Evaluation of Water Use Reduction Achieved Through Residential Toilet Fixture Replacements

Mendelsohn House - San Francisco

by

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INTRODUCTION

The purpose of this study was to measure the water savings achieved with toilet fixture replacements in an apartment complex. A secondary purpose was to determine the extent to which maintenance service calls could be reduced when aging toilet fixtures are replaced with new fixtures. The Mendelsohn House apartment project in downtown San Francisco volunteered the information they gathered over the past several years in connection with their fixture replacement program. That data was used for the analysis that follows.

A very special thank you goes to Mr. Willie Abasta, Site Administrator for the Mendelsohn project. Mr. Abasta was of immense assistance in furnishing information on the replacement program and its effects, including historical records on water use and maintenance service calls.

BACKGROUND

The Mendelsohn House is a Todco Development project located in downtown San Francisco[1] just three blocks south of Market Street. Mendelsohn's 189 apartment units are largely occupied by senior citizen residents. At the time of construction in 1988, all units were fitted with 3.5 gallons per flush (13 litres per flush) gravity-fed toilet fixtures. Since 2007, the occupancy rate at Mendelsohn has remained constant at near 100 percent.

High-Efficiency Toilets (HETs)

In 1999, the first high-efficiency toilet (HET) fixtures were introduced to the North American marketplace, all of which were gravity-fed dual-flush units. Later, in 2001, the first pressure-assist single-flush HET fixtures were field tested in California by manufacturers and the water utilities. Upon completion of those trials and subsequent product refinement, the first pressure-assist HETs were introduced into the marketplace in 2003. All of those first units utilized the Sloan Flushmate IV pressure vessel and flushing system.

Since the original introduction of the Flushmate-equipped HETs, many toilet manufacturers have refined their bowl designs and improved the hydraulic matching of the Flushmate unit with their fixture bowls. As a result, flush noise levels have been much reduced and pressure-assist fixtures may now be found in residences, hotel guest rooms, and other areas where noise is considered to be an important selection factor.

Toilet Replacement Project

In April 2010, Mendelsohn began a toilet fixture replacement project in which 192 of the 22-year old non-efficient gravity-fed fixtures were replaced by two different Kohler two-piece 1.0 gallon (3.8 litres) per flush pressure-assist fixtures equipped with the Sloan Flushmate IV system:

- Kohler K-3519 Highline Pressure Lite[2] (K-4304 bowl[3] and K-4484 tank)
- Kohler K-3531 Wellworth Pressure Lite[4] (K-4303 bowl and K-4484 tank)

Installation of the replacement fixtures was performed by a licensed plumber. Replacements were completed by May 4, 2010.

[1] Located at 737 Folsom Street – http://www.todco.org/aboutus.html
[2] http://www.us.kohler.com/onlinecatalog/detail.jsp?item=10452402&section=2&category=13&subcategory=117
[3] The K-4304 bowl qualifies as meeting the ADA requirements
[4] http://www.us.kohler.com/onlinecatalog/detail.jsp?item=10452502&section=2&category=13&subcategory=117&retail=false

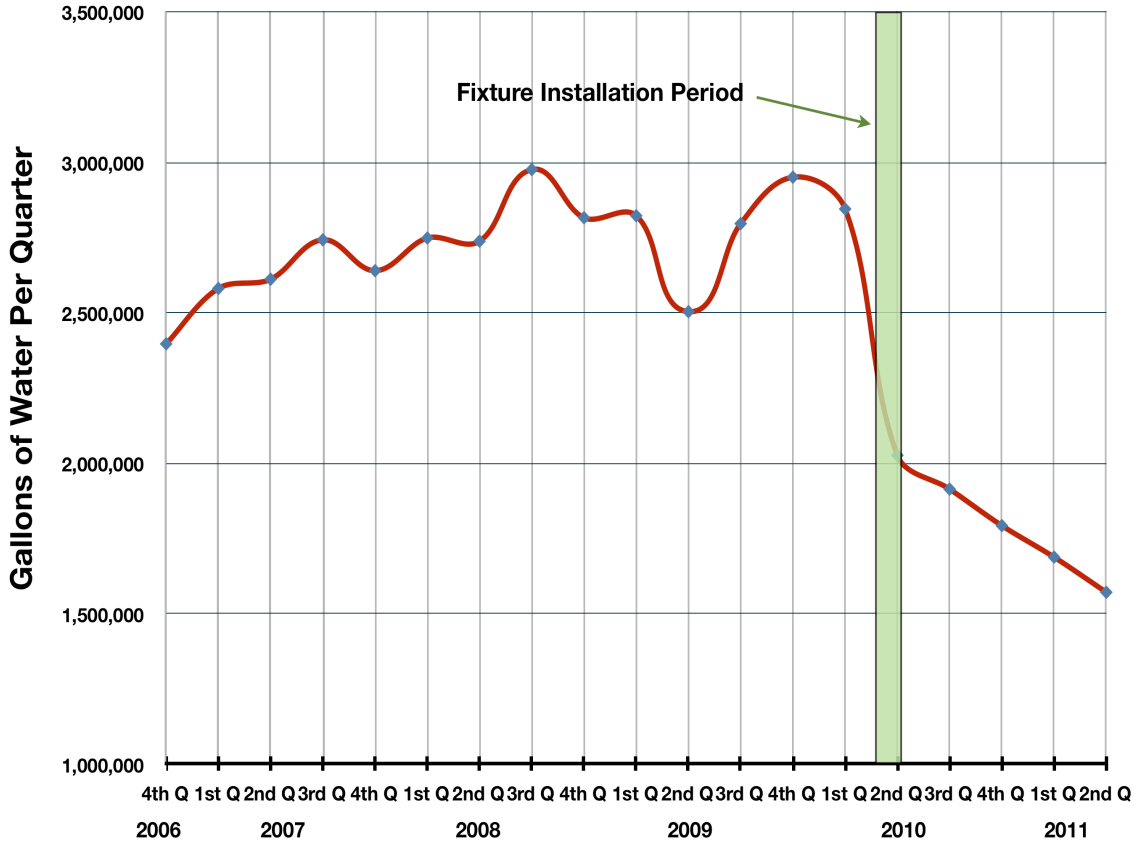
STUDY RESULTS

Utilities usage and maintenance service calls are continually tracked on a monthly basis by Mendelsohn. Using data collected both before and after the toilet fixture replacements, it is possible to calculate both the water use reductions and the reduced maintenance calls resulting from the project[5]. Using meter data from utility bills and in-house maintenance records, a downward trend in water demands was clearly evident after fixture replacement[6]. Concurrently, maintenance calls related to toilet fixtures declined as well.

Water Use

Figure 1 graphically displays water use by Mendelsohn over the study period.

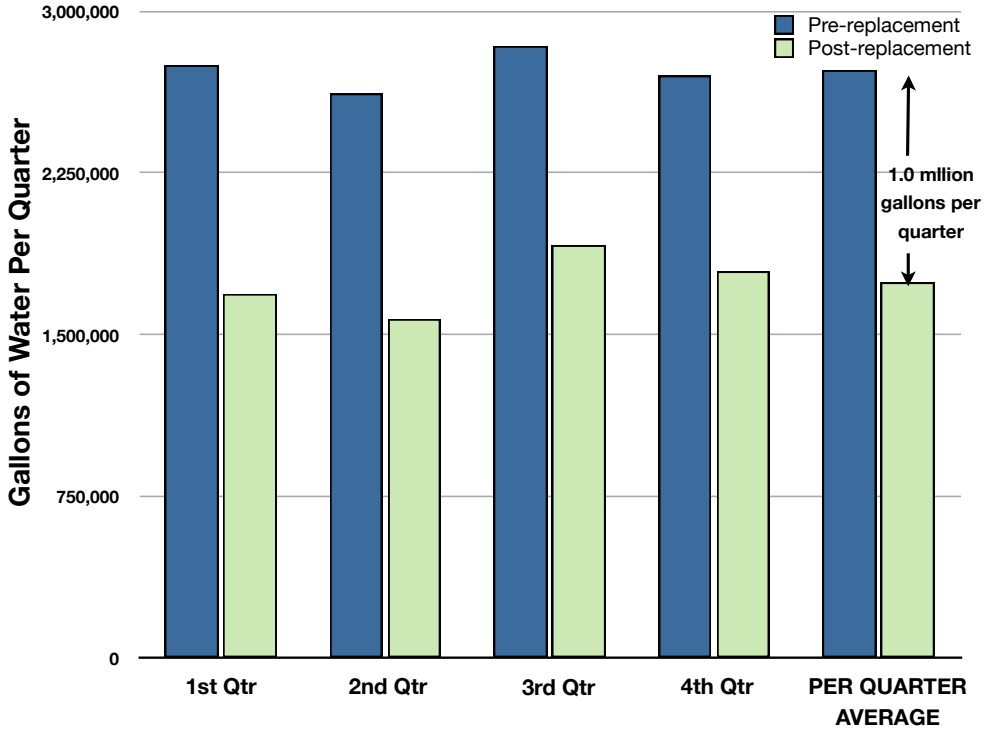
Figure 1. Water Usage - Mendelsohn Building



[5] It should be noted that Mendelsohn has little irrigated landscape and, as such, water consumption is confined almost entirely to interior uses and comfort systems.
[6] No other significant water efficiency measures were implemented during or after replacement.

Figure 2 shows a quarter-to-quarter and annual comparison of quarterly water usage 'before' and 'after' replacement. The reduction experienced amounted to approximately 1 million gallons per quarter.

Figure 2. Quarterly Water Usage - 2007-2011



The net savings achieved through the replacement project of about 1 million gallons per quarter is equivalent to approximately 56 gallons per day per replaced toilet.

Note: The 1999 AWWA Research Foundation Residential End Use Study (REUS) determined that the average person flushes a toilet approximately 5.1 times per day. This value is based upon people living in single-family homes where some people work or go to school and are not in residence for an entire day. However, the Mendelsohn complex is populated almost entirely by seniors that spend a larger portion of their day in their home than does the average REUS participant. For this analysis, we have assumed that the average flush count is 7.1 per day. Average occupancy is 2 persons per dwelling unit.

When these values are multiplied by the savings per flush (reducing from 3.5 to 1.0 gallons), the 'calculated' (or theoretical) savings for a two-person household with one toilet would be about 36 gallons per toilet per day. While many toilet replacement studies conclude with greater-than-expected savings, the magnitude of the difference between the expected vs. measured savings (36 expected vs. 56 measured) is a strong indication that additional savings were also achieved as a result of other factors. For example:

1. The replaced gravity-fed fixtures had been in use for approximately 22 years. Over that period of time, flush volume adjustments are typically made by maintenance personnel to correct for reported performance problems, sometimes involving replacement of fill valves,

flappers or entire flush valves. Because of such replacements and adjustments, it is likely that the flush volume of these gravity-fed fixtures may have been something other than 3.5 gallons (13 litres) at the time of replacement.[7] In the case of volumes exceeding 3.5 gallons, additional savings can be achieved with replacement. In the case of volumes significantly below 3.5 gallons, flush performance may be sacrificed and double-flushing is likely (see 3. below).

2. As evidenced by other studies involving the replacement or retrofit of aging gravity-fed toilet fixtures, leaks through the flappers or the overflow tubes within the tanks are a common condition. In the case of older fixtures fitted with ballcock-type fill valves[8], water pressure changes[9] can cause the fill valve to open, releasing water into the tank, increasing the water level above the overflow point, and sending water to drain through the overflow tube. Therefore, the replacement of an aging gravity-fed fixture with a new pressure-assist fixture eliminates those conditions[10] and contributes to water use reduction.

3. Frequent double-flushing to clear waste is the third cause of excessive water use with poor-performing toilet fixtures. Poor flush performance in both aging and new toilets can lead to user double-flushing. However, it is the older fixtures that are more prone to this trait, particularly if incorrect replacement parts have been installed in the tank or the flush volume of water has been changed from the original design flush volume (see 1. above).

Service Calls for Maintenance & Repairs

A second area of realized savings through the fixture replacement program was that of maintenance resources. Mendelsohn residents expect that the fixture in their room will perform satisfactorily, usually without regard to water consumption. Dissatisfaction will frequently result in a service call, leading to a visit by maintenance staff. Service calls to maintenance for toilet fixture issues are tracked by management. There were 80 service calls recorded for the 14 months prior to fixture replacement and 5 service calls in the 6 months following. Since September 2010, however, there have been no service calls required for the new fixtures. Table 1 shows that this replacement project contributed to service calls being cut by over 90 percent.

Table 1. Monthly Service Calls for Toilet Fixtures

	Average Service Calls for Fixture Maintenance
"BEFORE" Fixture Replacement (80 in 14 months)	5.7
"AFTER" Fixture Replacement (5 in 12 months)	0.4
Percent Change	-93%

[7] Measurements of the actual flush volumes and physical condition of the replaced fixtures were not a part of this analysis.
[8] As opposed to pilot type fill valves that are resistant to pressure changes.
[9] Usually occurring in the very early morning hours when municipal system pressures are at their highest.
[10] The replacement fixture in this case does not use a conventional fill valve. As such, the pressure-assist flush technology and fixture design does not contribute to these overflow conditions.

CONCLUSIONS

As with any such project that replaces aging inefficient toilet fixtures with HETs, water savings will result. However, the daily per fixture water savings of 56 gallons (110 litres) as disclosed by this study were not only significant, but were higher than the savings that would be expected solely from a flush volume reduction from 3.5 gallons (13 Litres) to 1.0 gallons (3.8 Litres). Other factors influenced the 'extra' savings achieved.

Table 2. Summary of Water Savings

Measured water savings[11]	= 56 gallons per fixture per day
'Calculated' water savings[12]	= 36 gallons per fixture per day
'Extra' savings attributed to other factors relating to the replaced toilets: 1. Fixture adjustments and parts replacements 2. Leakage and overflows 3. Double-flushing due to performance issues	

The secondary major benefit to the replacement program was a 93 percent reduction in service calls to maintenance (and associated labor cost reductions). This reduction is attributed to improved flush performance and fixture reliability, and the elimination of frequent repairs.

[11] Water consumption taken from Mendelsohn billing records
[12] Savings expected exclusively from a reduction in flush volume by 2.5 gpf (9.5 Lpf)