 gallons per installed MP 129, or about 9.1 acre-feet of water. Again, assuming implementation through a direct install program (installation included), the undiscounted cost per acre-foot of water saved would be approximately $1,614 per acre-foot.

At the higher end of the savings range (approximately 1,113,750 gallons per year) and a physical (useful) life of 20 years, aggregated savings would amount to about 22,275,000 gallons per installed MP 129, or about 68 acre-feet of water. The cost per acre-foot of water saved would be about $215 per acre-foot.

These are conservative estimates of water savings. In reality, however, there are many applications that run more than the 4 and 10 sterilizer loads per day assumed in the examples shown above.

From the viewpoint of the end-user, the water savings achieved through sterilizer retrofits in a large medical facility potentially yields two significant benefits: reduced water consumption and reduced flows to the sanitary sewer. Depending upon the frequency and timing of sterilizer use, peak flows could be reduced as well.

Because water and sewer rates vary significantly throughout the state, the economic benefits would likewise vary. Over a range of rates, however, benefits to the sterilizer operator would be as shown in Figures 4 and 5 on the following page.

Figure 4. Cost Savings-Jacket and Chamber Condensate Cooling Modification

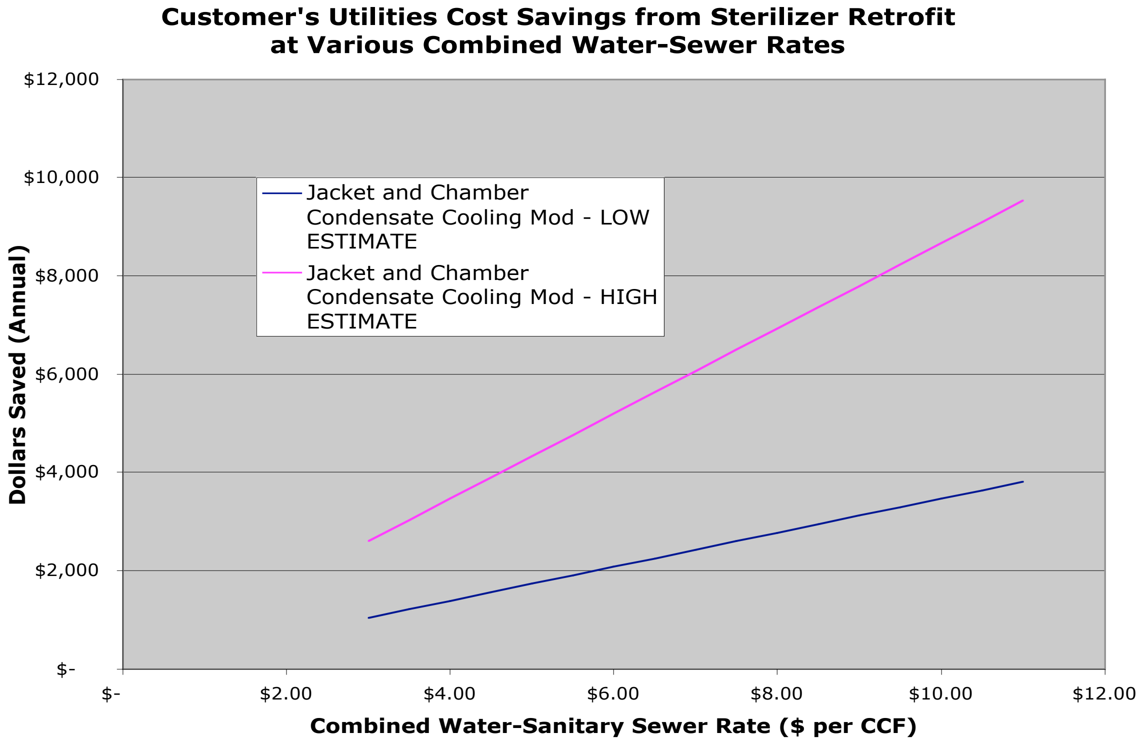
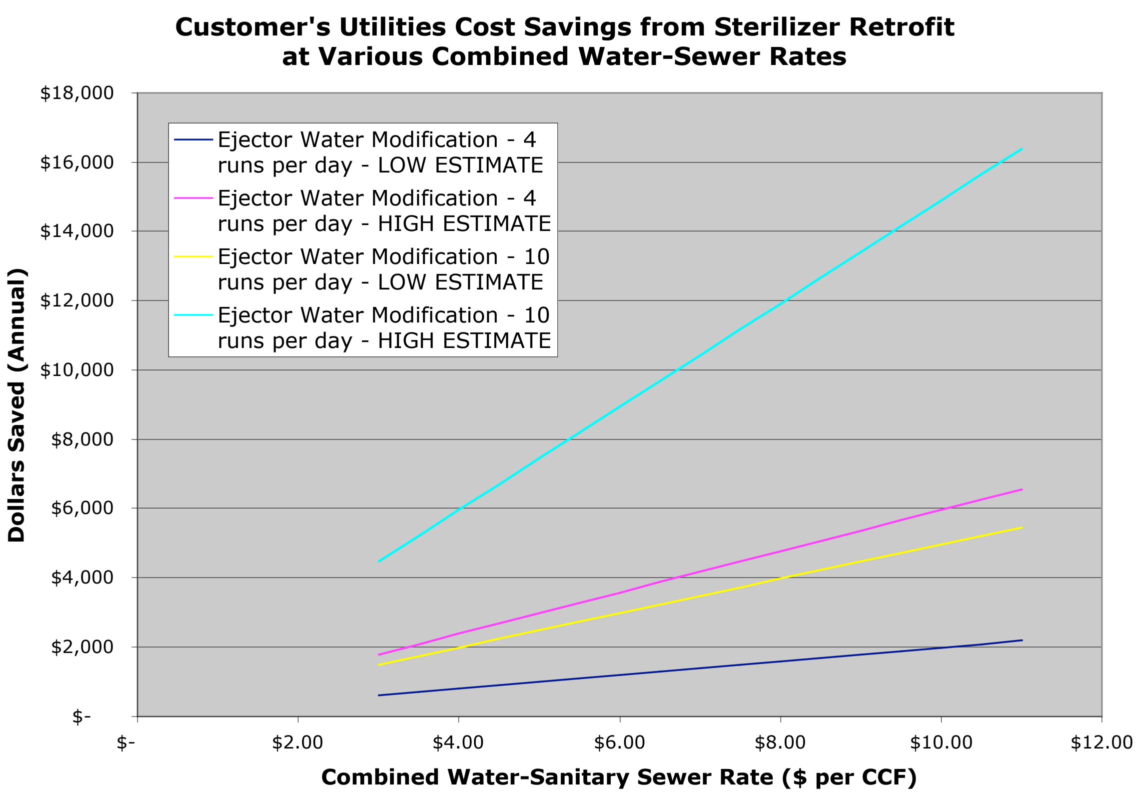


