



Waterless Urinals Report and Evaluation

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EXECUTIVE SUMMARY

The Massachusetts Environmentally Preferable Products (EPP) Procurement Program, based in the Commonwealth's central purchasing office, the Operational Services Division (OSD), uses the Commonwealth's purchasing power to reduce the environmental and public health impact of state government activities and foster markets for environmentally preferable products. In recent years, the EPP program has added waterless urinals to the list of green products that public agencies can purchase from state contracts. Massachusetts evaluated the performance of waterless urinals to assess whether, and how, waterless urinal installation should be scaled-up in public buildings in the Commonwealth. The consulting firms Aceti Associates and IEc conducted the analysis.

COSTS AND SAVINGS OF WATERLESS URINALS

Conventional urinals use between one to three gallons of water per flush. Thus, replacing conventional urinals with waterless versions yields significant water savings. For example, in a workplace with 1,000 men, replacing conventional urinals with waterless urinals would result in savings of approximately 1.56 million gallons annually, and an estimated \$21,000 in water and sewer costs.

Initial costs for waterless urinals vary depending on the price of the fixtures and the price of installation. In new construction, up-front savings can result from eliminating water supply lines, flush valves, sensors, and in some jurisdictions, drainage hook up charges. Annual costs for servicing waterless urinals vary depending on need, price, and longevity of replaceable cartridge traps, proper usage of liquid sealant, and any specialized cleaning products where recommended. For a workplace with 1,000 men, these costs range from approximately \$1,200-\$4,700 annually.

According to the U.S. Army Engineer Research and Development Center, simple payback time typically ranges from ½ to 3 years for new installation and retrofit with waterless urinals.

IMPLEMENTATION EXPERIENCE OF WATERLESS URINALS

We conducted interviews with facility managers and custodians that maintain waterless urinals at ten facilities, including offices, educational buildings, gyms, dorms, and one prison. Seven of the ten facilities reported an overall positive experience with waterless urinals; two facilities reported an overall negative experience, and one facility had a mixed experience. Facilities that installed waterless urinals as part of new construction had uniformly positive overall outcomes, reporting only isolated problems. In contrast, retrofit projects posed additional challenges that need to be addressed at installation to ensure proper functioning.

A facility's maintenance protocol and the type of urinal cartridge used appears related to implementation experience at some facilities. The two facilities interviewed that have had negative experiences with waterless urinals are a dormitory and a prison. In addition to the retrofit issues

discussed above, it appears that problems experienced at these facilities are exacerbated by 1) the relatively high, constant use that these urinals receive and 2) the potential for misuse and unmet needs for more frequent cartridge changes. Three potential factors studied do not appear to influence implementation experience: lack of maintenance staff training (all facilities report adequate training); mixed installation (i.e., conventional and waterless installed urinals in the same building); and the age of the urinal (facilities did not report an increase in problems with older waterless urinals).

RECOMMENDATIONS

IEc and Aceti Associates developed the following recommendations for waterless urinal diffusion based on the research and analysis conducted for this project:

- Waterless urinals appear to work well in most settings. The Commonwealth should continue to support their diffusion given the significant water conservation and water cost savings provided by the technology.
- Installation of waterless urinals is more straightforward during new construction. Retrofitting waterless urinals in existing bathrooms without renovation poses some challenges but can be accomplished successfully. Prior to a retrofit project, it is imperative that facilities 1) ensure that the slope of the drain line is ample, and 2) route drain lines to avoid problems such as sediment build up and 3) check that drain heights are appropriate to the brand to be purchased. Facilities are far less likely to encounter problems with retrofit projects if they make these preparations.
- Waterless urinals are being used successfully at stadiums, airports, offices, academic buildings, gyms, and a wide variety of other settings, and we recommend widespread diffusion of the technology. However, we do not recommend continued installation in dorms or prisons, which have experienced significant problems with waterless urinals. These problems appear to be due in part to resident misuse and limited availability of maintenance. Availability of maintenance staff is important for both daily cleaning and frequent cartridge changes/refills at facilities with high user loads.
- Facilities exploring the installation of waterless urinals should conduct cost, savings, and payback calculations. These calculations should include: unit cost, installation cost, cartridge replacement cost, cleaning supply cost, and water savings. These calculations should be based on facility-specific information including the number of conventional urinals to be replaced, the number of men at the facility, and water rate. In addition, calculations should be based on brand-specific information because cleaning supply and cartridge costs vary significantly by brand.
- Checking and changing waterless urinals cartridges often leads to escape of sewer gas in the bathroom, causing a temporary but significant odor problem. To avoid unpleasantness of sewer gas escape during cartridge changes, OSD or its vendors should communicate a flushing protocol to waterless urinal customers.

