Evaluation of Water Use Reduction Achieved Through Residential Toilet Fixture Replacements

Elsinore Valley Municipal Water District

Eastern Municipal Water District

by

Koeller and Company & Veritec Consulting Inc.

July 2011

Koeller & Company
5962 Sandra Drive
Yorba Linda, CA, 92886-5337
Tel (714) 777-2744 Mobile (714) 757-0679

Veritec Consulting Inc.
1495 Bonhill Road, #12
Mississauga, ON L5T 1M2
Tel (905) 696-9391 Mobile (416) 677-6193

TABLE OF CONTENTS

INTRODUCTION

Study purpose

Evaluate the water savings and user satisfaction associated with the replacement of existing 1.6 gallons per flush (gpf) and 3.5 gpf toilet fixtures in single family residences with the Niagara Conservation Stealth™ 0.8 gpf toilet fixture.

Study location

The study was conducted within the service areas of the following two adjacent water-providing utilities, both of which are located within Riverside County in Southern California:

Elsinore Valley Municipal Water District
31315 Chaney St, Lake Elsinore, CA 92530

Includes all or a portion of the communities of Lake Elsinore, Canyon Lake, Wildomar, Murrieta, and Perris.

Eastern Municipal Water District
2270 Trumble Road, Perris, CA 92572

Includes all or a portion of the communities of Moreno Valley, Hemet, San Jacinto, Perris, Menifee, Murrieta, Homeland, and Temecula, as well as areas in between.

Toilet fixture characteristics

The replacement toilet fixture was the Stealth™ Model N7716/N7714 toilet fixture sold by Niagara Conservation of Cedar Knolls, New Jersey, through Signature Sales of Corona, California.

The Stealth model is a two-piece close-coupled, round front, conventional bowl height fixture with a rated flush volume of 0.8 gpf (3.0 Lpf). It is certified to both the ANSI standard ASME A112.19.2/CSA B45.1 as well as to the U.S. EPA's WaterSense requirements. This particular Stealth model scored 600 gram on the Maximum Performance (MaP) test[1].

User satisfaction survey

During the post-installation period, customer participants were asked to complete a satisfaction survey that addressed the characteristics of the fixture, its performance, and the satisfaction with the installer. That survey is included as Appendix A.

Special Acknowledgements

A very special thank you goes to the following individuals for their leadership in soliciting study participants from among their respective customer bases and for providing historical and current meter readings used for the water savings analysis:

Mr. Rob Whipple
Elsinore Valley Municipal Water District

Ms. Stacy Rodriguez
Eastern Municipal Water District

Thanks also go to Mr. Sig Schmalhofer of Signature Sales, Inc. and Mr. Christopher Kim of California Conservation for expediting the delivery and successful installation of the replacement toilets.

[1] www.map-testing.com

EXECUTIVE SUMMARY

Water savings

In evaluating the water use reductions achieved through the toilet replacement program, it should be noted that the replacement protocol was substantially different between the two participating household groups. These differences (fixtures replaced and household size) are such that comparisons between the two groups will not yield meaningful conclusions. Key information is as follows:

		Elsinore	Eastern
Replacement protocol		Replace all fixtures in the household	Replace one fixture per household
Household size		3.4 persons	6.9 persons
Flush volume of replaced fixtures		1.6 gpf (6.0 Lpf)	3.5 gpf (13 Lpf)
Water savings (daily)	Per capita	14 gallons (53 Litres)	14 gallons (53 Litres)
	Per replacement toilet	25 gallons (95 Litres)	97 gallons (367 Litres)
Water savings (daily) – adjusted for average California household size[2]	Per replacement toilet	21 gallons (79 Litres)	40 gallons (151 Litres)

Note: The 1999 AWWA RF Residential End Use Study determined that the average person flushes a toilet in their home approximately 5.0 times per day. When this value is multiplied by the expected savings per flush (from 1.6 to 0.8 gallons in Elsinore and from 3.5 to 0.8 gallons in Eastern) the expected savings would be 4.0 gallons per capita per day (gcd) in Elsinore and 13.5 gcd in Eastern. While many toilet change-out studies achieve greater-than-expected savings, the magnitude of the difference between the expected vs. measured savings in the Elsinore homes (4.0 gcd expected vs. 14 gcd measured) is a strong indication that additional savings were also achieved by a significant reduction in the frequency of double-flushing and/or a significant reduction in toilet-related leakage.

