

# **High-Efficiency Plumbing Fixture Direct Install Water Savings Analysis**

for

## **Santa Clara Valley Water District**

5750 Almaden Expressway  
San Jose, California

and

## **California Urban Water Conservation Council**

716 Tenth Street, Suite 200  
Sacramento, California

October 2012

By

John Koeller  
Koeller and Company  
Yorba Linda, California  
[jkoeller@map-testing.com](mailto:jkoeller@map-testing.com)



## TABLE OF CONTENTS

<b>INTRODUCTION</b>	Page 2
<b>PROGRAM BACKGROUND</b>	3
<i>Fixture Replacements</i>	3
<i>Participating Properties</i>	4
<i>Data Collection</i>	4
<b>STUDY RESULTS</b>	6
<i>Methodology</i>	6
<i>Findings</i>	6
-Overall water savings	6
-Multi-family water savings	6
-Non-residential water savings	7
-Water savings by toilet replaced	7
<b>SUMMARY AND CONCLUSIONS</b>	9

## TABLES AND FIGURES

Table 1 – Toilet fixture replacements by community	3
Table 2 – Non-residential toilet fixture replacements	4
Table 3 – Properties participating in the program	4
Table 4 – Savings from all toilet fixture replacements	6
Table 5 – Residential properties, toilet replacement, and water savings	6
Table 6 – Water savings by non-residential category	7
Table 7 – Water savings by replaced toilet	7
Table 8 – Water savings summary	9
Figure 1 – HET installation months	5

## INTRODUCTION

The purpose of this study was to evaluate and estimate water savings that accrued from the replacement of slightly less than 5,000 aging high-volume toilets<sup>1</sup> in 80 multi-family residential and commercial properties within the service area of the Santa Clara Valley Water District (SCVWD). The replacement toilets chosen for the project were all High-Efficiency Toilets<sup>2</sup> (HETs).

The SCVWD engaged the services of an experienced retrofit contractor to perform the replacements; licensed plumbers were used to install all toilet fixtures. The replacements that are the subject of this study all took place during a period of approximately four years from July 2007 to May 2011. Except for a few instances noted later, all replacement installations involved only the toilet. SCVWD reports that other plumbing or appliance items within the subject properties were not replaced during the period of savings analysis.

The program was implemented in Santa Clara County. Water use data for the study was provided by the Cities of Morgan Hill, Mountain View, Palo Alto and Sunnyvale.

A very special thank you goes to Ms. Karen Koppett of the SCVWD. Ms. Koppett was instrumental in furnishing information and setting the direction of the study. Many thanks also go to the Cities of Morgan Hill, Mountain View, Palo Alto and Sunnyvale, where persons associated with the water billing departments spent a large number of hours retrieving billing data for the 80 properties covered by the study. This was a significant task and their work yielded results that were essential to the study conclusions.

---

<sup>1</sup> Replaced toilets consisted entirely of fixtures rated at 3.5 and 5.0 gallons per flush-gpf (13 and 19 liters per flush-Lpf)

<sup>2</sup> High-efficiency toilet (HET) fixtures are defined as those with an effective flush volume 20 percent less than the Federal maximum of 1.6 gallons (6.0 liters) per flush. As such, all HETs flush (on average) at 1.28 gallons (4.8 liters) or less.

## PROGRAM BACKGROUND

### Fixture Replacements

This analysis focused on the replacement of 4,954 aging toilet fixtures<sup>3</sup> with High-Efficiency Toilet (HET)<sup>4</sup> models, divided as follows:

**Table 1. Toilet fixture replacements by community**

Community	Multi-Family Residential	Non-Residential	Total
Sunnyvale	2,786	1,349	4,135
Mountain View	361	102	463
Morgan Hill	0	33	33
Palo Alto	96	227	323
<b>Total</b>	<b>3,243</b>	<b>1,711</b>	<b>4,954</b>

The program replaced aging 3.5- and 5.0-gallons per flush (gpf) fixtures with HETs<sup>5</sup>, most of which were gravity-fed tank-type fixtures. The gravity-fed fixture used was the Caroma Sydney Smart 305 dual-flush with elongated bowl, flushing at 1.3 gpf on the full flush and 0.9 gpf on the reduced flush<sup>6</sup>. This fixture model is certified to the WaterSense specification and carries the WaterSense label<sup>7</sup>. The few flushometer valve-bowl combinations replaced used the Zurn EcoVantage 1.28 gpf elongated bowl<sup>8</sup>. Replacement of 1.6-gpf fixtures was not a part of the SCVWD's replacement program.