INTRODUCTION

The Massachusetts Environmentally Preferable Products (EPP) Procurement Program, based in the Commonwealth's central purchasing office, the Operational Services Division (OSD), uses the Commonwealth's purchasing power to reduce the environmental and public health impact of state government activities and foster markets for environmentally preferable products. In recent years, the EPP Program has added waterless urinals to the list of green products that public agencies can purchase from state contracts. By eliminating the need for flush water, waterless urinals provide significant water savings and can also yield cost savings.

Massachusetts evaluated the performance of waterless urinals to assess whether, and how, waterless urinal installation should be scaled-up in public buildings in the Commonwealth. The purpose of this report is to better understand the implementation experience of facilities that have installed waterless urinals and the factors that contribute to a successful experience with this technology.

This report begins with a Technology Overview section, which describes waterless urinal technologies currently on the market in the U.S., compares the distinguishing features of different waterless urinal models, and discusses maintenance protocols and installation considerations. A discussion of environmental and economic benefits is also included. Next, this report presents the waterless urinal implementation experience at facilities included in this evaluation, including installation experience, and experience with use, maintenance and repair. Finally, we present recommendations for moving forward based on a synthesis of findings.

WATERLESS URINALS: TECHNOLOGY, CHALLENGES, BENEFITS AND APPLICATIONS

TECHNOLOGY

Waterless urinals resemble conventional urinals. The fixtures are typically made of vitreous china and are offered in white and a variety of colors. A few manufacturers have models in fiberglass reinforced polyester composite or stainless steel.¹ ADA compliant models are available. Waterless urinals do not use water or have flush mechanisms. Urine, which is 96% water, flows into the drainpipe system using gravity. Waterless urinals connect to standard 2-inch drain lines, but require no water supply piping.²

At least eight companies sell waterless urinals in the United States. These include Duravit USA, Ecotech Water LLC, Falcon Waterfree Technologies, Kohler Co., Sloan Valve Co., Waterless Co., ZeroFlush and Zurn Industries, LLC. Waterless Co. NoFlush™ Urinals are available on statewide contract FAC29 through Custodial Partners. OSD plans to solicit other technologies via a new statewide contract during calendar year 2009.

This overview of waterless urinal technology covers the following topics:

- Technologies currently on the market in the U.S.;
- Maintenance protocols and considerations;
- Authorization provided by plumbing codes for installation of the various technologies;
- Special considerations for installation in retrofit projects;
- Examples of waterless urinal use in a variety of locales and building types in New England and beyond;
- Incentives offered for installation; and
- Environmental, economic and hygienic benefits that can result from waterless urinal use.

Trap Designs and Maintenance Protocols

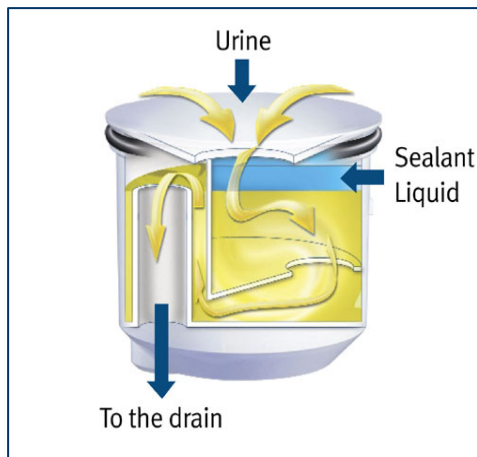
While flush urinal fixtures have a water-filled trap that prevents sewer gas from rising through the pipes, most waterless urinals utilize proprietary sealant liquids that act as a vapor trap. The liquids are composed primarily of oils or alcohols that are lighter than water. Urine passes through this liquid and flows down the drain. The sealant liquid, except for a tiny amount carried down the drain with each use, remains in place to trap odors and prevent them from entering the restroom.³

Manufacturers use three main types of drain trap designs.

Replaceable Trap Cartridge or Insert

Falcon, Sloan and Waterless brand urinals feature a removable, disposable plastic cartridge that is inserted into the fixture's drain opening. A typical design is shown in Figure 1. The trap designs do vary somewhat by manufacturer.

