

RESIDENTIAL ULTRA-LOW-FLUSH TOILET REPLACEMENT PROGRAM

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Executive Summary: In this study, 275 residential toilets were replaced with 3 models of Ultra-Low-Flush Toilets (ULFTs) as follows:

ULFT Manufacturer	Model	Number of Toilets Installed
Caroma	Tasman 270 (0.8/1.6 gpf)	61
Niagara	Flapperless	120
Gerber	Aquasaver	94
Total:		275

Water savings were measured by: (1) metering the water use per flush of each toilet replaced as well as each new ULFT; (2) monitoring 15% of the new ULFT's installed with flush counting devices; and (3) comparing indoor water use records prior to and after installation of the new ULFT. A follow-up customer satisfaction survey was also administered.

Customer satisfaction of the new ULFTs was high, with an overall performance rating average of 8.4 out of 10 (10 being excellent). Ninety-six percent of the participants with Caromas said they would recommend the new ULFT compared to 92% of those with Niagaras and 69% of those with Gerbers. Caromas rated best in clogging performance, with 96% of the respondents saying they never clogged, compared to 81% of the Niagaras and only 51% of the Gerbers. When asked about double-flushing, 74% of the respondents said they never had to double-flush Niagaras compared to 70% of Caromas and 53% of Gerbers. Based on the survey results, we found that each household averaged 2.96 persons and 2.7 toilets.

Before removal of the toilet to be replaced, water use per flush was metered. The average water use of the replaced toilets was 4.16 (gpf), with a range of 2.1 to 6.7 gpf. Once installed, water use per flush of the new ULFTs was also metered. The Niagaras averaged 1.69 gpf, the Gerbers 1.8 gpf, and the Caromas 1.68 gpf for the large volume flush and 0.88 gpf for the small volume flush. Caromas offered the greatest amount of savings due to the small volume flush feature, and the Niagara offered a high potential savings due to the absence of a leak-prone flapper valve. The flush counting devices showed that each new ULFT was flushed an average of 8.9 times per day.

The water savings achieved from this program were found to be two-fold: first, there were water savings associated with the reduced flush volume and second, water savings were achieved through a reduction of leaks associated with the older high flush toilets. Almost 75% of the participants with flush counters had their new ULFT installed during winter months; therefore the full extent of toilet leaks cannot be calculated until water use records are obtained after the ULFT is in place for a full winter period. This data will be available in March 2004.

Based on a preliminary evaluation of the data, a savings of 42 gallons per household per day, (or 15,511 gallons per household per year) was achieved by this program. Therefore, the total water savings achieved by this program is estimated to be 13.1 acre feet (4,265,525 gallons) per year, or 262 acre feet (85,310,500 gallons) over a 20 year period. This program is cost effective when compared to the estimated cost of future water development projects currently being planned.

PROGRAM OBJECTIVE

Replace 275 existing high-volume toilets in the District's residential service area with Ultra-Low-Flush Toilets (ULFTs) and determine water savings and cost effectiveness of this type of program in the Salt Lake Valley by:

- measuring the water use per flush of the existing toilets and the newly installed ULFTs;
- counting the number of flushes on a random selection of 15% of the new ULFTs by installing flush counting devices;
- comparing customer water use records prior to and after the new ULFT installation; and
- determining customer satisfaction levels, and gathering feedback and opinions with each type of toilet by performing a telephone follow-up survey.

INTRODUCTION

Indoor single-family residential use in the U.S. is reported to average 69.3 gallons per capita per day (gpcd), of which the largest proportion, 26.7%, is consumed by the toilet (Mayer et al., 1999). ULFTs are designed to use 1.6 gpf or less; older, high-volume toilets use 3.5 to 7 gpf. The Energy Policy Act of 1992 required that gravity-tank toilets, the most commonly used residential toilet, have a maximum volume of 1.6 gpf by January 1, 1994. Utah adopted the new law earlier, in 1991.

Toilet Replacement Programs

Significant water savings for toilet replacement programs have been demonstrated in a number of programs, as shown in Table 1. Most of these studies estimated water savings by comparing the water use records before and after the installation of the ULFTs and a few studies used data loggers to estimate water savings. The literature does not suggest that these programs metered water use of both the old toilet and the ULFT and/or monitored the number of flushes over time as done in this study.

Table 1. Comparison of Toilet Replacement Program Water Savings. (Modified from Amy Vickers, Handbook of Water Use and Conservation, p. 36, 2001.)

<i>Study</i>	<i>Water Savings</i>	<i>How Savings Were Calculated</i>
Austin, TX	29.3 gpd per toilet	Estimated from water bill
City of Barrie, Canada	16.4 gpcd	Calculated from 310 billing records of residential customers before and after installation
City of El Paso, TX	18.8% reduction in monthly bill per household	Calculated from 268 billing records of residential customers before and after installation
Los Angeles	31.7 gpd per toilet	Estimated from water bill
Metropolitan Water District of Southern California	29.9 gphd with 1 ULFT 20.6 gphd with 2 ULFTs 19.1 gphd with 3 ULFTs Ave per ULFT = 21.6 gphd	Estimated using statistical models of billed water use
New York City, NY	9.3 gpcd	Water use records of 72,359 residential units
Wilsonville & Lafayette, OR	2.6 gpf savings (67%) 11,550 gphy	Measured water use with data loggers
Seattle, WA	10.9 gpcd	Measured water use of 37 homes with data loggers before and after installation
Tampa Water Department, FL	38 g per household per day	Calculated from water use records of 395 homes with 375 control homes
Toronto, Canada	79 g per apartment per day	Monitored apartment complex with data loggers,
Tucson	33 gphd	Estimated from water bill