Table 2 displays the distribution of the 1,711 non-residential replacements by sector.

---

<sup>3</sup> The difference between the total number of fixtures replaced and the 4,954 is due largely to the exclusion from the analysis of: (a) those toilet replacements that were accompanied by concurrent high-efficiency urinal retrofits, (b) replacement installations with incomplete water consumption data either before or after the physical replacement took place, and (c) those generating anomalous water use data.

<sup>4</sup> The first HET fixtures were introduced to the North American marketplace in 1999. Since that date, over 1,300 different HET models from dozens of manufacturers exist in the U.S. marketplace. The U.S. EPA's WaterSense program endorses HETs and labels those models that perform to a high set of standards. The gravity-fed HET model installed in most locations is WaterSense labeled (see footnote 6 below).

<sup>5</sup> A total of 831 5.0-gpf toilet fixtures were replaced in multi-family buildings and included within this evaluation, all of which were located in Sunnyvale. The remaining 4,123 fixtures, all but 5 of which flushed at 3.5-gpf, were scattered throughout the four communities.

<sup>6</sup> Caroma model numbers 609130 bowl and 622322 tank; MaP score of 800 grams

<sup>7</sup> [http://www.epa.gov/watersense/docs/spec\\_het508.pdf](http://www.epa.gov/watersense/docs/spec_het508.pdf)

<sup>8</sup> Zurn model Z5615 bowl; MaP score of 800 grams when matched with a 1.28 gpf flushometer valve

**Table 2. Non-residential toilet fixture replacements**

Non-Residential Category	No. of 3.5-gpf Fixtures Replaced	No. of 5.0-gpf Fixtures Replaced	Total
Hospitality*	1,461	0	1,461
School	4	0	4
Retail & services	0	5	5
Office & medical	208	0	208
Gym-Health Club-Spa	22	0	22
Manufacturing & warehouse	7	0	7
Other	4	0	4
<b>Total</b>	<b>1,706</b>	<b>5</b>	<b>1,711</b>

\*-Hospitality includes lodging establishments and eating places

### Schedule of Replacements

Replacement of the 4,954 fixtures was spread over a period of four (4) years, beginning in July 2007 and concluding in May of 2011. Figure 1 shows the spread of installations by category over that period of time.

### Participating Properties

A total of 80 properties from the four communities participated in the replacement program and are benefitting from it. These are divided as follows:

**Table 3. Properties participating in the program**

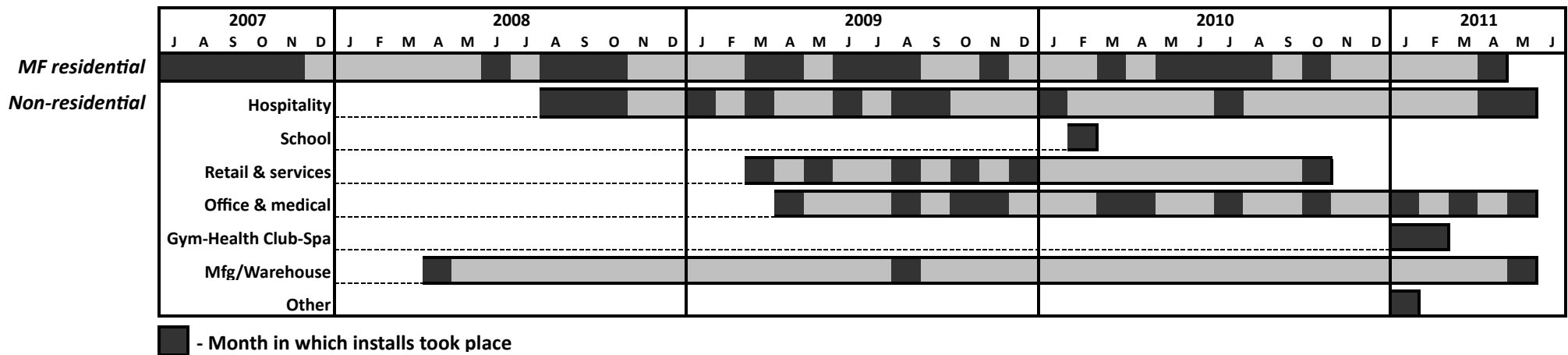
Community	Residential	Non-residential	Total
Sunnyvale	28	18	46
Mountain View	12	6	18
Morgan Hill	0	1	1
Palo Alto	4	11	15
<b>Total</b>	<b>44</b>	<b>36</b>	<b>80</b>

### Data Collection

For the purpose of assessing water use reductions achieved through the program, the SCVWD collaborated with the four retail water service providers to secure water meter readings for no less than one year following fixture installation. These meter readings were then compared to meter reads from periods prior to installation of from 12 to 36 months.

In addition to metered water consumption and property location, each data set for an individual participant (property) contained information on type of property, the number of fixtures replaced within the property, the flush volume of the replaced toilets, and the date of replacement. Information on population within the residential properties, occupancy rate of the hotels, and employment in the non-residential buildings in which toilets were replaced was not obtained and was not a consideration in the data collection or analyses.

Figure 1. HET Installation Months



## STUDY RESULTS

### Methodology

Metered water consumption data furnished by the retail water utilities (through SCVWD) were used to assess demand reductions, if any, resulting from toilet fixture replacements. Sub-metering or other fixture-specific monitoring of uses within homes and businesses was not performed. All results relied entirely upon data from utility meters and reports from the program contractor.

To reduce the effect of seasonal variations in climate (and, hence, water demand variances) from year to year, water demand during the four high-use summer months was excluded. Some of the participating water utilities are programmed for bimonthly billing of their customers, others bill monthly. As a result, in some cases, two billing periods were excluded while, in other cases, four billing periods were excluded.

Except for one property, all of the toilet replacements were made without other water efficiency improvements being made at the same time. That one property, with 468 replacement toilets, was therefore excluded from all analyses, since it was not possible to disaggregate water savings for the toilets alone.

### Findings

Water savings achieved through toilet fixture replacement were assessed for several different categories of end-user as well as for the flush volume of the old and new toilets

#### ***Overall water savings***

The replacement of toilet fixtures resulted in the following:

**Table 4. Savings from all toilet fixture replacements<sup>9</sup>**

	Multi-Family Residential	Non-residential	Total - all types
No. of properties	44	36	80
No. of toilets	3,243	1,711	4,954
Daily water savings per toilet (gallons)	38.0	43.7	40.0

#### ***Multi-family residential water savings***

For residential, the distribution of toilet replacements and water savings were as follows:

**Table 5. Residential properties, toilet replacement, and water savings**

Community	Multi-Family Residential Properties	Residential Toilets Replaced	Avg. Toilets Replaced per Property	Daily Water Savings Per Toilet (gals)
Sunnyvale	28	2,786	100	28.9
Mountain View	12	361	30	109.5
Morgan Hill	0	0	0	0
Palo Alto	4	96	24	33.8
<b>Total</b>	<b>44</b>	<b>3,243</b>	<b>74</b>	<b>38.0</b>

<sup>9</sup> Represents a mixture of aging toilets replaced: 3.5-gpf and 5.0-gpf. Replacement toilets all qualified as HETs.

### ***Non-residential water savings***

Non-residential installations fell into seven general categories, most participating properties being in the hospitality and office/medical classifications as noted in Table 6.

**Table 6. Water savings by non-residential category**

<b>Non-Residential Category</b>	<b>Properties</b>	<b>Toilets Replaced</b>	<b>Daily Water Savings Per Toilet (gals)</b>
Hospitality*	13	1,461	40.6
School	1	4	8.1
Retail & services	2	5	84.8
Office & medical	14	208	68.4
Gym-Health Club-Spa	2	22	19.2
Manufacturing & warehouse	3	7	56.5
Other	1	4	7.3
<b>Total</b>	<b>36</b>	<b>1711</b>	<b>43.7</b>

### ***Water savings by toilet replaced***

*(3.5 gallons per flush vs. 5.0 gallons per flush)*

The program contractor recorded the flush volume of the aging toilets replaced at each participating property, indicating whether the replaced fixtures had been functioning at 3.5-gpf or 5.0-gpf. Assuming that the contractor correctly assessed the flush volumes, Table 7 shows the savings associated with each category of replacement.

**Table 7. Water savings by replaced toilet**

<b>Flush Volume of Toilet Replaced</b>	<b>Properties</b>	<b>Toilets Replaced</b>	<b>Daily Water Savings Per Toilet (gals)</b>
<b><i>HETs replacing 3.5-gpf</i></b>	<b>73</b>	<b>4,118</b>	<b>41.2</b>
Multi-family Residential	38	2,412	39.5
Non-residential	35	1,706	43.6
<b><i>HETs replacing 5.0-gpf</i></b>	<b>7</b>	<b>836</b>	<b>34.0</b>
Multi-family Residential	6	831	33.7
Non-residential	1	5	84.8
<b>ALL REPLACEMENTS</b>	<b>80</b>	<b>4,954</b>	<b>40.0</b>

For multi-family residential installations, the data in Table 7 shows savings from replacing 3.5-gpf toilets slightly higher than those resulting from the replacement of 5.0-gpf fixtures. Specific data on the age or condition of the properties and the replaced fixtures is not available, nor was the resident population of the 44 residential properties. That is, the resident density of these properties may be significantly different between those replacing 3.5-gpf toilets and those very few properties with 5.0-gpf toilets. Because of these factors, we cannot estimate and compare the daily resident usage of the 5.0-gpf fixtures with the 3.5-gpf fixtures.



Another causal factor is the leakage of aging toilet fixtures, which usually played a large role in water savings figures for toilet fixtures. It is common in the older fixtures that leakage can be significant<sup>10</sup>, particularly in multi-family housing where the tenant is not responsible for maintaining the toilet fixture. When these leaking fixtures are replaced with new models, leakage is eliminated and water is saved (at least for a period of time). This factor, when combined with reduced flush volumes, can yield extraordinary water savings. The magnitude of those savings is largely influenced by the condition of those older fixtures, which, in turn, may be determined by the level of maintenance on the fixtures performed over their lifetime. In cases with attentive management and fixture maintenance, leakage is usually not significant. On the other hand, a lack of proper maintenance can result in ongoing leakage that is eliminated when the aging fixture is replaced with a new HET. In this case, we have no data on the physical condition of either the 3.5-gpf or the 5.0-gpf toilets removed and replaced.

Given the large number of water consumption variables existing in aging toilets installed in multi-family residential (physical condition of the aging toilet and occupancy of the dwellings), it is not wise to focus only on the rated flush volume changes when estimating water use reductions<sup>11</sup>. Rather, an overall number for all aging toilet replacements is more appropriate. Therefore, the combined daily water savings rate of 38.0 gallons per toilet (Table 5) is recommended as a planning number for the replacement of multi-family residential fixtures dating from the 1980s and previous.

---

<sup>10</sup> Leakage at gravity-fed toilets usually occurs for one or both of the following reasons: (a) degraded or incorrect flush valve seals (flappers) and (b) faulty fill valves (ballcock float arm type) that release water into the overflow tube as a result of system water pressure changes. In the latter case, this type of leakage can be eliminated by re-setting the water line in the tank.

<sup>11</sup> In this specific case, the 1.5 gpf difference between a 3.5 gpf and a 5.0 gpf toilet (which are very unlikely to be flushing at those rates) may not be reflective of savings potential. In addition, to estimate a savings based solely upon the delta between a 5.0 gpf toilet and a 1.28 gpf HET, for example, does not necessarily result in a reliable 'real world' number.

## SUMMARY AND CONCLUSIONS

In the properties covered in this analysis, the SCVWD's program targeted only toilet fixture replacements. The primary goal of the analysis was to derive daily water savings per toilet fixture based upon a total of 4,954 such replacements<sup>12</sup>. While this represents an adequate sample from which to draw some general water savings metrics to be applied elsewhere, the parsing of this number into smaller and smaller increments for more sector-specific metrics leads to unreliable data. However, the resulting water savings metrics for these sectors is still generally useful for rough projections of likely water use reductions when conservation programs are being developed or evaluated.

Key water savings findings from the study were as follows:

**Table 8. Water savings summary**

	Properties	Toilets Replaced	Daily Water Savings Per Toilet (gals)
<b>Overall</b>	<b>80</b>	<b>4,954</b>	<b>40.0</b>
Multi-family residential	44	3,243	38.0
Non-residential (commercial)	36	1,711	43.7
<b>Representative commercial installations</b>			
Hospitality	13	1,461	40.6
Office & medical	14	208	68.4
All others	9	42	31.0
<b>Multi-family residential installations</b>			
Replace a 3.5 gpf	38	2,412	39.5
Replace a 5.0 gpf	6	831	33.7
<b>Participating city</b>			
Sunnyvale	46	4,135	33.3
Mountain View	18	463	90.0
Morgan Hill	1	33	42.5
Palo Alto	15	323	53.6

<sup>12</sup> As noted in the report, however, other installations were removed from the analysis due to missing or inconsistent data.