FIGURE 1. REPLACEABLE TRAP CARTRIDGE⁴



The cartridges must be replaced periodically. Falcon and Sloan (Sloan sells Falcon's urinals and cartridges) recommend that the cartridge be replaced after every 6,000 to 7,000 uses.⁵ Liquid sealant is added at the time of cartridge replacement.⁶ Liquid sealant is also added to Waterless No-Flush Urinal cartridges when cartridges are replaced after every 7,000 – 10,000 uses, and replenished in between cartridge replacements, approximately every 1,500 uses.^{7, 8}

ZeroFlush urinals have a built-in trap in the fixture drain, similar to the design in Figure 1. A removable, disposable insert placed into the fixture forms the center and top of

the trap. The insert is replaced and sealant liquid added approximately every 15,000 uses.

Zurn urinals have a trap similar to the design in Figure 1. The trap is reusable, and is removed, cleaned and placed back into the fixture's drain opening after each approximately 9,000 uses. Liquid sealant is added after every 3,000 uses and after the trap is cleaned.⁹

The tops of replaceable trap cartridges/inserts serve as strainers. They feature small holes that allow urine to flow into the trap, but that prevent unwanted material such as chewing gum or cigarette butts from entering the trap.¹⁰

Urine Sediments

Urine, while 96% water, contains small amounts of dissolved solids. Some users have expressed concern about build up of urine sediments in drain pipes when using waterless urinals.¹¹ However, studies on the corrosive effects of urine on drain pipes have shown that build up is due more to the mineral content of water than to urine. While some waterless urinal users report that they rout their drain lines annually to keep them clear, other users have reported no build up problems.¹²

Each drain trap design and its corresponding maintenance protocol do have features that seek to prevent sediment build-up. Between urinal uses, some urine remains in the replaceable trap cartridge shown in Figure 1. Some of the solids settle out during that time and remain in the trap. However, some solids remain dissolved, and with each successive urinal use, urine containing these dissolved solids flows down the drain pipe.¹³ In order to flush down any soft sediments that have accumulated in the drainpipe between cartridge or insert replacements, maintenance protocols generally call for two to five gallons of water to be poured down the drain after the cartridge trap or insert is removed for replacement.¹⁴

Built-In Traps

Kohler and Duravit urinals have built-in traps, of a design shown in Figure 2.

FIGURE 2. BUILT-IN TRAP¹⁵



Maintenance for these traps involves flushing the system every 2 to 4 weeks with a several gallons of water. Duravit sells an adaptor unit that hooks up to a hose and allows flushing to be done at higher water pressure. Duravit recommends high pressure flushing. New liquid sealant is added after flushing is completed.¹⁶ Kohler recommends use of a cleaning liquid that dissolves urine sediments that build up in the trap, followed by flushing with water.¹⁷

Kohler waterless urinals have a removable strainer in the fixture that prevents unwanted materials from entering the trap.¹⁸ Duravit fixtures have three built-in drain holes in the urinal bowl.¹⁹

Long Lasting Cartridge with Self-Sealing Valve

EcoTech Water urinal cartridges use a permanent, self-sealing valve that does not utilize a liquid sealant. The EcoTech valve and cartridge are shown in Figures 3 and 4.

FIGURES 3 AND 4. SELF-SEALING VALVE AND CARTRIDGE²⁰



The self-sealing valve is treated to roll up when liquid is not passing through it, but flexible enough to open and permit liquid flow, from a drip to high rate flows. When the valve is closed, or when liquid is passing through it, the valve prevents sewer gas from entering the restroom. While cartridges with self-sealing valves can be removed if need be, they are designed to remain in place and last for many years. Ecotech provides a lifetime warranty on the cartridge, should any defect or malfunction occur within the lifetime of the urinal into which it was originally installed.²¹ Ecotech sells its own urinal fixture. However, Ecotech also sells its cartridges for use in waterless urinals manufactured by other companies.²²

Ecotech sells a cleaning product that helps to control the build-up of urine sediments on the Eco Urinal Cartridge self-sealing valve and potentially in drain lines. The firm's literature recommends that the Eco Urinal cartridge be removed and checked every month or so, and that cleaning fluid be applied if build-up is occurring.²³ The firm's representatives suggest that the periodic cartridge removal and check can be discontinued after a time if no build-up is occurring.²⁴

Table 1 summarizes the information provided above regarding waterless urinal trap designs and maintenance protocols.