Figure 5. Cost Savings-Ejector Water Modification



6. California Potential

The approximate number of installed sterilizer units in California for each of the three manufacturers is as follows[40]:

Amsco (Sterris)	4,700
Getinge-Castle	3,100
ARS	600
TOTAL	8,400

It is estimated by the manufacturers that approximately 2 percent of the units are already retrofitted with water saving technology. We estimate the total potential and capturable water-savings benefit of implementing the described measures to be as follows:

Jacket and Chamber Condensate Cooling Modification

- *Potential Savings*

  Low range: 98% x 8,400 units x 15.9 acre-feet = 130,900 acre-feet
  Or ….approximately 6,500 acre-feet per year

  High range: 98% x 8,400 units x 40 acre-feet = 329,200 acre-feet
  Or ….approximately 16,500 acre-feet per year

- *Capturable Savings*

  Capturable savings will depend, to a large extent, upon the technical skills and water agency priority given to the implementation of the measure. However, working aggressively with the industry that markets the modifications, a reasonably conservative estimate of capture rate would be 50 percent. As such, capturable savings would generally range between 3,200 and 8,200 acre-feet of water per year in California.

Ejector Water Modification

- *Potential Savings*

  Low range: 98% x 8,400 units x 9.1 acre-feet = 74,900 acre-feet
  Or….approximate 3,750 acre-feet per year

  High range: 98% x 8,400 units x 68 acre-feet = 560,000 acre-feet
  Or….approximately 28,000 acre-feet per year

- *Capturable Savings*

  With the same caveats as noted above, potential capturable savings would amount to between about 1,900 and 14,000 acre-feet per year. This large range of savings is representative of the uncertainty with regard to the hours of use of the currently installed sterilizer base. Before any decision is made to consider this measure for full BMP status, further independent investigations of the usage patterns of the installed base would be required.