Additional savings can be achieved in a toilet replacement program by using dual-flush toilets, which have two buttons - one button for the large volume flush (LVF) of 1.6 gpf for solid waste and one for the small volume flush (SVF) of 0.8 gpf for liquid waste. In a study in Toronto, Canada, all the toilets in an apartment building were replaced with 1.6/0.8 dual flush ULFTs resulting in a 17.4% (32.6 gallons per apartment per day) water savings due to the lower flush volume (Veritec, 2001). Replacing toilets with dual-flush ULFTs in Oregon resulted in a 67% savings compared to the old toilet (Pacific Northwest National Laboratory, 2001). In a study in Seattle using Caroma dual-flush and traditional ULFTs, the dual-flush saved 24% more than the 1.6 gpf traditional ULFT (Mayer, et al., 2002).

Another area of potential savings with a toilet replacement program is to solve the most common cause of toilet leakage: deteriorating flappers and seals. The National Association of Home Builders Research Center found that when retrofitting flappers with generic, standard flappers, 85% (28 of 33) toilet models used more than 1.6 gpf and averaged 2.91 gpf. A report by the City of Tucson on their Toilet Rebate Program concluded that at least 12% of the ULFTs installed as part of the program had recurring flapper leaks after 8 years (Woodard and Henderson, 2002). Replacing the toilets in the Veritec study resulted in more water savings from stopping leaks, most of which could be attributed to flapper leakage, than savings from replacing the old toilet (Veritec, 2001). In a Seattle retrofit study, replacing the toilets saved 10.9 gpcd due to the new ULFT using less water and another 4.3 gpcd due to stopping leaks (Mayer, et al., 2002). Since flappers typically need to be replaced several times during the life of a toilet, there is a high probability that the homeowner will install a generic flapper and the water use of the toilet will rise.

MATERIALS AND METHODS

Selection of ULFT Fixtures

The selection of ULFTs for this program was based on competitive pricing, the most efficient use of water, and high rankings in performance studies and customer satisfaction surveys:

- Caroma Caravelle Tasman 270 - offered additional potential savings because it is a 1.8/0.6 dual-flush ULFT.
- Niagara Flapperless N2216 - offered additional potential savings due to having a bucket that dumps the water when it tips, rather than a flapper that must seal.
- Gerber Aquasaver 207 - the most competitively-priced "traditional" toilet.

The following studies and customer satisfaction surveys were evaluated to determine which ULFTs would be best suited to the District's program.



Caroma dual-flush buttons

- Evaluation of New York City's Toilet Rebate Program, Final Report (Westat, 1996).
- Independent Toilet Testing Program, Ontario, Canada (Veritec, 2002).
- Ultra-Low-Flush Toilets - Customer Satisfaction Survey, Metropolitan Water District of Southern California (MWD, 1999).
- Consumer Report, February 1995, Consumer's Best Buy laboratory evaluations of toilets and showerheads (www.ConsumerReports.org).
- Terry Love's Consumer Toilet Report for 2002 (www.terrylove.com/crtoilet).

- Water Closet Performance Testing, Seattle Public Utilities and East Bay Municipal District (NAHB Research Center, 2002).
- A Survey of Purchaser Opinions about Ultra Low Flush Toilets. Published by the Los Angeles Department of Water and Power (Wirthlin Group, 1992).

Selection of Participants

In November of 2001, the District mailed a questionnaire (Appendix A) to its residential customers to determine interest and eligibility in the program.

Participants were selected using the following criteria: (1) homes and toilets must be older than 10 years, (2) no more than two toilets were replaced per home, (3) toilets located in the basement and listed as the least used toilet were not replaced, and (4) toilets in rental units were not replaced unless authorized by the owner. Six percent of the residential customers responded to the questionnaire, and toilet selection and Participant Agreement forms (Appendix B) were mailed to the eligible survey respondents.



Niagara Flapperless bucket

ULFT Installation and Water Use Data Collection

The District retained a licensed professional plumbing contractor to install the ULFTs and water use monitoring equipment in customer's homes. Before removing the old toilet, the contractor measured its flush volume by attaching a meter to the supply line and flushing 4 times. After installing the new ULFT, the contractor measured its water use in the same manner. The contractor also discussed the new ULFT with the homeowner so they would understand the flushing mechanism and lower flush volume.

Fifteen percent of the participants were randomly selected to have the contractor install flush counters on their new ULFTs. The flush counters kept track of the number of flushes with a device attached to the side of the tank with a float that moved up and down as the water level changed (see Appendix C for a detailed description).