TABLE 1. TRAP DESIGNS AND MAINTENANCE PROTOCOLS

VENDOR	FALCON/SLOAN	WATERLESS	ZEROFLUSH	ZURN	DURAVIT	KOHLER	ECOTECH
Trap Design	Replaceable Trap Cartridge or Insert				Built-In Trap		Permanent Cartridge
Trap Sealant	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid	Self-Sealing Valve
Permitted by MA Plumbing Code?	Yes	Yes	Yes	Yes	Yes	Yes	No (see page 12)
Trap Maintenance Protocol	Replace trap cartridge after every 6,000 to 7,000 uses. Add liquid sealant at time of cartridge replacement. Flush drainpipe with water before inserting new cartridge.	Replace trap cartridge after every 7,000 to 10,000 uses. Add liquid sealant at time of cartridge replacement, and replenish it after approx. 1,500 uses. Flush drainpipe with water before inserting new cartridge.	Replace trap insert after approx. every 15,000 uses. Add liquid sealant at time of insert replacement. Flush drainpipe with water before inserting new cartridge.	Remove, clean and replace trap after approx. 9,000 uses. Add liquid sealant at time of trap cleaning and replenish it after approx. 3,000 uses. Flush drainpipe with water before inserting new cartridge.	Every month or 3,000 uses, whichever comes first, flush trap with water. ²⁵ Flushing at high water pressure recommended.	Every 2 to 4 weeks, dissolve sediment in trap with cleaning liquid and flush with water.	If build up is occurring on valve, remove trap cartridge every two months, apply cleaning fluid and replace. ²⁶

Liquid Sealants - Environmental Considerations

A State of Minnesota Department of Administration website posting in 2004 described an Oregon Department of Parks and Recreation pilot installation of waterless urinals. The description mentioned that “one brand’s sealant has a pesticide that raises objections and carries an Environmental Protection Agency warning. Oregon officials claim the pesticide’s concentration is so small it would not be harmful in a drain field.”²⁷

David Haas, Environmental Analyst for the Commonwealth of Massachusetts Office of Technical Assistance and Technology, reviewed Material Specification Data Sheets for liquid sealants used by Duravit, Falcon/Sloan, Kohler, Waterless, ZeroFlush and Zurn. Mr. Haas concluded that the Kohler liquid sealant appeared to have undergone the most comprehensive review. The Kohler MSDS lists 100 percent of the components and provides answers other than “Not Applicable” for all sections. Based on the information available in the Material Specification Data Sheets, Mr. Haas also concluded that the Kohler liquid sealant is likely to be the most environmentally friendly. It has the lowest overall National Fire Protection Association (NFPA) rating; and has apparently considered the ecological consequences of use (biodegradable and phosphate –free).²⁸

Maintenance Considerations

Daily Cleaning

All waterless urinal manufacturers recommend a daily wipe down of the inside and outside of the fixture with a surface cleaner and soft cloth, as well as removal of any debris caught by the strainer. Duravit, Falcon/Sloan and Kohler recommend using their proprietary cleaners to wipe down the fixture surface.²⁹ The Kohler cleaner is the same fluid used to dissolve sediments in the trap once or twice per month.³⁰

Daily cleaning procedures for flush urinals frequently include pouring a bucket of water down the drain. Most manufacturers of waterless urinals with liquid sealant traps emphasize that pouring a bucket of water down the urinal will flush away the liquid sealant, leading to the escape of sewer gas into the restroom, as well as the need to replace the cartridge trap and/or sealant prematurely. Among the manufacturers of liquid sealant traps, only ZeroFlush indicates that their trap is engineered to withstand a typical bucket of water poured into the trap.³¹ The manufacturers of Ecotech cartridges indicate that their cartridges, made with self-sealing valves, can be flushed with water at any time.³²

This difference between maintenance procedures for flush urinals and waterless urinals with liquid sealant traps points to the importance of proper training of custodial staff in caring for waterless urinals. This can be a challenge if the facility does not have good oversight or control over who is doing the maintenance, or if there is a mixed installation (i.e. some buildings or locations with flush urinals cleaned with water and some with waterless urinals which require different cleaning procedures).³³

Odor Prevention

For liquid sealant systems, replacing the cartridge or adding liquid sealant before the sealant is fully depleted is key to preventing odor problems. This is another reason that proper training of maintenance personnel is important. Facility managers can make a preliminary estimate of how often

each urinal's cartridge will need to be changed or liquid sealant added, based on the number of males in the facility, the number of urinals, the estimated number of urinal uses per male per day and the number of days per week that the facility is in use. However, because the rate of depletion of the liquid sealant is dependent upon the actual usage of each urinal, some trial and error is involved in preventing odors while avoiding premature or overly frequent cartridge replacements or trap servicing.

