Plumbing Fixtures Market Overview:
Water Savings Potential for
Residential and Commercial Toilet and Urinals

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Executive Summary

This report provides an overview of the current state of the market and potential for water savings in residential and commercial toilets and urinals. These plumbing fixtures constitute one of the most significant uses of water, representing 26 percent of residential indoor water use (about 12 percent of total residential use) and 8.5 percent of total commercial water use, or a total of 2,735,675 million (2.7 trillion) gallons of water consumed nationally each year.

The following analysis demonstrate that market differentiation is possible, the market is already showing a trend towards higher efficiency, and the current generation of water-efficient products is proving to perform well. The vast majority of potential water savings are achievable in the residential toilet fixtures sector, based on the number of current and projected installations and economic opportunities for replacement. In all sectors, new construction offers a significant opportunity for improved water efficiency.

Table 1 summarizes the maximum potential for annual water savings in these three product categories. The calculations assume that all existing fixtures are replaced immediately with the most efficient currently available models (1.0 gpf toilets and 0 gpf urinals) and that new construction mandates the highest level of efficiency for all fixtures. The savings gain per unit depends on the mix of efficiencies of fixtures that are currently installed.

Table 1. Water Savings: Future Technical Potential (2030)			
Fixture	**Number of Existing Units**	**Number of Future Units (2003-2030)**	**Annual Water Savings (MGY)**
Residential Toilets	222 million	75 million	1,137,000
Commercial Toilets	44.5 million	11.1 million	129
Urinals	12.0 million	3.0 million	71
TOTAL			**1,137,200**

Having identified the maximum potential savings, further analysis is required to determine the percentage of that potential that could realistically be captured. The main considerations for identifying a targeted or economic potential are:

- Cost-effectiveness of replacement for existing fixtures
- Cost-effectiveness of high efficiency models compared to standard units for new construction
- Natural replacement rate of existing fixtures over time
- Potential reach of likely efforts to reach owners of existing fixtures for replacements.

The economic water savings potential, summarized in Table 2, accounts for the changing mix of products remaining in existing buildings and installed in new construction applications. Market share for each product category is based on reaching a reasonable level of the market over the projected 27-year period, assuming that a national program, as well as state and local efforts, support the introduction of new products and the fostering of price competition over time.

Table 2. Water Savings: Economic Potential				
Year	**Residential HETs (Millions)**	**Commercial HETs (Millions)**	**Commercial HEUs (Millions)**	**Total Economic Savings Potential (MGY)**
2003	94,393	9,494	3,952	107,839
2010	207,362	7,722	6,698	221,782
2020	110,253	6,971	9,291	126,515
2030	124,256	6,206	10,073	140,535

Technical and Market Research

Overview of Plumbing Fixtures Market

The estimated installed base of toilet fixtures as of 2003 is as follows:

- Residential toilet fixtures: 222 million units (30% 5^{+}gpf, 15 % 3.5 gpf, and 55% 1.6gpf)
- Commercial toilet fixtures: 44.5 million units (43-49% 3.5^{+} gpf)
- Commercial urinal fixtures: 12 million units (80% 1^{+} gpf)

See Plumbing Fixtures Baseline (pages18-21), for further detail.

Annual sales of residential toilets are driven by both replacement and new construction. Despite the increasing number of toilet fixtures in new homes, the remodeling and replacement sector slightly outpaces toilet purchased for new homes. The booming housing market and rapid pace of home improvement spending of recent years has led to healthy growth in the residential toilets sector. Of the 10.1 million toilets forecast to be sold in the U.S. in 2005, 5.2 million will be purchased as part of bathroom remodeling projects, compared to 4.7 new residential toilet installations estimated for residential new construction.[1] Remodeling projects are fairly evenly distributed across the country, with the greatest growth in the Northeast and the West. For these remodeling projects, the vast majority of product purchases—and even project planning—are conducted at large home centers.

The pace of growth in commercial fixtures is slower and was assumed for the purposes of this analysis to increase at the same rate as the national population.

Toilet Fixtures—Efficiency Improvements Over Time

Before 1975, gravity-fed toilet fixtures installed in the U.S. flushed at volumes of five gallons or more. By the early 1980s, "water saver" toilets with a 3.5-gallons-per-flush (gpf) maximum were mandated by most plumbing codes for residential new construction. In the same decade, some manufacturers introduced 1.6-gpf toilets into the U.S. marketplace. Subsequently, a number of local and state jurisdictions mandated that a maximum of 1.6-gpf be the standard for toilet fixtures installed in new homes. The commercial sector experienced a similar change in product flush volumes.

The patchwork of requirements nationwide, ranging from 1.6 to 3.5 gpf, resulted in inefficiencies for manufacturers, who developed and marketed separate product lines based on code requirements. While manufacturers could have opted to offer only the higher efficiency products across the country, the price premium and inferior product performance at the time did not make them attractive to consumers. As a result of the confusion in the market, the plumbing industry, along with water and wastewater industries and environmental organizations, encouraged the federal government to adopt uniform standards. The Energy Policy Act (EPAct) of 1992 established a maximum flush volume of 1.6 gpf for all toilet fixtures (with some exceptions).

[1] Kitchen and Bath Business, *2005 Market Forecaster Report*, VNU Publications, 2005.

The standard took effect on January 1, 1994 for all toilet fixtures except flushometer valve toilets (for commercial applications), which took effect for products manufactured starting on January 1, 1997. An American Water Works Association (AWWA) study of the impacts of EPAct on water consumption found that plumbing standards will achieve an estimated national water savings level of 8 percent, or 3.5 billion gallons per day, by 2020.[2] The largest single component of the savings was shown to be residential toilets.

Although the toilet fixtures sold in the mid 1990s met the flush volume requirement, they did not always perform well. "Low flow" toilets gained a reputation for poor quality and possibly even water waste based on anecdotes of toilets that required multiple flushes. To maintain competitiveness and protect corporate images, the plumbing industry invested in further product development to improve performance and restore customer confidence. By 2000, fixture performance had improved significantly, although many poor performers remained on the market. The lingering first impressions continue to influence consumer perceptions, creating challenges for water conservation programs and manufacturers in their efforts to promote the most water-efficient fixtures available.

Urinal Fixtures—Efficiency Improvements Over Time

Urinals experienced a reduction in flush volumes similar to that of toilet fixtures. Before the 1994 effective date of the federal standard, urinals typically flushed from 1.5 to as much as 5 gallons, with some urinals (trough-type) operating continuously.[3] EPAct, however, mandated a maximum flush volume of 1.0-gpf. Urinal fixtures performed their function satisfactorily at this reduced flush volume and so, unlike toilets, the reputation of urinals has not suffered.

Since 1994, manufacturers have not only improved the design and performance of toilet and urinal fixtures, but have pursued new designs and technologies that are even more efficient. In both fixture groups, water efficiency and flush performance have been addressed together as a single product design initiative.

Distribution Channels and Purchasing Patterns

Of the 150 million new efficient residential toilets that likely will be installed between 2004 and 2030, approximately half will be sold to builders for new construction. The other half will be sold to consumers, plumbers, contractors, facilities maintenance personnel and others as replacements for existing toilets or additions to existing homes. The distribution of toilet fixtures to the residential sector is directed in the U.S. at four primary outlets:

- Direct sales (e.g., homebuilders and other volume purchasers)
- Retail
- Wholesale plumbing suppliers
- Decorator showrooms

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[2] Lisa A Maddaus, and William O. Maddaus, *Quantifying the Benefits from Federal Plumbing Efficiency Standards*, AWWA 2001 Conference Proceedings.
[3] Amy Vickers, *Handbook of Water Use and Conservation*, WaterPlow Press, 2001.

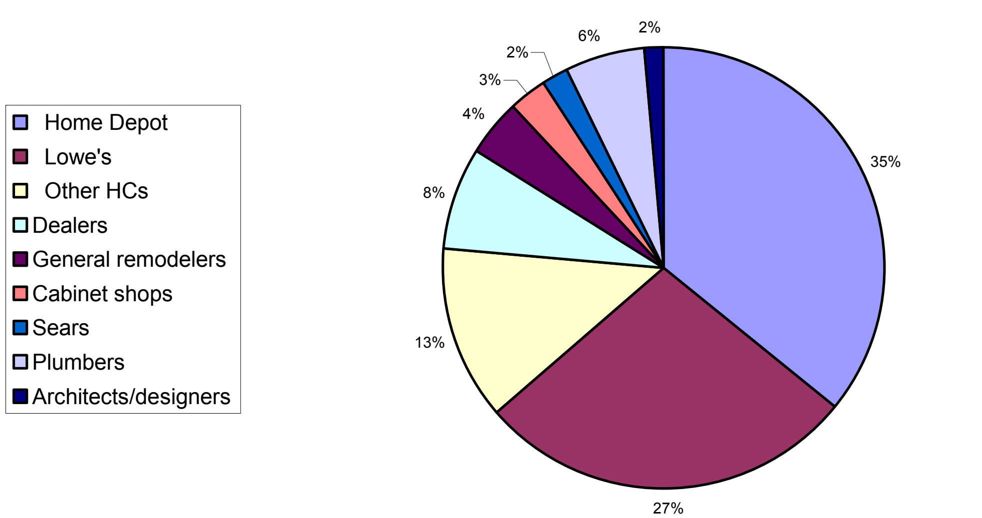
While most manufacturers have well-defined distribution systems in place, they often offer direct sales to major purchasers such as homebuilders and water agencies. In these cases, the distributor plays a minor role in the purchase transaction, the handling and warehousing of the product, and delivery to the consumer. Direct sales and volume purchases typically result in wholesale pricing of 20 to 50 percent less than the retail list price.

In some regions of the country, customers obtain toilets directly from their water providers through conservation programs (toilet giveaways and installation programs where the water provider purchases the toilets), but these represent a small share of the market. Most water conservation programs provide financial incentives that allow the consumer to choose and purchase a specific pre-qualified model.

Some manufacturers have smaller region-specific distribution systems. These companies tend to be new to the U.S. market or specialty producers. Many specialty producers focus on the water-efficiency message and concentrate their efforts in the West and Southwest, where water efficiency programs are most prevalent. Others that focus on new construction concentrate in the urban areas with the highest growth.

The retail sector is dominated by large home centers, such as Home Depot, Lowe's, and Sears. (See Figure 1.) These three chains alone account for over 44 percent of bathroom remodeling related revenues and well over 60 percent of total projects.[4]

Figure 1. Bath Remodeling Channels (No. of Jobs)



Do-it-yourself and "buy-it-yourself" projects (in which the homeowner purchases equipment but hires a contractor for installation) constitute over 85 percent of purchases. This handful of retailers holds a strong influence in plumbing fixture selection. This influence can take the form of the models they stock, special displays, signage and information readily available to customers, and the knowledge of sales staff.

At this time, retailers focus more on style and price than on flush volume, and in some cases, consumers may not be able to easily obtain information on water use or toilet performance

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[4] Kitchen and Bath Business, 2005.

without conducting significant research outside the store. Each national retailer tends to carry a limited number of brands, typically supplied by the larger manufacturers who can supply the volume required for a national market and negotiate premium display space in the stores. Retailers tend to calculate sales or profits by shelf space and are not willing or able to carry all of the most efficient fixtures in their stores. The newer technologies are not displayed and the choices for customers who request those technologies tend to be severely limited, often to catalog or special order status. Most customers, though, will want to see the product before buying it, thus limiting the effectiveness of special order sales. Further, the sales staff at many of the big box home improvement stores is unfamiliar with toilets, much less the most efficient products.

> Any changes in the home center sector offerings and marketing approaches will have a strong influence on the toilets purchased for retrofit applications in the future.

Given the difficulty in obtaining information about toilet water use and performance, water utility programs—particularly those offering ongoing education, lists of efficient models, and incentives—can have a strong influence on customer decision-making. A national effort to differentiate high-efficiency toilets that retailers can easily implement and consumers can easily understand would address some of the infrastructure challenges to promoting these products.

While using the same distribution network as is employed for residential toilet fixtures, manufacturers use a larger number of channels to reach the various commercial customers. Among the audiences that receive more focus are architects, engineers, specifiers, and professional organizations related to commercial-industrial construction. Popular venues include trade shows and green building conferences. The market for commercial toilet fixtures, however, is about one-sixth that of residential[5] and, as such, is considered a somewhat lower priority by some manufacturers.

Most urinals are marketed and distributed within the same framework as toilet fixtures. Non-water urinals, however, are marketed primarily with the water-efficiency, green building message. The audiences for this message are somewhat more concentrated than for conventional urinal fixtures. That is, marketing focus is upon green building initiatives of builders and government, architects, engineers, and specifiers with a green building direction, government agencies responsible for new building construction, water providers, and the like. Many local codes restrict the installation of non-water urinals. As a result, manufacturers must devote significant effort to dealing with code compliance issues on a local basis.

Influence of Water Utilities

In addition to the traditional market players, water conservation programs operated by water agencies have had a significant influence on the market. In California, water utilities that are members of the California Urban Water Conservation Council (CUWCC) invest an average of $12 million each year on residential HET replacement programs; in recent years, they have spent

[5] This is 23.8 million commercial toilets vs. 150 million residential toilets forecast from 2004 through 2030.

an additional million or more dollars on commercial toilet replacement programs. Outside of California, water agencies in conservation-oriented regions including New York City, Connecticut, Seattle, Austin, and several major Canadian cities have invested comparable amounts in high efficiency toilet programs. For example, New York spent $300 million on residential retrofit programs from 1994 to 1997. California is responsible for replacing about 2.5 million toilet fixtures. The Region of Waterloo, Ontario (450,000 persons) has given 40,600 rebates (1994 - 2005) and expects to continue with a maximum of 5,000 rebates per year. The City of Toronto (2.6 million persons) had budgeted for 732,000 rebates from 2002 to 2011.

Incentives for these programs range from about $30 to well over $100 per unit to the customer, and all have shown to be effective in influencing product sales. As noted above, water utility conservation programs may take several forms, including rebates to customers for purchasing models from a published list, to free installation of fixtures purchased directly by the water utility from the manufacturer. No matter the program design, the continuation of toilet replacement programs over a long period of time, combined with the increasing coordination of product testing and eligible product lists, has led water utilities to become one of the most significant factors in toilet fixture demand in North America.

> The greater the coordination among water utilities, the greater the influence water conservation can wield in the plumbing fixtures market.

Defining High Efficiency Fixtures

Absent any market-based or industry-accepted definition of what constitutes an efficient toilet or urinal fixture, several organizations in the water industry worked together in 2004 to establish a clear definition. This group defined the High-Efficiency Toilet (HET) as a fixture that flushes at least 20 percent below the 1.6-gpf/6.0-lpf maximum, or a maximum of 1.3-gpf/4.8-lpf. The plumbing industry has accepted this definition as a reasonable delineation for a new category of toilet fixture.

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-water urinals as well as the one-quart, one-liter, and one-pint urinals in development.

HETs and HEUs have not yet gained a large presence in the fixtures market. Three factors are expected to change this market over the coming decades:

- Performance improvements in high-efficiency fixtures that equal or surpass existing models
- Influence of water conservation programs run by water and wastewater agencies
- Increasing attention and interest in green building practices

Overview of Product Types and Performance Attributes

High-Efficiency Toilets (HETs)

The three types of HETs listed in Table 3 are currently commercially available:

Table 3. 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 Fixtures

In late 1998, the first gravity-fed dual-flush toilet fixture was introduced into the U.S. market by Caroma International, Ltd.[6] While the dual-flush concept of efficiency was well-established in Australia, Asia, and Europe, it was new to North America.[7] As a result, education of the specifiers, builders, building operators, and consumers was 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. By 2003, Vortens, a brand of the Lamosa Group, based in Monterrey Mexico, introduced the first competing gravity-fed dual-flush fixture. For the first time in five years, Caroma was about to experience competitive pressure on their fixture prices, which had been significantly higher than conventional gravity-fed 1.6-gallon toilets. This pricing discrepancy had discouraged the purchase of dual-flush toilets. Today, nine manufacturers, listed in Table 4, offer 44 dual-flush fixture models.

Table 4. Dual-Flush HETs	
Manufacturer	**Number of Models**
Caroma	13
Gerber	11
Kohler	6
Mancesa	1
Mansfield	7
Pegasus (Home Depot)	1
Toto	1
Vitra	1
Vortens	3
TOTAL	**44**

[6] 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.
[7] 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 flush for liquids only. The reduced flush ranges between 0.8 and 1.1 gallons depending upon the design of the fixture.

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 the public is educated about dual-flush, a condition that may take many years to achieve.

Pressure-Assist Single-Flush Fixtures

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 on its already-proven 1.6-gpf pressure-assist technology. The prototype Flushmate system was installed in over 30 fixtures, field tested, and evaluated by California water agencies. The marginal results from that field study[8] led to improvements in both the Flushmate product and the bowls to which it delivered water. Sloan now markets the system to all manufacturers. Today, seven manufacturers, listed in Table 5, produce 23 models of the 1.0-gpf pressure-assist toilet fixture. WDI International, a competitor to Sloan, supplies the pressure-assist unit for 11 of those models.

Table 5. 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**

This technology is suited to both residential and light commercial applications. In fact, representatives of Sloan Flushmate report that over 50 percent of all Flushmate pressure-assist systems are sold for residential installations.[9] The increasing acceptance of pressure-assist fixtures in residential settings is largely attributable to their positive portrayal on the popular HGTV (Home and Garden TV) channel, showing excellent flush performance and long-term reliability. In addition, despite the long-standing reputation that pressure-assist fixtures have for noise, newer models are hardly noisier than conventional gravity-fed fixtures.

Conventional Gravity-Fed Fixtures

This category consists of conventional gravity-fed fixtures with a flush volume meeting the HET criteria. Only one model, listed in Table 6, is currently offered in the U.S. market, although other manufacturers are capable of developing or have already developed such a prototype

[8] Koeller, Muir, Davies, De La Piedra, *A Field Study of 4.0-liter (1.0-gallon) Toilet Fixtures,* paper prepared for and presented at AWWA Water Sources Conference, January 2002.
[9] Personal communication, Paul Deboo, Sloan Flushmate

fixture. More toilet fixtures of this type will likely be introduced into the marketplace within the next several years.[10]

Table 6. Single-Flush HET	
Manufacturer	**Number of Product Offerings**
American Standard	1

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

Flushometer Valve and Bowl Fixtures

The last category of HETs is the flushometer valve and bowl toilets for commercial applications. The Sloan Valve Company introduced a new dual-flush flushometer valve in August 2005. It is too early to tell how successful this introduction will be. However, it is likely that dual-flush in non-public settings can be a viable option once the dual-flush concept is familiar to end-users. On the other hand, dual-flush in public applications (such as retail stores and public assembly areas) will take longer to have an effect upon water use since users may not be aware of the short flush option.

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 reported to be developing flushing urinals to be rated at as little as one pint of water. No such advanced products have yet made it into the U.S. marketplace.

Half-Gallon Urinals

Three manufacturers, listed in Table 7, produce and sell a single model of a 0.5-gpf urinal in the U.S.

Table 7. Half-Gallon HEUs	
Manufacturer	**Model**
American Standard	Innsbrook Model 6520
Kohler	Bardon™ K-4915
Mansfield Plumbing	Adam™ 401[9]

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

Unlike conventional urinals, both the American Standard and Kohler products house an integrated sensor-operated flush valve. The Mansfield product,[11] 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. They claim to meet all performance requirements at 0.7-gpf and above.

1-Pint, 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.[12] Although one-liter flushing urinals were 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. However, if certification requirements have to be modified to meet U.S. standards, their entrance to the marketplace is likely to be forestalled.

Non-Water Urinals

Non-water urinals by Falcon Waterfree and Waterless Company dominate the U.S. market. Both manufacturers offer urinal fixtures in vitreous china and composite materials. Table 8 lists the number of models currently within their product offerings.

Table 8. Non-Water HEUs

Manufacturer	Number of Product Offerings	
	Vitreous China	Composite Materials
Waterless Company[13]	1	5
Falcon Waterfree™ [14]	4	1

Uridan-USA offered non-water urinals through a distributor based in Florida, but that distributor has abandoned the product, citing the high cost of the European product and the lack of a vitreous china model.[15] The distributor later introduced the ZeroFlush non-water urinal, although the product is yet readily available. The German company, Duravit, has been offering the McDry non-water urinal[16] for several years in the U.S., although marketing is spotty at best. Other manufacturers of non-water urinals exist in Europe and elsewhere; some may choose to enter the U.S. market at a future date.

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[11] 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.

[12] 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.

[13] See http://www.waterless.com.

[14] See http://www.falconwaterfree.com. The Falcon Waterfree™ urinal is also marketed by the Sloan Valve Company as the Sloan Waterfree™ urinal at http://www.sloanvalve.com/waterfreeindex2.htm.

[15] "U.S. Distributor Abandons Uridan and Launches ZeroFlush," *Environmental Building News*, Volume 14, No. 6, June 2005.

[16] Duravit McDry Model No. 084435.

Cost-Effectiveness

Residential Toilet Fixtures

As new HET and HEU technologies and products are introduced into the marketplace, the pricing structure becomes more difficult to define. New manufacturers and products are increasing the level of competition in the U.S.. In addition, the increased use of offshore production by U.S. companies has reduced costs, enabling manufacturers to compete. Finally, the acknowledgement within the plumbing industry of the market potential of the water conservation and green building sectors has increased their attention to producing and marketing higher efficiency models compared to recent years.

As a result, toilet fixture prices have remained relatively constant for several years. New technologies, such as dual-flush and the 1.0-gpf pressure-assist, entered the marketplace at a price premium. Today, 1.0-gpf and 1.6-gpf fixtures are priced at about the same level and dual-flush toilets will soon be priced in the $120 to $140 range, competing head-on with all of the other technologies, including pressure-assist.

The bulk purchase price paid by builders, government, and water providers is generally significantly below that of retail pricing for the same products. Water providers can now bulk purchase dual-flush toilets at around $150-$165 and 1.0-gpf pressure-assist toilets at $150 or less. Retail prices to the consumer remain at 50 to 100 percent higher.

For water conservation programs directed at the consumer, any retail price premium for a more efficient model is usually offset by the incentive. In California, where the largest HET programs are underway or about to begin, rebates for residential installations range from $100 to $175 per installed HET. This is approximately twice the amount that was offered in the 1990s for conventional 1.6-gpf residential toilets.

Commercial Toilet Fixtures

Opportunities for the replacement of conventional toilet fixtures in the commercial sector are much more limited than in residential applications. Some of the key challenges to changes in the commercial market include:

- A smaller installed base of existing fixtures (44.5 million, compared to 222 million residential fixtures)
- 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, resulting in higher costs
- The lack of HETs in the flushometer valve and bowl category
- The reluctance of many end-users to replace existing, well-functioning fixtures, particularly when doing so may interrupt business operations or require other restroom modifications
- The need for significant capital to replace large numbers of fixtures; rebates by themselves may be insufficient to cover a significant portion of the replacement cost

- The lingering reputation of poor performance of "low-flow" toilet fixtures from the mid-1990s
- The difficulty that efficiency program managers have in reaching business owners and managers, whose attention is focused on day-to-day business operations

These and other factors have limited the success of commercial toilet replacement programs. Costs to develop and execute effective programs, whether of the rebate, voucher, or direct-installation type, are higher than for residential programs. The fixture costs for today's HET technologies (dual-flush and pressure-assist), however, are the same as those for residential since the fixtures are the same. They are assumed to be cost-effective for new construction applications, but not for replacement of fully functioning installed fixtures. The future costs for flushometer valve HETs are not yet known.

Urinal Fixtures

The replacement of existing urinals with HEUs is a rarity, with the exception of replacement with non-water urinals. Orrett documented that the replacement cost of the full fixture with a non-water urinal fell between $333 and $590 (including tax and installation in 2001), depending upon the model selected.[17]

The only urinals certified at 0.5-gpf are those manufactured by American Standard and Kohler, both of which house an integrated sensor-operated flush valve. The list price of these fixtures and related installation components is as follows:[18]

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

While the list prices would not necessarily be the quantity purchase costs for an aggressive or massive urinal replacement program, they do provide an upper boundary for these types of fixtures.

If a large-scale national effort focused on promoting HEU installations, it is expected that competition would drive more manufacturers into the HEU sector and prices would drop accordingly.

[17] Edwin B. Orrett, City of Petaluma, CA, Financial analysis of waterless urinals, Spreadsheet document. January 27, 2001.

[18] List prices for the urinal fixtures are taken from the Web sites of the respective firms on July 23, 2005.

Water Savings Potential

Plumbing Fixture Installations Baseline

One key to assessing the water savings potential of toilet and urinal replacements is determining the baseline from which water use reductions may be measured, both in terms of numbers of existing and projected models and their flush volumes. While HET flush volumes vary from 1.0-gpf to 1.3-gpf, the baseline of currently installed models also ranges from 1.6-gpf to 7.0-gpf. Similarly, the flush volumes for the current complement of HEUs varies from zero up to 0.5-gpf, while the installed baseline covers a range from 1.0-gpf to 5-gpf and higher.

Residential Toilet Fixtures Baseline

Based on U.S. Bureau of the Census surveys and counts[19] from 1970 to 2003, which included housing unit counts and bathrooms per dwelling unit, it was possible to develop an inventory (see Table 9) of residential toilet fixtures in the U.S. beginning before the 3.5-gpf fixtures became mandatory in the 1980s.

Table 9. Estimated Inventory of Installed Residential Toilets in the U.S.

Year	Toilets per Dwelling Unit	Installed Toilets (mils)
1970	1.11	74
1975	1.35	77
1980	1.40	113
1991	1.55	150
1993	1.57	155
2001	1.82	215
2003	1.84	222

In addition to the total inventory of installed fixtures, water savings potential is dependent on the actual flush volume of those units. Table 10 shows how the flush volume of installed units has changed over time, in keeping with prevailing codes and standards.

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

Table 10. Installed Residential Toilets: By Flush Volume (millions)[20]				
Year	**5.0-gpf & above**	**3.5-gpf**	**1.6-gpf**	**TOTAL**
1970	74	0	0	74
1975	77	0	0	77
1980	110	3	0	113
1991	113	37	0	150
1993	113	41	1	155
2001	74	37	104	215
2003	67	33	122	222

The increase in toilet fixtures per residential dwelling unit as noted in Table 11 can be attributed to the larger numbers of bathrooms constructed in new dwelling units since the late 1990s.

Table 11. Toilets Per Dwelling Unit: Existing and New Construction				
Year	**Toilets per existing dwelling unit**	**Toilets per new dwelling unit**		
		Single family	**Multi-family**	**All new units**
1997	1.75	2.51	1.68	2.34
1999	1.79	2.57	1.71	2.39
2001	1.82	2.62	1.75	2.45
2003	1.84	2.63	1.73	2.47

Based upon the above information and U.S. Census Bureau projections of population, the future inventory of installed fixtures is conservatively estimated as summarized in Table 12.

[20] Estimates by type of fixture were based upon an assumed 20-year useful life of residential fixtures, resulting in natural replacement of five percent annually.

Table 12. Projection of Installed Residential Toilets (millions)[21]				
Year	**5.0 gallons per flush and greater**	**3.5 gallons per flush**	**1.6 gallons per flush and less**	**TOTAL**
2003	67	33	122	222
2010	47	23	171	241
2020	28	14	226	268
2030	17	8	272	297
27-year change	(50)	(25)	150	75

From 2003 to 2030, an estimated 150 million new toilet fixtures of 1.6-gpf or less will be installed in residential dwellings in the U.S., a rate of approximately 5.5 million per year.

Commercial Toilet Fixtures Baseline

A current estimate of installed commercial toilet fixtures in the U.S. is not readily available. However, a recently developed estimate of such fixtures for California put the inventory at approximately 4.9 million units .[22] Of this, between 2.1 and 2.4 million are estimated to be inefficient, i.e., flushing at 3.5-gpf and above. A national estimate of installed units was extrapolated by estimating the percentage of total employment that California's non-farm employment represents (about 11 percent of the total for the country).[23] Using this ratio to estimate total commercial-type toilet fixtures for the entire nation would yield an estimate of approximately 44.5 million units in 2003, of which 19 to 22 million could be inefficient.

Growth in commercial toilet fixtures was assumed to track with population growth. We forecast that the inventory of 44.5 million fixtures will grow to approximately 56 million by the year 2030. During this period, the inventory of inefficient fixtures is expected to drop from its current level of 19 million to 22 million down to an estimated 6.8 million. Therefore, the purchase and installation of new, efficient commercial toilets (1.6-gpf or less) would amount to about 25 million over the 27-year period, or about 900,000 new commercial toilet fixture purchases and installations per year. (See Table 13.)

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[21] Based upon U.S. Census projections of population (U.S. Census Bureau, "U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin," 2004, http://www.census.gov/ipc/www/usinterimproj/, Table 2a, Projected Population of the United States, by Age and Sex: 2000 to 2050), a constant of 2.41 persons per housing unit, a constant of 2.47 toilets per new dwelling unit, and continuing natural replacement of existing toilet fixtures at 5.0 percent annually.

[22] Koeller and Company, "HET and HEUs, Potential Best Management Practices," Unreleased draft document, 2005.

[23] U.S. Department of Labor, Bureau of Labor Statistics, *Employment Situation Summary* and *State and Area Employment, Hours, and Earnings*, 2005.

Table 13. Projection of Installed Commercial Toilets (millions)[24]			
Year	**3.5 gallons per flush and greater**	**1.6 gallons per flush and less**	**TOTAL**
2003	20.5	24.0	44.5
2010	15.4	31.9	47.3
2020	10.2	41.2	51.4
2030	6.8	48.8	55.6
27-year change	(13.7)	24.8	11.1

Commercial Urinal Fixtures Baseline

As with commercial toilet fixtures, we have not found a reliable field survey or other count of urinals installed in commercial applications in the U.S. Therefore, for a very rough planning estimate of installations, the installed base of commercial toilets was used as an indicator. Over the years, the requirements of the applicable plumbing code(s) have changed with respect to ratios of toilets and urinals to building population. As an example, however, the Uniform Plumbing Code currently requires specific ratios of fixtures for 150 occupants (including customers) in these selected and typical applications, defined in Table 14.

Table 14. Typical Code Requirements for Plumbing Fixtures			
Type of Building or Occupancy	**Female Restroom**	**Male Restroom**	
	Toilet Fixtures	**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 one-quarter 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 commercial facilities would approximate 25 to 30 percent of the total number of toilet fixtures (men and women). Using this ratio, we further estimate that the number

[24] Based upon U.S. Census projections of population (U.S. Census Bureau, "U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin," 2004, http://www.census.gov/ipc/www/usinterimproj/, Table 2a, Projected Population of the United States, by Age and Sex: 2000 to 2050), a constant of 2.41 persons per housing unit, a constant of 2.47 toilets per new dwelling unit, and continuing natural replacement of existing toilet fixtures at 5.0 percent annually.

of urinals currently installed in commercial facilities to be approximately 12 million fixtures.[25] Of these, an estimated 20 percent are of the 1.0-gpf or non-water type, having been installed since the 1.0-gpf flush volume limit became effective through EPAct 92. (No reliable estimate of installed non-water urinals exists since such information is propriety to the two dominant manufacturers.)

Projections to 2030 for installed urinals are based upon expected employment growth. From 2003 to 2030, the total inventory is forecasted to increase by three million fixtures, while the proportion of those fixtures that are flushing at 1.0-gpf and less increases to slightly above 70 percent. Replacement of existing urinals, together with new construction, would require an estimated 8.8 million new efficient urinals in the 27-year period, or about 325,000 units per year. (See Table 15.)

Table 15. Projection of Installed Urinals (millions)[26]

Year	Greater than 1.0-gpf	1.0 gallons per flush and less	TOTAL
2003	9.6	2.4	12.0
2010	7.6	5.2	12.7
2020	5.4	8.5	13.9
2030	3.8	11.2	15.0
27-year change	(5.8)	8.8	3.0

Water Savings Potential

Residential Toilet Fixtures

<u>*Water Consumption in Residential HETs*</u>

Because HETs are relatively new to the market, 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. 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 changing behavior: the more users choose the "short" flush mode when appropriate, the more water is saved. The weighted average of short and full flushes (combined) is determined to a large degree by the ratio of flush counts for each of the two options. As summarized in a 2003

[25] At 25 to 30 percent of 44.5 million toilet fixtures. Subsequent analyses were performed at a conservative 12 million installed urinal fixtures.

[26] Based upon U.S. Census projections of population (U.S. Census Bureau, "U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin," 2004, http://www.census.gov/ipc/www/usinterimproj/, Table 2a, Projected Population of the United States, by Age and Sex: 2000 to 2050).

paper[27] 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 is shown in Table 16.

Table 16. 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
Weighted average	**246**		**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.

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

Water Savings Per Unit—Residential Toilets

Table 17 summarizes the volume of water saved per flush and per year for the various residential toilet fixtures that can be targeted for replacement. These figures are then applied in estimating the total water national savings potential for a water efficiency effort.

Table 17. Water Savings Per Unit—Residential Toilets				
	Replace with HET 1.0 gpf		**Replace with HET 1.25 gpf**	
Toilet to be Replaced	**Savings per Flush (gal)**	**Annual Savings/ Unit (gal)**	**Savings per Flush (gal)**	**Annual Savings/ Unit (gal)**
5^+ gpf	4.0	9,754	3.75	9,145
3.5 gpf	2.5	6,096	2.25	5,487
1.6 gpf	0.6	1,463	0.35	853

The assumptions for all residential toilets are:

- 365 days/year of use
- 1.31 persons per fixtures
- 5.1 flushes per day per person

Water Savings Technical Potential—Residential HETs

[27] Koeller and Company, *Dual-Flush Toilet Fixtures – Field Studies and Water Savings*, December 17, 2003b, http://www.cuwcc.org/products_tech.lasso.

Table 12 shows that approximately 67 million toilets with flush volumes of 5.0 gallons or more are installed in residential dwellings today. The estimated inventory of 3.5-gallon toilet fixtures is 33 million. The remainder of the installed inventory is 1.6-gallon toilets, for which we estimate that approximately 122 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.[28] Other studies showed slightly higher counts, in some cases as high as 6.4. We have used the 5.1 count as a conservative indicator of consumer habits.

Several scenarios were evaluated for their potential impact upon national water use, estimating technical potential (all units in the targeted categories) in each case. The scenarios are:

- Current technical potential: replacement of *all* existing residential 1.6-gpf and above toilets with HETs
- Targeting inefficient models: replacement of *all* existing residential 3.5-gpf and above toilets with HETs
- New construction focus: *all* new residential construction mandated with HETs
- Future technical potential: replacement of *all* existing residential toilets and mandate HETs for *all* new construction (2003-2030)

Current Technical Potential

The immediate replacement of 222 million existing residential toilets (of all flush volumes) with HETs would yield water savings as follows:

- Replacing with 1.0-gpf HETs – 1,033 billion gallons per year (BGY)[29]
- Replacing with 1.25-gpf HETs – 898 BGY

Targeting Inefficient Models

The immediate replacement of ONLY inefficient toilets (67 million 5.0+-gpf toilets and 33 million 3.5-gpf toilets) with HETs would yield water savings as follows:

- Replacing with 1.0-gpf HETs – 855 BGY
- Replacing with 1.25-gpf HETs – 794 BGY

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[28] Amy Vickers,*Handbook of Water Use and Conservation*, WaterPlow Press, 2001, and Peter Mayer, Personal communication, July 21, 2005.

[29] Calculated on the basis of 222 million existing residential toilet fixtures, divided as follows:

5.0-gpf and above	67 million
3.5-gpf	33 million
1.6-gpf	122 million
Total	222 million

New Construction Focus

All new residential construction from 2003-2030 mandated with HETs (approximately 74 million new toilets) yields water savings as follows:

- All new construction with HETs at 1.0-gpf – 104 BGY
- All new construction with HETs at 1.25-gpf – 60 BGY

Future Technical Potential

Table 18 summarizes the savings potential for immediately replacing all or only inefficient residential toilets as well as mandating that all future new construction install HETs only.

<table>
<tr><th colspan="4">Table 18. Future Technical Potential
(billion gallons of water savings in 2030)</th></tr>
<tr><th colspan="2" rowspan="2">Existing Installed Base Alternatives</th><th colspan="2">New Construction Mandate</th></tr>
<tr><th>1.0-gpf</th><th>1.25-gpf</th></tr>
<tr><td rowspan="2">Replace all existing residential toilets (222 million units)</td><td>1.0-gpf</td><td>1,137</td><td>1,093</td></tr>
<tr><td>1.25-gpf</td><td>1,002</td><td>958</td></tr>
<tr><td rowspan="2">Replace all existing inefficient residential toilets (100 million units)</td><td>1.0-gpf</td><td>959</td><td>915</td></tr>
<tr><td>1.25-gpf</td><td>898</td><td>854</td></tr>
<tr><td colspan="4">Note: All figures are rounded.</td></tr>
</table>

Water Savings Economic Potential—Residential HETs

Using the Future Technical Potential as a starting point, calculating the economic water savings potential involved determining the flush volume and potential water savings of the appropriate replacement models. Single-flush and Flushometer Valve HETs were not considered given the lack of commercial availability. Since pressure-assist toilet fixtures are comparable in cost to dual-flush, have been shown to consume less water on average than the dual-flush units, and water savings are not dependent on user behavior (selecting the short flush when appropriate), the analysis assumed that 1.0 gpf pressure-assist or other technologies would be the replacement model of choice.

Replacing a standard (1.6 gpf) toilet fixture with a 1.0 gpf HET yields an annual cost savings of only $3.00-5.00.[30] This is hardly a sufficient sum to influence a consumer's purchasing decision, even assuming a 20-year fixture lifetime, or even doubling the savings to account for wastewater cost savings. Cost savings for replacing a 3.5 gpf fixture with a 1.0 gpf unit would be $12-20 per year, and for replacing a 5.0 gpf unit would be $20-32 per year. Replacing the inefficient units begins to look more economically attractive, particularly when considering the cost savings over the lifetime or even over five to seven years (the typical tenure of a U.S. household in a home).

[30] Assuming average to higher water costs of $1.50-2.50 per hundred cubic feet (HCF) (1 HCF = 748 gallons).

However, replacements are more likely to be driven by bathroom remodeling projects planned regardless of water cost savings or water agency conservation programs.

Since cost savings are not likely to be the compelling message to all consumers, HETs must meet one or more of the following characteristics:

- Retail price of HETs must be competitive with standard toilet fixtures
- Water conservation financial incentives must reduce any significant price premium
- HET style and performance must meet or exceed those of standard fixtures
- Superior performance attributes must be conveyed simply and effectively to purchasers

Assuming that 1.0 gpf pressure-assist fixtures are already cost-competitive at retail for consumers, the analysis should discount the natural rate of replacement through retirement or replacement of older toilet fixtures (assumed to be 5 percent per year). Since the replacement rate assumes that the least efficient toilets will be replaced first, the economic water savings potential declines the longer it takes to initiate and implement a replacement program, despite the increasing number of total installed fixtures.

Finally, the analysis takes into consideration the ability of a potential national water efficiency program—supported by state and local water conservation efforts—to reach and influence the replacement of existing installed toilet fixtures. The analysis assumes that in the first few years, such a national program would reach 10 percent of older inefficient fixtures beyond the natural replacement rate, 5 percent of newer (1.6 gpf) existing models, and 25 percent of new construction installations. It is assumed that program success would lead to changing prices and market practices and market share of efficient units would increase to 35 percent of installations in new construction by 2010, 70 percent by 2020, and 85 percent by 2030. Consumer awareness and continuing remodeling efforts would also increase the replacement rate of existing installed units (despite the declining number models that would remain in place), reaching a steady state of 30 percent of older efficient model replacements beyond the natural retirement rate.

The annual water savings potential based on all these considerations is summarized in Table 19.

Table 19. Economic Water Savings Potential—Residential HETs

Year	Number of 6.0 gpf units (Mil)	Number of 3.5 gpf units (Mil)	Number of 1.6 gpf units (Mil)	Total Units installed (Mil)	Economic Water Savings Potential (MGY)
2003	67	33	122	222	94,393
2010	47	23	171	241	207,362
2020	28	14	226	268	110,253
2030	17	8	272	297	124,256

Commercial Toilet Fixtures

Water Consumption in Commercial HETs

Because of the wide variations in the end-use applications within the commercial 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 19 million and 22 million inefficient toilets are estimated to currently exist in the commercial sector. We have used the midpoint of 20.5 million as a conservative measure of replacement opportunities. However, data are not available that would stratify the 20.5 million by their flush volume. Therefore, because all of these toilets were installed prior to the EPAct 92 1.6-gpf mandate, we have assumed 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 inefficient commercial fixtures are of the flushometer valve type. In order to convert these toilets to an HET classification, the entire bowl and valve would require replacement. Yet, while 1.0-gpf valves exist in the marketplace, 1.0-gpf flushometer bowls do not. Therefore, to project savings based upon an HET scenario for these toilets must assume that at such time as a replacement program begins there will be suitable product available.

For all of the other inefficient toilet fixtures in commercial applications (all of which are tank-type), there exist numerous HET models in the current marketplace, as discussed earlier (Product Types and Performance Attributes).

Water Savings Per Unit—Commercial Toilets

Vickers states that employees' toilet use in the workplace is three flushes per day for women and one flush per day for men.[31] Using this information, the current national employment data discussed earlier, population growth data,[32] and the inventory of efficient and inefficient toilet fixtures in commercial applications, the same four alternatives were evaluated for the commercial sector. Table 20 summarizes the volume of water saved per flush and per year for the various commercial toilet fixtures that can be targeted for replacement.

Table 20. Savings Per Commercial Toilet Fixture

	Replace with HET 1.0 gpf		Replace with HET 1.25 gpf	
Toilet to be Replaced	**Savings per Employee (gal)**	**Annual Savings/Unit (gal)**	**Savings per Employee (gal)**	**Annual Savings/Unit (gal)**
3.5 gpf	1,560	4,691	1,430	4,300
1.6 gpf	312	938	182	547

[31] Amy, Vickers, *Handbook of Water Use and Conservation*, WaterPlow Press, 2001.

[32] Based upon U.S. Census projections of population (U.S. Census Bureau, "U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin," 2004, http://www.census.gov/ipc/www/usinterimproj/, Table 2a, Projected Population of the United States, by Age and Sex: 2000 to 2050) and U.S. Department of Labor, Bureau of Labor Statistics, "Employment Situation Summary," Table A, August 2005, http://www.bls.gov/news.release/empsit.nr0.htm.

The assumptions for commercial toilets are:

- 260 days/year of use
- 2 flushes per day per person
- Non-farm employment of 133.8 million people
- Made estimates of distribution of population and efficiency of fixtures to come up with a representative average for each scenario (detailed in Appendix).

Water Savings Technical Potential—Commercial HETs

Current Technical Potential

The replacement of all 44.5 million existing commercial toilets (of all flush volumes) with HETs would yield water savings as follows:

- Replacing with 1.0-gpf HETs – 119 billion gallons per year (BGY)
- Replacing with 1.25-gpf HETs – 101 BGY

Targeting Inefficient Models

The replacement of only the 20.5 million inefficient toilets with HETs would yield water savings as follows:

- Replacing with 1.0-gpf HETs – 96 BGY
- Replacing with 1.25-gpf HETs – 88 BGY

New Construction Focus

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

- All HETs at 1.0-gpf – 10 BGY by 2030
- All HETs at 1.25-gpf – 6 BGY by 2030

Future Technical Potential

Table 21 summarizes the water savings potential for replacing all 44.5 existing toilets or all 20.5 inefficient toilets as well as mandating that all new construction (11.1 million additional toilets) install HETs only.

Table 21. Summary of Commercial HET Water Savings Potential (billions of gallons per year - 2030)

Existing Installed Base Alternatives		**New Construction Mandate**	
		1.0-gpf	**1.25-gpf**
	1.0-gpf	129	125

Replace *all* existing commercial toilets	1.0-gpf	129	125
Replace *all* existing commercial toilets	1.0-gpf 1.25-gpf	103 107	102 107
	1.25-gpf	99	94
Note: All figures are rounded.			

Water Savings Economic Potential—Commercial HETs

Determining the economic potential of commercial HETs is less complex than in the residential sector. Assuming that 1.0 gpf HETs are price competitive and cost-effective for new installations, the analysis uses estimates of new construction installations of 25 percent in 2010, 35 percent in 2020, and 50 percent in 2030. The replacement rate is assumed to be low, or about 8 percent, due to the economic and business concerns about replacing working fixtures in most businesses as discussed earlier. Based on these assumptions, the economic water savings potential is summarized in Table 22.

Table 22. Economic Water Savings Potential—Commercial HETs			
Year	**Number of Installed Units (3.5 gpf)**	**Number of Installed Units (1.6 gpf)**	**Economic Water Savings Potential (MGY)**
2003	20.5	24.0	9,494
2010	15.4	31.9	7,722
2020	10.2	41.2	6,971
2030	6.8	48.8	6,206

Commercial 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. However, the analysis yielded an estimate (see Plumbing Fixtures Baseline) of 12.0 million urinals currently installed in CII applications across the country. Vickers reports that the average use of a urinal is two times per day by the average male.[33]

Water Savings Per Unit—Commercial Urinals

There is currently no field data providing the average flush volume of the pre-EPAct 92 urinal. Given the lack of data, the analysis conservatively assumes that inefficient urinals use 2.0 gpf. The assumptions behind these per-unit savings estimates are detailed in the Appendix.

Table 23. Savings Per Urinal Fixture (Gallons/Year)		
Replacement Fixture	**Replacing Inefficient Models (2 gpf)**	**Replacing Post EPAct 92 Models (1 gpf)**
0.5 gpf Urinal	4,332	1,450
1-Liter (0.26 gpf) Urinal	5,026	2,146

[33] Amy Vickers, *Handbook of Water Use and Conservation*, WaterPlow Press, 2001.

Non-water Urinal (0 gpf)	5,776	2,899

Water Savings Technical Potential—Commercial Urinals

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

- Current technical potential: replacement of all existing urinals of 1.0-gpf and above with HEUs
- Targeting inefficient models: replacement of all existing inefficient urinals (>1.0-gpf) with HEUs
- New construction focus: all new CII construction mandated with HEUs
- Future technical potential: replace all existing urinals or inefficient urinals with HEUs and mandate HEUs for new construction.

Current Technical Potential

The replacement of all 12 million existing commercial flushing urinals (of all flush volumes) with HEUs would yield estimated water savings today as follows:

- Replacing with 0.5-gpf HEUs – 45 billion gallons per year (BGY)
- Replacing with 0.26-gpf HEUs – 53 BGY
- Replacing with 0-gpf non-water HEUs – 63 BGY

Targeting Inefficient Models

The replacement with HEUs of ONLY the 9.6 million commercial flushing urinals that currently flush at greater than 1.0-gpf, yielding estimated water savings today as follows:

- Replacing with 0.5-gpf HEUs – 42 BGY
- Replacing with 0.26-gpf HEUs – 48 BGY
- Replacing with 0-gpf non-water HEUs – 56 BGY

New Construction Focus

All new CII construction mandated with HEUs,[34] yielding water savings[35] as follows:

- All HEUs at 0.5-gpf – 4 BGY by 2030
- All HEUs at 0.26-gpf – 6 BGY by 2030
- All HEUs at 0-gpf non-water type – 9 BGY by 2030

[34] As noted earlier, new construction from 2004 through 2030 is forecasted to require an additional 3 million urinals.
[35] Assumes current requirement of mandating a maximum of 1.0-gpf urinals in all new construction is the baseline for determining savings potential.

Future Technical Potential

Table 24 shows the water savings potential of either replacing all 12 million existing urinal fixtures or only existing inefficient models to HEUS and mandating that all new construction install HEUs only for the estimated 3 million additional units projected by 2030.

Table 24. Summary of Commercial HEU Water Savings Potential (billions of gallons per year - 2030)				
Existing Installed Base Alternatives		**New Construction Mandate (3 million new units)**		
		0.5-gpf	**0.26-gpf**	**Non-water**
Replace all Existing Urinals (12 million units)	0.5-gpf	50	52	54
	0.26-gpf	58	60	62
	Non-water	67	69	71
Replace all Existing Inefficient Urinals Only (9.9 million units)	0.5-gpf	46	48	50
	0.26-gpf	53	55	57
	Non-water	60	62	64
Note: All figures are rounded.				

Water Savings Economic Potential—Commercial HEUs

The assumptions for commercial urinals' market share are similar to that of commercial toilet fixtures. Replacement of existing units is estimated at 8 percent per year, and market share of new installations is estimated to reach 25 percent in 2010, 35 percent in 2020, and 50 percent by 2030.

Unlike the toilet fixtures categories, the analysis does not assume that a single high efficiency category will dominate the market. Based on current trends in product offerings, market acceptance, and questions about maintenance and performance, the mix of HEUs is forecast as follows:

- 2010: 75 percent 0.5 gpf; 10 percent 0.0 gpf; 15 percent 0.26 gpf (1-Liter)
- 2020 and 2030: 70 percent 0.26 gpf, 20 percent 0.5 gpf; and 10 percent 0.0 gpf

The economic water savings potential estimate for commercial HEUs takes into account both the changing mix by flush volume of the installed base of fixtures, as well as the likely changes in the types of HEUs that will be selected as replacement or new fixtures. The estimate is summarized in Table 25.

Table 25. Economic Water Savings Potential—Commercial HEUs			
Year	Number of HEU Replacement Units (Millions)	Number of HEUs in New Construction (Millions)	Economic Water Savings Potential (MGY)
2003	0.96	0	3,952
2010	1.024	0.7	6,698
2020	1.112	1.155	9,291
2030	1.2	1.35	10,073

Other Considerations (non-water benefits)

The most efficient toilet and urinal fixtures do not sacrifice performance for low water use (or high efficiency). The plumbing industry has, by and large, successfully addressed the complaints related to the early 1.6-gallons-per-flush (gpf) toilets of the 1990s. With new design approaches and new technologies, performance of the fixtures has been enhanced while, at the same time, water use has been reduced.

Test Method Assessment and Needs

Certification Testing

In 2003, the U.S certification test requirements for toilet fixtures changed somewhat as a revised consensus standard was adopted through the American Society of Mechanical Engineers (ASME) standards process. The current performance testing requirements[36] for toilet fixture certification, which are approved by the American National Standards Institute (ANSI) as national standards, include:

- Surface wash (ink line) test
- Granule and ball test
- Mixed media with neutrally buoyant wastes (sponge/paper) test
- Water consumption test

Table 26 details the current requirements along with those from the previous edition of the standard that have either been eliminated or modified.

In addition to these flush performance tests, other tests are performed on the fixture, including tests for trap seal depth and trap seal restoration, and a test for transport of wastes in a drainline.

Drainline Test (to test ability to transport waste through a drainline): Toilet sample is connected to a 4-in. drainline installed at a 2 percent slope. One hundred 0.75-in. diameter floating polypropylene balls are added to bowl water, and toilet is flushed. Average carry distance of balls must be 40 feet or greater.

For dual-flush toilet fixtures, a water exchange test of the reduced or "short" flush is conducted as part of the certification process.

Dye Test (to test water exchange of reduced flush for a dual-flush toilet): 30 ml of dye solution is added to bowl water and mixed and toilet is flushed. Minimum dilution ratio of 17:1 must be achieved (i.e., minimum of 94.1 percent of water must be exchanged during flush).

Certification must be completed by a certified laboratory, such as:

- International Association of Plumbing and Mechanical Officials (IAPMO) Testing and Services, L.L.C., Ontario, CA
- National Association of Home Builders Research Center, Inc., Upper Marlboro, MD
- SGS U.S. Testing Company, Inc., Tulsa, OK
- Canadian Standards Association International (CSA), Toronto Ontario M9W 1R3, Canada
- CSA International, Cleveland OH

[36] As specified in ASME A112.19.2-2003, *Vitreous China Plumbing Fixtures and Hydraulic Requirements for Water Closets and Urinals, an American National Standard* and in ASME A112.19.14-2001, *Six-Liter Water Closets Equipped With a Dual Flushing Device, an American National Standard.*

Table 26. Overview of Performance Tests							
	Performance Tests Previously Within A112.19.6-1995 Standard					**New Mixed Media Tests Within A112.19.2-2003 Standard**	
	Ball	**Granule**	**Surface Wash (Ink Line)**	**Dye**	**Water Consumption**	**Neutrally Bouyant Wastes (Sponge, Paper)**	**Granule & Ball**
Changes from 1995 to 2003 standard	Eliminated from the standard	This test replaced by the Granule & Ball Test	No change - remains in the 2003 standard	Eliminated from this standard (remains in the A112.19.14 dual-flush standard)	No change - remains in the 2003 standard	New test	New test - replaces existing Granule Test: 100 - 1/4" balls added to existing granules
Test Description	100 floating 3/4" polypropylene balls in the bowl	2500 floating granules in the bowl	Water soluble ink line marked 1" below rim of bowl around entire bowl circumference	30 ml of dye solution added to bowl water	Water consumption (flush volume) determined over range of static water pressures (20, 50, and 80 psi)	20 floating sponges (1.1-in by 0.8-in by 0.8-in) and 8 paper balls (Kraft paper) in the bowl; total of 28 media	2500 floating granules in the bowl plus 100 nylon 1/4" diameter balls sinking in the bowl
Performance Requirement	Flush minimum of 75 balls	No more than 125 granules visible in bowl after flush	No more than total of 2" of ink line remaining; no remaining segment longer than 1/2"	Dilution ratio of at least 100:1 shall be achieved after flushing once	Average water consumption (over all 3 pressures) shall not exceed 1.6 gal for "low consumption" units; average may not be more than 2.0 gal at any one pressure.	A minimum of 22 of the mixed media must be flushed out of the fixture on the first flush	No more than 125 granules visible in bowl after flush; no more than 5 balls visible after flush

Drawbacks of the current performance requirements for toilets are:

- The certification test media is not realistic (sponges, plastic granules, plastic granules, Kraft paper).
- The minimum performance requirement is too easy to pass. As such, the use of certification test media may not be indicative of actual performance in the field.
- The certification requirements do not require complete evacuation of the waste in the toilet fixture, whereas in actual practice a consumer expects a complete flush.
- The test results may not be repeatable from lab to lab or operator to operator.

The primary benefits of the current requirements are:

- Certification test media is easy to obtain and to use.
- Certification test media is reusable and inexpensive.

Flushing urinal fixtures are subject to the same national standard for certification (A112.19.2-2003). Performance requirements, however, are limited to a trap seal depth test, a surface wash test, a dye test, and a water consumption test (1.0-gpf maximum).

Non-water urinals of plastic-type materials are subject to a separate standard developed through IAPMO.[37] The ASME is developing a national standard for non-water urinals made of vitreous china, A112.19.19-2005. This standard is scheduled for completion in late 2005.

Non-certification Testing

The two most popular and widely used voluntary non-certification toilet testing programs in North America are the Maximum Performance (MaP) Testing and the testing to the Los Angeles Department of Water and Power (LADWP) Supplemental Purchase Specification (SPS) requirements. The requirements of both these programs will be combined in late 2005 to form the Uniform North American Requirements (UNAR) for toilet fixtures. UNAR is expected to largely replace the separate LA SPS and MaP testing programs.

Maximum Performance (MaP) Testing

MaP testing was created in 2003 by 22 North American water providers and related organizations to identify for their customers those toilet fixtures that provide at least satisfactory flush performance. MaP is voluntary and entirely performance-based. Since publication of the first report in December 2003, four subsequent editions of the MaP testing reports have been published. The latest version, the Fifth Edition,[38] was released in September 2005. This version rates the performance of 176 different toilet fixture models. MaP reports are widely used by consumers, builders, plumbers and plumbing contractors, retailers, distributors, facilities managers and others in their purchase decisions.

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[37] IAPMO/ANSI Z124.9-2004, *Plastic Urinal Fixtures, an American National Standard*.

[38] The MaP Fifth Edition report, which includes the full test protocol, may be downloaded from http://www.cuwcc.org/uploads/product/MaP-5th-Edition-Revised-9-14-05.pdf.

While MaP testing measures the flush performance of all toilets, only those models that can fully remove a minimum of 250g of soybean paste and 4 loose balls of toilet paper while returning a minimum 2-in. trap seal are deemed to meet the minimum MaP performance threshold. The soybean test media is added to the bowl in 50g increments, each of which is contained within a thin latex casing similar to that of a sausage. The 250g benchmark identified in MaP is based on the results of a British medical study and represents the *average maximum* loading for men during the study period. Meeting the 250g minimum score in MaP testing is significantly more difficult than meeting the current minimum performance requirements for certification.[39]

LADWP SPS

The SPS is also voluntary for manufacturers. This standard was developed in 2000 by LADWP, IAPMO, and Koeller and Company in response to concerns by water providers over flapper failure and the ability of plumbers and homeowners to adjust the flush volume of their gravity-flush toilets to more than 1.6-gpf. The SPS[40] focuses on two main areas to improve long-term water savings:

- Use of durable, chemical-resistant flush valve seals
- Restricting maximum flush volumes under maximum adjustment and pressure conditions

In addition to these requirements, the part number for replacement flappers, where applicable, and the manufacturer's phone number must be permanently marked on the interior of the toilet tank, underside of the toilet tank lid, or the overflow tube. In the 2005 revision, to be released shortly, only pilot-type fill valves (i.e., fill valves that do not "creep" and are not typically affected by variations in supply pressures) will be allowed.

Specific provisions within the 2004 version of the SPS are as follows:

Durable/Chemical Resistant Trim:

- Tanks equipped with a flush valve shall contain a flush valve seal that is classified "compliant" when tested in Clorox® (bleach) and 2000 Flushes® (bleach).

Maximum Flush Volume:

- Any in-tank barrier, bucket, or "dam" designed to restrict, retard, or slow the flow of water through the open flush valve shall be tamper-proof and permanently affixed to the tank, such that any attempt to tamper with or remove the barrier or dam by cutting or breaking it shall render the entire tank unusable, and either:

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[39] Of the 44 certified models that were MaP tested for the original work in 2003, 20 failed to meet the minimum 250g benchmark.

[40] A description of the SPS requirements, including the full test protocols, may be found at http://www.cuwcc.com/Uploads/product/LADWP-SPS-ULFTReqs.pdf.

- Maximum capacity of tank (or in-tank water containment vessel) shall not exceed 2.0 gallons or,
- Maximum volume of water discharged by the toilet, when field adjustment of original or replacement tank trim is set at its maximum water-use setting, shall not exceed 2.0 gallons.

Currently, 176 toilet fixtures[41] are certified to the SPS:

- Gravity-flush toilet fixtures 123
- Pressure-assist toilet fixtures[42] 53
- Total 176

There are no known non-certification test protocols for urinal fixtures at this time. However, it is expected that UNAR will be expanded to encompass other plumbing products, one of which will be urinal fixtures.

Technical Issues

Apart from certification and non-certification testing, other performance issues remain in the minds of some consumers that could impede the implementation of a toilet or urinal initiative.

Drainline Transport—Toilet Fixtures

Although anecdotal stories about water-efficient toilets causing drainline plugging are not uncommon, there is little scientific data to date to support such assertions. A recent comprehensive drainline study[43] concluded that efficient toilets flushing with only 1.6 gallons of water could typically transport solid waste greater than 60 feet (200g of waste, 3-in. diameter pipe, 2 percent slope), a carry distance far greater than most residential applications would require. The results of this study agree with the results of the 1992 work completed by Professor John A. Swaffield and Dr. Lawrence S. Galowin.[44]

Toilet flushing accounts for approximately 30 percent of the total indoor water demands of a typical household. By reducing from a 3.5-gpf toilet to a 1.6-gpf model, the total volume of wastewater discharged from a home would be reduced by about 16 percent. Because of the contribution to total wastewater flow received at the treatment plant by inflow/infiltration and from industrial/commercial/institutional facilities, the total reduction in wastewater flows resulting from the replacement of all 3.5-gpf toilets with 1.6-gallon models will be somewhat

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[41] Note: The 176 fixtures currently certified to the SPS are NOT the same 176 fixtures that have been tested to MaP requirements. Eighty fixtures meet the requirements of the SPS and achieve the 250g waste removal threshold of MaP.
[42] Pressure-assist toilet fixtures automatically qualify for certification to SPS requirements.
[43] Canada Mortgage and Housing Corporation and Veritec Consulting, Inc., *Evaluation of Water-Efficient Toilet Technologies to Carry Waste in Drainlines,* March, 2005, http://www.cuwcc.org/uploads/product/Drainline-Report-3-11-05.pdf.
[44] John A. Swaffield,andDr. Lawrence S. Galowin,*To the Limits – Wastes in Drainage Systems – Transport in Drainlines – Unsteady Flow Conditions*, 1992.

(and, in some cases, significantly) less than 16 percent. Conversion to 1.6-gpf toilets should not negatively affect the operation of wastewater treatment plants, and may actually improve the operation (and lower its cost) by concentrating the solids loading.

Non-water Urinal Maintenance and Drainline Issues

Non-water urinals typically use either a mechanical trap or manually replenished non-water liquid trap to prevent sewer gas from passing though the urinal and into the building interior. Although these urinals use no water, there is still some debate regarding their application. This technology elicits the following concerns:

- Literature provided by the manufacturers of liquid-trap designs often says that the proprietary liquid they use must be replenished only every 7,000 uses. Although there is no independent scientific study to support or refute this claim. Anecdotal evidence provided by several installation sites suggests that the actual number may be approximately half of this value. Therefore, non-water urinals may not be as cost-effective to operate as some marketing literature implies. They may actually be more costly to operate than water-using fixtures, particularly where water costs to the end-user do not reflect the real cost of water supply and delivery.
- There is the potential for sewer gas transfer should mechanical seals fail.
- There is the potential for mineral buildup in the drainline. Some installations have reported significant buildup and even total drainline blockage. To date, there is no independent scientific study concerning this issue.[45]
- There is a need for a greater level of maintenance and cleaning for urinals that use no water. A lack of proper maintenance can contribute to odor problems, which is the case with flushing urinals as well.
- There is the potential that HEUs that flush with only one quart of water could better meet customer expectations than the non-water type. High efficiency flushing urinal fixtures (at 1-quart or less) offer almost all of the benefits associated with non-water urinals but none of the potential drawbacks.

[45] It should be noted, however, that reports of buildup and blockage behind non-water urinals do not report on the conditions before the non-water urinal replaced the flushing urinal. Therefore, it is incorrect to imply that such buildup was caused solely by the non-water urinal. Such stories abound and, as a result, the reputation of non-water urinals is damaged, even though the causes of buildup or blockage are not verified.

Appendix: Assumptions for Water Savings Calculations[46]

Residential Toilet Fixtures: Per Unit Fixtures Savings

Replacing 5 gal+ toilet with HET at 1.0:
365 days x 1.31 persons per fixture x 5.1 flushes per day per person x 4.0 gals reduction =
9,754 gals/year/fixture savings

Replacing 5 gal+ toilet with HET at 1.25:
365 days x 1.31 persons per fixture x 5.1 flushes per day per person x 3.75 gals reduction =
9,145 gals/year/fixture savings

Replacing 3.5 gal toilet with HET at 1.0:
365 days x 1.31 persons per fixture x 5.1 flushes per day per person x 2.5 gals reduction =
6,096 gals/year/fixture savings

Replacing 3.5 gal toilet with HET at 1.25:
365 days x 1.31 persons per fixture x 5.1 flushes per day per person x 2.25 gals reduction =
5,487 gals/year/fixture savings

Replacing 1.6 gal toilet with HET at 1.0:
365 days x 1.31 persons per fixture x 5.1 flushes per day per person x 0.6 gals reduction =
1,463 gals/year/fixture savings

Replacing 1.6 gal toilet with HET at 1.25:
365 days x 1.31 persons per fixture x 5.1 flushes per day per person x 0.35 gals reduction =
853 gals/year/fixture savings

Commercial Toilet Fixtures: Per Unit Fixtures Savings

Replacing 3.5 gal+ toilet with HET at 1.0:
260 days x 2.0 flushes per day per person x 3.0 gals reduction =
1,560 gals/person/year

Replacing 3.5 gal+ toilet with HET at 1.25:
260 days x 2.0 flushes per day per person x 2.75 gals reduction =
1,430 gals/person/year

Replacing 1.6 gal toilet with HET at 1.0:
260 days x 2.0 flushes per day per person x 0.6 gals reduction =
312 gals/person/year

Replacing 1.6 gal toilet with HET at 1.25
260 days x 2.0 flushes per day per person x 0.35 gals reduction =

46 Assumptions and calculations provided by John Koeller, Koeller and Company.

182 gals/person/year

Using the current non-farm employment of 133.8 million and the division of fixtures as follows:
- 1.6: 24.0 million
- 3.5+: 20.5 million
- Total: 44.5 million

Assume employment is divided in the same proportion:
- Using 1.6-gpf fixtures: 72.16 million
- Using 3.5-gpf and above: 61.64 million
- Total: 133.8 million persons

We can then determine the average savings per fixture is as follows.

For 3.5+ fixtures replaced with 1.0-gpf HET fixtures:
1560 gals/person/year x 61.64 million persons divided by 20.5 million fixtures =
4,691 gals/toilet/year

For 3.5+ fixtures replaced with 1.25-gpf HET fixtures:
1430 gals/person/year x 61.64 million persons divided by 20.5 million fixtures =
4,300 gals/toilet/year

For 1.6 fixtures replaced with 1.0-gpf HET fixtures:
312 gals/person/year x 72.16 million persons divided by 24 million fixtures =
938 gals/toilet/year

For 1.6 fixtures replaced with 1.25-gpf HET fixtures:
182 gals/person/year x 72.16 million persons divided by 24 million fixtures =
547 gals/toilet/year

Commercial Urinal Fixtures: Per Unit Fixtures Savings

Given the lack of reliable data about the average flush volume of the existing installed base of inefficient product (those installed prior to EPAct 92 effective date), we assumed that their flush volume averaged 2.0-gpf. This is a very conservative figure. We also assumed that one-half of the nations employees were males.

Replacing 2.0-gpf urinal (avg) with HEU at 0.5-gpf :
260 days x 2.0 flushes per day per male person x 1.5 gals reduction = 780 gals/person/year

Replacing 2.0-gpf urinal (avg) with HEU at 1-liter-per-flush (0.26-gpf):
260 days x 2.0 flushes per day per male person x 1.74 gals reduction = 905 gals/person/year

Replacing 2.0-gpf urinal (avg) with HEU 00-gpf:
260 days x 2.0 flushes per day per male person x 2 gals reduction = 1040 gals/person/year

Replacing 1.0-gpf urinal (avg) with HEU at 0.5-gpf :
260 days x 2.0 flushes per day per male person x 0.5 gals reduction = 260 gals/person/year

Replacing 1.0-gpf urinal (avg) with HEU at 1-liter-per-flush (0.26-gpf):
260 days x 2.0 flushes per day per male person x 0.74 gals reduction = 385 gals/person/year

Replacing 1,0-gpf urinal (avg) with HEU 00-gpf:
260 days x 2.0 flushes per day per male person x 1 gals reduction = 520 gals/person/year

The division of fixtures was estimated as follows:

- 1.0-gpf: 2.4 million
- Inefficient (average flush volume of 2.0-gpf): 9.6 million
- Total: 12 million

Using the current non-farm employment of 133.8 million, assuming that one-half were males, and assuming employment is divided in the same proportion as the division of fixtures (above):

- Using 1.0-gpf fixtures: 13.38 million males
- Using fixtures above 1.0-gpf (average of 2.0-gpf): 53.32 million males
- Total: 66.9 million males

We can then determine the average savings per fixture is as follows:

For 2.0-gpf (avg) urinal fixtures replaced with 0.5-gpf urinal fixtures:
780 gals/person/year x 53.32 million males divided by 9.6 million fixtures =
4,332 gals/urinal/year

For 2.0-gpf (avg) urinal fixtures replaced with 1-liter-per-flush (0.26-gpf) urinal fixtures:
905 gals/person/year x 53.32 million males divided by 9.6 million fixtures =
5,026 gals/urinal/year

For 2.0-gpf (avg) urinal fixtures replaced with non-water (0.00-gpf) urinal fixtures:
1040 gals/person/year x 53.32 million males divided by 9.6 million fixtures =
5,776 gals/urinal/year

For 1.0-gpf (avg) urinal fixtures replaced with 0.5-gpf urinal fixtures:
260 gals/person/year x 13.38 million males divided by 2.4 million fixtures =
1,450gals/urinal/year

For 1.0-gpf (avg) urinal fixtures replaced with 1-liter-per-flush (0.26-gpf) urinal fixtures:
385 gals/person/year x 13.38 million males divided by 2.4 million fixtures =
2,146 gals/urinal/year

For 1.0-gpf (avg) urinal fixtures replaced with non-water (0.00-gpf) urinal fixtures:
520 gals/person/year x 13.38 million males divided by 2.4 million fixtures =
2,899 gals/urinal/year