While the measured savings of 14 gcd in Eastern is similar to the expected savings of 13.5 gcd, this expected savings would only be achieved if all of the existing toilets had been replaced, whereas, only about one-third were replaced. As such, the Eastern results also indicate savings from reduced double-flushing and/or a reduction in toilet-related leakage.

User satisfaction

The satisfaction survey was provided to each of the households participating in the replacement program about three months following toilet installation. Of the 42 survey documents provide to those households, 33 were returned. The results showed that the performance-related factors of waste removal, clogging, double-flushing, bowl cleaning, and noise were all rated highly for the Stealth fixture. In the cases of clogging, bowl cleaning, and double-flushing, users reported that occurrence of these problems was less than experienced with the fixture that was removed.

[2] In order to compensate for higher occupancies (and resulting higher toilet usage) in the subject households, savings per toilet fixture were adjusted to average California household size of 2.87 persons

BACKGROUND & METHODOLOGY

Project toilet

In 1999, the first high-efficiency toilet (HET) fixtures[3] 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 introduced. In 2006, the first gravity-fed single-flush 1.28 gpf (4.8 Lpf) HETs entered the marketplace. Then, in 2010, the 0.8 gpf (3.0 Lpf) Niagara Stealth fixture was released, certified to the national standard[4], and subsequently MaP tested[5] and WaterSense[6] certified. It is that fixture that is the subject of this analysis.

The Stealth model installed for this study is a two-piece close-coupled, round front, conventional bowl height fixture. This particular Stealth model scored 600 grams of waste removal on the MaP test. A specification sheet for this product is included as Appendix B.

Selection of candidate homes for fixture replacements

Study homes were solicited by water conservation representatives of the two utilities through direct mail and other approaches. Prospective participants were fully informed of the nature of the study and the type of high-efficiency toilet fixture being offered. Participation by single family residents was voluntary. Removal and disposal of the existing toilet fixtures and installation of the replacement fixtures was done without cost to the resident. All such costs for were borne by product manufacturer and the respective utilities.

Study homes – characteristics and occupancy

All study homes were located within the service areas of the two utilities noted above, divided as follows:

	Elsinore	Eastern	Total
No. of single family dwellings in the study	18	24	42
Total occupancy of dwellings (persons)	61	166	227
No. of toilets in the dwellings	34	67	101
Persons per dwelling unit	3.4	6.9	5.40
Persons per toilet fixture	1.79	2.48	2.25
No. of fixtures replaced for the study	34*	24**	58
Original flush volume of fixtures replaced	1.6 gpf	3.5 gpf	

Notes: *-all fixtures in the dwelling replaced
**-one fixture in the dwelling replaced

Fixture installation and measurement of water consumption

Removal of the old toilet fixtures and installation of the Stealth was performed by appointment with each of the participating residents. All installations took place largely during the second quarter of 2010. Once the participating water utilities had secured the participants and installations were complete, those utilities provided the historical water use data for each of the 42 participating customer dwellings. In most cases, five years of historical data was made available. Tracking and measurement of post-installation water consumption began in July 2010. Approximately one year's worth of data was provided by the utilities for post-installation water use (concluding in May 2011).

[3] A high-efficiency toilet is defined as one with an effective flush volume of 1.28 gallons (4.8 litres) or less
[4] ASME A112.19.2/CSA B45.1
[5] www.map-testing.com
[6] www.epa.gov/watersense/

STUDY RESULTS

The study was comprised of two elements: an analysis of achieved water savings and a survey of study participants directed at determining satisfaction with the product and its installation.