Falcon/Sloan and ZeroFlush indicate that because of their trap designs, their traps will fill with sediment well before the liquid sealant is depleted. For this reason, slow urine flow and/or liquid sealant rising through the drain holes in the top of the cartridge or insert will signal that the cartridge/insert is overdue for replacement, rather than odor problems.³⁴ In a restroom with more than one waterless urinal, slow flow or the appearance of liquid sealant in the urinal bowl may make it easier to pinpoint which individual fixtures require a new insert or cartridge. When restroom odor signals the need for trap maintenance, servicing all of the waterless urinal traps in the restroom may seem easier and less unpleasant than identifying which urinal needs maintenance. However, approaching trap maintenance in this fashion can increase a facility's costs for trap cartridges and liquid sealant.³⁵

Some facilities managers have mentioned that the escape of sewer gas into the restroom when cartridges/inserts are removed from waterless urinals for replacement or cleaning can make this task quite unpleasant.³⁶ One manufacturer suggests that pouring a bucket of water down the drainpipe immediately upon removal of the cartridge/insert can reduce the odor.³⁷ Another recommends spraying deodorizer into the open trapway after the cartridge trap has been removed to control urine odors.³⁸ The Falcon Waterfree online store offers a foaming housing cleaner that "provides an instant odor block during the cartridge change process while helping clean the urinal housing."³⁹ There are some reports that use of urinals with trap designs shown in Figures 2 and 3 ameliorate this problem,⁴⁰⁴¹⁴² but, in general, very little overall experiential feedback on these trap designs was available for this report. See the "Implementation Experience" section of this report for some additional comments.

Table 2 summarizes a number of maintenance considerations that facilities should take into account when selecting and maintaining waterless urinals.

Installation

Plumbing Code

Almost all jurisdictions and plumbing codes permit the installation of waterless urinals with liquid sealant traps.⁴³ Waterless urinals with liquid sealant traps are covered within two American National Standards Institute (ANSI) standards: American Society of Mechanical Engineers (ASME) A112.19.19-2006 for vitreous china non-water urinal fixtures and International Association of Plumbing and Mechanical Officials (IAPMO) Z124.9-2004 for plastic urinal fixtures. Some locales, including the Commonwealth of Massachusetts,⁴⁴ do not currently allow the installation of urinals with self-sealing waterless waste valves of the type shown in Figure 3. These urinals are listed by IAMPO as qualifying to "IAPMO Guide Criteria for Waterless Urinals, IGC 161-2006a."⁴⁵ The Massachusetts plumbing code requires that traps have a liquid seal.⁴⁶ Further, the state's plumbing

code prohibits self-sealing waste valves under a provision barring mechanical traps. Mechanical traps are not allowed because of the potential for malfunction.⁴⁷