[40] Data was gathered from vendor sources deemed reliable, but cannot be guaranteed.

VII. Residential and Small Commercial Weather-Based Irrigation Controllers

1. Background

Irrigation accounts for a large proportion of total urban water demand. It is also a key driver of peak demand, and a significant source of urban runoff. Most studies and green industry professionals also believe that over-watering is widespread among the region's urban landscapes. All these factors combined suggest that conservation activity in this arena is likely to yield rich dividends on a number of different fronts.

Several approaches have been tried in the past to improve outdoor water use efficiency, such as, behavior modification through education, surveys/audits, conservation rate structures, and ordinances (e.g., day-of-week irrigation limits, Model Landscape Ordinance), and through application of modern technology (e.g., weather-based controllers, drip irrigation, gray-water reuse). Strategies based upon behavior modification, or application of new technology, are by no means mutually exclusive—in fact using them in concert usually leads to significant synergies.

Our goal in this section is to summarize key aspects of what we know about weather-based irrigation controllers. Weather-based controllers attempt to match irrigation to plant evapotranspiration (ET) needs, hence they are also referred to as ET controllers. Large, expensive, ET controllers for use in commercial landscapes have been available for some time. Recently, however, smaller, inexpensive units for use in residential settings have also started to appear on the market, opening up a conservation tool that heretofore was unavailable. Several of these newer, smaller, units have been extensively field tested during the last several years. Here we summarize what has been learned through these field studies and make recommendations about how best to integrate ET controllers into the existing framework of conservation PBMPs.

<u>Types of Weather-Based Controllers</u>

Weather-based (ET) irrigation controllers are available for as little as a hundred to several thousand dollars[41]. The technology underlying the different makes and models can be grouped into three broad categories, and within each category one may find ET controllers that either completely replace the existing controller, or make the existing controller "smarter" by piggybacking on it.

(1) *Controllers independent of broadcast signals*. The controller estimates irrigation schedules based upon on-site sensors. Some models may embed in their internal memory historical ET data for a given location, which is then modified on a real-time basis by on-site sensors. Some models may use a single sensor (temperature and/or solar radiation); others may incorporate additional sensors (rainfall and/or soil moisture).

[41] *Options for Weather-Based Irrigation Control for Residential and Small Commercial Sites Workshop*, 2003, Handbook prepared by California Urban Water Conservation Council; co-hosted by East Bay Municipal Water District and Santa Clara Valley Water District.

(2) *Controllers dependent upon broadcast signals*. The controller receives a signal broadcast from an off-site location indicating the level of ET, which is then used for estimating irrigation requirements. The customer may be required to subscribe to this signaling service, apart from purchasing the controller. The frequency with which signals are sent can vary (daily, bi-weekly, or as-required). Some models may also have the ability to integrate additional on-site sensors, such as rain collectors, to improve scheduling precision for the individual site.

(3) *Controllers with remote programming ability*. The controller is capable of both sending and receiving signals. Remote programming ability may be labor saving in large applications, and the controller can be designed to signal back if and when unauthorized tampering takes place. The latter feature makes these types of controllers especially useful in pay-for-performance programs.

The simplest controllers have embedded historical ET data and a single on-site sensor. Such models do not require a signal service subscription. In principle, additional on-site sensors could be integrated with embedded ET controllers to improve their accuracy, albeit at increased cost. At the other extreme are controllers with both a send and receive capability, making them remotely programmable and tamper proof. Any of these technologies will "work"—in the sense that each will modify irrigation schedules taking weather into account. The key is figuring out which technology model is most suited and cost-effective for a given setting.