Water Savings

The extent of the water savings analysis was limited by the resources available and the fixture replacement guidelines established by the two water utilities.

1. All water consumption data used for this study was derived from utility billing records (meter readings) for the participating properties. Therefore, changes in water using habits by residents during the periods before and after toilet replacement could not be isolated for the analysis.

   The meter readings include both indoor and outdoor use and do not provide the information necessary to distinguish between the two. Therefore, irrigation demands are included and, as such, weather patterns can dictate much of the water use during the periods covered. Therefore, it is important to capture historical water use for an extended period prior to fixture replacement in order to gain some estimate of indoor water use reduction due to the fixture change. Our analysis used these meter readings exclusively to develop a preliminary estimate of savings resulting from the reduced toilet fixture flush volumes.

2. Elsinore replacements included all of the toilets within each of the participating dwellings in that service area; the Eastern replacements, however, were limited to one toilet per dwelling unit. There is no data available to show whether or not the highest use toilets were replaced in the Eastern homes. As such, the reliability of the assessment of water savings on a per toilet or per person basis is limited and reductions achieved in each of the two utility service areas cannot be directly compared with one another.

3. All of the Elsinore replacements involved the removal of 1.6 gpf (6.0 Lpf) toilet fixtures, while the Eastern participating homes replaced 3.5 gpf (13 Lpf) fixtures.

Household water use was tracked for each of the 42 households for approximately one year following the installation of the Stealth fixtures. Post-installation meter readings were compared with pre-installation water use for up to five years of history. Figures 1, 2, 3, and 4 display the trends in water usage (in gallons per capita per day (gpcd)) in the participating homes before and after fixture replacement.

Specific findings are as follows:

<u>Elsinore</u>

In the case of Elsinore participants, the study process included replacing all 34 of the 1.6 gpf fixtures in the 18 homes[7]. Figure 1 shows the long-term variance in water use by quarter as irrigation-driven seasonal peaks and valleys occur. The general post-installation downward trend in overall water use is evident, which, for the purpose of this study, is attributed to indoor

[7] The homes in the Elsinore Valley service area were largely of pre-2001 construction and all contained 1.6 gpf toilet fixtures. Of the total of 18, however, 8 were of 1986 construction or earlier. As such, some degree of leakage could be expected on the older model toilets if they had not been adequately maintained, especially if they contained older flappers and ballcock type fill valves, rather than pilot valves. However, toilet leakage was not measured as part of this study.

reductions. Figure 2 summarizes the quarterly consumption for the period of one year before and one year after the installation of the subject toilet fixtures.

Estimated water savings for replacing 1.6 gpf (6.0 Lpf) fixtures with the Stealth amounted to approximately 14 gallons (53 L) per capita per day or approximately 25 gallons (96 L) per day per fixture[8]. In addition to the reduced flush volume, some measure of these savings can be attributed to:

1. reduction of double flushing that may have occurred with the older toilets[9], and
2. elimination of leaks associated with the older toilets that were replaced. However, leakage was not measured as a part of this study.

Eastern

It is important to note that the estimated savings from the Eastern replacements reflect only the savings from replacing one 3.5 gpf fixture in the home[10]. We have no knowledge certain of whether the replaced fixture was in a high-use bathroom or a seldom used bathroom.

Estimated water savings for a single 3.5 gpf fixture replacement in the Eastern Homes amounted to approximately 14 gallons per capita per day, equal to approximately 97 gallons per day per fixture with an average user household occupancy of 6.9 persons. However, for an average California occupancy of 2.87 persons per household[11], average water savings would be instead calculated at 40 gallons per day per fixture, a more realistic metric for application to future projects where 3.5 gpf (13 Lpf) fixtures are being replaced.

As with the Elsinore replacements, an undetermined portion of these savings can be attributed to the elimination of older leaking fixtures, the balance being the result of the significant reduction in flush volume and double flushing.