TABLE 2. MAINTENANCE CONSIDERATIONS

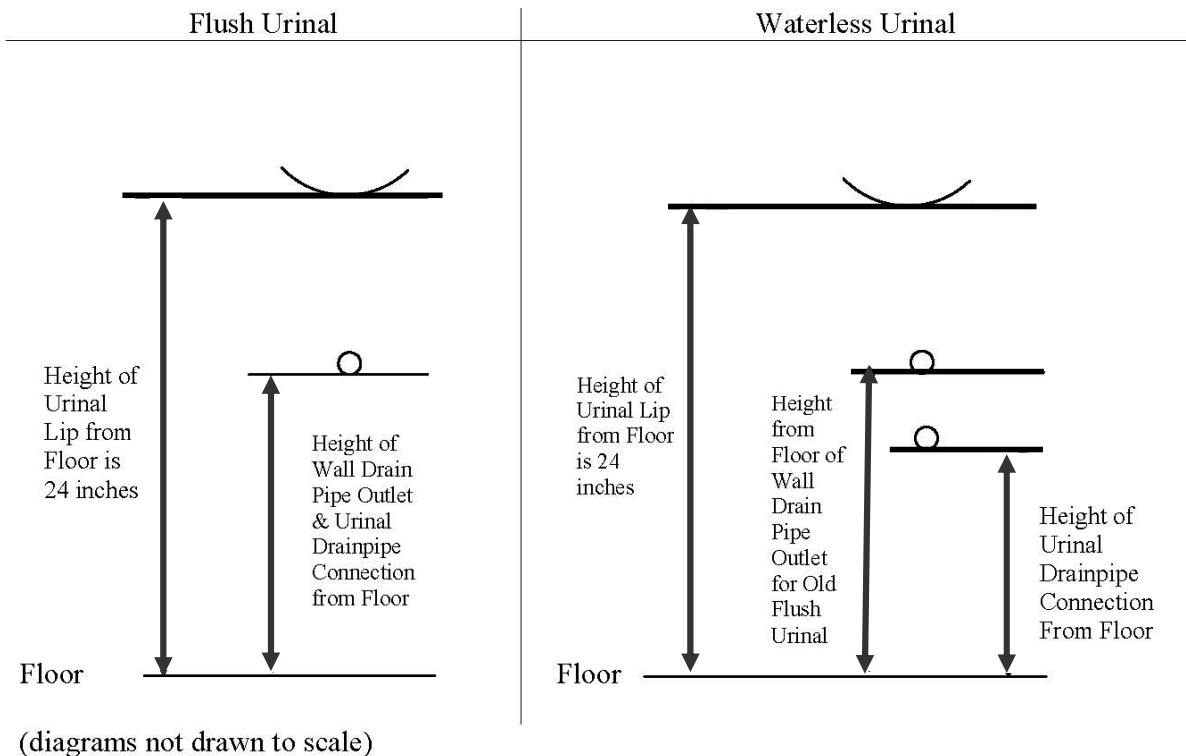
<p>DAILY CLEANING</p> <ul style="list-style-type: none"> • Some waterless urinal manufacturers recommend use of their proprietary surface cleaner for daily wipe down of the fixture. • Pouring a bucket of water down the drain is often part of the daily cleaning procedures for flush urinals, but will lead to odor problems and higher replacement costs for trap cartridges and/or liquid sealant for most brands of waterless urinals. Proper training of custodial staff is key. <p>ODOR PREVENTION</p> <ul style="list-style-type: none"> • For most liquid sealant systems, replacing the cartridge or adding liquid sealant before the sealant is fully depleted is key to preventing odor problems. Proper training of custodial staff is key. <ul style="list-style-type: none"> ○ For some liquid sealant traps, slow urine flow and/or liquid sealant appearing in the urinal bowl will signal that the cartridge/insert is overdue for replacement, rather than odor problems. This makes it easier to pinpoint which urinals need maintenance. • The escape of sewer gas into the restroom when cartridges/inserts are removed from waterless urinals for replacement or cleaning can make this task unpleasant. <ul style="list-style-type: none"> ○ Flushing with water immediately upon cartridge removal, or the application of deodorizers/cleaners to the open trapway may reduce sewer gas odor.

The process of installing waterless urinals is similar to the process for flush urinals. Waterless urinals are used both in new construction and to replace existing flush urinals. However, a number of special considerations may affect feasibility of use or installation costs in retrofit projects.

Drainpipe Height

In order to achieve a proper lip height, waterless urinals may require a lower drainpipe outlet than the flush urinals they are replacing. Plumbing codes often limit how high a urinal lip may be from the floor. In Massachusetts, the Architectural Access Board regulates the lip height for ADA compliant urinals. The lip height for non-ADA urinals is at the manufacturer's recommendation.⁴⁸ A 24" floor-to-lip height is common.⁴⁹ In some cases, waterless urinal fixtures have a longer vertical distance between the urinal lip and the drainpipe connection than flush urinals. Therefore, if the lip of a waterless urinal is to be at the proper height, the fixture's drainpipe connection may fall below the drainpipe outlet in the wall used for the flush urinal being replaced. Figure 5 illustrates this situation.