Flush Counter in a Caroma

Project Schedule

<i>Description</i>	<i>Date</i>
Mail Questionnaire to Customers	November 2001
Notice Inviting Proposals to ULFT suppliers	February 4, 2002
Notice Inviting Bids to Install the ULFTs	June 8, 2002
Award of Contract	July 17, 2002
Supply and Installation of ULFTs	August 2002 to January 2003
Install, Read, and Un-Install Monitoring Equipment	August 2002 to February 2003
Customer Satisfaction Survey by Phone	January/February 2003
Compare Water Use Records	March/April 2003
Compile Results and Write Report	April/May 2003
Present Report and Publish on Internet	July 2003

RESULTS AND DISCUSSION

There were 203 program participants; 131 participants received 1 ULFT and 72 received 2 ULFTs. The total number of replaced toilets was 275. Niagaras accounted for 44% (120 toilets), Gerbers 34% (94 toilets) and Caromas 22% (61 toilets).

Follow-up Customer Satisfaction Survey

District staff completed a Follow-up Customer Satisfaction Phone Survey with 92% (187) of the 203 program participants. See Appendix D for a complete set of survey questions and answers.

The number of persons per household changed in 28% of the households from the beginning of the study to the end, but the average size remained nearly the same, increasing from 2.95 to 2.96, with the largest household having 10 persons. There was an average of 2.7 toilets per household, with a range of 1 to 6. Eighty-three percent of the new ULFTs were installed in bedroom bathrooms, 11% in basement bathrooms, and the remaining 6% in other bathrooms such as the hall, kitchen or laundry bathrooms.

When asked about overall performance of the toilet, on a scale of 1 to 10, with 10 being excellent, participant's rated Caromas the highest at 8.9, Niagaras at 8.8 and Gerbers at 7.8. When asked if they would recommend the ULFT, 96% said yes for the Caroma, 92% for the Niagara and 69% of the Gerbers. Two percent said they would not recommend the Caroma compared to 5% of the Niagara and 22% of the Gerber.

Caromas rated best in clogging performance, with 96% of the respondents saying they never clogged, compared to 81% of the Niagaras and only 51% of the Gerbers. In comparison to their old toilet, respondents said only 4% of the Caromas clogged up more than the old toilet, compared to 13% of the Niagaras and 46% of the Gerbers.

When asked about double-flushing, 74% of the respondents said they never had to double-flush Niagaras compared to 70% of Caromas and 53% of Gerbers. Respondents also said that 12% of Niagaras needed double-flushing more than their old toilet compared to 19% of the Caromas and 32% of the Gerbers.

When asked if they had any additional comments many said thanks for the good program and they appreciated taking part. A few commented they were very relieved to find that the horror stories they'd heard about ULFTs weren't true. Six respondents said they could tell a noticeable drop in their water bill.

The Caroma was a popular toilet due to the dual-flush system, additional water savings, and good performance. Fourteen percent of the participants with Caromas who added comments said they loved the dual-flush feature. Fourteen percent said they would like another one and they show off the toilet to their neighbors; not one said they were unsatisfied. Nine percent said the toilet bowl was too long (longer than their old bowl) and 11% said it required more cleaning, although it was easier to clean than their old toilet. None complained about clogging, double-flushing, or water running. Thirty percent of those who had both a Caroma and a Gerber said they much preferred the Caroma over the Gerber; only 4% said they preferred the Gerber.

The Niagara was popular for its unique flushing mechanism and good performance. Ten percent of those adding comments who had a Niagara said they would like another one and 2% said they show off the toilet. Eleven percent said the flush is louder than their old toilet, but most said they were used to it and it was worth it for the water savings. Only 2% said they had problems with double flushing or clogging and 4% said they were having problems with the toilet running and said they would call the plumber. Three percent said they didn't like the flush handle being located on the side of the tank and that the toilet required more cleaning than their old toilet. Four percent said they preferred the Niagara over the Gerber. Two percent commented they couldn't use self-cleaning tablets with this toilet because of the bucket flush. No one said they were unsatisfied with the Niagara.

The Gerber was the least popular toilet, with only 1% of those adding comments saying they would like another one. Many preferred the Niagara (6%) or the Caroma (18%) and 6% said they were very unsatisfied. Twenty percent said the Gerber was having problems with the chain getting caught and the flapper leaking. Seven percent said it was clogging and 3% said they have to double flush often. Three percent said they didn't like the flushing handle; that they had to hold it down for the entire flush, and 3% commented there were other problems with the flushing mechanism. A few said that even though they were having problems with the Gerber, at least they were saving water, and others asked how could they be saving water if it kept leaking.

Metered Water Use of Existing Toilet and Newly Installed ULFT

Water use was metered on 259 of the 275 old, replaced toilets; 16 were broken or leaking badly enough that water use couldn't be measured. The average water use of the old toilets was 4.16 gpf, with a range of 2.1 gpf to 6.7 gpf and almost 65% of the old toilets used over 4 gpf. All 275 new ULFT's water use per flush was also metered. The Gerber's flush volume had the highest variation, with an average of 1.8 gpf and a range of 1.6 to 2.1 gpf. The Niagaras averaged 1.7 gpf and the Caromas averaged 1.7 gpf for the large volume flush (LVF) and 0.9 gpf for the small volume flush (SVF). Twenty-three percent of the Caromas (LVF) flushed 1.6 gallons or under compared to 15% of the Niagaras and only 4% of the Gerbers. The average water use of all ULFTs (except the SVF of the Caroma) was over the 1.6 gallon maximum allowed by the EPAct of 1992. In a study testing flush volumes of 31 different models of new ULFTs, approximately 50% also used more than 1.6 gpf (Veritec, 2002).