[8] Occupancy of the Elsinore homes averaged 3.4 persons per dwelling. At the average California occupancy of 2.87 persons per household, water use reduction would instead be projected at approximately 21 gallons per day per fixture at this reduced occupancy.

[9] Depending upon the age of the Elsinore houses and the vintage of the replaced toilets in those houses, it is likely that many of the toilets were manufactured prior to 1998. Many 1.6 gpf (6.0 Lpf) models manufactured and sold prior to 1997 experienced performance issues that frequently led to double-flushing by the user.

[10] The homes in the Eastern portion of the study ranged in age from 20 to 50 years; 21 of the 24 homes were constructed in the 1982 to 1991 period, however. All Eastern homes were reported to be equipped with 3.5 gpf toilet fixtures, except for one with a 5.0 gpf fixture. Average occupancy of the Eastern homes in the study was 6.9 persons per household, an exceptionally high number, and approximately two and one-half times the average for the State of California, which is near 2.87 persons per household.

[11] U.S. Census: http://quickfacts.census.gov/qfd/states/06000.html

Figure 1. Elsinore Valley MWD - Stealth Houses

-Replacement of 34 - 1.6 gpf fixtures with 0.8 gpf fixtures in 18 homes-

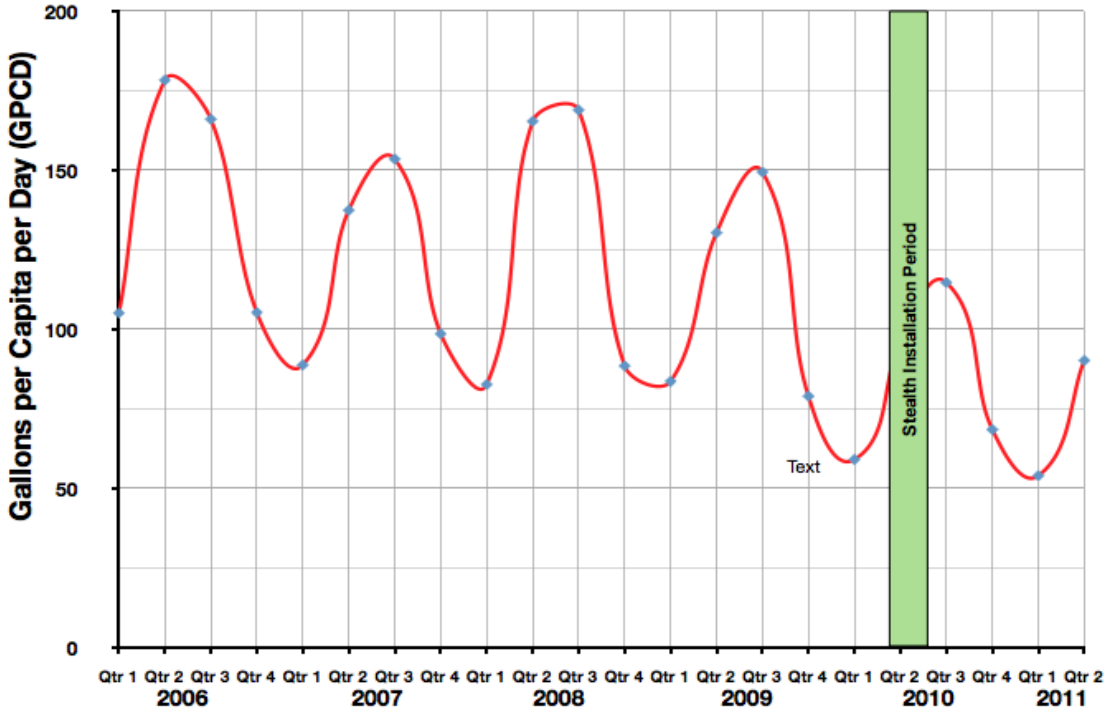


Figure 2. Elsinore Valley MWD - Stealth Houses

-Quarter-to-Quarter Change in GPCD-

Replacement of 34 - 1.6 gpf fixtures with 0.8 gpf fixtures in 18 homes-

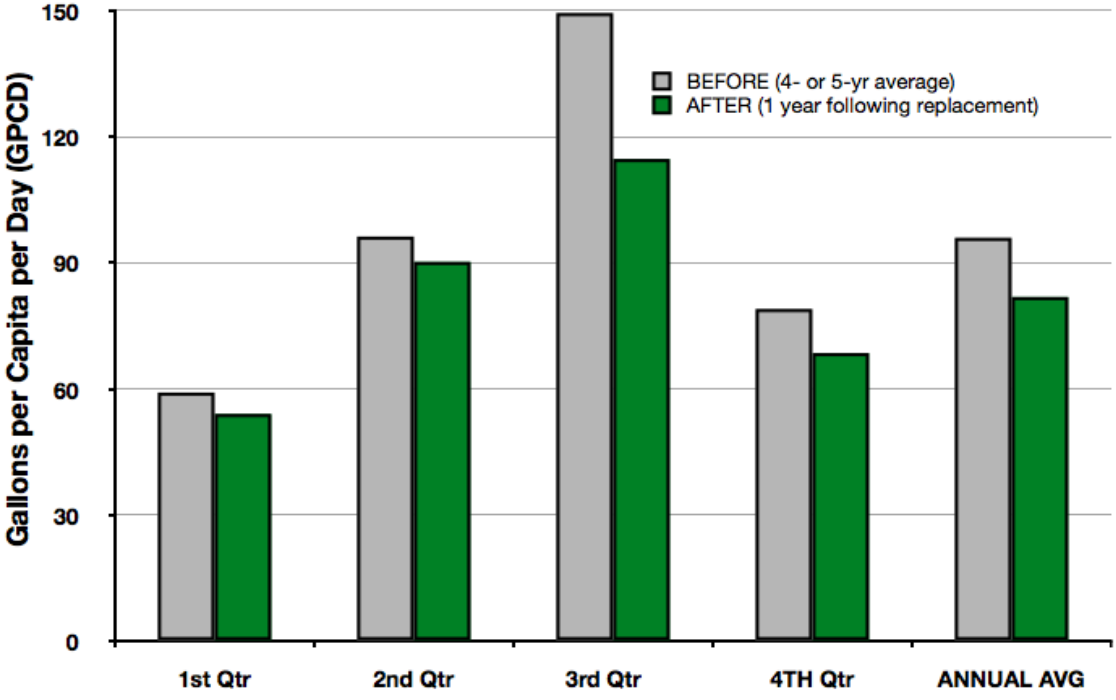


Figure 3. Eastern Municipal Water District - Stealth Houses

-Replacement of 24 - 3.5 gpf fixtures with 0.8 gpf fixtures in 24 homes-

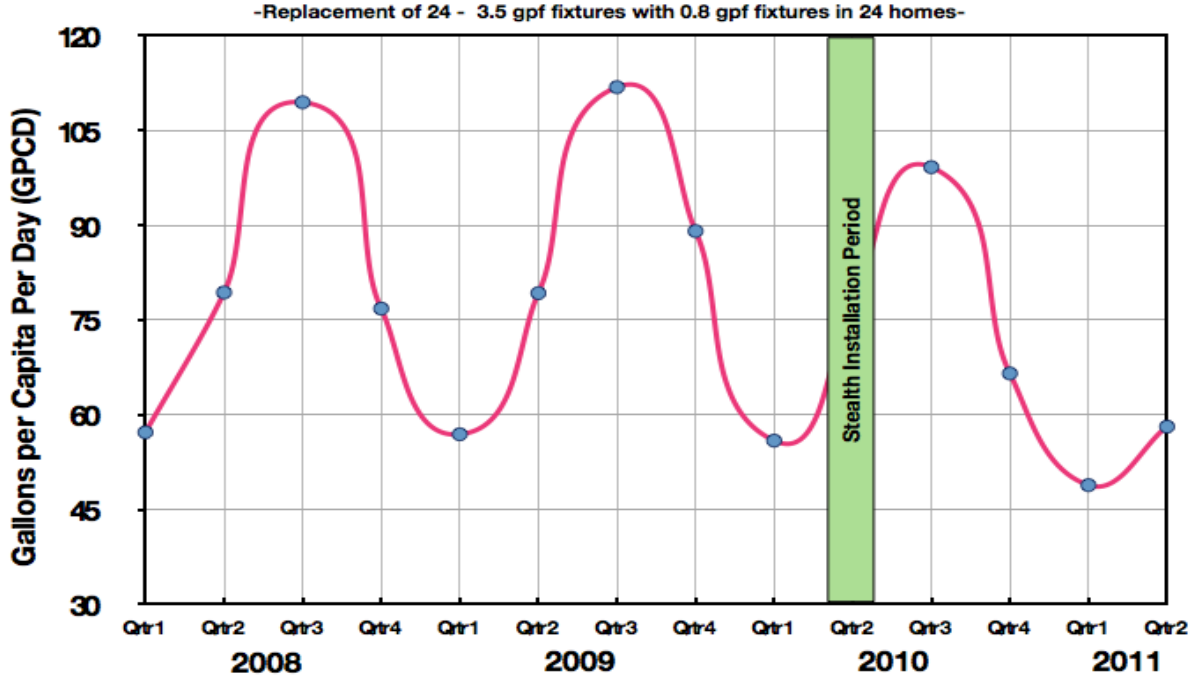
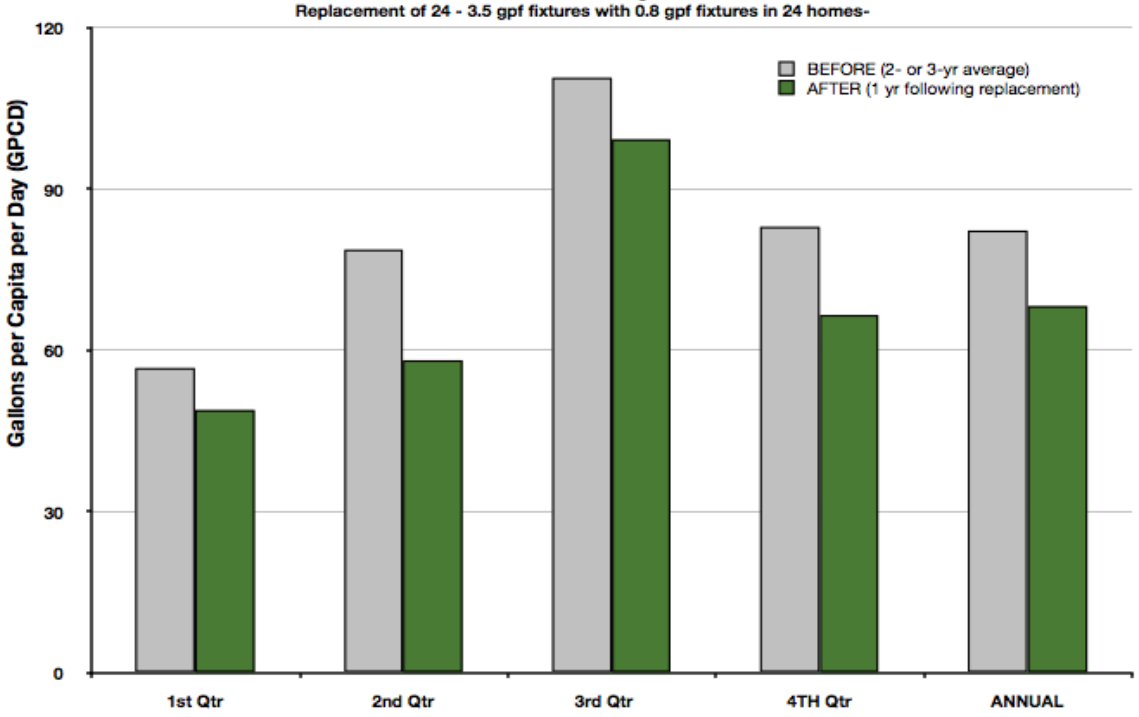