<u>Behavioral Assumptions—Implications For Program Design</u>

The design of ET controller retrofit programs can greatly affect both the level of water savings, as well as the level of customer satisfaction. When residential ET controllers first became available, hope existed that a "hang it on the wall and walk away" approach would work, allowing water agencies to adopt fairly low-cost programs to distribute this new technology. Key to this expectation was the assumption that homeowners probably irrigate near optimum during the peak summer season but usually fail to properly scale irrigation up or down during the off-summer seasons (Figure 6). In such a scenario, simply transferring summer schedules from the existing to the retrofitted controller, or estimating a baseline schedule using simple rules of thumb, could be expected to generate marked savings. However, if excess irrigation is actually due less to inattention, and more due to a lack of knowledge on the customer's part (Figure 7), then savings depend to a greater extent on getting the baseline schedule right, which, in turn, implies a higher level of customer service during the retrofit phase and thereafter.

Water agencies should carefully assess which of the above two worlds its customers inhabit, before embarking on an ET controller retrofit program. In the context of ET controllers, we believe a mythology has arisen claiming that most residential customers alter their irrigation schedules no more than 2-4 times a year. Southern California's larger single family homes, especially in Irvine (see the two Irvine studies cited later), have been found to display a fairly sharp seasonal pattern—in other words, a pattern more like Figure 7 than Figure 6. While it is tempting to explain away these counterintuitive findings by attributing them to Irvine's steeply inclining rate structure, it is also possible that these patterns are more general, which is why agencies must carefully assess this issue.

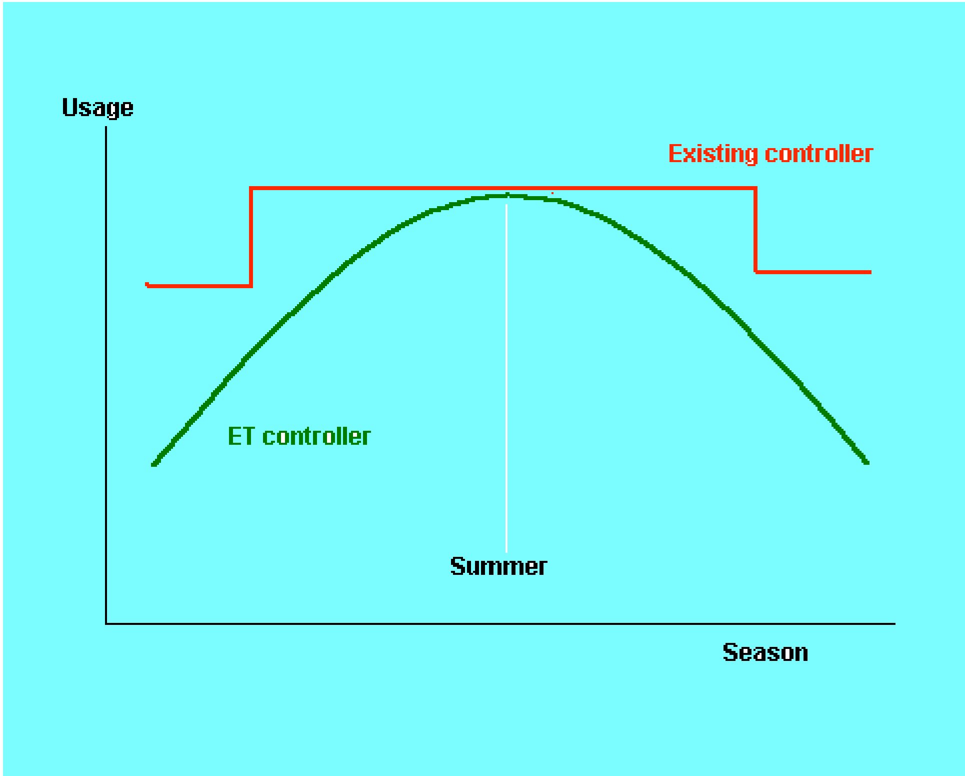


Figure 6. Peak summer schedule relatively accurate, customer inattentive

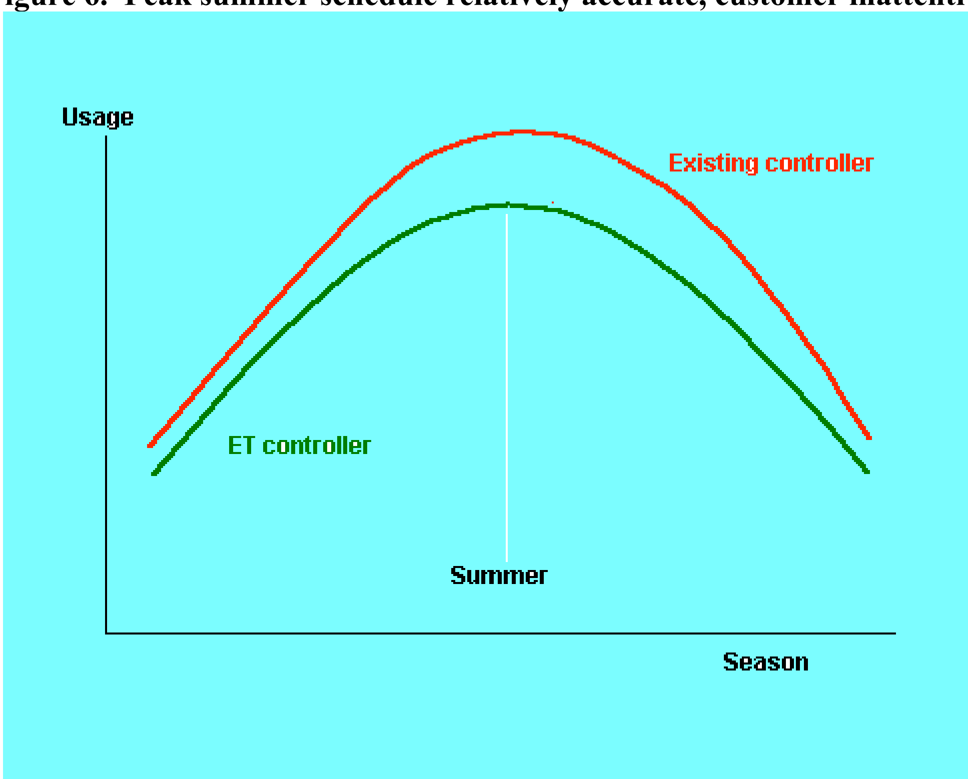


Figure 7. Customer relatively attentive, but not knowledgeable

2. Technological Efficacy

Several studies[42] have now been completed documenting the efficacy of ET controllers. The key findings of these studies are as follows.

Two studies performed in Irvine, California (Hunt et al., 2001; Diamond, 2003), and one in Denver, Colorado (Aquacraft, 2001 and 2002), specifically examine the efficacy of a broadcast-signal type controller (WeatherTRAK). A more recent study sponsored by the Metropolitan Water District of Southern California compares the performance of the above controller to two non-broadcast type controllers —a controller that modifies historical ET data using a temperature sensor (AquaConserve), and a controller that imputes ET by measuring solar radiation (WeatherSet). Although these studies do not suggest that all of the above controllers perform equally well, they do suggest that each has the potential of saving substantial amounts of water when correctly programmed with accurate baselines schedules in accordance with manufacturers' instructions. Additional studies are underway to fully understand the pros and cons of each type of controller technology. Technology vendors also continue to refine their products.

3. Water Savings Estimates

Assuming technological efficacy of the ET controller, water savings will become primarily a function of landscape size and the level of over-watering taking place prior to the ET controller retrofit. Studies that have evaluated water savings have come up with similar results, which is comforting. For example, Hunt et al. (2001) estimated that an ET controller program marketed to the top third (in terms of consumption) single-family homes in Irvine Ranch Water District's (IRWD) service area would reduce total residential consumption between 10 and 11 percent, or outdoor consumption by approximately 24 percent. A later evaluation of a follow-on program in IRWD's service area targeted at single-family homes also estimated a 10 percent reduction in total household consumption (Diamond, 2003). Both of these programs tested the performance of a broadcast-signal ET controller (WeatherTRAK). Addink and Rodda (2002) evaluated savings achieved by embedded historical-ET controllers (AquaConserve) in three agencies (Denver, Colorado; Sonoma, California; Valley of the Moon, California) and estimated that outdoor consumption in these three agencies declined by 21 percent, 23 percent, and 28 percent, respectively.