FIGURE 5. POTENTIAL DRAINPIPE CONNECTION ISSUE



Some brands of waterless urinals can be installed at the typical drain height for siphon-jet flush urinals. However, waterless urinals are less likely to be compatible with the typical drain height for wash-out flush urinals.⁵⁰

If an existing drainpipe height is incompatible with the height needed for a particular brand of waterless urinal, one option is to lower the drainpipe in the wall. However, this added expense may put a retrofit out of reach for some facilities.⁵¹ It may be possible to identify another brand or model of waterless urinal that can be installed at the existing drain height. The extra space needed to accommodate a cartridge trap in a waterless urinal fixture has been suggested as a reason why brands with this trap design require a lower drain height in order to comply with the recommended lip height.⁵² On the other hand, with the trap design shown in Figure 2, Kohler claims that they can replace Kohler flush urinals with Kohler waterless urinals without drainpipe height adjustments.⁵³

Drainpipe Slope

Another consideration for retrofit projects is that drain lines need to slope at least $\frac{1}{4}$ inch per foot to insure sufficient flow, and cannot be made of copper pipe, which corrodes. (Test kits are available to determine if drainpipes are sloped properly for retrofit. See <http://www.falconwaterfree.com/pdf/029-Pitch.pdf>.)⁵⁴ Finally, care must be taken in retrofits because some old pipes develop a reverse slope over the years. While this is not a problem with flush urinals, it tends to cause problems with waterless units.⁵⁵

Falcon/Sloan claims that they can create the proper ¼ inch per foot slope within the drainpipe, if necessary. They install a 1½” diameter tube within the existing 2” diameter drainpipe. The tube is attached to the fixture’s drainpipe connection at one end and can run at a slope the full 6 to 10 inch length of the drainpipe to empty directly into a vertical stack pipe.⁵⁶

Prior Build-up in Drainpipes

If pipe narrowing has occurred due to prior urine sediment build-up in drain lines to which waterless urinals are retrofitted, flow problems or back ups can occur. While flushed water can force its way through a narrowed pipe, gravity-fed urine is more likely to be obstructed in this situation.⁵⁷ Not only can this affect urinal function, but further precipitation of solids can occur if urine remains in the drain pipe rather than promptly flowing through. In this case, encrustation in the pipe worsens.⁵⁸ Therefore, for retrofit projects, drain lines should be cleaned out with a power sewer snake with a rotating cutter head before waterless urinals are installed.⁵⁹

Drainpipe Maintenance

The ease of snaking drainpipes once waterless urinals have been installed is a factor worth considering in both new construction and retrofits. The diameter of the drainpipe connection in waterless urinal fixtures ranges from ¾” to 2”, depending on the brand. Those drainpipe connections with a diameter less than 2” are attached to a 2” drainpipe using an adaptor. Some facilities managers have expressed a preference for a 2” diameter connection, which makes it much easier for the drainpipe to be snaked, if necessary, without removing the urinal fixture from the wall.⁶⁰

Falcon/Sloan claims that their fixture drain connection diameter of 1 ½”, allows a 1¼” hand snake with bulb (gimlet) head can be used without removing the fixture from the wall. A drill (drum) auger of same size and type can also be used if deployed slowly and carefully.⁶¹ However, a 2’ drainpipe connection allows a 1 ½” snake to be used without removing the fixture.⁶²

Table 3 summarizes possible installation issues that facilities should be aware of.

APPLICATIONS

Waterless urinals have been in use in the U.S. and abroad for 15 years.⁶³ Waterless urinals are used in a wide variety of locales and building types. In Massachusetts, waterless urinals are in place at:

- Retail properties such as Faneuil Hall in Boston,⁶⁴ the IKEA in Stoughton⁶⁵ and Simons Properties malls in Saugus, Braintree, Burlington, and Chestnut Hill;⁶⁶
- Corporate properties such as Genzyme’s headquarters in Cambridge⁶⁷ and Boston Scientific in Natick;⁶⁸
- Institutions of higher education such as Harvard University,⁶⁹ Quinsigamond Community College in Worcester and the University of Massachusetts at Dartmouth;⁷⁰
- Municipal properties such as Boston City Hall, the Brookline Health Department, the Needham Public Library⁷¹ and the Concord/Carlisle High School Pool locker rooms;⁷² and
- Travel facilities such as Logan Airport’s Terminal A.

The experiences of a number of public and private facilities in Massachusetts using waterless urinals are described in detail later in this report.