Water savings per flush was calculated by subtracting the average water use of the new ULFTs from the average use of the replaced toilets (4.16 gpf). The SVF of the Caroma offered the greatest savings at 3.28 gpf and the Gerber the least at 2.36 gpf (Table 2).

Table 2. Metered Water Use per Flush of the 275 New ULFTs.

<i>Gallons per flush (gpf)</i>	<i>Niagara (120)</i>	<i>Gerber (94)</i>	<i>Caroma – LVF (61)</i>	<i>Caroma – SVF (61)</i>
0.8 gpf				23% (14)
0.9 gpf				77% (47)
1.6 gpf	15% (18)	4% (4)	23% (14)	
1.7 gpf	84% (101)	19% (18)	77% (47)	
1.8 gpf	1% (1)	55% (52)		
1.9 gpf		13% (12)		
2.0 gpf		7% (7)		
2.1 gpf		1% (1)		
<i>Average Use</i>	<i>1.69 gpf</i>	<i>1.80 gpf</i>	<i>1.68 gpf</i>	<i>0.88 gpf</i>
<i>Water Savings¹</i>	<i>2.47 gpf</i>	<i>2.36 gpf</i>	<i>2.48 gpf</i>	<i>3.28 gpf</i>

¹ Water savings per flush was calculated by subtracting the average water use of the new ULFTs from the average water use of the replaced toilets (4.16)

Flush Counter Data

Fifteen percent (42) of the ULFTs received a flush counter device for an average of 50 days: 13 Caromas, 14 Gerbers and 15 Niagaras. For this test group, the average number of people per household was 2.83 (range of 1-6) and there was an average of 2.29 toilets per household (range of 1-4). The data listed in this section are from this test group of 42 ULFTs with installed flush counters.

Flushes per Day.

On average, each ULFT was flushed 8.9 times a day. Niagaras were flushed 7.9 times a day compared to 9.6 times for the Gerber and 9.5 for the Caroma. The Caroma has two flushes, and 59.6% (5.67 flushes) of the time the small volume flush (SVF) was used compared to 40.4% (3.84 flushes) for the large volume flush (LVF). The average water savings per flush of the Caromas was weighted to account for these proportions (0.596*gpf of SVF + 0.404*gpf of LVF = average gpf). With an average of 2.83 persons per household, the average number of flushes per person per toilet per day averaged 3.1 times per day (this does not include other toilets in the household).

Average Water Savings.

The average water use of the old toilet was 4.03 gpf compared to 1.56 gpf for the ULFTs, resulting in 2.47 gpf savings (these calculations include the weighted average of the Caroma). These savings are slightly greater than those in a toilet retrofit study in Seattle, where the average flush volume of the old toilet was 3.61 and the new ULFTs averaged 1.38 gpf, giving a savings of 2.23 gpf (Mayer, et al., 2002).

The lower flush volume saved an average of 22.7 gphd (8.0 gpcd), or 8,286 gphy (2,928 gpcy) for each ULFT. For all 275 toilets combined, this amounts to 2,278,650 gallons (7 acre feet) per year. The range of water savings in this study group was great, from 180 to 59,121 gphy. The ULFT that saved only 180 gphy was a Gerber in the basement of a home that had 4 toilets and only 2 people living in it. The ULFT that saved 59,121 gphy was a Niagara installed in a home with 6 people and only 1 toilet.

People per Household.

The average number of people per household in this test group was 2.83. More water was saved per ULFT when more people lived in the home, with an average of 26,078 gallons per household per year (gphy) savings with 6 people per household compared to only 4,742 gphy saved with only 1 person per household (Table 3).

Toilets per Household.

The average number of total toilets per household was 2.29. When comparing water savings based on how many total toilets were in a household, more savings were achieved in those households with fewer toilets. Households with 4 toilets saved only 2,912 gphy per new ULFT compared to 19,767 per year in households with only 1 toilet, and an overall average of 8,286 gphy (Table 3).

When two ULFTs were installed in a household, an average of 6,582 gphy was saved by each new ULFT compared to 8,968 gphy savings when only one toilet was installed, regardless of which room the toilet was installed in.

ULFT Installation Location.

When comparing which room the ULFTs were installed in, replacing basement toilets resulted in the least amount of savings (1,539 gphy) and the main bathrooms the greatest amount of savings (10,589 gphy). The 1,539 gphy savings in a basement ULFT was very low compared to the average of the rest of the ULFTs at 9,430 (Table 3).

Comparison of ULFTs.

Caromas saved the most water per toilet with an average of 9,797 gphy, compared to 7,957 for the Niagaras and 7,237 for the Gerbers. Basement toilets had a large impact on water savings and when taken out of the calculations, Caromas were still highest at 10,213, compared to Niagaras at 9,720 and Gerbers at 7,880 (Table 3).

Double-flushing will take away from the overall savings. According to the Customer Satisfaction Follow-up Survey, double-flushing occurred more than once a week on 29% of the Gerbers, 19% of the Caromas and 12% of the Niagaras. Daily double-flushing occurred on 5% of the Gerbers, 4% of the Caromas and 1% of the Niagaras.

Table 3. Water Savings of the 42 ULFTs installed with Flush Counting Devices.