Figure 4. Eastern MWD - Stealth Houses

-Quarter-to-Quarter Change in GPCD-

Replacement of 24 - 3.5 gpf fixtures with 0.8 gpf fixtures in 24 homes-



User Satisfaction

Approximately three months following fixture installation, user satisfaction surveys were provided by the water utilities to the 42 customer households receiving the Stealth fixture. The survey document is included as Appendix A.

Of the 42 households, 33 completed surveys were returned. Results were as follows:

Appearance of the fixture
Cosmetic appearance – 100% “excellent” or “very good”
Size of water surface area in the bowl (water spot) – 100% “excellent” or “very good”

Flush performance of the fixture
Waste removal and bowl cleansing – 94% “excellent” or “very good”
Blockage/clogging – 90% experienced no clogging at any time; 94% experienced less clogging than their old toilet
Double flushing - 87% experienced less double flushing than their old toilet
Bowl cleaning – 75% experienced better cleaning than their old toilet
Noise associated with flushing and refill - 100% “excellent” or “very good”

Appendix A

User Satisfaction & Performance Survey
Niagara STEALTH 0.8-gallon toilet fixture

Today's date:_____

Your full name:			
Your contact phone number:			
Address where installed:	(street)>>		
	(city)>>	(zip)>>	
Number of persons in your household:	Adults (over 16 yrs):_____	Children:_____	

Your new STEALTH replaced a:	5 gallon toilet	3.5 gallon toilet	1.6 gallon toilet	I Don't know
	☐	☐	☐	☐

The environment and water conservation

I wanted to replace my old toilet with a new Niagara STEALTH toilet because:	I want to reduce my water bill	I want to save water and improve our environment	I was convinced by someone that it was a good idea	My old toilet is broken or needs replacing	Other reason (explain below)
	☐	☐	☐	☐	☐

If "Other", please explain:

Please rate the cosmetic appearance (finish and design) of your new STEALTH

	Excellent	Very Good	Satisfactory	Unsatisfactory
Appearance of tank	☐	☐	☐	☐
Appearance of bowl	☐	☐	☐	☐
Overall appearance of toilet	☐	☐	☐	☐

Please rate the flush performance of your new STEALTH

How did you find the.....	Excellent	Very Good	Neutral-neither good nor unsatisfactory	Unsatis-factory	Unsatis-factory & unaccep-table
Performance of the flush cycle and cleansing the sides of the bowl?	☐	☐	☐	☐	☐
Size of the water surface area in the bowl?	☐	☐	☐	☐	☐
Noise with tank filling?	☐	☐	☐	☐	☐

Noise with toilet flushing?	☐	☐	☐	☐	☐

Did you ever experience a blockage or clogging of the bowl?	No ☐	Yes ☐

If "yes", please explain:

	Nearly always (50%+ of the time)	Frequently (10-50% of the time)	Rarely (Less than 10% of the time)	Never
How often have you been required to "double-flush" to ***remove the waste from the bowl?***	☐	☐	☐	☐
How often have you been required to "double-flush" to ***clean the sides of the bowl?***	☐	☐	☐	☐

Comparing the new STEALTH toilet with your old toilet

I must double flush the new STEALTH more or less than my old water-wasting toilet	More often ☐	Less often ☐
The new toilet clogs more/less frequently than my old toilet	More often ☐	Less often ☐
My new toilet's flush cleans the sides of the bowl more/less effectively than my old toilet	More often ☐	Less often ☐

Overall results

	Definitely	Maybe	No	Undecided
I would recommend this new STEALTH toilet to others	☐	☐	☐	☐

Please provide any additional comments you may have on your new STEALTH toilet: