NATURAL RESOURCES DEFENSE COUNCIL

NRDC Comments on CEC's

2009 Rulemaking Proceeding on Appliance Efficiency Regulations Phase II
Docket No. 11-AAER-1

September 30, 2011

Submitted by:

Edward Osann and Tracy Quinn
Natural Resources Defense Council

On behalf of the Natural Resources Defense Council and our more than 250,000 members and online activists in California, we respectfully submit these proposals for the development of new appliance efficiency standards under the proposed scoping order covering 2012–2014.

NRDC is generally very supportive of proposals made by stakeholders at the August 31, 2011 scoping workshop on consumer and office electronics, lighting and water-using products. We encourage CEC to move forward on all these proposals.

NRDC has identified a number of products as presenting some of the largest and most cost-effective energy and water efficiency opportunities. We enclose our own proposals on the following products:

- **Lavatory Faucets and Faucet Replacement Aerators**: Residential lavatory and kitchen faucets account for approximately 15.7 percent of indoor residential water use – equivalent to more than 132 billion gallons of water used in California each year. This standard proposal sets the maximum flow rate for lavatory faucets and lavatory replacement aerators at 1.5 gpm at 60 psi, effective January 1, 2014 and expands the definition of lavatory replacement aerator to include all flow restricting accessories, including flow regulators, aerator devices and laminar devices. This thereby ensures that all lavatory faucets sold in California adopt minimum water efficiency design best practices to minimize water waste.

- **Toilets and Urinals**: Residential toilets account for approximately 30 percent of indoor residential water use—equivalent to more than 252 million gallons of water consumed each year. This standard proposal revises the current standards in Title 20 regulations to conform to the legislatively enacted performance standards of AB715 by having toilets have 1.28 gallons per flush and urinals have 0.5 gallons per flush effective January 1, 2014. Moreover, the standard corrects the omission of flushometer valve toilets, removes any possible ambiguity regarding compliance, and reflects current law to avoid confusion in the marketplace among stakeholders. This thereby ensures that all toilets and urinals sold in California adopt minimum water efficiency design best practices to minimize water waste.

- **Water Meters**: There are currently about nine million single family homes in California, of which about 90 percent are estimated to be metered. Current voluntary meter standards for accuracy, developed by American Water Works Association, do not require testing at levels indicative of household leaks. Therefore, under current meter accuracy requirements, leaks as large as 200 gallons per day can go undetected. Waterwiser.org estimates that as many as 20 percent of single family home toilets leak. Applied to the entire state, that could equal as much as 1 billion gallons per day.

In addition, NRDC is separately submitting a set of proposals on efficiency standards for the following energy-using products:

- **Set-Top Boxes (STB)**
- **Game Consoles**
- **Personal Computers (PC)**
- **Computer Servers**

We thank the Commission for the opportunity to provide input into the 2009 Rulemaking Proceeding on Appliance Efficiency Regulations Phase II, and stand ready to provide any additional information. We look forward to working with the Commission on these critical water efficiency opportunities.

Respectfully submitted,

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Proposal Information Template – Lavatory Faucets and Faucet Replacement Aerators

2011 Appliance Efficiency Standards

Prepared by: Ed Osann and Tracy Quinn

September 30, 2011

CONTENTS

Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the California Energy Commission's (Commission) appliance efficiency regulations (Title 20, Cal. Code Regulations,, §§ 1601 – 1608) This report specifically covers lavatory faucets and faucet replacement aerators.

Background

WaterSense estimates that there are 27 million residential lavatory faucets in California.[1]* This is based on an assumed one-to-one ratio of lavatory faucets to residential bathrooms.[2] In addition to the existing stock, approximately 3 million new faucets are sold each year for installation in new homes or replacement of aging fixtures in existing homes.[3] Of these 3 million faucets, roughly two-thirds of those are lavatory faucets (approximately 2 million units).[1] Residential lavatory and kitchen faucets account for approximately 15.7 percent of indoor residential water use — equivalent to more than 132 billion gallons of water used in California each year.[4]

This standard proposal aims to ensure that all lavatory faucets sold in California adopt minimum water efficiency design best practices to minimize water waste. The proposed standard is structured to follow the 2007 WaterSense specifications for lavatory faucets and lavatory replacement aerators.

Overview

Description of Standards Proposal	We recommend that California adopt a standard for lavatory faucets and faucet aerators per the following: ➢ Revise Table H-1 in 1605.1(h)(1) to set the maximum flow rate for <u>lavatory faucets</u> and <u>lavatory replacement aerators</u> at 1.5 gpm at 60 psi, effective January 1, 2014. ➢ Expand the definition of lavatory replacement aerator to include all flow restricting accessories, including flow regulators, aerator devices, and laminar devices (as per WaterSense definition). .

[1] WaterSense High-Efficiency Lavatory Faucet Specification Support Statement
* California rates were calculated by taking 12% of U.S. numbers provided, (assumes California population comprises 12% of US population)

[2] U.S. Census Bureau, American Housing Surveys for the United States, 1970-2003.

[3] Business Trend Analysts, 2006. “2005/2006 Outlook for the U.S. Plumbing Fixtures and Fittings Industry.” <www.mindbranch.com/catalog/print_product_page.jsp?code=R225-358>

[4] Mayer, Peter W. and William B. DeOreo. Residential End Uses of Water. Aquacraft, Inc. Water Engineering and Management. American Water Works Association. 1998.

California Stock and Sales	2014 California Stock – approximately **27 million lavatory faucets** • Assuming 1 lavatory faucet per full bathroom and 1 lavatory faucet per half bathroom, [American Housing Survey, 1970-2003] Projected sales from 2014 through 2025 – approximately **17 million lavatory faucets** Assumed full stock turn over in approximately 25 years.
Energy Savings and Demand Reduction	We estimate that the standard would result in the following annual energy savings attributed to heating water after stock turn over (not including the embedded energy of water: • **130 million kWh hours.** • **4.7 Bcf of natural gas**
Economic Analysis	There is no incremental price difference between a product meeting this proposed standard and other less efficient lavatory faucets and lavatory replacement aerators. The average homeowner replacing their lavatory faucets or retrofitting them with lavatory faucet accessories (e.g.aerator, laminar flow device, flow restrictor) that meet this proposed standard will see the following savings: • Water and Wastewater: **$3.26/year**. • Energy (homes with electric water heating): **$9.91/year** • Energy (homes with gas water heating): **$7.82/year**
Non-Energy Benefits	We estimate that the standard would result in the following water savings after full stock turn over: • 33 million gallons per day (MGD) or **12 billion gallons annually**.
Environmental Impacts	We are not aware of any adverse environmental impacts that will be created by the proposed standard.
Acceptance Issues	We do not anticipate any acceptance issues that will be created by the proposed standard.

Federal Preemption or other Regulatory or Legislative Considerations	The Energy Policy Act of 1992 originally set the maximum flow rate for both lavatory and kitchen faucets at 2.5 gallons per minute (gpm) at 80 pounds per square inch (psi) static pressure. In 1994, American Society of Mechanical Engineers (ASME) A112.18.1M-1994–Plumbing Supply Fittings set the maximum flow rate for lavatory faucets at 2.2 gpm at 60 psi. In response to industry requests for conformity with a single standard, in 1998, the U.S. Department of Energy adopted the 2.2 gpm at 60 psi maximum flow rate standard for all faucets (see 63 FR 13307; March 18, 1998). This national standard is codified in the U.S. Code of Federal Regulations at 10 CFR Part 430.32. As a point of reference, the maximum flow rates of many of the pre-1992 faucets range from 3 to 7 gpm.1 The EPA WaterSense specification with a maximum flow rate of 1.5 gpm and 60-psi was first adopted in 2007. Other than the aforementioned maximum flow rate standards, there currently are no universally accepted performance tests or specifications (e.g., rinsing or wetting performance standards) for faucets. • Note that Federal preemption of state standards no longer applies to plumbing fixtures and fittings, as per Federal Register, Vol. 75, No. 245, December 22, 2010, p 80289. • Note that while these products are federally covered products under EPCA, DOE has determined that states are no longer preempted from setting stronger standards

Methodology and Modeling used in the Development of the proposal

Savings estimates were developed using the best available data from a number of sources as well as our own assumptions as detailed below.

Data, Analysis and Results

Sales

Specific sales numbers for lavatory faucets and faucet replacement aerators in California were not able to be obtained in preparation with this document. Sales values used in this template are based on population projections provided by the California Department of Finance. The population projections were used to estimate housing growth, which, for use in these calculations, is assumed to maintain the same proportions of single family, multi-family and other types of residences over time. It was also assumed that the number of lavatory faucets would be equivalent to the number of toilets, although this is a conservative estimate because many homes have two lavatory faucets in one bathroom. Furthermore, it was assumed that the average number of toilets per residential type would remain the same through the projected time period. The number of toilets in California, delineated by housing type, comes directly from the American Housing Survey [American Housing Survey, 1970-2003].

Table 1: Sales Estimates

	Average # Lavatory Faucets per Housing Type	New Housing Units (2014 - 2025)	New Lavatory Faucets from New Construction (2014 - 2025)	New Faucets from Replacement[1] (2014 - 2025)
Single Family	2.12	1,180,000	2,500,000	NA
Multi-Family	1.37	570,000	780,000	NA
Other	1.37	80,000	110,000	NA
Total	NA	1,830,000	3,390,000	13,500,000

[1] Assumes a replacement rate of 4%.

Total estimated sales of lavatory faucets and/or faucet replacement aerators for the period 2014 through 2025 is the sum of lavatory faucets purchased for new construction and replacement of existing and is approximately 17 million.

Savings Estimates

The following text, explaining potential water and energy savings estimates for the proposed standard, is from the WaterSense High Efficiency Lavatory Faucet Specification Supporting Statement. National estimations have been replaced with California specific calculations based on work conducted by NRDC staff.

To estimate water and energy savings that can be achieved by products that meet this specification, WaterSense examined the Seattle (2000) and EBMUD (2003) Aquacraft retrofit studies, which provided actual water consumption reductions generated by the installation of high-efficiency, pressure-compensating 1.5 gpm aerators on lavatory faucets. WaterSense expects the results under this specification to be similar to what was found in these two studies. These studies indicate that installing high-efficiency aerators can yield significant reductions in household water consumption. Post faucet retrofit, the weighted average daily per capita reduction in water consumption achieved was 0.6 gallons per capita per day (gcpd). It is important to note that in both of these studies, kitchen faucets in each household were retrofitted with 2.2 gpm pressure compensating aerators. While these retrofits contributed in part to overall reductions in household water consumption, the retrofits simply brought those kitchen sink faucets up to current water-efficiency standards, therefore, WaterSense decided to set aside this confounding influence in order to estimate the water savings.

Assuming the average household consists of 2.6 people[1], this equates to an average annual household savings of approximately 570 gallons of water (see Calculation 1).

Calculation 1. Average Household Water Savings

(0.6 gallons/person/day) (2.6 people/household) (365 days) = 570 gallons/household annually

Extrapolated to the state level, potential estimated water savings could be as great as 9.1 billion gallons annually (see Calculation 2). These estimates clearly demonstrate the significant water savings potential of high-efficiency lavatory faucets and accessories.

Calculation 2. California Water Savings in 2025

(570 gal/year) · (16,000,000 households w/ plumbing fixtures) = 9.1 billion gallons per year

Based upon these estimates, the average household could save more than 70 kWh of electricity (see Calculation 3) or 350 cubic feet of natural gas (see Calculation 4) each year. California savings could exceed 130 million kWh hours and 4.7 billion cubic feet (Bcf) of natural gas each year (see Calculations 5 and 6).

Calculation 3. California Water Savings at full stock turn over (estimated in 2040)

(0.6 gallons/person/day) (54 million people) = 33 million gallons per day

Calculation 4. Electricity Saving per Household

(570 gal/year · 0.70) · (176.5 kWh of electricity/1,000 gal) = 70 kWh of electricity per year

Calculation 5. Natural Gas Savings per Household

(570 gal/year · 0.70) · (0.8784 Mcf of natural gas/1,000 gal) = 0.35 Mcf (350 cubic feet) of natural gas per year

Calculation 6. California Electricity Savings Potential in 2025

(9,120,000,000 gal · 0.70 · 0.115) · (176.5 kWh of electricity/1,000 gal) = 130 million kWh of electricity statewide

Calculation 7. California Natural Gas Savings Potential in 2025

(9,120,000,000 gal · 0.70 · 0.844) · (0.8784 Mcf of natural gas/1,000 gal) = 4.7 million Mcf of natural gas statewide = 4.7 Bcf of natural gas statewide

These calculations are based upon the following assumptions:

- Approximately 70 percent of faucet water used in a household is hot water (Tampa and Seattle Aquacraft studies).
- Approximately 11.5 percent of occupied residences in California heat their water using electricity (2005 Residential Energy Consumption Survey).
- Approximately 84.4 percent of occupied residences in California heat their water using natural gas (2005 Residential Energy Consumption Survey).
- Water heating consumes 0.1765 kWh of electricity per gallon of water heated assuming:
    - Specific heat of water = 1.0 BTU/lb · º F
    - 1 gallon of water = 8.34 lbs
    - 1 kWh = 3,412 BTUs
    - Incoming water temperature is raised from 55º F to 120º F (Δ 65 º F).
    - Water heating process is 90 percent efficient, electric hot water heater.

Calculation 8.

[(1 gal · 1.0 BTU/lbs · º F) (1KWh/3,412 BTUs) / (1 gallon/8.34 lbs) · 65º F] / 0.90 = 0.1765 kWh/gal

- Water heating consumes 0.8784 Mcf of natural gas per 1,000 gallons of water heated assuming:
  - o Specific heat of water = 1.0 BTU/lb · º F
  - o 1 gallon of water = 8.34 lbs
  - o 1 Therm = 99,976 BTUs
  - o Incoming water temperature is raised from 55º F to 120º F (Δ 65 º F)
  - o Water heating process is 60 percent efficient, natural gas hot water heater

Calculation 9.

[(1 gal · 1.0 BTU/lbs · º F) (1Therm/99,976 BTUs) / (1 gallon/8.34 lbs) · 65º F] / 0.60 = 0.009053 Therms/gal

Calculation 10.

0.010428 Therms/gal · 1,000 gal · 1Mcf/10.307 Therms = 0.8784 Mcf/kgal

Cost Effectiveness

There is no incremental price difference between a product meeting this proposed standard and other less efficient lavatory faucets and lavatory replacement aerators.

Calculation 11.Household Cost Savings - Water

(570 gallons/year) ($5.72/1,000 gallons[5]) = $3.26/year

Calculation 12. Household Cost Savings – Energy (Electricity)

($6.65) (70 kWh/year) ($0.095/kWh) = $9.91/year

Calculation 13. Household Cost Savings – Energy (Gas)

($4.56) (0.35 Mcf/year) ($13.04/Mcf) = $7.82/year

[5] Raftelis Financial Consulting. Water and Wastewater Rate Survey. American Water Works Association. 2004

Proposed Standards and Recommendations

The proposed recommendations are:

- Revise Table H-1 in 1605.1(h)(1) to set the maximum flow rate for lavatory faucets and lavatory replacement aerators at 1.5 gpm at 60 psi, effective January 1, 2014.
- Expand the definition of lavatory replacement aerator to include all flow restricting accessories, including flow regulators, aerator devices, and laminar devices (as per WaterSense definition).

Table 2: Proposed Standard

Product	Current Standard	Proposed Standard
Lavatory Faucet[a]	2.2 gpm @ 60 psi	1.5 gpm @ 60 psi

[a] Pursuant to the definition of faucet in Section 1602(h) of Title 20 regulations, this standard would also apply to faucet replacement aerators, sold separately.

Bibliography and Other Research

As indicated within the document.

References and Appendices

Appendix A: WaterSense High Efficiency Lavatory Faucet Specification Supporting Statement

WaterSense® High-Efficiency Lavatory Faucet Specification

Supporting Statement

I. Introduction

The WaterSense program released its High-Efficiency Lavatory[1] Faucet Specification (specification) on October 1, 2007, to promote and enhance the market for water-efficient lavatory faucets. The goal of this specification is to allow consumers to identify and differentiate products in the marketplace that meet this specification's criteria for water efficiency and performance.

This specification addresses lavatory faucets and lavatory faucet accessories[2] in private use, such as those found in residences, and private restrooms in hotels and hospitals. Since these types of faucets are used primarily for hand washing and other sanitary activities, such as face washing and razor rinsing, WaterSense believes that maximum flow rates can be reduced enough to impact national water consumption while at the same time not negatively impacting user satisfaction. This specification is not intended to address kitchen faucets, which have a very different set of uses and performance criteria, or public restroom faucets (e.g., airports, theaters, arenas, stadiums, offices, and restaurants), which already have national performance standards and criteria to which they should conform.

II. Current Status of Faucets

WaterSense estimates that currently there are 222 million residential lavatory faucets in the United States. This estimate is based on an assumed one-to-one ratio of lavatory faucets to residential bathrooms.[3] In addition to the existing stock, approximately 25 million new faucets are sold each year for installation in new homes or replacement of aging fixtures in existing homes.[4] Of these 25 million faucets, roughly two-thirds of those are lavatory faucets (approximately 17 million units). Residential lavatory and kitchen faucets account for

[1] Lavatory is the terminology used in the Energy Policy Act of 1992 and ASME A112.18.1 to describe the types of faucets to which the standards apply. In this specification, lavatory means any bathroom sink faucets intended for private use.

[2] Accessory, as defined in ASME 112.18.1, means a component that can, at the discretion of the user, be readily added, removed, or replaced, and that, when removed, will not prevent the fitting from fulfilling its primary function. For the purpose of this specification, an accessory can include, but is not limited to lavatory faucet flow restrictors, flow regulators, aerator devices, laminar devices, and pressure compensating devices.

[3] U.S. Census Bureau, American Housing Surveys for the United States, 1970-2003.

[4] Business Trend Analysts, 2006. "2005/2006 Outlook for the U.S. Plumbing Fixtures and Fittings Industry." <www.mindbranch.com/catalog/print_product_page.jsp?code=R225-358>

approximately 15.7 percent of indoor residential water use in the United States[5]—equivalent to more than 1.1 trillion gallons of water used each year.

The Energy Policy Act of 1992 originally set the maximum flow rate for both lavatory and kitchen faucets at 2.5 gallons per minute (gpm) at 80 pounds per square inch (psi) static pressure. In 1994, American Society of Mechanical Engineers (ASME) A112.18.1M-1994–Plumbing Supply Fittings set the maximum flow rate for lavatory faucets at 2.2 gpm at 60 psi. In response to industry requests for conformity with a single standard, in 1998, the U.S. Department of Energy adopted the 2.2 gpm at 60 psi maximum flow rate standard for all faucets (see 63 FR 13307; March 18, 1998). This national standard is codified in the *U.S. Code of Federal Regulations* at 10 *CFR* Part 430.32. As a point of reference, the maximum flow rates of many of the pre-1992 faucets range from 3 to 7 gpm. Other than the aforementioned maximum flow rate standards, there currently are no universally accepted performance tests or specifications (e.g., rinsing or wetting performance standards) for faucets.

III. WaterSense High-Efficiency Lavatory Faucet Specification

<u>Scope</u>

The WaterSense program developed this specification to address criteria for improvement and recognition of water-efficient and high-performance lavatory faucets and lavatory faucet accessories. WaterSense labeled lavatory faucet accessories can be incorporated into the design of new faucets to control the flow rate and provide the mechanism for meeting this specification's criteria, or can be purchased separately and retrofit onto existing older faucets to provide water efficiency and performance. This specification focuses solely on the category of lavatory faucets intended for private use because of the differences in the uses and performance expectations between private lavatory faucets and kitchen or public restroom faucets. Lavatory faucets are used primarily for hand washing and other sanitary activities, such as teeth brushing, face washing, and shaving. For these activities, discussions with faucet manufacturers and water utility representatives provided a general consensus that a reduction in the maximum flow rate from 2.2 gpm (the current federal water-efficiency standard) to 1.5 gpm, as established by this specification, is not very noticeable for most users. The most noticeable differences are increased wait times when filling the basin or waiting for hot water. While decreasing a faucet's maximum flow rate increases user wait time for these activities, WaterSense determined the potential water savings gained from the primary use of lavatory faucets (i.e., washing and rinsing) outweigh any potential inconvenience caused by increased wait times and will not negatively impact overall user satisfaction.

Kitchen sink faucets were excluded from this specification because the different uses and user expectations require other considerations for defining performance. One major performance consideration is a kitchen faucet's ability to effectively rinse dishes. Kitchen faucets also are commonly used for pot or container filling, and significantly increased wait times might not be acceptable to most users. WaterSense determined that reducing the maximum flow rates of kitchen faucets would create issues of user satisfaction and be counter to its program goals of

[5] Mayer, Peter W. and William B. DeOreo. Residential End Uses of Water. Aquacraft, Inc. Water Engineering and Management. American Water Works Association. 1998.

increasing efficiency while maintaining or improving performance. In order to maintain user satisfaction and ensure a high level of performance, a maximum flow rate greater than what is suitable for lavatory faucets might need to be considered for kitchen faucets. Some type of wetting or rinsing performance test also might need to be included. In addition, there is an emerging area of research and development in multiposition control lever faucet technologies that offer users “high” and “low” settings for different activities. While performance data are not yet available, these technologies might prove to be effective in using water more efficiently. For these reasons, WaterSense intends to evaluate the possibility of developing a WaterSense specification for kitchen faucets at a later date.

Public restroom and metering faucets (faucets that are set to discharge a specific amount of water or run for a specified period of time for each use) also were excluded from this specification because of their differing uses and performance expectations and because standards governing their maximum flow rate already exist. Public restroom faucets, for example, are used almost exclusively for hand washing or simple rinsing, compared to lavatory faucets in homes and in other private bathrooms that face a myriad of uses. As a consequence, the maximum flow rate for these public restroom and metering fixtures can be set significantly lower than the flow rate for private lavatory faucets without negatively impacting user satisfaction. Also, a separate set of standards already apply to these types of fixtures. Codified in the *U.S. Code of Federal Regulations* at 10 *CFR* Part 430 (specifically §430.32(o) Faucets) are standards setting the maximum flow rate for metering faucets at 0.25 gallons/cycle. Section 5.4.1 and Table 1 of ASME A112.18.1/CSA B125.1–Plumbing Supply Fittings also establish the maximum flow rates for public lavatory (other than metering) faucets at 0.5 gpm. As a consequence, this category of faucet is not covered by the current specification. If WaterSense decides to address water efficiency and performance for these types of faucets, it will do so under a separate specification at a later time.

Water-Efficiency and Performance Criteria

The water-efficiency component of this specification establishes a maximum flow rate of 1.5 gpm at an inlet pressure of 60 psi. Lowering the maximum flow rate from 2.2 gpm to 1.5 gpm (both at 60 psi) represents a 32 percent reduction, which is consistent with WaterSense’s stated goal of improving efficiency by at least 20 percent. Even when installed in systems with high water pressure (up to 80 psi), faucets designed to this specification will have maximum flow rates of approximately 1.75 gpm, which still represents a greater than 20 percent increase in efficiency. WaterSense chose to specify a test pressure of 60 psi to maintain consistency with the current industry standard (ASME A112.18.1–Plumbing Supply Fittings) to which all faucets sold in the United States must comply.

The requirements of this specification are also in harmony with other international standards. The Joint Standards Australia/Standards New Zealand Committee established standards for the rating and labeling of water-efficient products (AS/NZS 6400:2005). As part of the standard, water-efficient faucets are rated on a scale of 1 to 6 based on maximum flow rates. Under this system, comparable 1.5 gpm WaterSense labeled lavatory faucets would receive a 5 out of 6 star rating, meeting criteria for maximum flow rates between 4.5 liters per minute (L/min) (1.2 gpm) and 6.0 L/min (1.6 gpm).

Meeting or exceeding user expectations via the establishment of performance criteria for WaterSense labeled products is an important aspect of the WaterSense program. From the outset of discussions with interested parties, WaterSense was aware that performance of water-efficient lavatory faucets is affected by low water pressures. To ensure user satisfaction with WaterSense labeled lavatory faucets or lavatory faucet accessories across a range of possible user conditions, WaterSense has established a minimum flow rate of 0.8 gpm at 20 psi in the specification.

In developing these water-efficiency and performance criteria, WaterSense evaluated comments received during the draft specification's public forum and public comment period (see *Response to Issues Raised During Public Comment on February 2007 Draft Specification for WaterSense℠ Labeling of High-Efficiency Lavatory Faucets*). WaterSense also considered user satisfaction data generated from four high-efficiency lavatory faucet retrofit studies and the impact of pressure changes on product flow rates for various types of lavatory faucet accessories.

WaterSense established a maximum flow rate of 1.5 gpm at 60 psi because interested parties that provided comments on the draft specification generally agreed that a flow rate of 1.5 gpm would provide no noticeable difference for most users. In addition, data collected from retrofit studies demonstrate a high level of user satisfaction with high-efficiency lavatory faucets that have maximum flow rates of 1.0 and 1.5 gpm. Aquacraft, Inc. conducted retrofit studies in Seattle, Washington (2000)[6] and East Bay Municipal Utility District (EBMUD), California (2003)[7] in which they replaced existing lavatory faucet aerators with 1.5 gpm pressure compensating aerators. In the Seattle study, 58 percent of the participants felt their faucets with the new aerators performed the same or better than their old faucet fixtures and 50 percent stated they would recommend these aerators to others. In the EBMUD study, 80 percent of the participants felt their faucets with the new aerators performed the same or better than their old faucet fixtures, and 67 percent stated they would recommend these aerators to others. A third Aquacraft, Inc. retrofit study conducted in Tampa, Florida (2004)[8] replaced existing lavatory faucet aerators with 1.0 gpm pressure compensating aerators. The participants in this study were receptive to an even higher-efficiency fixture, with 89 percent saying their new aerators performed the same or better than their old faucet fixtures and would recommend them to others. Seattle Public Utilities also provided WaterSense with survey results of customer use and satisfaction with 1.0 gpm pressure compensating aerators distributed through the utility's direct-mail showerhead and faucet aerator pilot program. According to its survey, 94 percent of the participants that received the free aerators installed them and only 2 percent disliked the aerators and removed them.[9]

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[6] Seattle Home Water Conservation Study: The Impacts of High-Efficiency Plumbing Fixture Retrofits in Single-Family Homes, December 2000.

[7] Water Conservation Study: Evaluation of High-Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in the East Bay Municipal Utility District Service Area, July 2003.

[8] Tampa Water Department Residential Water Conservation Study: The Impacts of High-Efficiency Plumbing Fixture Retrofits in Single-Family Homes, January 2004.

[9] Seattle Public Utilities. "Showerhead/Aerator Pilot Program Summary." Unpublished.

WaterSense established a minimum flow rate of 0.8 gpm at 20 psi for several reasons. First, WaterSense felt this minimum flow rate was reasonable to ensure user satisfaction in homes with low water pressure based on comments that were received regarding the draft specification. Second, WaterSense received comments from several utilities regarding programs in which 1.0 gpm lavatory faucet aerators are provided to customers. These products have shown a high level of user satisfaction, and WaterSense wants to recognize these products and the efforts of the utilities to ensure that additional water savings can be achieved through such programs. Third, WaterSense wants to avoid restricting design options to the extent possible. The specification leaves open the possibility for the use of fixed orifice flow control devices (with a maximum flow rate of 1.5 gpm) instead of restricting manufacturers to the use of pressure compensating devices. Under the specification, a 1.5 gpm maximum flow rate fixed orifice aerator could qualify for use of the label (according to currently available product specifications and flow curves). Pressure compensating devices with maximum flow rates between 1.5 and 1.0 gpm could also qualify for the use of the WaterSense label (according to currently available product specifications and flow curves). WaterSense believes that this approach allows for the greatest degree of design freedom for manufacturers and supports existing utility programs, while still ensuring a high level of performance and user satisfaction.

In order for high-efficiency lavatory faucets to effectively emerge in the market following the release of the final version of this specification, the market must ideally be equipped to produce the faucets or faucet technology that the specification requires. WaterSense is not currently aware of any lavatory faucets on the market with a maximum flow rate of 1.5 gpm. There are, however, several types and models of faucet components and accessories currently available that have the capability to control the flow to the level that is required by this specification. As a result, WaterSense is confident that faucets and faucet accessories that meet the requirements of this specification can be readily brought to market.

Potential Water and Energy Savings

To estimate water and energy savings that can be achieved by products that meet this specification, WaterSense examined the Seattle (2000) and EBMUD (2003) Aquacraft retrofit studies, which provided actual water consumption reductions generated by the installation of high-efficiency, pressure-compensating 1.5 gpm aerators on lavatory faucets. WaterSense expects the results under this specification to be similar to what was found in these two studies. These studies indicate that installing high-efficiency aerators can yield significant reductions in household water consumption. Post faucet retrofit, the weighted average daily per capita reduction in water consumption achieved was 0.6 gallons per capita per day (gcpd). It is important to note that in both of these studies, kitchen faucets in each household were retrofitted with 2.2 gpm pressure compensating aerators. While these retrofits contributed in part to overall reductions in household water consumption, the retrofits simply brought those kitchen sink faucets up to current water-efficiency standards, therefore, WaterSense decided to set aside this confounding influence in order to estimate the water savings. Assuming the average household consists of 2.6 people, this equates to an average annual household savings of approximately 570 gallons of water (see Calculation 1).

Calculation 1. Average Household Water Savings
0.6 gpcd · 2.6 people/household · 365 days = 570 gallons annually

Extrapolated to the national level, potential estimated water savings could be as great as 61 billion gallons annually (see Calculation 2). These estimates clearly demonstrate the significant water savings potential of high-efficiency lavatory faucets and accessories.

Calculation 2. National Water Savings
570 gal/year · 107,574,000[10] occupied residences w/ plumbing fixtures = 61 billion gallons

Based upon these estimates, the average household could save more than 70 kWh of electricity (see Calculation 3) or 350 cubic feet of natural gas (see Calculation 4) each year. National savings could exceed 3 billion kWh hours and 20 billion cubic feet (Bcf) of natural gas each year (see Calculations 5 and 6).

Calculation 3. Electricity Saving Per Household
(570 gal/year · 0.70) · (176.5 kWh of electricity/1,000 gal) = 70 kWh of electricity per year

Calculation 4. Natural Gas Savings Per Household
(570 gal/year · 0.70) · (0.8784 Mcf of natural gas/1,000 gal) = 0.35 Mcf (350 cubic feet) of natural gas per year

Calculation 5. National Electricity Savings Potential
(61,000,000,000 gal · 0.70 · 0.40) · (176.5 kWh of electricity/1,000 gal) = 3 billion kWh of electricity nationwide

Calculation 6. National Natural Gas Savings Potential
(61,000,000,000 gal · 0.70 · 0.56) · (0.8784 Mcf of natural gas/1,000 gal) = 20 million Mcf of natural gas nationwide = 20 Bcf of natural gas nationwide

These calculations are based upon the following assumptions:

- Approximately 70 percent of faucet water used in a household is hot water (Tampa and Seattle Aquacraft studies).
- 42,788,000 (approximately 40 percent) of occupied residences in the United States heat their water using electricity.[11]
- 60,222,000 (approximately 56 percent) of occupied residences in the United States heat their water using natural gas.[12]

[10] U.S. Department of Housing and Urban Development and U.S. Census Bureau. American Housing Survey for the United States 2005. Table 1A-4 page 5.

[11] U.S. Department of Housing and Urban Development and U.S. Census Bureau. American Housing Survey for the United States 2005. Table 1A-5, page 6.

[12] U.S. Department of Housing and Urban Development and U.S. Census Bureau. American Housing Survey for the United States 2005. Table 1A-5, page 6.

- Water heating consumes 0.1765 kWh of electricity per gallon of water heated assuming:
  - Specific heat of water = 1.0 BTU/lb · º F
  - 1 gallon of water = 8.34 lbs
  - 1 kWh = 3,412 BTUs
  - Incoming water temperature is raised from 55º F to 120º F (∆ 65 º F).
  - Water heating process is 90 percent efficient, electric hot water heater.

Calculation 7.
[(1 gal · 1.0 BTU/lbs · º F) (1KWh/3,412 BTUs) / (1 gallon/8.34 lbs) · 65º F] / 0.90
= 0.1765 kWh/gal

- Water heating consumes 0.8784 Mcf of natural gas per 1,000 gallons of water heated assuming:
  - Specific heat of water = 1.0 BTU/lb · º F
  - 1 gallon of water = 8.34 lbs
  - 1 Therm = 99,976 BTUs
  - Incoming water temperature is raised from 55º F to 120º F (∆ 65 º F)
  - Water heating process is 60 percent efficient, natural gas hot water heater

Calculation 8.
[(1 gal · 1.0 BTU/lbs · º F) (1Therm/99,976 BTUs) / (1 gallon/8.34 lbs) · 65º F] / 0.60
= 0.009053 Therms/gal

Calculation 9.
0.010428 Therms/gal · 1,000 gal · 1Mcf/10.307 Therms = 0.8784 Mcf/kgal

Cost Effectiveness and Payback Period

The average homeowner retrofitting their lavatory faucets with WaterSense labeled high-efficiency lavatory faucet accessories (e.g., aerator, laminar flow device, flow restrictor) will realize accompanying $3.26 savings on water and wastewater cost annually due to lower water consumption (see Calculation 10).

Calculation 10. Annual Water and Wastewater Cost Savings
570 gallons/year · $5.72/1,000 gallons[13] = $3.26/year

Factoring in the accompanying energy savings, the average household with electric water heating may save an additional $6.65 (70 kWh/year · $.095/kWh), for a combined annual savings of $9.91. The average household with natural gas water heating, may save an additional $4.56.(0.35 Mcf/year · $13.04/Mcf), for a combined annual savings of $7.82.

[13] Raftelis Financial Consulting. Water and Wastewater Rate Survey. American Water Works Association. 2004.

Assuming that the average household has two lavatory faucets[14], replacing the aerators in each lavatory faucet with a WaterSense labeled aerator would save $1.63 per faucet on annual water and wastewater costs. The average payback period for the replacement of two lavatory faucet aerators would be approximately 10 months for those with electric water heating and 12 months for those heating with natural gas (See Calculations 11 and 12).

Calculation 11. Average Payback Period (Electric Water Heating)
$8.00 / [$3.26/year + (70 kWh/year · $.095/kWh)] = 0.8 years (~10 months)

Calculation 12. Average Payback Period (Natural Gas Water Heating)
$8.00 / [$3.26/year + (0.35 Mcf/year · $13.04 /Mcf)] = 1.0 years (~12 months)

These calculations are based upon the following assumptions:

- WaterSense labeled retrofit devices retail for $4.00 each.
- Average cost of electricity is $0.095/kWh[15].
- Average cost of natural gas is $13.04/Mcf[16].

Unit Abbreviations:
Bcf = billion cubic feet
BTU = British thermal unit
F = Fahrenheit
gal = gallon
gpcd = gallons per capita per day
gpm = gallons per minute
kgal = kilogallons
kWh = kilowatt hour
lbs = pounds
L/min = liters per minute
Mcf = thousand cubic feet
psi = pressure per square inch

WaterSense assumes that the cost of new faucets manufactured and sold as WaterSense labeled fixtures will not increase significantly since in many cases the manufacturer will simply need to substitute the current flow regulating device with a similar, more efficient rated device. In many cases this will be as simple as switching from the current 2.2 gpm aerator or laminar flow device to a comparable 1.5 gpm WaterSense labeled device

[14] U.S. Department of Housing and Urban Development and U.S. Census Bureau. American Housing Survey for the United States 2005. Table 1A-3 page 4.

[15] Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, Energy Information Administration. <www.eia.doe.gov/cneaf/electricity/epa/epat7p4.html>

[16] Short-Term Energy Outlook, Energy Information Administration. <www.eia.doe.gov/steo>

Proposal Information Template – Toilets and Urinals

2011 Appliance Efficiency Standards

Prepared by: Ed Osann and Tracy Quinn

September 30, 2011

CONTENTS

Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the California Energy Commission's (Commission) appliance efficiency regulations (Title 20, Cal. Code Regulations,, §§ 1601 – 1608) This report specifically covers toilets and urinals.

Background

In 2007, the California Legislature enacted AB 715, which establishes more stringent standards for covered types of toilets and urinals to take full effect January 1, 2014.

- Our first recommendation is to take the largely ministerial action to revise the current standards in Title 20 regulations to conform with legislatively enacted standards.
- Technical corrections to Title 20 regulations are needed to conform to the law and remove any possible ambiguity regarding compliance.
- Title 20 should reflect current law to avoid confusion in the marketplace among stakeholders.
- Failure to revise the performance standards in Title 20 would lead to inconsistency in the application of certification requirements for manufacturers (See 1608(c)(4)).

WaterSense estimates there are currently 27 million residential toilets in California.[1] In addition to the existing stock, approximately 1.2 million new toilets are sold each year for installation in new homes or replacement of aging fixtures in existing homes.[2] Residential toilets account for approximately 30 percent of indoor residential water use—equivalent to more than 252 million gallons of water consumed each year.[3]

This standard proposal aims to ensure that all toilets and urinals sold in California adopt minimum water efficiency design best practices to minimize water waste. The proposed standard is structured to follow the requirements established in AB 715.

[1] U.S. Census Bureau, American Housing Surveys for the United States, 1970-2003
* California rates were found by taking 12% of U.S. numbers found

[2] Plumbing Fixtures market Overview: Water Savings Potential for Residential and Commercial Toilet and Urinals. D&R International. September 30, 2005

[3] Mayer, Peter W. and William B. DeOreo. Residential End Uses of Water. Aquacraft, Inc. Water Engineering and Management. American Water Works Association. 1998.

Overview

Description of Standards Proposal	We recommend that California adopt a standard for toilets and urinals per the following:
	➢ Revise Table I in 1605.1(i) to conform with AB 715 performance standards with an effective date of January 1, 2014
	    ➢ Toilets – 1.28 gallons per flush
	    ➢ Urinals – 0.5 gallons per flush
	➢ Correct the omission of flushometer valve toilets (other than blowout toilets) from Table I.
	➢ Revise 1604(i) to incorporate ASME A112.19.2 and A112.19.14 (as specified in AB 715), to cover dual-flush toilets.

California Stock and Sales	2011 California Stock • Residential Toilets - approximately 27 million o Assuming per full bathroom and 1 toilet per half bathroom, [American Housing Survey, 1970-2003] • Commercial Toilets – approximately 5 million [Koeller, 2005] • Urinals – approximately 1.44 million [WaterSense Specification for Flushing Urinals Supporting Statement, 2009 (12% of 12 million)] Projected sales from 2014 through 2025 • Residential Toilets – 17 million • Commercial Toilets – 260,000 • Urinals – 400,000
Energy Savings and Demand Reduction	The energy savings attributed to this standard would be the energy costs embedded in the water savings this standard provides.

Economic Analysis	There is no incremental price difference between a product meeting this criteria and toilets and urinals meeting the current standard. Estimated lifetime savings per product: • Residential Toilets – **$200** • Commercial Toilets – **$200** • Urinals – $**400**
Non-Energy Benefits	We estimate that the standard would result in the following water savings by 2025: • Residential Toilets – 65 million gallons per day (MGD) • Commercial Toilets – 11 MGD • Urinals – 2.6 MGD • **Total - 78 MGD**
Environmental Impacts	We are not aware of any adverse environmental impacts that will be created by the proposed standard.
Acceptance Issues	Although there has been a history of user dissatisfaction with some of the early water efficient toilets and urinals, the WaterSense flush performance criteria has been improved and made more rigorous in order to establish higher levels of performance for HETs and ensure customer satisfaction with these products. [WaterSense Specification for Flushing Urinals Supporting Statement, 2009]
Federal Preemption or other Regulatory or Legislative Considerations	The Energy Act of 1992 established the maximum flush volume for water closets and urinals manufactured in or imported into the United States after January 1, 1994,. These requirements are codified in the Code of Federal Regulations at 10 CFR Part 430.[4] Federal preemption of state standards no longer applies to plumbing fixtures and fittings, as per *Federal Register* /Vol. 75, No. 245 /December 22, 2010 /80289.

[4] WaterSense Tank-Type High-Efficiency Toilet Specification Support Statement, 2009.

Methodology and Modeling used in the Development of the proposal

Savings estimates were developed using the best available data from a number of sources as well as our own assumptions as detailed below.

Data, Analysis and Results

Sales

Specific sales numbers for toilets and urinals in California were not able to be obtained in preparation with this document. Sales values used in this template are based on population projections provided by the California Department of Finance. The population projections were used to estimate housing growth, which, for use in these calculations, is assumed to maintain the same proportions of single family, multi-family and other types of residences over time. It was assumed that the average number of toilets per residential type (single family, multi-family, other) would remain the same through the projected time period.

Residential Toilets

Total # Toilets= (Average # toilets / housing unit) x # housing units

The number of toilets in California, delineated by housing type, comes directly from the American Housing Survey [American Housing Survey, 1970-2003].

Table I: Number of Toilets in California

	Average # Toilets per Housing Type	New Housing Units (2014 - 2025)	Toilet Sales from New Construction (2014 - 2025)	Toilet Sales from Replacement[1] (2014 - 2025)
Single Family	2.12	1,180,000	2,500,000	NA
Multi-Family	1.37	570,000	780,000	NA
Other	1.37	80,000	110,000	NA
Total	NA	1,830,000	3,390,000	13,500,000

[1] Assumes a replacement rate of 4%.

Total estimated sales of lavatory faucets and/or faucet replacement aerators for the period 2014 through 2025 is the sum of lavatory faucets purchased for new construction and replacement of existing and is approximately 17 million.

Commercial Toilets

Sales calculations for commercial toilets are based on the following assumptions:

- Current stock – 5 million [Koeller, 2005]
- Replacement rate of 4% [Koeller, 2005]
- Growth rate of 60,000 per year [Koeller, 2005]

Calculation 1. Approximate Annual Commercial Toilet Sales

[(5,000,000 commercial toilets) (0.04/year)] + (60,000 new commercial toilets) = 260,000 sales/year

Urinals

According to WaterSense, approximately 300,000 new urinals are sold in the United States every year.[5] California is approximately 12% of the United States on a population basis; therefore it is assumed that 36,000 of those urinals are sold in California each year. During the period 2014 through 2025, sales of urinals in California could be approximately 400,000.

Savings Estimates

Residential Toilets

To estimate the potential water savings impact of toilets using the new standard, we assumed that the average person flushes 5.1 times per day at home.[3]

Calculation 1.Average Daily Flushes per Toilet

(5.1 flushes/person/day)(40 x 10^6 people in California) / (27 x 10^6 toilets) = 7.6 flushes/toilet/day

The savings calculation below is the added savings of a 1.28 gpf over a 1.6 gallons per flush and does not take into consideration the current stock of various toilets currently used in homes in California.

Calculation 2. Annual Savings per Toilet

(0.5 gpf) (7.6 flushes/toilet/day) (365 days/year) = 1,387 gallons/year

Calculation 3. Annual Savings in California by 2025

(11 years) (17,000,000 toilets/year) (1,387 gallons/toilet/year) = **X billion gallons**

[5] Plumbing Fixtures Market Overview: Water Savings Potential for Residential and Commercial Toilet and Urinals. D&R International. September 30, 2005

Commercial Toilets

If the standard goes into effect in 2014, the following savings is estimated by 2025.

Calculation 4. Annual Savings in California by 2025

(11 years) (260,000 toilets/year) (1,387 gallons/toilet/year) = **4 billion gallons (11 MGD)**

Urinals

Assuming that the average urinal is flushed approximately 18 times per day and is in use 260 days per year [WaterSense Specification for Flushing Urinals Supporting Statement, 2009], replacing a single 1.0 gpf urinal with a 0.5 gpf model could save more than 2,300 gallons of water per year.

Calculation 5. Annual Individual Water Savings from Replacing 1.0 gpf Urinals

(18 flushes/day) x (0.5 gallons saved/flush) x (260 days/year) = 2,340 gallons/year

Calculation 4. Annual Savings in California by 2025

(2,340 gallons/urinal/year) (400,000 urinals sold) = **936 million gallons**

It should be noted that toilets meeting this proposed standard have been on the market several years and therefore some of the current stock may already meet or exceed this standard.

Cost Estimates

Residential Toilets

Calculation X. Estimated lifetime water cost savings per toilet

(1,387 gallons/toilet/year) ($5.72/1,000 gallons[6]) (25 years useful life) = $198

Commercial Toilets

Calculation X. Estimated lifetime water cost savings per toilet

(1,387 gallons/toilet/year) ($6.06/1,000 gallons) (25 years useful life) = $210

Urinals

Based on WaterSense product research [WaterSense Specification for Flushing Urinals Supporting Statement, 2009], there seems to be very little price difference between high-efficiency fixtures and flushing devices and their standard counterparts. In fact, some of the fixtures are sold as 0.5/1.0 gpf

[6] Raftelis Financial Consulting. Water and Wastewater Rate Survey. American Water Works Association. 2004

fixtures, capable of being used at either flush volume. Similarly, some models of the flushometer valves are available in 0.5 gpf or 1.0 gpf versions at the same price.

Calculation X. Estimated lifetime water cost saving per urinal

(2,340 gallons/year) ($6.06/1,000 gallons) (30 years useful life) = $425

Proposed Standards and Recommendations

Table 2: Proposed Standard

Product	Current Standard	Proposed Standard
Gravity tank-type water closets	1.6 gallons per flush (gpf)	1.28 gpf
Flushometer valve water closets (other than blowout water closets)	1.6 gallons per flush (gpf)	1.28 gpf
Flushometer tank water closets	1.6 gallons per flush (gpf)	1.28 gpf
Electromechanical hydraulic water closets	1.6 gallons per flush (gpf)	1.28 gpf
Urinals	1 gpf	0.5 gpf

Bibliography and Other Research

As indicated within the document.

References and Appendices

Appendix A: WaterSense® Toilet Specification Supporting Statement

Appendix B: WaterSense® Specification for Flushing Urinals Supporting Statement

Appendix C: Koeller, J. 2005. "High Efficiency Plumbing Fixtures – Toilets and Urinals." California Urban Water Conservation Council.

WaterSense® Tank-Type High-Efficiency Toilet Specification Supporting Statement

I. Introduction

The WaterSense Program released its performance specification for tank-type high-efficiency toilets (HETs) (Specification) on January 24, 2007, to promote and enhance the market for water-efficient toilets. The goal of this Specification is to differentiate products in the marketplace that meet this Specification's criteria for efficiency and performance and help consumers identify these water-efficient products.

This Specification addresses toilets typically found in homes, and in light commercial settings, such as hotels and restaurants. It does not address valve-type commercial toilets typically found in public restrooms (e.g., airports, theaters, arenas, schools) or composting toilets, both of which have different designs, patterns of use, and performance requirements.

II. Current Status of Toilets

WaterSense estimates there are currently 222 million residential toilets in the United States. This estimate is based on an assumed one-to-one ratio of toilets to bathrooms.[1] In addition to the existing stock, approximately 10 million new toilets are sold each year for installation in new homes or replacement of aging fixtures in existing homes.[2] Residential toilets account for approximately 30 percent of indoor residential water use in the United States—equivalent to more than 2.1 trillion gallons of water consumed each year. [3]

The Energy Policy Act of 1992 established the maximum flush volume for all gravity tank-type, flushometer tank, and electromechanical hydraulic toilets at 1.6 gallons per flush (gpf). These requirements are codified in the *Code of Federal Regulations* at 10 *CFR* Part 430 (specifically §430.32(q) Water Closets). Federal regulations also require that all toilets sold in the United States be tested and certified in accordance with the test requirements specified in American Society of Mechanical Engineers (ASME) A112.19.2–Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals. All dual-flush toilets sold in the United States also must comply with ASME A112.19.14–Six-Liter Water Closets Equipped with a Dual Flushing Device.

In addition, there are several voluntary, non-certification toilet testing programs. These tests are frequently required by water utilities for toilets to qualify for rebates under local water conservation toilet replacement programs. Two of the most popular and widely used voluntary testing programs in North America are the Maximum Performance (MaP) Testing of Popular Toilet Models and the Los Angeles Department of Water and Power Requirements for Ultra-Low-Flush-Toilets, Supplementary Purchase Specification to ASME A112.19.2 (LADWP SPS). MaP is entirely performance based, testing a toilet's maximum ability to remove waste starting

[1] U.S. Census Bureau, American Housing Surveys for the United States, 1970-2003.
[2] Plumbing Fixtures market Overview: Water Savings Potential for Residential and Commercial Toilet and Urinals. D&R International. September 30, 2005
[3] Mayer, Peter W. and William B. DeOreo. Residential End Uses of Water. Aquacraft, Inc. Water Engineering and Management. American Water Works Association. 1998.

with a 50 gram soybean paste sample and increasing at 50 gram intervals. A minimum passing score is 250 grams. The LADWP SPS requires the use of durable, chemical-resistant flush valve seals, and restricts maximum flush volumes under maximum trim adjustment and pressure conditions.

One problem with the number of different voluntary toilet testing programs in existence was the lack of uniformity or consistent requirements. Manufacturers found it difficult and costly to develop products that met the requirements of multiple testing programs, and water authorities were unsatisfied with the limited availability of qualified products. Consumers found the patchwork of toilet specifications, requirements, and “approved toilet lists” confusing at best. To remedy this situation, in 2004, members of the plumbing industry and water utilities combined the MaP Testing and LADWP SPS standards to create the Uniform North American Requirements (UNAR) for Toilet Fixtures: Guidelines and Specifications. UNAR is a voluntary system for qualifying toilet fixtures that achieve sustainable water savings and ensure a high level of customer satisfaction with flushing performance.

In developing this Specification, WaterSense adopted the framework of the UNAR standard while making several significant changes to the water-efficiency and performance criteria. WaterSense estimates that there are currently 68 toilet models on the market that meet the requirements of this specification and would be qualified to apply for and use the WaterSense label.

III. WaterSense Tank-Type High-Efficiency Toilet Specification

Scope

The WaterSense Program developed this Specification to address criteria for improvement and recognition of water-efficient and high-performance tank-type toilets. These toilets are commonly found in residential and light commercial settings and include the standard gravity type found in most homes, pressure assisted, and electrohydraulic assisted toilets. The majority of these fixtures are single flush toilets, toilets with one constant flush volume, though an increasing number of dual flush models are coming to market. Dual flush toilets have two flush volumes—a full flush for solids and a reduced flush for liquids only. WaterSense initially focused on residential toilets because they are the largest water consuming fixture in homes.

Commercial valve-type (a.k.a., flushometer valve) toilets were excluded from this specification because of their differing design, patterns of use, and performance expectations. Commercial valve-type toilets are tankless, relying on water pressure controlled by flushing valves to remove waste rather than gravity. Because of the fundamental difference in design, a different set of technical requirements is needed. Commercial valve-type toilets also have a different pattern of use than residential or light commercial tank-type toilets and will likely require different performance specifications. For example, the test media needing to be cleared by a commercial valve-type toilet may need to include a paper toilet seat cover and potentially more paper. If WaterSense decides to address this type of toilet, it will do so under a separate specification at a later time.

Water Efficiency Criteria

The water-efficiency component of the Specification establishes a maximum effective flush volume of 1.28 gpf for all HETs. This value represents a 20 percent reduction from the current

1.6 gpf standard and is consistent with WaterSense's stated goal of increasing product efficiency by at least 20 percent. Under this Specification, there are two ways by which an HET can meet the effective flush volume criteria:

- Single flush toilet must use 1.28 gpf or less; or
- Dual flush toilets must have a full flush no more than 1.6 gpf and a reduced flush no more than 1.1 gpf. Field studies indicate that in actual use such toilets will flush 1.28 gpf or less, on average.

Performance Criteria
In light of the history of poor performance and user dissatisfaction with several of the early 1.6 gpf ultra-low flush (ULF) toilets in the early 1990's, WaterSense wanted to ensure that WaterSense labeled HETs consistently perform at a high level and meet or exceed user expectations. The Flush Performance Criteria (Section 4.0) of the Specification ensures this level of performance and is based on the UNAR standard, with two key differences. First, the WaterSense specification increased the mass of the soy bean paste test media from 250 grams to 350 grams. WaterSense decided to make the Specification more rigorous in order to establish a higher level of performance for HETs and ensure customer satisfaction with these products.

Second, WaterSense also decided to switch from cased media, as used in UNAR, to an uncased media. Several manufacturers reported variability in test results when using cased media and expressed concern over the sample reliability. In addition, the primary justification for using cased media—reusability to save time and reduce costs—while important requirements in a research and development mode when many repeated tests are performed, were not as critical in regards to this HET specification, as a maximum of only five tests are required. The uncased media provides a more realistic sample and has a more established testing track record. For these reasons, WaterSense adopted the use of uncased media.

Potential Water Savings
The 222 million residential toilets in use today are a mix of the current standard 1.6 gpf fixtures and older, pre-1992 models. Water consumption in these older models range from 3.5 gpf to more than 5.0 gpf, depending on age and model. Table 1 provides a breakdown of the mix of the existing toilet stock.

To estimate the potential water savings impact of HETs, WaterSense assumed that the average person flushes 5.1 times per day at home.[4] With an estimated population of 296 million people in the United States and 222 million residential toilets in use, this equates to 6.8 flushes/toilet/day (see Calculation 1). Assuming that 10 percent of the existing 222 million toilets in the United States could reasonably be expected to be replaced with WaterSense labeled HETs, the total daily savings potential is approximately 246 million gallons per day (see Table 1 and Calculation 2). This equates to more than 89.7 billion gallons each year (see Calculation 3).

Calculation 1.Average Daily Flushes per Toilet

[4] Peter W. Mayer and William B, DeOreo. *Residential End Uses of Water*. Aquacraft, Inc. Water Engineering and Management. American Water Works Association. 1998. p. 94.

(5.1 flushes/person/day)(2.96 x 10^8 people) / (2.22 x 10^8 toilets) = 6.8 flushes/toilet/day

Table 1. Number of Toilets by Flush Volume and Potential Savings[5]

GPF	# of toilets (millions)	# of toilets replaced given 10% replacement of existing fixtures (millions)	Savings per flush by switching to 1.28 HET (gpf)
5.0	67	6.7	3.72
3.5	33	3.3	2.22
1.6	122	12.2	0.32
Total	222	22.2	—

Calculation 2.Total Daily Savings
(If 10% of all existing toilets replaced with 1.28 gpf HET)

5.0 gpf: (6.7 x 10^6 toilets) (3.72 gpf) (6.8 flushes/toilet/day) = 169,483,200 gallons/day

3.5 gpf: (3.3 x 10^6 toilets) (2.22 gpf) (6.8 flushes/toilet/day) = 49,816,800 gallons/day

1.6 gpf: (12.2 x 10^6 toilets) (0.32 gpf) (6.8 flushes/toilet/day) = 26,547,200 gallons/day

Total Daily Savings 245,847,200 gallons/day

Calculation 3.Total Annual Savings

(245,847,200 gallons/day) (365 days/year) = 89,734,228,000 gallons/year
89.7 billion gallons/year

[5] Plumbing Fixtures market Overview: Water Savings Potential for Residential and Commercial Toilet and Urinals. D&R International. September 30, 2005

WaterSense® Specification for Flushing Urinals Supporting Statement

I. Introduction

The WaterSense program released its flushing urinal specification on October 8, 2009, to promote and enhance the market for high-efficiency flushing urinals. The intent of this specification is to assist consumers in identifying and differentiating those products that have met EPA's criteria for water efficiency and performance.

This final specification addresses flushing urinals—urinals that use water to convey waste through a trap seal into a gravity drainage system—and their flushing devices. Devices utilizing other techniques such as non-water urinals, composting urinals, and retrofit devices or other aftermarket retrofit systems are not covered by this specification.

II. Current Status of Urinals

There are an estimated 12 million urinals currently in use in the United States, and an additional 300,000 new urinals are sold for installation in new buildings or for replacement of aging fixtures each year.[1] Of the 12 million existing urinals, up to 65 percent (7.8 million) are inefficient units with flush volumes exceeding the current maximum flush volume allowed by federal standards—some by as much as 3.0 gallons per flush. The Energy Policy Act of 1992 established the maximum flush volume for all urinals manufactured in the United States after January 1, 1994, at 1.0 gallons per flush (gpf) (3.9 liters per flush [Lpf]). These requirements are codified in the *Code of Federal Regulations* at 10 *CFR* Part 430 (specifically §430.32[r] Urinals).

Since the federal standards were enacted, manufacturers have developed urinals that use significantly less water than the standard 1.0 gpf fixtures. These high-efficiency fixtures can save at least 0.5 gallons of water per flush compared to standard 1.0 gpf fixtures, resulting in a savings of more than 2,300[2] gallons per urinal per year. Replacing pre-1994, inefficient urinals with these new high-efficiency fixtures can save even more water.

WaterSense product research has shown that there are at least eight manufacturers offering nearly 40 models of high-efficiency flushing urinals that are expected to meet the requirements of this specification and would be qualified to apply for and use the WaterSense label.

[1] *Plumbing Fixtures Market Overview: Water Savings Potential for Residential and Commercial Toilet and Urinals*. D&R International. September 30, 2005.
[2] According to data from the U.S. Department of Labor Statistics and Amy Vickers, *Handbook of Water Use and Conservation*, Water Plow Press, 2001, it is estimated that the average urinal is flushed 18 times per day. Savings are based on the assumption that urinals are typically used 260 days per year.

III. WaterSense Specification for Flushing Urinals

Scope

WaterSense has finalized this specification to address criteria for improving and promoting water-efficient, high-performance flushing urinals. It only applies to urinals that use water to convey liquid waste through a trap seal into a gravity drainage system. This includes the ceramic (vitreous china), plastic, or stainless steel urinal fixture and the pressurized (i.e., flushometer valve) or gravity tank-type flushing device.

Non-water urinals, composting urinals, and retrofit devices or other aftermarket retrofit systems are not included within the scope of this specification. Non-water urinals[3], though often very similar in appearance to flushing urinals, are different in design, components, how they function (i.e., remove waste), and are subject to significantly different standards. In the United States, two consensus-based American National Standards Institute (ANSI) standards specify the performance requirements for non-water urinals: American Society of Mechanical Engineers (ASME) A112.19.19–*Vitreous China Nonwater Urinals* and ANSI/International Association of Plumbing and Mechanical Officials (IAPMO) Z124.9–*American National Standard for Plastic Urinal Fixtures*. These two standards are designed to ensure a high level of performance for non-water urinals. At this time WaterSense has no basis to propose improvements to these existing standards, thus WaterSense has no means to help purchasers distinguish among these products based on either their efficiency or performance.

It should be noted that non-water urinals, by design, are inherently water-efficient and although the specification does not apply to these products, this specification does not preclude or prevent their use in water efficiency, green building or other conservation programs. In fact, non-water urinals continue to be compatible with and a key component of LEED and other green building programs. WaterSense encourages designers, specifiers, and facility managers to consider all available technologies when making purchasing decisions concerning water using products, including non-water urinals. The specification and WaterSense label are simply one of many tools available to help consumers make informed purchasing decisions. If decision-makers decide to specify and install water-using urinals, then WaterSense encourages them to choose products with the WaterSense label.

Composting urinals are part of a self-contained engineered system with different design and performance requirements, and as such would require unique specification criteria beyond this scope. Composting urinals also are inherently water-efficient as they do not use water.

Retrofit devices are not addressed because the intent of the specification is to recognize and label complete, fully functioning fixtures or fittings, and not individual sub-components.

[3] Defined by the applicable ANSI standards as “a plumbing fixture that is designed to receive and convey only liquid waste through a trap seal into the gravity drainage system without the use of water for such function.”

Water-Efficiency Criteria

The water-efficiency component of the specification establishes a maximum average flush volume of 0.5 gpf (1.9 Lpf) when tested in accordance with ASME A112.19.2/Canadian Standards Association (CSA) B45.1, ASME A112.19.3/CSA B45.4, or IAPMO Z124.9, as applicable. This value represents a 50 percent reduction from the current 1.0 gpf standard and is consistent with WaterSense's stated goal of increasing product water efficiency by at least 20 percent.

WaterSense selected the 0.5 gpf average maximum flush volume as its criteria for water efficiency because this value is consistent with the currently accepted industry definition for high-efficiency urinals and therefore is widely accepted by water-efficiency stakeholders and manufacturers. Also, manufacturers have been selling urinals that meet or exceed this standard for several years.

As a change from the draft specification, prior to testing the manufacturer must specify the designed maximum flush volume of the urinal fixture or flushing device (the "rated" flush volume). This rated flush volume must be less than or equal to 0.5 gpf. When the product is tested, its average maximum flush volume must not exceed the manufacturer's rated flush volume. The intent of this requirement is to ensure that WaterSense labeled fixtures and flushing devices that are marketed as performing at a specific flush volume actually perform at that stated flush volume. It also serves to clarify which flush volume manufacturers should include on products and product packaging and provides the consumer with informative and accurate information about the product's water consumption.

Performance Criteria

Currently, all flushing urinals are subject to national performance standards approved by ANSI. Ceramic flushing urinal fixtures are subject to the performance requirements of ASME A112.19.2/CSA B45.1, stainless steel urinal fixtures are subject to the performance requirements of ASME A112.19.3/CSA B45.4, and plastic urinal fixtures must comply with IAPMO Z124.9. Pressurized flushing devices (e.g., flushometer valves) used on the urinals are subject to American Society of Sanitary Engineering (ASSE) #1037—*Pressurized Flushing Devices (Flushometers) for Plumbing Fixtures*, while gravity tank-type flushing devices are subject to the requirements of ASME A112.19.2/CSA B45.1.

For urinal fixtures, the only new significant requirement in this final specification is that they must comply with all applicable sections of ASME A112.19.2/CSA B45.1, A112.19.3/CSA B45.4, or IAPMO Z124.9 at the manufacturer specified flush volume (rated flush volume) rather than at the current federal standard of 1.0 gpf.

For flushing devices, there are several additional requirements in the specification that go beyond the requirements of ASSE #1037 (for pressurized flushing devices) and ASME A112.19.2/CSA B45.1 (for flush tank [gravity-type] flushing devices). In addition to complying with all aspects of the applicable standards, three additional requirements apply to all flushing devices:

- The flushing device's primary actuator must be of a non-hold-open design.

- The flushing device must not be adjustable as to its rated flush volume beyond a specified tolerance of ± 0.1 gpf (0.4 Lpf).
- The flushing device must be designed such that replaceable or maintainable parts are not intended to be interchangeable with parts that would cause the device to exceed its rated flush volume.

The non-hold-open design requirement is designed to eliminate the ability to increase the device's flush volume by holding the actuator open. This requirement has been revised from what was proposed in the draft specification to apply only to the flushing device's primary actuator. This change primarily affects sensor-activated flushing devices that incorporate manual actuators or overrides for emergency or maintenance use. These secondary manual actuators are not intended to be used as the main actuator for these flushing devices, and therefore typically would not meet this requirement. WaterSense recognizes that requiring secondary actuators to comply with this requirement could be cost prohibitive and design restrictive, and would not significantly contribute to water savings.

The non-adjustability requirement ensures that the product's water consumption in the field can be maintained. This requirement also has been revised from the draft specification to include a specific tolerance allowance. This change reflects the frequent need for field adjusting of flushing devices to account for site-specific differences in water pressures, inherent fluctuations or variances in flushing performance of individual flushing devices, and fine-tuning different flushing device and fixture combinations to achieve maximum performance. Pressurized flushing devices are allowed to have a flush volume adjustment as long as it does not allow the rated flush volume to vary by more than ± 0.1 gpf from the device's manufacturer specified flush volume (rated flush volume). For gravity tank-type flushing devices, the maximum volume of water discharged by the tank when the tank trim is adjusted to its maximum water use setting cannot vary by more than ± 0.1 gpf from the device's rated flush volume. These changes simply acknowledge the inherent variability of all flushing devices when installed in the field.

WaterSense is maintaining the requirement that the flushing devices be designed such that replaceable or maintainable parts are not interchangeable with parts that would cause the device to exceed its rated flush volume. This requirement, to the extent it can be controlled through this specification, is designed to help prevent the intentional or unintentional change from the product's rated flush volume to a higher flush volume, which could not only reduce water savings, but impact the product's performance (e.g., the urinal may flood) as the flushing device and urinal fixture are no longer matched to perform with the same flush volume. For example, a flushing device rated at 0.5 gpf that accepted existing replacement1.0-gpf pistons or diaphragms would not be a product that meets WaterSense's intentions for this requirement. It is important to note that WaterSense has, however, made a change to this requirement from the draft specification. Under the final specification the manufacturer must attest to the applicable certifying body that its products comply with this specific requirement rather than relying on the licensed certifying body to verify that the product meets this requirement. Manufacturer attestation shifts responsibility for ensuring compliance with this design intent to the manufacturer.

Many pressurized flushing devices on the market today already incorporate features that meet the new requirements, and therefore should not encounter technical difficulties in complying with the final specification. While the non-interchangeable parts requirement might create a new burden for some manufacturers, WaterSense has determined that all three of these requirements are essential for preserving the long-term efficiency and performance of WaterSense labeled flushing urinals.

Product Marking

In response to several public comments, discussions with stakeholders concerning the marking of other WaterSense labeled products, and changes made to Section 3.0 of the specification, WaterSense has revised the product marking requirements found in Section 6.0 to require the manufacturer to mark the product and product packaging with the rated flush volume. This is as opposed to marking the product and/or the product packaging in accordance with 16 CFR 305.11(f). This change provides several benefits. First, it clears up any confusion regarding which flush volume value to use (i.e., the actual or maximum water consumption, as both are allowed and vaguely defined in the CFR). Second, it helps purchasers easily identify flushing devices and urinal fixtures that have the same rated flush volume and that can be used together as a system to meet the requirements of the specification. Lastly, clear marking, in conjunction with the non-interchangeable parts requirements of this specification, could help eliminate the installation or retrofitting of inappropriate replacement parts that could adversely affect performance and long-term water savings.

Potential Water Savings

WaterSense labeled flushing urinals that use a half-gallon of water or less per flush have the potential to save significant amounts of water both individually and at the national level. Assuming that the average urinal is flushed approximately 18 times per day and is in use 260 days per year, replacing a single inefficient 1.5 gpf urinal with a WaterSense labeled 0.5 gpf model could save more than 4,600 gallons of water per year (see Equation 1).

Equation 1. Annual Individual Water Savings From Replacing 1.5 gpf Urinals
(18 flushes/day) x (1.0 gallons saved/flush) x (260 days/year) = 4,680 gallons/year

Nationwide, if all 7.8 million pre-1994, inefficient urinals were replaced with WaterSense labeled models, more than 36 billion gallons could be saved per year (see Equation 2). It is important to note that many of the existing inefficient urinals have flush volumes significantly higher than 1.5 gpf. Since the exact breakdown of all existing urinals is unknown, WaterSense is assuming a 1.5 gpf flush volume as a conservative estimate. Because of this, the actual water savings potential could be much higher.

Equation 2. Annual National Water Savings From Replacing 1.5 gpf Urinals
(7.8 million inefficient urinals) x (4,680 gallons/year/urinal) = 36.5 billion gallons/year

Cost-Effectiveness

Urinals are relatively expensive when compared to other restroom plumbing fixtures, with the fixture cost averaging about $350 and flushometer valve cost averaging about $200 (based upon WaterSense product research). Fortunately, there seems to be very little price difference between high-efficiency fixtures and flushing devices and their standard counterparts. In fact, some of the fixtures are sold as 0.5/1.0 gpf fixtures, capable of being used at either flush volume. Similarly, some models of the flushometer valves are available in 0.5 gpf or 1.0 gpf versions at the same price. Because there is no cost difference between the standard and high-efficiency models, installing high-efficiency urinals in new construction or as part of the normal replacement process is cost-effective with immediate payback and realized water cost savings.

Replacing an older, inefficient urinal with a flush volume of 1.5 gpf with a 0.5 gpf WaterSense labeled urinal will save more than $850 over the useful life of the urinal (see Equation 3)—$300 more than the initial cost of the fixture and flushometer valve (assuming the useful life for fixtures and flushometer valves is 30 years and the total of water and wastewater cost is $6.06/1,000[4] gallons).

Equation 3. Estimated Lifetime Water Cost Savings From Replacing a 1.5 gpf Urinal
(4,680 gallons/year) x $6.06/1,000 gallons) x (30 years useful life) =$850.82

Without rebates or some other economic incentive, replacing properly functioning 1.0 gpf urinals with 0.5 gpf WaterSense labeled urinal might not make sense from a purely economic standpoint. It can, however, when done communitywide, significantly contribute to reducing water demand and delaying the need to develop new water supply and treatment capacity and infrastructure.

IV. Certification and Labeling

Independent Labeling of Urinal Fixtures and Flushing Devices

WaterSense has established an independent third-party product certification process, described on the WaterSense Web site at www.epa.gov/watersense/specs/certification.htm. Under this process, products are certified to conform to applicable WaterSense specifications by accredited third-party licensed certifying bodies. Manufacturers are then authorized to use the WaterSense label in conjunction with certified products.

With flushing urinals, it is not uncommon for a company to manufacture only the ceramic, stainless steel, or plastic urinal fixture and to require the use of another company's flushing device. The urinal fixtures' specification sheets for these products often indicate which make and model valves are best suited for use with the urinal. Correspondingly, there are some manufacturers that only make flushometer valves that can be used with other manufacturers' urinal fixtures.

WaterSense is retaining its proposed approach of allowing each urinal fixture and flushing device to be certified and labeled as either a complete system or independently as a urinal fixture or flushing device. For products certified and labeled separately, WaterSense will require manufacturers to clearly indicate on product documentation that the fixture or flushing device should be used with a WaterSense labeled counterpart with the same rated flush volume to ensure that the entire system meets the requirements of this specification for water efficiency and performance. This approach is the common industry practice and ensures that WaterSense is not significantly increasing the burden associated with the certification of high-efficiency

[4] Raftelis Financial Consulting. *Water and Wastewater Rate Survey*. American Water Works Association. 2006.

flushing urinals. It also enables purchasers to easily identify and match labeled components with the same flush volumes.

Product Sampling for Certification

WaterSense has added new requirements specifying how certifying bodies are to select and sample products for certification. Sampling was not previously addressed in the draft specification, either directly or by reference. The requirements specify that the manufacturer must provide, at a minimum, three samples of the model to be tested. Of those, the certifying body must choose at least one at random for testing to the requirements of the specification. This sampling regime is modeled after the recommended sampling scheme for initial certification as specified in Section A4 of the Nonmandatory Appendix A Demonstrating Compliance to ASME A112.19.2 and is consistent with sampling requirements specified in the WaterSense high-efficiency tank-type toilet specification.

High-Efficiency Plumbing Fixtures – Toilets and Urinals

1. Background

Advent of Low-Flow Fixtures

Beginning in 1992, a new water-efficiency standard for toilets and urinals became the law in California. The maximum flush volume for each of these fixtures was lowered to 1.6 gallons and 1.0 gallons, respectively. This action closely followed or was coincident with similar requirements imposed by other state and local jurisdictions throughout the U.S. A patchwork pattern of requirements resulted, forcing the plumbing industry to develop and market two separate product lines…those for the "efficient states" and those for "not-so-efficient states." Consequently, the plumbing industry, the water and wastewater industry, and environmental organizations all encouraged the U.S. Congress to adopt uniform standards for the entire country. (A more complete history of this evolutionary process may be found in separate reports by the U.S. General Accounting Office[1] and by Potomac Resources, Inc.[2])

The products that resulted from this process were given the various labels of ultra-low-flow, ultra-low-flush, low-flow, and similar. Although most early versions of the toilet fixtures flushed at 1.6 gallons or less, they did not necessarily perform well and, thus, did not always result in satisfied customers and users. To this day, the reputation of some early "low flow" toilet fixtures still exists and influences water conservation programs[3]. As a result of early problems, the plumbing industry embarked upon fresh product development to improve performance and thereby restore customer confidence and satisfaction. By 1997, fixture performance had improved significantly.

High-Efficiency Definition

In the absence of any clear definition or stratification of toilet and urinal fixtures that perform *more efficiently* than the prescribed maximums, the Council worked with selected member water providers[4] in 2004 to establish such a definition for toilets. The High-Efficiency Toilet (HET) is defined as a fixture that flushes at 20 percent below the 1.6-gpf/6.0-lpf maximum or less, equating to a maximum of 1.3-gpf/4.8-lpf.

For the purpose of this analysis, the High-Efficiency Urinal (HEU) is defined as a fixture that flushes at 0.5-gallons (1.9-lpf) or less. This definition includes existing 0.5-gpf urinals and non-

[1] U.S. Government Accounting Office, 2000. *Report to Congressional Requesters, WATER INFRASTRUCTURE, Water-Efficient Plumbing Fixtures Reduce Water Consumption and Wastewater Flows,* GAO/RCED-00-232, August.

[2] Osann, Edward R. and Young, John E., Potomac Resources, Inc. 1998. *Saving Water, Saving Dollars: Efficient Plumbing Products and Protection of America's Waters,* April.

[3] This is particularly important as manufacturers and the water industry attempt to "convince" customers that high-efficiency fixtures with even lower flush volumes are going to perform.

[4] Some member water providers (EBMUD, Santa Clara Valley Water District, and MWDSC) were in the process of constructing or implementing toilet programs for high-efficiency toilets and needed to have criteria established in order to qualify fixtures for their respective programs.

water urinals as well as the one-quart and one-liter urinals currently in development by several manufacturers.

High-Efficiency Toilets (HETs)

Three types of HETs currently exist in the marketplace.

Table 1. Types of high-efficiency toilet technologies

Technology	Certified Flush Volumes
Dual-flush	0.8-1.1-gpf and 1.6-gpf
Pressure-assist single flush	1.0-gpf
Gravity-fed single flush	1.28-gpf and less

Dual-Flush

In late 1998, the first gravity-fed dual-flush toilet fixture was introduced into the U.S. market by Caroma International, Ltd.[5] While the dual-flush concept of efficiency was well-established in Australia and the European continent, it was new to North America[6]. As such, education of the specifiers, builders, building operators, and consumers as to its benefits was (and remains) critical to successful market penetration of this technology. The most persuasive argument in favor of the technology was the entry of other manufacturers as competitors to Caroma.

While Caroma attempted to establish its presence in the marketplace with the "green building" and water-efficiency practitioners, other manufacturers saw the potential of these sectors and began development of their own dual-flush products. In 2003, the first competing gravity-fed dual-flush fixture was introduced by Vortens, a brand of the Lamosa Group, based in Monterrey Mexico. For the first time in five years, Caroma was about to experience competitive pressure on their fixture prices which, at that time, had been significantly higher than conventional gravity-fed 1.6-gallon toilets. It is well-known that this pricing discrepancy had discouraged the purchase of dual-flush toilets by the marketplace.

From 2003 to 2005, more manufacturers entered the marketplace and today, the following manufacturers have a total of 48 dual-flush fixture models in their North American product lines:

[5] Prior to this time, Kohler had developed and introduced into the marketplace the Power-Lite™ dual-flush toilet, powered by an electrically operated pump (which therefore requires an electrical service in the vicinity of the toilet). The Power- Lite™ line of fixtures exists today but is expensive.

[6] The dual-flush option on a toilet fixture provides the user with two flushing choices, a full 1.6-gallon flush for solids and liquids or a reduced ("short") flush for liquids only. The reduced flush ranges between 0.8 and 1.1 gallons depending upon the design of the fixture.

Table 2. Dual-Flush HETs

Manufacturer	Number of Product Offerings
Caroma	13
Duravit	2
Gerber	11
Kohler	6
Mancesa	1
Mansfield	7
Pegasus (Home Depot)	1
Toto	1
Vitra	2
Vortens	3
Western Pottery	1
TOTAL	48

Dual-flush fixtures are best suited to residential applications or commercial non-public applications. The installation of dual-flush fixtures in public facilities is not recommended until such time as the public is aware and educated about dual-flush, a condition which may take many years to achieve.

Pressure-Assist Single-Flush

The second category of HETs consists of the 1.0-gpf pressure-assist technology introduced in California in 2000. Sloan Flushmate, a division of Sloan Valve Company, developed a 1.0-gpf (3.8-lpf) pressure-assist system based upon their already-proven 1.6-gpf pressure-assist technology. The prototype 1.0-gpf Flushmate system was installed in approximately 36 fixtures from St. Thomas Creations and other manufacturers, field tested, and evaluated by California water agencies. The marginal results from that field study[7] led to improvements in both the Flushmate product and the bowls to which it delivered water. Sloan then marketed the system to all manufacturers. Today, six manufacturers produce 12 models of the 1.0-gpf pressure-assist toilet fixture. In addition, WDI International, a competitor to Sloan, supplies a similar device for 11 models from another manufacturer.

This technology is suited to both residential and light commercial applications. Although the pressure-assist toilet fixture has a long-standing reputation for being noisy, the latest models approach conventional gravity-fed fixtures in terms of noise associated with the flushing action. That is, noise levels have been reduced through the redesign of the toilet bowls.

There are currently 23 different models of 1.0-gpf (3.8-lpf) pressure-assist toilets available from the seven manufacturers, with additional manufacturers likely to introduce products in this category in the near future.

[7] Koeller, Muir, Davies, De La Piedra, 2001. *A Field Study of 4.0-liter (1.0-gallon) Toilet Fixtures,* paper prepared for and presented at AWWA Water Sources Conference, January 2002.

Table 3. Pressure-Assist 1.0-gpf Single-Flush HETs

Manufacturer	Number of Product Offerings
Capizzi	3
Gerber	11
Mancesa	1
Mansfield	4
Peerless Pottery	2
St. Thomas Creations	1
Vortens	1
TOTAL	23

Conventional Gravity-Fed

This next category consists of conventional gravity-fed fixtures with a flush volume meeting the HET criteria. Only one model currently exists in the marketplace, although other manufacturers are capable of developing or have already developed such a prototype fixture. More toilet fixtures of this type will likely be introduced into the marketplace within the next several years[8].

Table 4. Single-Flush HET

Manufacturer	Number of Product Offerings
American Standard	1

One would expect that because the gravity-fed technology has been in existence in the U.S for decades and does not require special devices, linkage, or equipment, the cost of this type of fixture would be the least of all three technologies. Intense competition among the HET manufacturers, coupled with the demand for HETs by "green building programs" and water-efficiency initiatives, and the sourcing of product from a variety of locations all over the world, is dramatically influencing pricing trends. Overall, pricing trends are downward, but not always in a logical or predictable pattern.

Flushometer Valve & Bowl

The last category of HETs is that of flushometer valve and bowl toilets for CII applications. No valve and bowl combinations are yet available in the marketplace that are designed for either dual-flush or for single-flush consumption below the 1.3-gpf HET threshold. However, Sloan Valve Company is currently marketing a dual-flush flushometer valve with a view toward opening the CII market to these types of installations.

[8] One competing manufacturer intends to introduce two such gravity-fed single-flush models in 2005.

High-Efficiency Urinals (HEUs)

Two types of HEUs currently exist in the marketplace, 0.5-gpf flushing urinals and non-water urinals. Several manufacturers are developing flushing urinals to be rated at one liter, one quart, or less. By Spring 2006, such advanced products will be available within the U.S. marketplace.

Half-Gallon Urinals

Three manufacturers each produce and sell a single model of a 0.5-gpf urinal in the U.S. marketplace. Those manufacturers are American Standard, Kohler, and Mansfield with the following products:

Table 5. Half-Gallon HEUs

Manufacturer	Model
American Standard	Innsbrook Model 6520
Kohler	Bardon™ K-4915
Mansfield Plumbing	Adam™ 401[9]

Unlike conventional urinals, both the American Standard and the Kohler products house an integrated sensor-operated flush valve. The Mansfield product[9], on the other hand, must be coupled with a 0.5-gpf flushometer valve from one of the valve manufacturers. Other manufacturers have urinals in their existing product lines that are certified at 1.0-gpf but are claimed to meet all performance requirements at 0.7-gpf and above.

1-Quart and 1-Liter Urinals

Several manufacturers are in the process of researching and/or developing urinals that flush on one liter or less, in some cases as low as one pint of water[10]. Although one-liter flushing urinals have recently been publicly introduced in Europe, these fixtures are not yet available in North America. It is highly probable that such products will appear in the marketplace within the next several years. One impediment may be that certification requirements may have to be modified, a process that could forestall their appearance here. Because one-liter (or less) urinals are a distinct possibility, we have included them in our analysis.

Non-Water Urinals

Two manufacturers, Falcon Waterfree and Waterless Company, dominate in the U.S. market with non-water urinals. Both manufacturers offer urinal fixtures in a choice of materials: vitreous china and composite materials. Zurn Plumbing Products recently introduced a single model of a vitreous china non-water urinal as well. Table 6 lists the number of models currently within the product offerings of all three companies.

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[9] The Mansfield Adam™ 401 urinal is only certified at 1.0-gpf, but the company claims that it will meet ANSI/ASME requirements at 0.5-gpf.

[10] One manufacturer currently offers a urinal system that is claimed to adjust the flush volume in accordance with the "demand" upon the urinal fixture. By internally calculating the actual "need" for water, the fixture varies the flush volume based upon that calculation. They are thus able to offer an "effective flush volume" below 0.5-gpf, according to the manufacturer.

Table 6. Non-Water HEUs

Manufacturer	Number of Product Offerings	
	Vitreous China	Composite Materials
Waterless Company	1	5
Falcon Waterfree	4	1
Zurn Plumbing Products	1	0

Uridan-USA previously offered non-water urinals through a distributor based in Florida. That distributor has abandoned the product, citing the high cost in the U.S. of the European product and the lack of a vitreous china model.[11] The distributor has gone on to introduce the **ZeroFlush** non-water urinal[10], although the product is not available in California. Finally, the German company, **Duravit**, has been offering the McDry non-water urinal[12] for several years in the U.S. marketplace, although marketing is spotty at best and we have seen no McDry's in California buildings. Other manufacturers of non-water urinals exist in Europe and elsewhere, some of which may choose to enter the U.S. market at some future date.

2. Inventory of Installed Fixtures

One important key to assessing the water savings potential of HETs and HEUs is to establish the baseline from which water use reductions may be measured. While HET flush volumes currently vary from as low as 1.0-gpf to as high as 1.3-gpf, so does the baseline for comparison vary from as low as 1.6-gpf up to as much as 7.0-gpf. The installed base of residential and commercial toilets in California has been estimated in a few recent studies. A similar case exists for urinals, where flush volumes of as high as five (5.0) gallons and above characterize older models that may still be in use.

Residential Toilet Fixtures

Three recent estimates are available of installed toilet fixtures in California. The first estimate (Table 7) from the Pacific Institute[13] was based upon the relationship of toilets to population at a ratio of 0.76 toilets per person. Population was then used to establish the installed base of toilets in each category of fixture, supplemented with data from the California Urban Water Conservation Council (Council) on actual water conservation program replacements.

Table 7. Estimate of Residential Toilets Installed in California-Pacific Institute

Year	6.0 gallons per flush	3.5 gallons per flush	1.6 gallons per flush	TOTAL
2003	7.3 million	13.0 million	7.3 million	27.6 million
2020	3.7 million	6.7 million	24.0 million	34.4 million

[11] Environmental Building News, 2005. "U.S. Distributor Abandons Uridan and Launches ZeroFlush," Volume 14, No. 6, June 2005.
[12] Duravit McDry Model No. 084435
[13] Pacific Institute, 2003. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*, November.

The second estimate, by Koeller and Company[14] used new construction data from 1970 forward to 2001, including data on bathrooms per new dwelling unit, supplemented with a natural replacement rate of four (4.0) percent annually and data from the Council on actual water conservation program replacements. Projections forward from 2001 were made using California Department of Finance projections of population and assume no ongoing water conservation initiatives focused on residential toilet replacement after 2001.

Table 8. Estimate of Residential Toilets Installed in California - Koeller

Year	5.0+ gallons per flush	3.5 gallons per flush	1.6 gallons per flush & less	TOTAL
2001	5.6 million	4.6 million	9.4 million	19.6 million
2005	4.8 million	3.9 million	12.5 million	21.2 million
2015	3.1 million	2.6 million	18.5 million	24.2 million
2020	2.6 million	2.1 million	21.4 million	26.1 million
2030	1.7 million	1.4 million	26.7 million	29.8 million
2040	1.1 million	0.9 million	32.1 million	34.1 million

The third estimate of residential fixtures was developed independently by Mitchell of M.Cubed, Inc. for CALFED and projects to the year 2030[15]. It uses fixture count data from the 1998 American Housing Survey, together with dwelling unit counts from the 1990 and 2000 U.S. Census and population projections from the California Department of Finance. It anticipates a five (5.0) percent natural annual replacement rate and uses the population forecast to estimate the expected new construction.

Table 9. Estimate of Residential Toilets Installed in California - Mitchell

Year	Over 1.6 gallons per flush	1.6 gallons per flush & less	TOTAL
2001	11.1 million	10.2 million	21.3 million
2005	9.3 million	13.3 million	22.6 million
2015	6.2 million	19.5 million	25.7 million
2020	5.0 million	22.1 million	27.1 million
2030	3.3 million	26.5 million	29.8 million

Figures 1, 2 and 3 compare the three estimates. The two estimates shown in Tables 8 and 9, each of which was developed with different input variables and approaches, are in substantial agreement. Therefore, they will be used as the most accurate indicator of today's conditions.

[14] Koeller and Company, 2003a. Unpublished report on the impact of dual-flush toilets on California water use, June.
[15] Mitchell, David, for M.Cubed, Inc., no date. "Toilet Forecast" (spreadsheet analysis).

Figure 1. ESTIMATE AND PROJECTION OF INSTALLED RESIDENTIAL TOILET FIXTURES IN CALIFORNIA

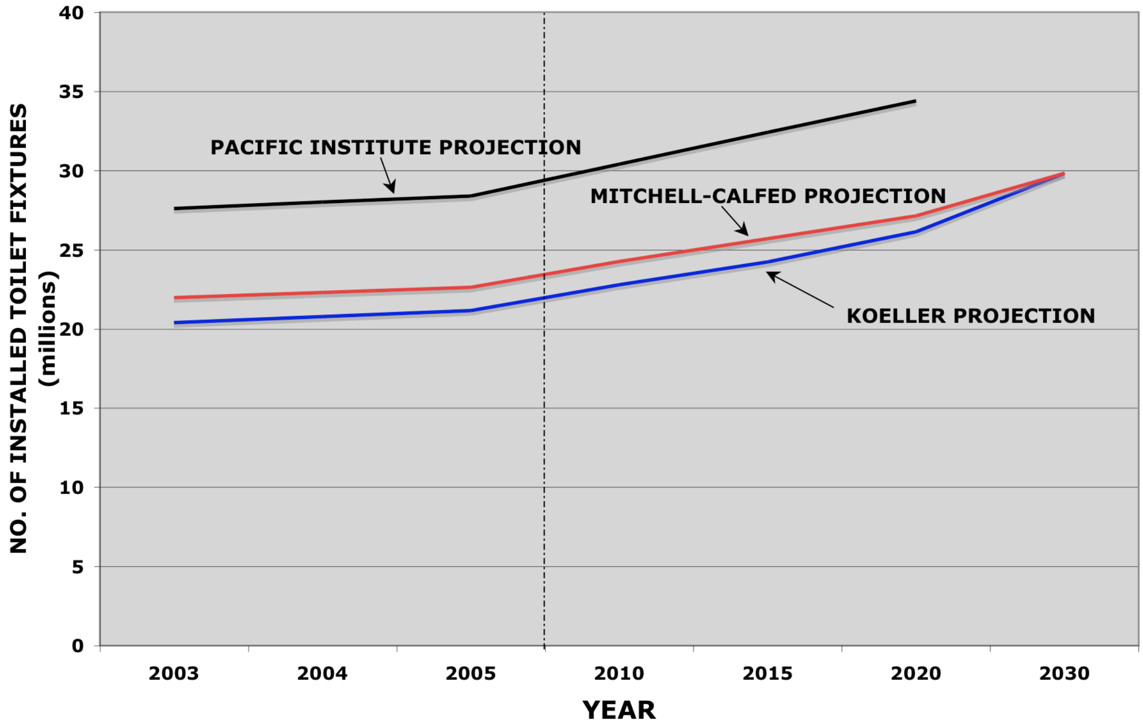
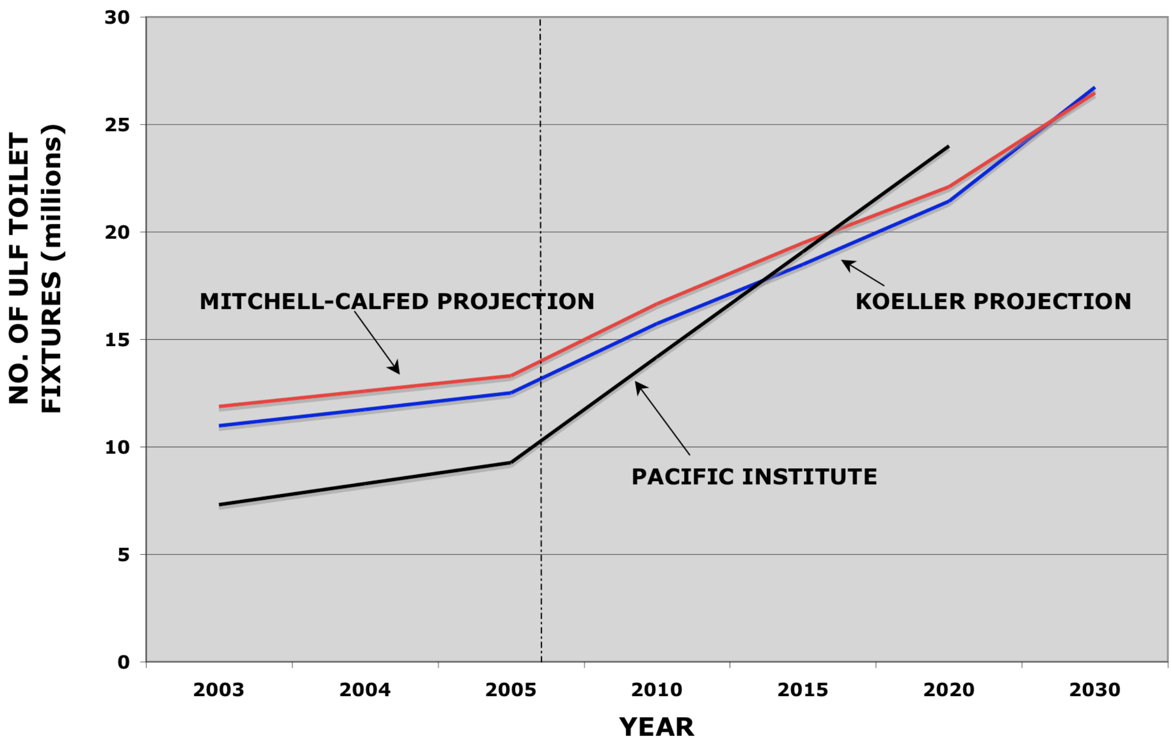


Figure 2. PROJECTION OF INSTALLED ULF TOILET FIXTURES - CALIFORNIA (ULF toilet fixtures at 1.6-gpf and below)



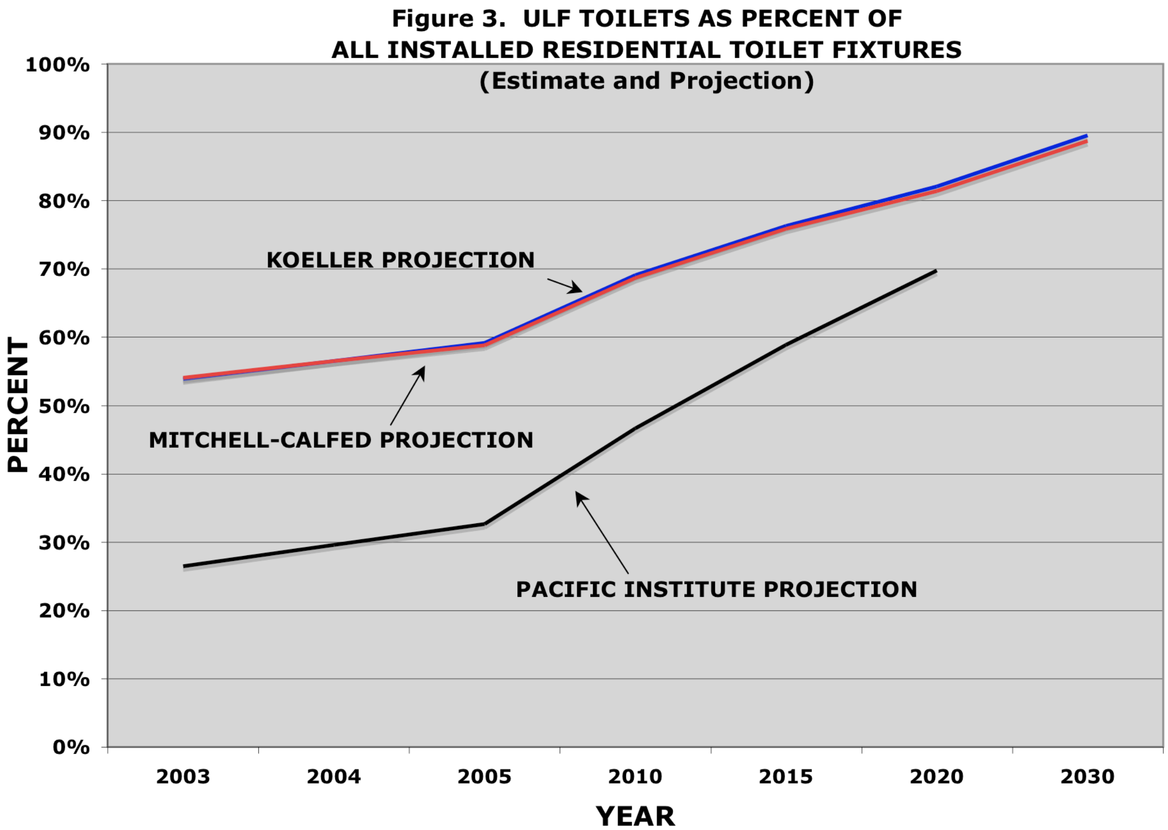


Figure 3. ULF TOILETS AS PERCENT OF
ALL INSTALLED RESIDENTIAL TOILET FIXTURES
(Estimate and Projection)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
PERCENT
KOELLER PROJECTION
MITCHELL-CALFED PROJECTION
PACIFIC INSTITUTE PROJECTION
2003
2004
2005
2010
2015
2020
2030
YEAR

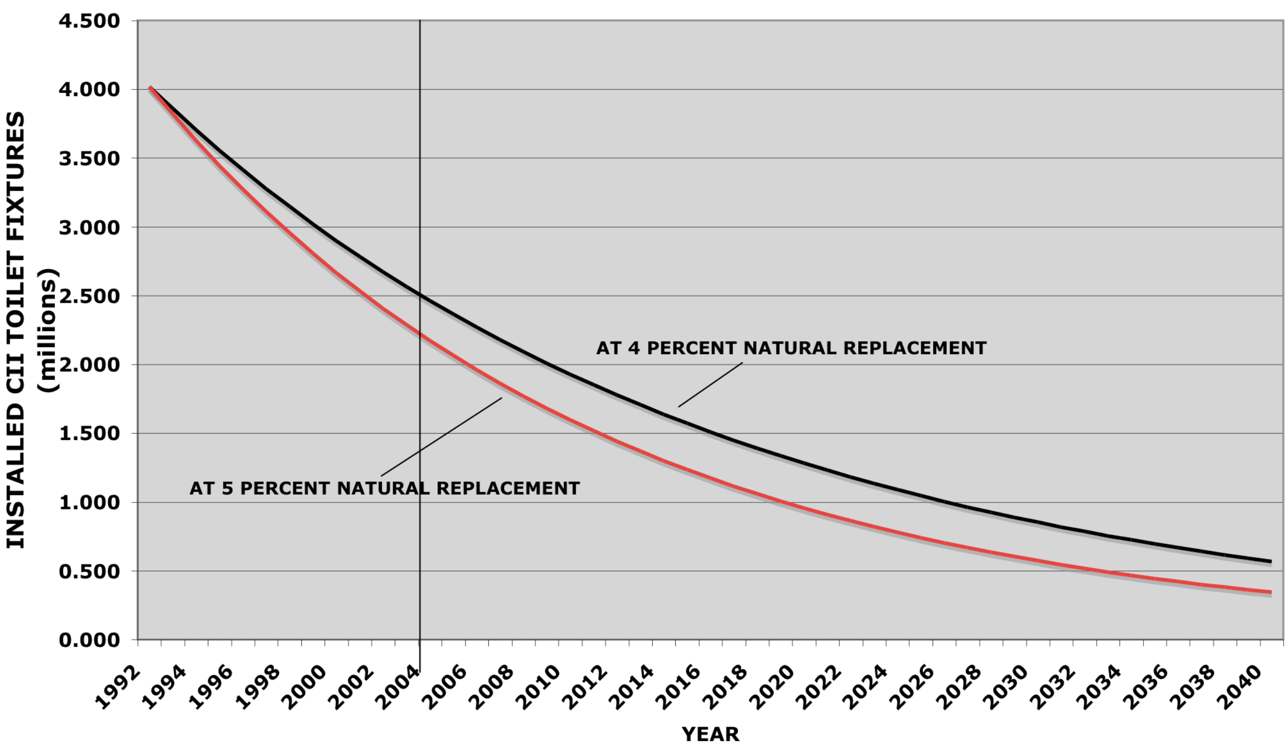
CII Toilet Fixtures

The installed base of non-efficient toilet fixtures in commercial, institutional, and industrial (CII) applications in California has been estimated as between 2.1 and 2.4 million fixtures. In 1992, prior to the effective date of EPAct legislation, it was estimated that approximately 4.001 million fixtures were installed in CII applications[16], all of which would be considered (today) as non-efficient. In the absence of reliable data for years after 1992, projections were made from 1992 using two different natural replacement rates.

Assuming a natural replacement rate of five (5.0) percent annually, Mitchell estimates that the current (2005) inventory of non-efficient fixtures in this category is approximately 2.1 million fixtures. At a more conservative natural replacement rate of four (4.0) percent[17], the 2005 inventory would be about 2.4 million fixtures.

Figure 4 illustrates the trend in replacements and inventory at the two replacement rates. For the purpose of a potential savings analysis, the more conservative 2.1 million fixtures will be used.

Figure 4. ESTIMATE AND PROJECTION OF NON-EFFICIENT CII TOILETS INSTALLED IN CALIFORNIA



16 Mitchell, David, for M.Cubed, Inc., no date. "CII Toilet Data" (spreadsheet analysis).

17 The CII sector includes all types of toilet fixture, gravity-fed tank-type, flushometer tank pressure-assist, and flushometer valve. They are generally assumed to have physical lives of 20, 25, and 30 years, respectively. An overall average of 25 years is assumed, leading to a 4.0 percent annual replacement rate.

No field survey or similar estimate is known to exist as to the current inventory of 1.6-gpf toilet fixtures in the CII sectors. However, using employment growth as an indicator of facility growth, an estimate was developed for 2005. Based upon statewide employment of 13.9 million persons in 1992[18], and 16.8 million today[19], a rough estimate of toilet fixtures in 2005 would be about 4.9 million, of which between 2.1 and 2.4 million are of the non-efficient type as noted earlier.

Using population growth projections for California to the year 2030[20] and assuming that employment will grow at the same rate, we estimate that the inventory of CII toilets will grow by about 1.5 million by 2030, resulting in an installed base of about 6.4 million fixtures at that time.

CII Urinals

We have not found a reliable field survey or other count of urinals installed in CII applications in California. Therefore, for a very rough planning estimate of installations, the installed base of CII toilets was used as an indicator. Over the years, the requirements of the applicable plumbing code(s) have changed with respect ratios of toilets and urinals to building population. As an example, however, the Uniform Plumbing Code currently requires the following ratios of fixtures for 150 occupants (including customers) in these selected and typical applications:

Table 10. Typical Code Requirements for Plumbing Fixtures

Type of Building or Occupancy	Female Restroom - Toilet Fixtures	Male Restroom	
		Toilet Fixtures	Urinal Fixtures
Office or public buildings	8	2	2
Office or public buildings-employee use	7	6	3
Colleges and universities	5	4	5
Institutional (other than hospitals)	8	6	3
Restaurants, pubs, lounges	2	2	1
Hospitals-employee use	7	6	3
Assembly places-public use	8	2	2

From the table above, it appears that, with today's code requirements, urinal fixtures in men's restrooms are approximately 26 percent of the total number of toilet fixtures for the occupancies shown. Although history has seen changes in the mix, we conservatively estimate that today the number of urinals in CII facilities would approximate 25 to 30 percent of the total number of toilet fixtures (men and women). Therefore, we further estimate that the number of urinals installed in California CII facilities to be in the range of 1.3 to 1.5 million fixtures.[21] Of these, an estimated 25 percent are of the 1.0-gpf type, having been installed since that flush volume limit became effective in California.

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[18] State of California, Employment Development Department, 2005a. March 204 Benchmark, Data from 1990 to 2005, June 17.
[19] State of California, Employment Development Department, 2005b. "Quick Statistics" (web page)
[20] State of California, Department of Finance, 2004. *Population Projections by Race/Ethnicity for California and Its Counties 2000–2050,* Sacramento, California, May.
[21] At 25 to 30 percent of 4.9 million toilet fixtures. Subsequent analyses were performed at 1.4 million.

California population growth to 2030 indicates that the installed base of urinal fixtures will grow from 1.4 million to approximately 1.83 million by that date, assuming that employment growth and new construction generally follow population growth at the same pace.

3. Water Savings Estimates

Residential Applications – Toilet Fixtures

Because HETs are a relatively new product (except for dual-flush), reliable field studies of water savings are scarce. For the purpose of this analysis, the savings assessment for residential applications is divided into the two main fixture categories, dual-flush and 1.0-gpf pressure-assist.

All of the dual-flush studies conducted to date have involved Caroma fixtures, which offer the 0.8-gpf and 1.6-gpf flush options. It should be noted that other dual-flush fixtures now in the marketplace offer other volume options, such as 1.0- and 1.6-gpf.

The key to reducing average flush volumes is convincing users to use the "short" flush mode when possible. The weighted average of "short" and full flushes (combined) is determined by the ratio of flush counts for each of the two options. As summarized in a 2003 paper[22] covering the results of five previous field studies, the flush ratio and flush volume of the 0.8/1.6-gpf dual-flush fixtures installed in residential applications ranged as follows:

Table 11. Dual-Flush Toilet Fixtures in Residential Applications

Study	No. of dual-flush fixtures studied	Ratio of "short" to full flushes	Average water consumption per flush
Canada Mortgage & Housing Corp.	60	1.6 to 1 – SF 4.0 to 1 - MF	1.11-gpf
Seattle Home Water Cons. Study	40	not measured	1.25-gpf
Oakland – Residential Water Study	35	not measured	1.34-gpf
Oregon SWEEP Study	50	1.9 to 1	1.30-gpf
Jordan Valley Study	61	1.48 to 1	1.20-gpf

Overall, the weighted average of the flush volumes for all 246 test fixtures was 1.23-gpf. Newer dual-flush toilets, some of which rate the "short" flush at 1.0 or 1.1 gallons will have higher flush volumes, probably averaging between 1.25 and 1.30.

The 1.0-gpf pressure-assist fixtures are also well-suited to residential applications, particularly single family. In fact, representatives of Sloan Flushmate report that over 50 percent of all Flushmate pressure-assist systems are sold for residential installations.[23] This phenomena is largely attributable to two factors that have only recently affected the trend toward residential use:

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[22] Koeller and Company, 2003b. Dual-Flush Toilet Fixtures – Field Studies and Water Saviings, December 17. Available for download from: **http://www.cuwcc.org/products_tech.lasso**
[23] Personal communication, Paul Deboo, Sloan Flushmate.

(a) The HGTV (Home and Garden TV) channel, which is widely viewed by do-it-yourselfers and others remodeling or upgrading residential bathrooms. The portrayal of pressure-assist as possessing excellent flush performance and long-term reliability has resulted in increased residential installations.

(b) The reduction of noise associated with the flush action of the typical pressure-assist toilet. New models, including the HETs, are substantially quieter than similar models of the 1990s, thereby making them more acceptable in the home.

However, no independently developed, authoritative studies of water savings from pressure-assist HETs in residential applications have yet been conducted. Therefore, our analysis of these units was based solely upon the certification measurements of 1.0-gpf.

Table 8 shows that approximately 4.8 million toilets with flush volumes of 5.0 gallons or more are installed in California residential dwellings today. The estimated inventory of 3.5-gallon toilet fixtures is 3.9 million. The remainder of the installed inventory is 1.6-gallon toilets, for which we estimate that 12.5 million exist.

Vickers and Mayer both cite the Residential End Uses of Water Study and estimate that the average number of daily flushes per person in residential applications is 5.1[24]. Other studies showed slightly higher counts, in some cases as high as 6.4. However, we have used the 5.1 count as a conservative indicator of consumer habits.

Several alternative scenarios were evaluated for their impact upon California water use:

(a) Replacement of all existing residential 1.6-gpf and above toilets with HETs
(b) Replacement of all existing residential 3.5-gpf and above toilets with HETs
(c) All new residential construction mandated with HETs
(d) Combination of a. and c.

Alternative a

The replacement of 21.16 million existing residential toilets (of all flush volumes) with HETs would yield water savings as follows:

- Replacing with 1.0-gpf HETs – 367,000 acre-feet per year (AFY)[25]
- Replacing with 1.25-gpf HETs – 314,000 AFY

[24] Vickers, Amy, 2001. Handbook of Water Use and Conservation, WaterPlow Press. AND Mayer, Peter, 2005, personal communication, July 21.

[25] Calculated on the basis of a current statewide population of 34.47 million persons and a total installed inventory of 21.16 million toilet fixtures, divided as follows:

5.0-gpf and above	4.77 million
3.5-gpf	3.88 million
1.6-gpf	12.51 million
Total	21.16 million

Alternative b

The replacement of ONLY non-efficient toilets (4.8 million 5.0+-gpf toilets and 3.9 million 3.5-gpf toilets) with HETs would yield water savings as follows:

- Replacing with 1.0-gpf HETs – 291,000 AFY
- Replacing with 1.25-gpf HETs – 269,000 AFY

Alternative c

All new residential construction mandated with HETs. Yields water savings as follows:

- All HETs at 1.0-gpf – 52,000 AFY by 2030
- All HETs at 1.25-gpf – 31,000 AFY by 2030

Alternative d

Table 12 shows the results of combining alternatives a or b together with c to secure conversion of existing toilets to HET technology AND mandate that all new construction install HETs only.

Table 12. Summary of Residential HET Initiative Combinations (AFY of Water Savings - 2030)

Existing Installed Base Alternatives		Alternative c - New Construction Mandate 1.0-gpf	Alternative c - New Construction Mandate 1.25-gpf
Alternative a – Replace all Existing Residential Toilets	1.0-gpf	419,000	398,000
	1.25-gpf	366,000	344,000
Alternative b – Replace all Existing Non-Efficient Resid Toilets Only	1.0-gpf	343,000	322,000
	1.25-gpf	321,000	300,000

CII Applications – Toilet Fixtures

Because of the wide variations in the end-use applications within the CII sector, and because authoritative data on the installed base is less available, the determination of potential water savings is based upon more assumptions and, as such, is less reliable.

As noted earlier, between 2.1 and 2.4 million non-efficient toilets are estimated to exist in the CII sector. We have used the 2.1 million figure as a conservative measure of replacement opportunities. However, data are not available that would stratify the 2.1 million by flush volume. Therefore, because all of these toilets were installed prior to California's 1.6-gpf mandate, we know that these fixtures all flush at 3.5-gpf and above and, as such, use that figure for this analysis.

An undetermined number of the non-efficient CII fixtures are of the flushometer valve type. In order to convert these toilets to an HET classification, the entire bowl would require replacement and the valve retrofitted with a diaphragm kit rated at 1.0-gpf. Yet, while 1.0-gpf valves exist in the marketplace, 1.0-gpf flushometer bowls do not. Therefore, to predict savings based upon an

HET scenario for these toilets must assume that at such time as a replacement program begins there will be product available.

For all of the other non-efficient CII toilet fixtures (all of which are tank-type), there exist numerous HET models in the current marketplace, as shown in Tables 2, 3, and 4.

Vickers states that employee's toilet use in the workplace is three flushes per day for women and one flush per day for men.[26] Using this information, the current California employment data discussed earlier, population growth data[27], and the inventory of efficient and non-efficient CII toilet fixtures, the same four alternatives were evaluated for the CII sector.

Alternative a

The replacement of all 4.9 million existing CII toilets (of all flush volumes) with HETs would yield water savings as follows:

- Replacing with 1.0-gpf HETs – 38,000 acre-feet per year (AFY)
- Replacing with 1.25-gpf HETs – 32,000 AFY

Alternative b

The replacement of ONLY the 2.1 million non-efficient toilets with HETs would yield water savings as follows:

- Replacing with 1.0-gpf HETs – 29,000 AFY
- Replacing with 1.25-gpf HETs – 26,000 AFY

Alternative c

All new CII construction mandated with HETs. Yields water savings as follows:

- All HETs at 1.0-gpf – 5,000 AFY by 2030
- All HETs at 1.25-gpf – 3,000 AFY by 2030

Alternative d

Table 13 describes the effects of combining alternatives a or b with c to secure full or partial conversion of 4.9 million existing toilets to HET technology and mandate that all new construction (1.5 million additional toilets) install HETs only.

[26] Vickers, Amy, ibid.

[27] State of California, Department of Finance, 2004. *Population Projections by Race/Ethnicity for California and Its Counties 2000–2050,* Sacramento, California, May.
State of California, Department of Finance, 2005. *E-1 City / County Population Estimates, with Annual percent Change, January 1, 2004 and 2005.* Sacramento, California, May.

Table 13. Summary of CII HET Initiative Combinations (AFY of Water Savings - 2030)

Existing Installed Base Alternatives		Alternative c - New Construction Mandate 1.0-gpf	Alternative c - New Construction Mandate 1.25-gpf
Alternative a – Replace all Existing CII Toilets	1.0-gpf	43,000	41,000
	1.25-gpf	37,000	35,000
Alternative b – Replace all Existing Non-Efficient CII Toilets Only	1.0-gpf	34,000	32,000
	1.25-gpf	31,000	29,000

CII Applications – Urinal Fixtures

Addressing the category of urinals and, specifically, the impact of HEUs, is somewhat more difficult due to the lack of authoritative information on the installed base of urinal fixtures in California. However, we estimated in Section 2 of this report that between 1.3 and 1.5 million urinals currently exist in CII applications in the state. Vickers reports that the average use of a urinal is two times per day by the average male.[28] Again, based upon current employment in California and the current inventory of installed urinals, we estimate current urinal water usage to be 28,000 AFY, growing to 32,000 AFY by 2030 without further urinal flush volume reductions or significant urinal replacement programs.

The estimates of potential savings were developed for four implementation alternatives:

(a) Replacement of all existing urinals of 1.0-gpf and above with HEUs
(b) Replacement of all ONLY the existing non-efficient urinals (>1.0-gpf) with HEUs
(c) All new CII construction mandated with HEUs
(d) Combination of a or b with c.

Alternative a

The replacement of ALL 1.4 million existing CII urinals (of all flush volumes) with HEUs would yield estimated water savings today as follows:

- Replacing with 0.5-gpf HEUs – 21,000 AFY
- Replacing with 0.26-gpf HEUs – 24,000 AFY
- Replacing with 0-gpf non-water HEUs – 28,000 AFY

Alternative b

The replacement with HEUs of ONLY the 1.05 million CII urinals that currently flush at greater than 1.0-gpf, yielding estimated water savings today as follows:

- Replacing with 0.5-gpf HEUs – 20,000 AFY
- Replacing with 0.26-gpf HEUs – 22,000 AFY
- Replacing with 0-gpf non-water HEUs – 25,000 AFY

[28] Vickers, Amy, ibid.

Alternative c

All new CII construction mandated with HEUs[29], yielding water savings[30] as follows:

- All HEUs at 0.5-gpf – 2,000 AFY by 2030
- All HEUs at 0.26-gpf – 3,000 AFY by 2030
- All HEUs at 0-gpf non-water type – 4,000 AFY by 2030

Alternative d

Table 14 shows the water savings potential of combining alternatives a or b with c to secure conversion of all or a portion of the 1.4 million existing urinals to HEU technology AND mandate that all new construction install HEUs only.

Table 14. Summary of CII HEU Initiative Combinations (AFY of Water Savings - 2030)

Existing Installed Base Alternatives		Alternative c - New Construction Mandate		
		0.5-gpf	0.26-gpf	Non-water
Alternative a – Replace all Existing Urinals	0.5-gpf	23,000	24,000	25,000
	0.26-gpf	26,000	27,000	28,000
	Non-water	30,000	31,000	32,000
Alternative b – Replace all Existing Non-Efficient Urinals Only	0.5-gpf	22,000	23,000	24,000
	0.26-gpf	24,000	25,000	26,000
	Non-water	27,000	28,000	29,000

29 As noted earlier, new statewide construction to 2030 is forecasted to require an additional 430,000 urinals.

30 Assumes all 1.0-gpf urinals in new construction, which would add 4,032 AFY of water use by 2030.

4. Cost-Benefit Analyses

More experience probably exists within the water conservation community in the implementation of residential toilet replacement programs than any other water-efficiency initiative. Costs have been well-defined for a number of outreach and implementation approaches, most of which have been tried, fine-tuned, and very successful in California. These include:

- Rebate programs
- Voucher programs
- Full-service direct-installation programs
- Giveaway free-distribution programs
- Combinations of the above

Water agencies and municipalities have chosen their particular approach based upon a variety of factors: economics and budget, the demographics of their constituency, age of housing, urgency of water use reductions, involvement of the constituent business community (retailers, distributors, etc.), customer relations policies and impacts, and, of course, politics, to name a few. Over the years, many water agencies and municipalities have refined their programs to a point where they became very unique to their situation, but extremely effective in reaching their community and accomplishing their water use efficiency goals.

On the other hand, broad experience with large CII toilet replacement programs does not exist, other than dealing with the lodging industry, where the replacement of all toilets within a particular establishment is attractive to the toilet manufacturer and to the water agency or municipality.[31] In this case, most agencies and municipalities offer rebates to the owners, rather than become involved directly in the purchase and/or installation process.

It is not the purpose of this paper to detail all of the nuances and costs of toilet replacement programs. Rather, the analysis of economics was focused on general costs of implementation at a planning level. Recent experience was used to apply cost factors to the various alternatives discussed earlier.

With regard to urinals, however, there has been little experience (and limited success) within the water conservation community with massive urinal replacement or retrofit programs[32]. Therefore, much of the economic analyses here is based upon general assumptions as to costs.

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[31] This occurs even though the data gathered through a study sponsored by the Council showed that the replacement of toilets within hotel-motel sector yielded some of the lowest water savings per installed ULF toilet:
California Urban Water Conservation Council, 1997. *The CII ULFT Savings Study, Final Report*, Table S-1, by Hagler Bailly Services, Inc., August 5.
[32] When the term "replacement" is used, it is in the context of complete replacement of a urinal fixture and of the diaphragm within the flush valve serving it; when the term "retrofit" is used, it is in the context of replacing parts within a urinal flush valve (the diaphragm, for example) to reduce the flush volume of the fixture without replacing the vitreous china. It is rare that merely throttling down a urinal flush valve from 1.0-gpf (or greater) to 0.5-gpf will result in a urinal that actually performs satisfactorily. In fact, some urinal manufacturers agree that their 1.0-gpf products can be flushed at as low as 0.7-gpf and still meet the minimum performance standards referenced in the plumbing codes. However, they do not

Residential Applications – Toilet Fixtures

Whereas the existing BMP14 is targeted at the replacement of residential toilet fixtures, this analysis is essentially directed at evaluating a more aggressive stance, that is, replacing residential toilet fixtures with HETs, rather than with conventional 1.6-gallon toilet fixtures.

Costs for HETs are declining steadily as more product enters the marketplace. As noted in Section 1 of this paper, 13 manufacturers are currently competing at the HET level. This is very significant, given that only one manufacturer addressed this market sector just seven years ago. Consequently, competition is very intense, both on product performance and on cost, thereby benefiting the consumer, as well as the water agencies and municipalities and the programs they sponsor.

Table 15a summarizes cost and savings information for the three alternatives[33] under the residential category. Because the method of implementation of any alternative is undetermined at this time, an average cost of $200 per toilet replacement was assumed[34]. In addition, it was assumed that the water provider implementing a program would include the entire cost of the toilet fixture within the rebate (or other subsidy) amount.

Table 15a. Summary of Expected Water Savings and Costs - Residential Toilets

		With 1.0-gpf Toilet Fixtures			With 1.25-gpf Toilet Fixtures		
Alternative	No. of residential fixtures in category (millions)	AF Savings (millions) (a)	Implementa-tion Cost to Water Authorities ($ millions)	$ per AF (c)	AF Savings (millions) (b)	Implementa-tion Cost to Water Authorities ($ millions)	$ per AF (c)
a – Replace all existing toilets with HETs	21.2	9.18	$4,240	$462	6.28	$4,240	$675
b- Replace existing non-efficient toilets with HETs	8.7	7.28	$1,740	$239	5.38	$1,740	$323
c – Mandate HETs in new construction	8.6	1.30	$43	$33	0.62	$43	$69

(a) Savings accumulated over 25-year life of pressure-assist toilet fixture
(b) Savings accumulated over 20-life of gravity-fed toilet fixture
(c) Assumes that rebate (or other subsidy) covers **ENTIRE** cost of the fixture

recommend installing a 0.5-gpf kit into a flushometer valve (a retrofit) and expecting fully satisfactory performance. As such, the analyses in this paper assume that all urinal initiatives will be replacements, rather than retrofits.

[33] The effect of combining either alternative (a) or alternative (b) with the mandate of alternative (c) may derived by adding the cost and savings data and computing the overall cost per acre-foot.

[34] Assumes a rebate program with an implementation and administrative cost of $50 per replaced fixture; full purchase cost of the fixture estimated at $150, for a total cost of $200. Installation cost is not included. The rebate amount may, however, be less than the purchase cost of the fixture and, as such, the overall cost of the program would then be less than $200.

The cost per acre-foot (to the program implementer) of water saved would be reduced significantly if the subsidy was limited, for example, to one-half the cost of the fixture plus program administrative costs. With that revised assumption, costs and benefits would be as shown in Table 15b.

Table 15b. Summary of Expected Water Savings and Costs - Residential Toilets

Alternative	No. of residential fixtures in category (millions)	With 1.0-gpf Toilet Fixtures: AF Savings (millions) (a)	With 1.0-gpf Toilet Fixtures: Implementation Cost to Water Authorities ($ millions)	With 1.0-gpf Toilet Fixtures: $ per AF (c)	With 1.25-gpf Toilet Fixtures: AF Savings (millions) (b)	With 1.25-gpf Toilet Fixtures: Implementation Cost to Water Authorities ($ millions)	With 1.25-gpf Toilet Fixtures: $ per AF (c)
a – Replace all existing toilets with HETs	21.2	9.18	$2,650	$289	6.28	$2,650	$422
b- Replace existing non-efficient toilets with HETs	8.7	7.28	$1,088	$149	5.38	$1,088	$202
c – Mandate HETs in new construction	8.6	1.30	$43	$33	0.62	$43	$69

(a) Savings accumulated over 25-year life of pressure-assist toilet fixture
(b) Savings accumulated over 20-life of gravity-fed toilet fixture
(c) Assumes that rebate (or other subsidy) covers **ONE-HALF** the cost of the fixture

As stated in the Council's draft Cost and Savings Study[35] (p. 54-64), program costs range from $155 to $230 per toilet replacement. That study is designed to evaluate factors related to BMP 14. As such, it does not incorporate the higher cost of HET fixtures and instead cites historical information (some of which is very dated) for conventional 1.6-gpf toilet replacement programs as anticipated in BMP 14. Whereas conventional fixtures are shown in the study to cost between $60 and $120, HETs are currently priced in the range from $150 to $300, depending upon the type of fixture and current conditions in the marketplace (i.e., pricing "what the market will bear"). As noted earlier, prices are dropping significantly and water agencies and municipalities willing and able to negotiate quantity purchases of HETs have been able to purchase quality HET products at $150 for their free distribution and direct installation programs. On the other hand, the retail customer (who is the candidate for a rebate program) visiting their local retail supplier today should expect to pay near $200 for the same fixture. Because of these vast cost differences (to both the water provider and to the end use customer), it was necessary to use an overall average for Tables 15a and 15b.

[35] California Urban Water Conservation Council, 2005. *Draft Revision, BMP Cost & Savings Study*, by A&N Technical Services, March.

CII Applications – Toilet Fixtures

Opportunities for the replacement of conventional toilet fixtures in the CII sector are much more limited than in residential applications. Several factors contribute to this:

- A smaller installed base of existing fixtures, i.e., 4.9 million as compared to 21.2 million residential fixtures today.
- Higher costs of fixtures, due to more stringent code, permitting, and installation requirements, as well as a large number of flushometer valve and bowl fixtures, which require more installation effort and higher resulting costs.
- The lack of HETs in the flushometer valve and bowl category.
- The reluctance of many end-users to permit replacement of existing, well-functioning fixtures, particularly when doing so may interrupt business operations or cause other restroom modifications to be required.
- The need for significant capital to replace large numbers of fixtures; rebates by themselves are usually insufficient to cover a significant portion of the replacement cost.
- The reputation of "low-flow" toilet fixtures that follows from the bad experiences of the early to mid-1990s; frequently, that reputation overshadows any willingness that a business owner might have to take a "risk" and replace toilet fixtures UNLESS the existing fixtures are causing problems.
- The difficulty that water agencies and municipalities have in reaching out to business owners and managers, whose attention is more focused on day-to-day business operations than the efficiencies that might be gained in the area of water.

Because of these factors (and others), the success of CII toilet replacement programs in achieving meaningful water use reductions has been marginal. Costs to develop and execute effective programs, whether of the rebate, voucher, or direct-installation type, are higher than for residential programs. Based again upon experience with past and existing programs, and considering the higher prices of HETs today, we have assumed a cost of $250 per rebated HET for the purpose of this analysis.[36]

Table 16a summarizes cost and savings information for the same three alternatives under the commercial category. For this analysis, it was assumed that the water provider implementing a program would include the entire cost of the toilet fixture within the rebate (or other subsidy) amount.

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[36] The BMP Cost and Savings Study (CUWCC, 2005) cites the Santa Clara Valley Water District CII program as costing $270 per HET installation on a direct-install basis. However, this program is directed only at tank-type installations and is using a pressure-assist 1.0-gpf HET as a replacement toilet. While this is definitely representative of the cost for both pressure-assist 1.0-gpf and gravity-fed dual-flush HETs, it is not necessarily going to be representative of the cost for flushometer valve and bowl installations, for which replacement HET product is yet to be introduced to the marketplace.

The $250 cost is assumed for a typical rebate program. In this analysis, the cost is based upon a $75 per unit program implementation cost and an average purchase cost of the fixture at $175. The rebate amount may, however, be less than the purchase cost of the fixture and, as such, the overall cost of the program would then be less than $250.

Table 16a. Summary of Expected Water Savings and Costs - CII Toilets

		With 1.0-gpf Toilet Fixtures			With 1.25-gpf Toilet Fixtures		
Alternative	No. of CII fixtures in category (millions)	AF Savings (millions) (a)	Implementation Cost to Water Authorities ($ millions)	$ per AF (c)	AF Savings (millions) (b)	Implementation Cost to Water Authorities ($ millions)	$ per AF (c)
a – Replace all existing toilets with HETs	4.9	0.95	$1,225	$1,289	0.64	$1,225	$1,914
b- Replace existing non-efficient toilets with HETs	2.1	0.73	$525	$724	0.52	$525	$1,010
c – Mandate HETs in new construction	1.5	0.13	$8	$60	0.06	$8	$125

(a) Savings accumulated over 25-year life of pressure-assist toilet fixture
(b) Savings accumulated over 20-life of gravity-fed toilet fixture
(c) Assumes that rebate (or other subsidy) covers **ENTIRE** cost of the fixture

As would be the case with a residential program, the cost per acre-foot (to the program implementer) of water saved would be reduced significantly if the subsidy was limited to one-half the cost of the fixture plus program administrative costs[37]. With that revised assumption, costs and benefits would be as shown in Table 16b.

Table 16b. Summary of Expected Water Savings and Costs - CII Toilets

		With 1.0-gpf Toilet Fixtures			With 1.25-gpf Toilet Fixtures		
Alternative	No. of CII fixtures in category (millions)	AF Savings (millions) (a)	Implementation Cost to Water Authorities ($ millions)	$ per AF (c)	AF Savings (millions) (b)	Implementation Cost to Water Authorities ($ millions)	$ per AF (c)
a – Replace all existing toilets with HETs	4.9	0.95	$796	$838	0.64	$796	$1,244
b- Replace existing non-efficient toilets with HETs	2.1	0.73	$341	$471	0.52	$341	$656
c – Mandate HETs in new construction	1.5	0.13	$8	$60	0.06	$8	$125

(a) Savings accumulated over 25-year life of pressure-assist toilet fixture
(b) Savings accumulated over 20-life of gravity-fed toilet fixture
(c) Assumes that rebate (or other subsidy) covers **ONE-HALF** the cost of the fixture

[37] Amounting to an average cost of $87.50 attributable to the fixture (at one-half) plus $75 for administrative and implementation costs, for a total cost of $162.50 per toilet fixture.

CII Applications – Urinal Fixtures

The replacement within water conservation programs of existing urinals with HEUs is a rarity, with the exception of replacement with non-water urinals. The cost of replacement of the full fixture with a non-water urinal was documented by Orrett[38] as costing between $333 and $590 (including tax and installation), depending upon which model of urinal was chosen. Prices have declined since that study, however, and the average cost for a non-water urinal is approximately $275. Adding a $75 per unit cost for program administration and implementation brings the average total cost to $350 for this analysis.

The only urinals certified at 0.5-gpf are those manufactured by American Standard, Kohler, and Mansfield (refer to Table 5), two of which house an integrated sensor-operated flush valve. The list price of the fixtures and the integrated valve is as follows[39]:

American Standard Innsbook - $901 to $1,195
Kohler Bardon™ Touchless™ - $1,241

While the list prices today would not necessarily be the quantity purchase costs for an aggressive or massive urinal replacement program, the do provide an upper boundary for these types of fixtures. Assuming that, at some future date, water agencies and municipalities were to undertake HEU programs as a part of BMP compliance, it is extremely likely that competition would drive more manufacturers into this sector and prices would drop. For the purpose of this analysis, we have therefore assumed that 0.5-gpf and 0.26-gpf urinals (including the requisite flush valves) would ultimately cost approximately $375 each. A $75 program implementation cost would bring the total cost to $450 per urinal for this analysis.

Fixture life for all categories of urinals was assumed at 30 years, based upon analyses by a team of water conservation professionals on behalf of the Metropolitan Water District.[40]

Table 17a summarizes cost and savings information for the same three alternatives as evaluated for toilet fixtures. Within this table, it was assumed that the water provider implementing a program would include the entire cost of the urinal fixture within the rebate (or other subsidy) amount.

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[38] Orrett, Edwin B., 2001. City of Petaluma, Financial Analysis (of waterless urinals), spreadsheet document. January 27.
[39] List prices for the urinal fixtures taken from the websites of the respective firms on July 23, 2005.
[40] April 2005 spreadsheet documents prepared by a Project Advisory Committee of member water agencies analyzing the potential savings from 0.5-gpf and non-water urinals for the derivation of recommended subsidy levels for these types of fixtures.

Table 17a. Summary of Expected Water Savings and Costs - CII Urinals

Alternative	No. of CII urinal fixtures in category (millions)	With 0.5-gpf Urinals AF Savings (millions) (a)	With 0.5-gpf Urinals Implementation Cost to Water Authorities ($ millions)	With 0.5-gpf Urinals $ per AF (b)	With 0.26-gpf Urinals AF Savings (millions) (b)	With 0.26-gpf Urinals Implementation Cost to Water Authorities ($ millions)	With 0.26-gpf Urinals $ per AF (b)
a – Replace all existing urinals with HEUs	1.40	0.63	$630	$1,000	0.72	$630	$875
b- Replace existing non-efficient urinals with HEUs	1.05	0.60	$473	$788	0.66	$473	$716
c – Mandate HEUs in new construction	0.43	0.06	$0.10	$2	0.09	$0.10	$1

Alternative	No. of CII urinal fixtures in category (millions)	With Non-Water Urinals AF Savings (millions) (a)	With Non-Water Urinals Implementation Cost to Water Authorities ($ millions)	With Non-Water Urinals $ per AF (b)
a – Replace all existing urinals with HEUs	1.40	0.84	$490	$583
b- Replace existing non-efficient urinals with HEUs	1.05	0.75	$368	$490
c – Mandate HEUs in new construction	0.43	0.12	$0.20	$2

(a) Savings accumulated over 30-year life of urinal

(b) Assumes that rebate (or other subsidy) covers **ENTIRE** cost of fixture

As would be the case with a toilet replacement program, the cost per acre-foot (to the program implementer) of water saved would be reduced significantly if the subsidy was limited to one-half the cost of the fixture plus program administrative costs[41]. With that revised assumption, costs and benefits would be as shown in Table 17b.

[41] Amounting to an average cost of $87.50 attributable to the fixture (at one-half) plus $75 for administrative and implementation costs, for a total cost of $162.50 per toilet fixture.

Table 17b. Summary of Expected Water Savings and Costs - CII Urinals

Alternative	No. of CII urinal fixtures in category (millions)	With 0.5-gpf Urinals: AF Savings (millions) (a)	With 0.5-gpf Urinals: Implementation Cost to Water Authorities ($ millions)	With 0.5-gpf Urinals: $ per AF (b)	With 0.26-gpf Urinals: AF Savings (millions) (b)	With 0.26-gpf Urinals: Implementation Cost to Water Authorities ($ millions)	With 0.26-gpf Urinals: $ per AF (b)
a – Replace all existing urinals with HEUs	1.40	0.63	$354	$561	0.72	$354	$491
b- Replace existing non-efficient urinals with HEUs	1.05	0.60	$265	$442	0.66	$265	$402
c – Mandate HEUs in new construction	0.43	0.06	$0.10	$2	0.09	$0.10	$1

Alternative	No. of CII urinal fixtures in category (millions)	With Non-Water Urinals: AF Savings (millions) (a)	With Non-Water Urinals: Implementation Cost to Water Authorities ($ millions)	With Non-Water Urinals: $ per AF (b)
a – Replace all existing urinals with HEUs	1.40	0.84	$298	$354
b- Replace existing non-efficient urinals with HEUs	1.05	0.75	$223	$298
c – Mandate HEUs in new construction	0.43	0.12	$0.20	$2

(a) Savings accumulated over 30-year life of urinal
(b) Assumes that rebate (or other subsidy) covers ONE-HALF the cost of the fixture

5. California Potential

Residential Applications – Toilet Fixtures

Over 26 million toilet fixtures exist in California, of which nearly 11 million are estimated to be non-efficient, i.e., rated at a flush volume in excess of 1.6-gpf. Water conservation programs directed at the residential sector have been very successful in some municipalities and agency service areas where toilet replacement has been seriously and aggressively addressed. According to Council data on BMP 14, approximately 2 million residential toilets have been replaced through water conservation programs through 2004.

Ample opportunity exists to target the remaining 3.5-, 5.0-, and 7.0-gpf non-efficient toilets in the state, totaling an estimated 8.7 million fixtures. While saturation is approached in some areas, thus making program marketing somewhat more difficult and costly, many areas are largely untouched by significant residential toilet replacement initiatives. Some argue that freeridership is too high in a typical rebate program to make such a program cost effective. However, HET-focused programs will not experience freeridership until such time as HETs become commonplace and the consumer is aware of the benefits. Until then, it appears that as a first priority and as a legitimate PBMP, the existing 8.7 million non-efficient residential toilets all represent viable potential for future programs. As a second priority, we would recommend that, apart from the PBMP process, the Council examine the feasibility of supporting legislation that would mandate HETs in new residential construction statewide.

CII Applications – Toilet Fixtures

CII toilet replacement programs are quite a different story. As noted earlier, marketing a rebate or voucher program to the various CII sectors is difficult in most cases and takes a degree of special expertise. Program and fixture costs are higher and rebates are less attractive to business owners occupied with day-to-day business operations. Direct-installation programs wherein a "full service" replacement is provided are probably the most successful.

Furthermore, HETs are only available for certain replacements (i.e., tank-type installations), because there is no flushometer valve fixture (yet) in the marketplace. Of the 2.1 million non-efficient CII toilets, probably one-half are of the tank-type and, as such, represent viable potential for programs similar to the direct-install HET program of the Santa Clara Valley Water District, that currently targets CII customers. The cost of this program (excluding district staff time) is $269 per installed HET[42].

In this category, we recommend that the Council monitor the toilet fixture market and, at such time as suitable HETs for flushometer valve installations become available (which is likely in 2006), that BMP 9 incorporate HETs as a feasible means to achieve the required water savings. Until that time, examine the feasibility of legislation mandating HETs in new CII construction[43].

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[42] Personal communication, Karen Morvay, July 25, 2005.
[43] Effective at such time as acceptable flushometer valve and bowl HETs are widely available.

CII Applications – Urinal Fixtures

The total acre-feet savings associated with the various urinal alternatives discussed in this paper are very similar to those for CII toilet fixtures. The difficulty of marketing fixture replacement programs to the CII sector are the same for urinals as they are for toilets. Up to now, the replacement of urinal fixtures with HEUs has been left to the manufacturers of the non-water urinals. Given the plumbing code issues associated with non-water urinals, the manufacturers have done moderately well without significant help from the water conservation community (other than very modest rebates). It would appear that the CII sector is best approached and convinced when a “package” of improvements are made available AND the water agency, municipality, and/or product manufacturer can provide full-service installation. That is, removing the business owner, manager, or operator from the details of specifications, permits, purchase, and installation.

Therefore, we recommend that CII HETs and HEUs be included as a unit when creating programs and when considering them for PBMP status. In addition, as with CII HETs, we recommend that the Council consider supporting legislation mandating HEUs in future new construction.

Proposal Information Template – Residential Water Meters

2011 Appliance Efficiency Standards

Prepared by: Ed Osann and Tracy Quinn

September 30, 2011

CONTENTS

Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the California Energy Commission's (Commission) appliance efficiency regulations (Title 20, Cal. Code Regulations,, §§ 1601 – 1608) This report specifically covers Residential Water Meters.

Background

Accurate accounting of water is essential for advancing water efficiency efforts in the State of California. Residential water meters are used by water suppliers to record customer water consumption. There are approximately 9 million single family homes[1] in California. Of these, NRDC estimates that 90% of the single family homes in California have residential water meters. The accuracy of meters is an important factor in accounting for water losses, both in the distribution system and on the customer side. The American Water Works Association (AWWA) has developed voluntary standards for several types of water meters, but these standards are not adequate. None of the meter standards require meter testing at extended low flows indicative of typical customer side leakage. According to the AWWA Residential End Use Study conducted by AWWA, at least 13.7% of all indoor water use in single family homes is due to leaking toilets and dripping faucets. In addition, Waterwiser.org estimates that 20% of toilets leak. In California alone there are about 27 million residential toilets, over 5 million of which could have leaks. Meters that simply meet the current AWWA standards may allow leaks as large as 200 gallons per day can go undetected. Applied to the entire state, that could equal as much as 1 billion gallons per day.

This issue is particularly important for California because of our current building code. The California State Building Standards Commission adopted the 2010 California Residential Code, which includes the 2009 International Residential Code as established by the International Code Council in September 2008. A key component in the 2010 code adoption is the addition of residential fire sprinklers in all new one-and two-family dwellings and townhouse construction statewide. To accommodate for the potential high flow a sprinkler system would require if used, many utilities are simply increasing the sizes of the water meters. This practice has the effect of reducing the utility's ability to measure low flows in the home. In addition to not detecting leaks, these meters may also be unable to detect the use of faucets and other low flow activities.

This standard proposal aims to ensure that the most common residential water meters sold in California are capable of adequately measuring water at extended low flows.

[1] California Department of Finance.

Overview

Description of Standards Proposal	We recommend that California adopt a standard for two types of Residential Water Meters. 1. Positive Displacement (covered by AWWA standard C-700) The proposed standard is structured in two tiers, in order to capture low-hanging fruit early while leaving enough time for manufacturers to implement significant design changes in a second tier.

Size	Current AWWA Minimum Test Flow (GPM)	Proposed Tier 1 Standard Effective January 1, 2014 (GPM)	Proposed Tier 2 Standard Effective January 1, 2016 (GPM)
1/2"	0.25		
1/2" x 3/4"	0.25		
5/8"	0.25	0.25	0.125
5/8" x 1/2"		0.25	0.125
5/8" x 3/4"	0.25	0.125	0.125
3/4"	0.5	0.25	0.25
3/4" x 3/4"		0.5	0.25
3/4" x 1"		0.5	0.5
1"	0.75	0.5	0.375
1 1/2"	1.5	1.25	0.75
2"	2	1.5	1

2. Single Jet (covered by AWWA standard C-712)

Size	Current AWWA Minimum Test Flow (GPM)	Proposed Standard Effective January 1, 2014 (GPM)
5/8"	0.25	0.0625
5/8 x 3/4"	0.25	0.0625
3/4"	0.5	0.125
1"	0.75	0.25
1.5"	0.5	0.5
2"	0.5	0.5

California Stock and Sales	2011 California Stock – approximately **8 million residential water meters (**Assumes 90% of single family homes have water meters). Annual sales for the residential sector are projected to be about 590,000 per year during the period 2014 – 2025, Total sales between 2014 and 2025 are estimated at **8.18 million meters**.
Energy Savings and Demand Reduction	The energy savings attributed to this standard would be the energy costs embedded in the water savings this standard provides.
Economic Analysis	Water meters capable of accurately measuring extended low flows are currently more expensive than meters only capable of meeting the AWWA standards, but the price differential was not immediately available for use in this template. Further market research is required.
Non-Energy Benefits	We estimate that the standard would result in the following water savings between 2014 and 2025 • **25 MGD**.
Environmental Impacts	We are not aware of any adverse environmental impacts that will be created by the proposed standard.
Acceptance Issues	Meter manufacturers that are not currently capable of producing a residential water meter that meets this standard are likely to oppose it.
Federal Preemption or other Regulatory or Legislative Considerations	The American Water Works Association has voluntary standards, but they are not adequate for water efficiency considerations.

Methodology and Modeling used in the Development of the proposal

Savings estimates were developed using the best available data from a number of sources as well as our own assumptions as detailed below.

Data, Analysis and Results

Sales

Sales are based on number of single family homes in California which was calculated by relating the number of single family homes to population as projected by the California Department of Finance.

Assumptions:

- In 2011, 90% of single family homes were metered
- In 2017, all single family homes will be metered
- Metering of currently non-metered homes will occur in a linear fashion.
- One meter per single family home
- Proportion of single family homes to total housing units will remain the same during the time period used for projections
- Relationship of population to number of housing units will remain the same during the time period used for projections

Table 1: Sales Estimates

	New Housing Units (2014 - 2025)	New Meters from Replacement[a] (2014 - 2025)	Total # New Meters (2014-2025)
Single Family	1,180,000	7,000,000	8,180,000

[a] Assumes a replacement rate of 5%.

Full turnover of existing meters should occur in 2027.

Savings Estimates

The following assumptions were used to determine a conservative estimate of the impact this standard could have on water savings in California.

- Single family residential water meters range in size from 5/8" to 2", for the purposes of this calculation it is assumed that all meters are ¾".
- The AWWA voluntary standard requires a minimum test flow of 0.5 gallons per minute (gpm) for ¾" meters. Specific accuracy requirements at this range vary based on meter type but are typically ± 1.5%.
- Twenty percent of toilets leak, for the purpose of this calculation we'll assume that 10 percent of these leaks will be large enough to be measured by water meters meeting the proposed standard.
- For ease of calculation, we will assume one toilet per household; therefore leaks occur in 20% of the metered single family households.

- Furthermore, we assume 50% of the measured leaks will be identified and fixed by the consumer.
- For the purposes of this calculation we assume the leak is ¼ gpm.
- Number of new meters = new construction plus 5% replacement rate of existing meters

Calculation X. Estimate of water savings

(# New meters) (0.2*0.1*0.5) (0.25 gallons/minute) (60 minutes/hour) (24 hours/day)

Average annual water savings is about **2.1 million gallons per day (MGD).**

Water savings between 2014 and 2025 is estimated at **25 MGD**.

Cost Effectiveness

No information was available at the time.

Proposed Standards and Recommendations

The proposed recommendations are:

1. Positive Displacement (covered by AWWA standard C-700)

The proposed standard is structured in two tiers, in order to capture low-hanging fruit early while leaving enough time for manufacturers to implement significant design changes in a second tier.

Size	Current AWWA Minimum Test Flow (GPM)	Proposed Tier 1 Standard Effective January 1, 2014 (GPM)	Proposed Tier 2 Standard Effective January 1, 2016 (GPM)
1/2"	0.25		
1/2" x 3/4"	0.25		
5/8"	0.25	0.25	0.125
5/8" x 1/2"		0.25	0.125
5/8" x 3/4"	0.25	0.125	0.125
3/4"	0.5	0.25	0.25
3/4" x 3/4"		0.5	0.25
3/4" x 1"		0.5	0.5
1"	0.75	0.5	0.375
1 1/2"	1.5	1.25	0.75
2"	2	1.5	1

2. Single Jet (covered by AWWA standard C-712)

Size	Current AWWA Minimum Test Flow (GPM)	Proposed Standard Effective January 1, 2014 (GPM)
5/8"	0.25	0.0625
5/8 x 3/4"	0.25	0.0625
3/4"	0.5	0.125
1"	0.75	0.25
1.5"	0.5	0.5
2"	0.5	0.5

Bibliography and Other Research

As indicated within the document.

References and Appendices

None