	<i>People per household</i>	<i>Number of toilets per household</i>	<i>Number of flushes per day per household</i>	<i>Water saved gallons per household per day</i>	<i>Water saved gallons per household per year</i>
Number of people in the household.					
1 (7)	1.0	2.0	5.2	13.0	4,742
2 (13)	2.0	2.2	7.6	17.9	6,531
3 (8)	3.0	2.4	5.8	14.3	5,232
4 (11)	4.0	2.6	11.0	27.4	9,986
6 (3)	6.0	2.0	23.5	71.4	26,078
<i>Average 2.83 (42)</i>	2.8	2.3	8.9	22.7	8,286
Total number of toilets (old toilets plus new ULFTs) per household.					
1 (4)	2.8	1.0	18.6	54.2	19,767
2 (24)	2.6	2.0	8.4	18.9	6,895
3 (12)	3.3	3.0	7.7	22.3	8,138
4 (2)	3.0	4.0	2.8	8.0	2,912
<i>Average 2.29 (42)</i>	2.8	2.3	8.9	22.7	8,286
Number of new ULFTs installed per household.					
1 (30)	2.5	2.1	9.6	24.6	8,968
2 (12)	3.6	2.7	7.1	18.0	6,582
ULFT installation location.					
Main bath(20)	2.9	2.2	11.2	29.0	10,589
Bedroom bath (4)	3.5	2.0	10.0	27.7	10,118
Hall/half bath (3)	2.3	2.3	8.3	22.9	8,367
Upstairs bath(4)	3.3	2.0	9.6	22.1	8,051
Master bath (6)	2.7	2.5	6.3	14.1	5,128
Basement bath (5)	2.2	2.8	1.6	4.2	1,539
<i>All but basement (37)</i>	2.9	2.2	9.9	25.2	9,198
<i>Average (42)</i>	2.8	2.3	8.9	22.7	8,286
Which ULFT was installed (includes all ULFTs).					
Caroma (13)	2.8	2.2	9.3	26.8	9,797
Gerber (14)	3.1	2.4	9.6	19.8	7,237
Niagara (15)	2.5	2.3	7.9	21.8	7,957
<i>Average (42)</i>	2.8	2.3	8.9	22.7	8,286
Which ULFT was installed excluding those installed in basements.					
Caroma (12)	2.8	2.2	9.7	28.0	10,213
Gerber (12)	3.2	2.2	10.4	21.3	7,780
Niagara (12)	2.8	2.3	9.6	26.6	9,720
<i>Average (36)</i>	2.9	2.2	9.9	25.2	9,198

Preliminary Before and After Installation Billing Comparisons

Water savings due to the repair of leaks associated with installation of the new toilets can be calculated by comparing winter water use records before and after installation of the new ULFT. It should be noted that 74% of the participants with water measuring and flush counter equipment had their new ULFT installed during winter months; therefore the full extent of toilet leaks cannot be calculated until water use records are obtained after the ULFT is in place for a full winter period. This data will be obtained in March 2004. The savings due to leaks will then be revised accordingly and may reflect an increase in savings due to leaks. The preliminary data show a savings of 42 gphd, or 15,511 gphy. Since the decreased flush volume accounts for only 22.7 gphd, the remaining 19.3 gphd, or 46% of the savings can be attributed to fixing leaks.

CONCLUSIONS

The purpose of this program was to measure the water savings and calculate the cost effectiveness of replacing older high flush toilets with new ULFTs. The water savings achieved from this program were found to be two-fold: first, there were water savings associated with the reduced flush volume, and second, water savings were achieved through a reduction of leaks associated with the older high flush toilets. It is interesting to note that 46%, almost half, of the water savings was attributed to fixing leaks associated with the old toilet. Based on the preliminary evaluation of the data, Table 4 shows the water savings results.

Table 4. Average Water Savings per Toilet

	<i>Average Water Saved Per ULFT Per Year (gallons)</i>	<i>Average Water Saved Per ULFT Per Year (gallons)</i>
Flush Volume	22.7 (54%)	8,286
Savings due to leaks ¹	19.3 (46%)	7,225
<i>Total:</i>	<i>42</i>	<i>15,511</i>

¹74% of the participants with flush counters had their new ULFT installed during winter months; therefore the full extent of toilet leaks cannot be calculated until water use records are obtained after the ULFT is in place for a full winter period. This data will be obtained in March 2004. The savings due to leaks will then be revised accordingly and may reflect an increase in savings due to leaks.

The average water saved per ULFT per year totals 15,511 gallons. Since 275 toilets were replaced, this totals 13.1 acre feet (4,265,525 gallons) per year, or 262 acre feet (85,310,500 gallons) over 20 years.

The average water use of the old replaced toilets was 4.16 gpf, with a range of 2.1 to 6.7 gpf. The average water use of the new ULFTs (1.68 for the LVF of the Caroma, 1.69 for the Niagara, and 1.8 for the Gerber) was over the 1.6 gpf maximum allowed by the EPAct of 1992. The Caroma offered the greatest amount of savings due to almost 60% of the flushes being the small volume flush, and the Niagara offered a high potential savings due to not having a leak-prone flapper.

On average, there were 2.96 people and 2.7 toilets per household. On average, each ULFT was flushed 8.9 times a day. The data show greater water savings with larger household sizes and fewer toilets per household. Replacing basement toilets resulted in low water savings, and replacing 1 toilet per household resulted in a higher savings per toilet than replacing 2 toilets per household.

Customer satisfaction was high with the new ULFTs, with overall performance rating average of 8.4 out of 10 (10 being excellent). Over 85% of the participants said they would recommend the new ULFT (Caroma 96%, Niagara 92%, Gerber 69%). The Caroma and Niagara ULFTs were rated high in clogging and double-flushing performance and were consistently rated higher than the Gerber.

Cost Effectiveness Evaluation: The total cost of toilet replacement program is summarized below:

Description	Cost
Toilet Installation	\$25,127
Purchase of 275 ULFTs	\$25,046
Toilet Flush Measuring Equipment	\$3,130
Mailing Expenses	\$1,207
Legal Advertising	\$2,728
Less Participant's Cost of \$20 per ULFT	(-\$5,500)
JVWCD's Staff Time	\$3,262
Total Cost: \$55,000	
<i>\$200 per ULFT; or without installation and water use monitoring equipment costs only \$97 per ULFT.</i>	

Assuming a 20 year life of the new ULFT, a water savings of 42 gallons per day, and 4% interest, the annual cost for this program is \$313 per acre foot. This program is cost-effective when compared to the estimated cost of future water development projects currently being planned for by JVWCD, including Utah Lake M&I via membrane treatment Phase 1 of \$400-500 and Phase 2 of \$550 to \$650 per acre foot. The annual cost of future toilet voucher replacement programs that JVWCD is considering will be more cost-effective since installation of the ULFTs and data monitoring equipment and services will not be included.



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Appendix A: Questionnaire for Selection of ULFT Program Participants

Jordan Valley Water Conservancy District is considering a new indoor water conservation program which will involve retrofitting existing single-family dwellings with new water-conserving toilets. This will be a pilot program and study to determine the amount of water savings which can be achieved by replacing older, high-flush toilets. Additional information regarding this potential program is provided below.

How will the program work?

The District will hire a qualified contractor to supply and install the toilets in single-family dwellings within the District's retail service area.

How many toilets will be available?

This has not been determined; however, the number of toilets will be limited.

How much will it cost?

The District will supply and install the toilets for \$2 a month for one year (added to your water bill), for a total of \$24, or for a one-time, up-front cost of \$20, to eligible homeowners.

What kind of toilets will be furnished?

The District will furnish toilets which: 1) have shown to be water conserving, 2) are supplied by a reputable manufacturer, and 3) have shown to be high in customer satisfaction.

How do I find out if I'm eligible?

Please fill out the questionnaire at right and return it to the District no later than November 16, 2001. A District employee will contact you at a later date if you are eligible.

If you have questions, please call our hotline at 1-877-728-3420.

When will the toilets be installed?

If this program proceeds as planned, the new toilets will be installed between April and June, 2002.

What's the catch?

Participants will be asked to sign a simple agreement and complete follow-up questionnaires

regarding the study. Some participants will be required to have equipment installed on the new toilet or their outside meter for one year that will monitor water use.

Name: _____

Address: _____

Daytime phone

#: _____

Account

#: _____

1. Is this a: (please circle one)

Home Apartment Business

2. Are you a: Homeowner Renter

3. How old is your home? _____

4. How long have you lived in your home? _____

5. How many toilets are in your home? _____

6. Please provide the following information regarding the toilets in your home:

Appx yr last replaced	Location in home	Most-used toilet (rank 1-3, 1 being most used)
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Toilet 1 _____ _____ _____

Toilet 2 _____ _____ _____

Toilet 3 _____ _____ _____

7. Which of the toilets shown above would you like to have replaced? _____

8. How many people live in your home? _____

9. Would you be interested in participating in this pilot program and study? yes no

10. Would you be willing to have water-use monitoring equipment installed near your new toilet? yes no

11. Which method of payment would you prefer:

_____ \$2/month for one year (added to your water bill)

_____ Pay \$20 up front

**PLEASE FAX OR MAIL THIS COMPLETED FORM NO
LATER THAN DECEMBER 3, 2001, TO:**

**Jordan Valley Water Conservancy District
Attn: ULFT Study
P.O. Box 70
West Jordan, Utah 84088-0070
Fax # (801) 565-4399**

Appendix B: Ultra Low Flush Toilet Study Participation Agreement Form

This Ultra Low-Flush Toilet (ULFT) Study Participation Agreement (Agreement) is made between Jordan Valley Water Conservancy District (District) and, the owner(s) (Participant) of the home located at , (Home).

Participant and the District agree as follows:

Agreement

1. Purpose and Nature of Study

- A. The ULFT Study (Study) will measure impacts on water use resulting from the replacement of Participant-s existing toilet with an Ultra Low-Flush Toilet, isolation valve, wax ring and water tube designed to save water. A Contractor (Contractor) selected by the District will replace the existing toilet, connect the ULFT to Participant-s plumbing system, may install equipment that monitors water use, and perform other work described in this Agreement. The Contractor shall be a plumber/plumbing contractor that is properly licensed in the State of Utah.
- B. The District will be responsible for all costs of the Study, except for a fee which shall be paid by Participant. If Participant elects to pay the fee upon the execution of this Agreement, the fee amount shall be twenty dollars (\$20.00) for each toilet replaced in Participant-s home. If, however, Participant elects to include the fee on Participant's retail water service account with the District, the fee amount shall be twenty-four dollars (\$24.00) for each toilet replaced in Participant-s home, and Participant shall pay this amount in 12 equal installments, one installment each month until payment in full.
- C. The Contractor will be responsible for removal and disposal of the existing toilet; the purchase, installation and connection of a ULFT; and the installation and removal of water use monitoring equipment. At the conclusion of the Study, all ULFTs will become the property of Participant.
- D. Participant and District agree that only those homes with plumbing systems which, in the opinion of the District, are able to support the safe replacement of an existing toilet with a ULFT without significant repairs or modifications of the Home or its plumbing system, will be included in the Study. The parties further agree that the Contractor shall make an initial inspection to determine suitability of the Home for the Study. The inspection shall be limited to those portions of Participant-s plumbing system that in the Contractor's opinion are directly involved in the replacement of the toilets.
- E. The Study will begin on the date this Agreement is signed by Participant and by the District, and it will expire on June 30, 2003.

2. Installation of Fixtures and Appliances

- A. The Contractor will replace the Participant-s existing toilet(s) with a ULFT selected by the Participant from those made available by the District.
- B. The District makes no representation or warranty (i) that Participant will be satisfied with the performance of the ULFT or (ii) that the ULFT actually will use less water than the existing toilet.

1. Connections to Plumbing System

The Contractor will make necessary connections to Participant-s existing toilet plumbing. Such connections may include reasonable, inexpensive plumbing repairs required to ensure the proper functioning of the ULFT. The District reserves the right to terminate this Agreement if, after the initial inspection, conditions are revealed which require repairs to Participant-s existing plumbing deemed by the District to be unreasonable. In this case, the District will restore Participant-s existing toilet to pre-Study conditions.

4. Limits of the District's Responsibility

- A. The District will not be responsible for any cost or work that is not directly related to the removal of existing toilet(s), the installation of the ULFT and/or its proper functioning, and the connection of the

Appendix C: Veritec Flush Counter Installation Instructions

Source: Veritec Consulting, Inc., 1495 Bonhill Rd, Unit #12, Mississauga, Ontario, L5T1M2
(905)696-9391, veritec@sympatico.ca

Step 1: Ensure all parts are in good condition.

Counter includes: one aluminum clip to hold the sensor in place inside the tank, one digital display flush counter (requires single "AA" battery not included), one straightened paper clip to use as a reset key, installation instructions.

Step 2: Installing Flush Counter

- Remove toilet tank lid and place aluminum clip over the edge of the toilet tank (see Figure 1).
- Place water level sensor inside the tank approximately one inch above **lowest water level during flush cycle** (see Figure 2).
- Fix wires in aluminum clip to hold in place.
- Flush toilet with lid removed ensuring that water level drops below bottom of sensor.
- Check display to see if count has increased by one count. If so, installation is correct. If not, adjust level of sensor and repeat installation.
- Replace tank lid, record date and time and **start** number on the display or reset display to zero.
- The counter is ready to record the number of flushes.
- Let the display box hang out of sight behind tank; twist wires to hold the display at the proper height (see Figure 3 and Figure 4).

Step 3: Resetting Counter to Zero.

There are small holes on the display box in all four corners. Insert ends of the 'reset' paper clip into the two holes on the top of the display simultaneously such that contact is made with both 'reset' screws, this will reset the counter to zero.



Figure 1: Aluminum Clip location
Figure 3: Flush Counter set-up



Figure 2: Sensor location
Figure 4: Counter set-up



Appendix D: Follow-up Customer Satisfaction Survey Questions and Results

Total number of participants in program: 203
 Total number of participants who received 1 toilet: 131
 Total number of participants who received 2 toilets: 72

Total number of survey participants: 92% (187 of 203 participants)
 Non-Respondents: 8% (16 of 203)

- moved (3)
- no voice mail or didn't return calls (12)
- didn't want to participate - couldn't speak English (1)

QUESTION #1: What type of toilet/s replaced your old toilet? 275 total toilets were replaced

- 61 Caroma
- 120 Niagara
- 94 Gerber

QUESTION #2: Where were these toilets installed in your home?

	<i>Basement & Downstairs</i>	<i>Bedroom Bath</i>	<i>Exercise Room</i>	<i>Main Bath</i>	<i>Kitchen</i>	<i>Laundry</i>	<i>Half Bath</i>	<i>Powder Room</i>	<i>Hall Bath</i>	<i>Master Bath</i>	<i>Upstairs</i>
Caroma (61)	4	5	0	29	0	1	1	0	1	9	11
Niagara (120)	10	18	1	50	1	0	0	1	5	17	17
Gerber (94)	17	10	0	29	0	0	2	0	4	20	12
Total (275)	31	33	1	108	1	1	3	1	10	46	40

QUESTION #3: How many toilets do you have in your home?

Average of 2.7 toilets per household

QUESTION #4: How many people live in your home?

Average of 2.96 persons per household

QUESTION #5: Compared to your old toilet, does the new toilet clog or plug up more, the same, or less?

	<i>More</i>	<i>Same</i>	<i>Less</i>
Caroma (53)	3.8% (2)	52.8% (28)	43.4% (23)
Niagara (114)	13.2% (15)	47.4% (54)	39.5% (45)

Gerber (87)	42.5% (37)	40.2 % (35)	17.2% (15)
Total (254)	21.3% (54)	46.1% (117)	32.7% (83)

QUESTION #6: How often does the new toilet plug or clog?

	<i>Daily</i>	<i>Twice Weekly</i>	<i>Once a Week</i>	<i>Once a month</i>	<i>Once</i>	<i>Never</i>
Caroma (53)	0	0	0	3.8% (2)	0	96.2% (51)
Niagara (114)	0.9% (1)	1.8% (2)	0.9% (1)	13.4% (15)	2.6% (3)	80.7% (92)
Gerber (87)	3.4% (3)	3.4% (3)	11.5% (10)	27.6% (24)	3.4% (3)	50.6% (44)
Total (254)	1.6% (4)	2.0% (5)	4.3% (11)	16.1% (41)	2.4% (6)	73.6%(187)

QUESTION #7: Compared to your old toilet, do you have to double-flush your toilet more, the same, or less?

	<i>More</i>	<i>Same</i>	<i>Less</i>
Caroma (53)	18.7% (10)	54.7% (29)	26.4% (14)
Niagara (114)	12.3% (14)	54.4% (62)	33.3% (38)
Gerber (87)	32.2% (28)	48.3% (42)	19.5% (17)
Total (254)	20.5% (52)	52.4% (133)	27.2% (69)

QUESTION #8: How often do you have to double-flush?

	<i>Daily</i>	<i>Once a Week</i>	<i>Once a Month</i>	<i>Once</i>	<i>Never</i>
Caroma (53)	3.8% (2)	15.1% (8)	11.3% (6)	0	69.8% (37)
Niagara (114)	0.9% (1)	11.4% (13)	11.4% (13)	2.6% (3)	73.7% (84)
Gerber (87)	4.6% (4)	24.1% (21)	16.1% (14)	2.3% (2)	52.9% (46)
Total (254)	2.8% (7)	16.5% (42)	13.0% (33)	2.0% (5)	65.7% (167)

QUESTION #9: Compared to your old toilet, how well does the new toilet clear the bowl - does the new toilet require more, the same, or less cleaning?

	<i>More</i>	<i>Same</i>	<i>Less</i>
Caroma (53)	35.8% (19)	43.4% (23)	20.8% (11)
Niagara (114)	16.6% (19)	55.3% (63)	28.1% (32)
Gerber (87)	18.4% (16)	58.6% (51)	23.0% (20)
Total (254)	21.3% (54)	53.9% (137)	24.8% (63)

QUESTION #10: Would you recommend this toilet to others?

	<i>No</i>	<i>Maybe</i>	<i>Yes</i>
Caroma (53)	1.9% (1)	1.9% (1)	96.2% (51)
Niagara (114)	5.3% (6)	2.6% (3)	92.1% (105)
Gerber (87)	21.8% (19)	9.2% (8)	69.0% (60)
Total (254)	10.2% (26)	4.7% (12)	85.0% (216)

QUESTION #11: One a scale of 1 to 10, with 10 being high, how would you rate the overall performance of the toilet?

	<i>Overall Average Rating</i>	<i>Standard Deviation</i>	<i>Average rating of participants with 2 ULFTs</i>	<i>Average rating of participants with 1 ULFT</i>
Caroma (53)	8.90	1.3	8.90	8.90
Niagara (114)	8.76	1.4	8.84	8.71
Gerber (87)	7.78	2.0	7.73	8.00
Total (254)	8.44	1.7	8.26	8.67

QUESTION #12: One a scale of 1 to 10, with 10 being high, how would you rate the quality of installation by the contractor?

Average: 9.4

QUESTION #13: Do you have any additional comments or suggestions on the toilets or the program?

<i>Comments</i>	<i>Caroma (44)</i>	<i>Niagara (98)</i>	<i>Gerber (70)</i>	<i>Total</i>
Pleased with the program, thanks	21	37	18	76
Would like more of the same toilet	6	10	1	17
Contractor did fast, clean, good work	5	9	5	19
Shows this toilet off to neighbors	6	2	0	8
Glad horror-stories you hear about ULFTs aren't true	1	2	0	3
Excited about unique flushing mechanism	6	2	0	8
Can tell water use has dropped, water bill is down	2	2	2	6
Comfortable seat	1	0	0	1
Contractor won't return calls	0	2	2	4
Clogs or plugs up	0	2	5	6
Has to double flush	0	1	2	3
Toilet keeps running (flapper, chain, bucket problem)	0	4	14	9
Had to get used to using less paper	1	3	2	6
Louder than old toilet	1	11	1	13
Pets can't access lower water in bowl	1	1	0	2
Bowl is too long (longer than old toilet bowl)	4	1	0	5
Lower water in bowl requires more cleaning	5	3	1	9
Took a long time to get the toilet from first notification	2	2	3	7
Possible problem with flushing mechanism	4	1	2	7
Doesn't like handle or button flushing mechanism	1	3	2	6
Can't use self-cleaning tablets in bucket	0	2	0	2
Plumber didn't caulk fully	1	0	2	3
Not satisfied with this toilet	0	0	4	4
Prefers other ULFT over this one	2	0	17	19