[42] Hunt, T., Lessick, D., Berg, J., Wiedmann, J., Ash, T., Pagano, D., Marian, M., and Bamezai, A., *Residential Weather-Based Irrigation Scheduling: Evidence From the Irvine "ET Controller" Study*, 2001 (http://www.irwd.com/conservation).
Addink, S., and Rodda, T. W., *Residential Landscape Irrigation Study Using Aqua ET Controllers*, 2002, (http://www.cuwcc.org/).
Aquacraft, *Performance Evaluation of WeatherTRAK Irrigation Controllers in Colorado*, 2001 and 2002, (http://www.aquacraft.com).
Diamond, D., *Project Review of the Irvine ET Controller Residential Runoff Reduction Study*, 2003, (http://www.irwd.com/reports).
Jordan, A., Lang, R., and Gonzales, M., *High Tech World Meets the Residential Irrigation Controller to Save Water in Santa Barbara County*, 2004 (forthcoming in AWWA conference proceedings).
Metropolitan Water District of Southern California, *Weather Based Controller Bench Test Report*, 2004.
The Saving Water Partnership, *Water Efficient Irrigation Study Final Report*, 2003, (http://www.cityofseattle.net/util/RESCONS/papers).

A more recent study of WeatherTRAK controllers in Santa Barbara found an even greater level of savings, mainly because the program targeted sites with very large landscapes (approximately 1 acre). Although not necessarily representative of the average California water agency, these findings underscore the strong relationship between landscape size and water savings as commonsense would dictate.

4. Customer Satisfaction and Outreach

Customer Satisfaction

Only two studies have examined this issue in some detail (Hunt et al., 2001; Aquacraft, 2001), and both report a high level of satisfaction with ET controllers. Unfortunately, both studies focus on the same broadcast-signal controller (WeatherTRAK), so it is difficult to compare customer satisfaction across different types of controllers.

Hunt et al. (2001) state that over 80 percent of study participants found overall performance of the WeatherTRAK controller to be either "good" or "very good", and over 90 percent found the controller to be either "convenient" or "very convenient" to use. However, the customer service provided by the Irvine Ranch Water District during the course of this study probably exceeded that which would normally be provided by a water agency when implementing a controller retrofit program.

Aquacraft (2001) states that based on a total of 10 test sites: "Compared to the old controller 5 users rated WeatherTRAK as better, 2 as less, and 4 about the same. Six users would recommend the system to a friend." Over 90 percent of study participants in both studies rated the appearance of their landscape as about the same, or better, than before.

In spite of such high levels of satisfaction with the technology, however, only one in four participants in the Irvine study (Hunt et al., 2001) and one in ten in the Denver study (Aquacraft, 2001) were willing to pay $4 or more per month for the signal fee associated with a broadcast-type controller like WeatherTRAK.

Customer Outreach and Programs

As mentioned earlier, when residential ET controllers first became available it was hoped that a "hang it on the wall and walk away" approach would be feasible, allowing water agencies to distribute this technology in a fairly low-cost manner. Field experience gathered since that time has dashed these hopes, however. Experience from Irvine (Hunt et al., 2001), and more recently from Santa Barbara (Jordan et al., 2004) demonstrates that savings and customer satisfaction greatly depend upon getting the baseline schedule right (requiring measurement of nozzle precipitation rates and so on; rules of thumb do not work), and upon educating the customer, and perhaps even their landscape caretaker, about proper irrigation scheduling and irrigation system maintenance, as well as about proper horticultural practices. These studies make a compelling case that ET controller distribution programs *must factor in a significant level of outreach effort in order to achieve water savings goals*.

5. Cost and Cost-Effectiveness

ET controllers both save water, but have the potential to reduce runoff. They also offer customers added convenience, which is of unknown value as of yet. The full lifecycle cost of a broadcast-signal ET controller, including unit cost, installation cost, and the monthly signal fee is quite high and would equate or fall below the water savings benefit only among some of the largest residential customers (Hunt, et al., 2001). The benefit-cost ratio is likely to be more favorable in the case of embedded historical-ET controllers since no signal fees are incurred, although it is still not clear whether the water savings are equivalent between the two ET controller technologies.

Although a comparative cost-effectiveness analysis of broadcast versus non-broadcast ET controllers has not been conducted to our knowledge, it is worth repeating what is known about the cost-effectiveness of broadcast-signal ET controllers. For example, in Irvine, Hunt et al., (2001) demonstrate that even if only the top-third of high water using single-family homes are retrofitted with WeatherTRAK controllers, the lifecycle water savings benefit to the customer would roughly equal $338 (customer savings are valued at $720 per acre-foot) compared to a total lifecycle cost of $528 (of which $353 represent signal fees) over a ten year product life cycle. Fortunately, this analysis also shows that the water savings benefit to IRWD is approximately $204, so that by offering a rebate IRWD can bring customer benefits in line with customer costs. In spite of the rebate, however, the overall benefit-cost ratio to the customer would still be close to one (or, by implication, the payback period roughly ten years), which is not the sort of incentive that makes individuals rapidly adopt new technology.

Several conclusions follow from the above discussion. First, targeting of high-water users to some extent is necessary to have a sensible program. Second, ET controllers should be marketed as much for their lifestyle and convenience features as for their water savings so that customers are drawn to this new technology. Green industry professionals should also be co-opted through outreach efforts to expand and transform the market for ET controllers[43]. Finally, a serious attempt must be made, whether through conservation rates, or through education, to sensitize customers to the consequences of bad irrigation habits, which we expect will make them significantly more open to new technologies such as ET controllers.

6. Summary

Market

Existing studies paint a positive picture about the technical efficacy of residential and small commercial weather-based irrigation controllers. In addition, their water savings potential rivals that of ultra-low-flush toilets on a per household basis.

[43] Bennett, D., and Smith, J., *Bringing Smarter Sprinkler Clocks to Market*, 2003, (http://www.cityofseattle.net/util/RESCONS/papers).

According to the California Department of Finance, there were roughly 7 million single-family detached homes in the state in 2003. We estimate conservatively that roughly only a quarter of these have automatic irrigation controllers and a landscape size large enough to justify weather-based irrigation controllers. Exact figures are difficult to come by at this stage, but assuming that on average landscape areas planted with turf and shrubs in these households works out to roughly 2,000 (turf equivalent) square feet, and that roughly 17 inches of irrigation per year are applied over and above what is necessary (based upon findings from Irvine, and author's preliminary estimate from another evaluation in progress), then the theoretical savings potential in this sector works out to roughly 114,000 acre-feet per year. Including the savings potential of other attractive sites, such as homeowner associations, parks, and other small commercial sites would raise this estimate even more.

We estimate the total cost of generating these savings to range roughly between $270 and $810 per acre-foot for non-broadcast and broadcast-type controller technologies (cost data underlying these estimates are taken from Hunt et al. [2001]).

Given the large likely market, and the possibility of making a significant impact on residential outdoor water use for which at present few other reliable tools are available, we believe that this technology easily merits designation as a PBMP. We also believe that costs of weather-based irrigation controllers will continue to decline over time, as the technology matures and demand expands, and that benefits (water savings, runoff reduction, customer convenience) will be better quantified by future studies, all of which could considerably improve the cost-benefit calculus.

Issues of Concern

Water agencies, however, need to consider several issues before adopting this technology to a full best management practice in its own right. For non-broadcast type controllers, technological efficacy still remains bit of an issue. For broadcast-type controllers, other issues remain on the table including: (1) location and coverage of urban weather stations, which obviously affects the accuracy of ET measurements transmitted to broadcast-type controllers; (2) how to ensure that customers continue to subscribe to the fee-based signaling service; (3) the amount and structure of the rebate and whether the initial purchase should be rebated or the signal service, or both; (4) whether signal service costs should be billed directly to the customer or along with the water bill. Finally, irrespective of the kind of controller at issue, the question remains whether weather-based controllers should be integrated with residential audits. Field experience both suggests that targeting of high water users is necessary, and that a good bit of effort is required up front to establish accurate baseline schedules to maximize water savings.

Manufacturers and Technology Advancements

Different manufacturers and vendors are continuing to pursue different ET controller technologies as well as different business models, which will influence how rapidly these controllers can be disseminated. Almost all manufacturers appear to have proprietary technologies, which deters water utilities to some extent, since none wants to be locked into working with just one technology or one vendor. Ideally, the industry would establish technical standards for both the signaling service and the receivers, such that customers could freely choose between different controllers and different signal vendors, mixing and matching as necessary. But since we do not yet detect solid moves by the industry in that direction, we expect absence of technical standards to act as bit of a dampener on the rate of (ET controller) market transformation and expansion in the short run.