TABLE 3. INSTALLATION ISSUES

<p>PLUMBING CODE</p> <ul style="list-style-type: none"> • Massachusetts plumbing code does not currently allow the installation of urinals with self-sealing valves. <p>RETROFIT PROJECTS</p> <ul style="list-style-type: none"> • <i>Correct Drain Pipe Height.</i> Some waterless urinals may require a lower drainpipe height than the flush urinal being replaced. In this case, options are to: <ul style="list-style-type: none"> ○ Lower the drainpipe in the wall. This will add expense to the waterless urinal installation. ○ Try to identify another brand or model of waterless urinal that can be installed at the existing drain height. • <i>Proper Slope and Drain Pipe Material.</i> Existing drain lines must slope at least ¼ inch per foot to insure sufficient flow, and cannot be made of copper pipe, which corrodes. <ul style="list-style-type: none"> ○ Falcon/Sloan can install a tube within the existing drainpipe to create the proper pitch, if necessary. ○ Existing drain lines must not have a reverse slope. ○ Drain lines must be clean before urinal installation. <p>DRAINPIPE MAINTENANCE</p> <ul style="list-style-type: none"> • Waterless urinals with a drainpipe connection diameter of 2” can make it easier for the drainpipe to be snaked without removing the fixture from the wall.

Elsewhere in New England, waterless urinals are installed at:

- Institutions of higher education such as the University of New Hampshire, the University of Vermont⁷³ and Yale University;⁷⁴ and
- Tourism destinations and travel facilities, such as Mount Snow in Vermont, the Sunday River Ski Resort in Maine⁷⁵ and Maine Turnpike rest stops.⁷⁶

Across the country, waterless urinals are in place at:

- Military Bases. Waterless Co. LLC indicates that they have projects at about 20% of the major military bases in the U.S. Several of their larger projects are at North Island Naval Air Station in San Diego, CA, with 217 urinals, and the U.S. Army facility at Fort Huachuca, AZ with 240 Waterless urinals.⁷⁷

- Federal facilities such as NASA/JPL in Pasadena, CA, as well as many national parks, U.S. Post Offices and GSA federal buildings.⁷⁸
- State facilities, including many of the nineteen office buildings that are part of the New York State Office of General Services campus in Albany.⁷⁹ The state of Arizona has required all urinals installed in state buildings after January 1, 2005 to be water free fixtures.⁸⁰
- County facilities. As of April, 2007, Lee County, Florida had over 100 waterless urinals installed in county buildings. The urinals in all new Lee County buildings are waterless, and the County plans to spend up to \$100,000 per year retrofitting older buildings with waterless urinals.⁸¹
- Municipal facilities such as Chicago City Hall and city buildings in Fort Collins, Colorado.⁸²⁸³
- Schools, such as Millenium Elementary School in Kent, WA,⁸⁴ San Dieguito Union High School District in San Diego,⁸⁵ El Paso, Texas Independent School District⁸⁶ and the University of Washington.⁸⁷
- Tourism destinations such as the Venetian Hotel and Casino in Las Vegas and Walt Disney World.⁸⁸⁸⁹

Across the country, waterless urinals are installed in a number of facilities that see significant use, such as:

- Stadiums. The baseball stadium in Lee County, Florida where the Red Sox have had their spring training facility has been completely converted to waterless urinals.⁹⁰ Arizona Stadium, an outdoor football stadium on the campus of the University of Arizona in Tucson, has a seating capacity of 57,803.⁹¹ As a result of the installation of waterless urinals, the stadium saves 22,000 gallons of water *per game*— about enough water to fill an average backyard swimming pool.⁹²
- Airports. The Denver International Airport and the Baltimore-Washington International Airport, as well as London’s Heathrow Airport in Great Britian have been converted to waterless urinals.⁹³⁹⁴⁹⁵

INCENTIVES

Several cities and water systems, including Austin, TX, Seattle, WA⁹⁶ and the Metropolitan Water District of Southern California,⁹⁷ offer rebate incentives for the installation of urinals that don’t use water. Further, many new construction projects underway are becoming certified as “green buildings” under the LEED (Leadership in Energy and Environmental Design) program developed by the U.S. Green Building Council.⁹⁸ Installing waterless urinals can help garner points towards LEED certification through the Innovative Wastewater Technologies Credit (by reducing potable water use for sewer conveyance) and through the Water Use Reduction Credit (by maximizing water efficiency within buildings). The 30% reduction necessary to earn two points for the Water Use Reduction Credit is achievable by using low-flow lavatory faucets with automatic controls (typically sufficient to achieve a 20% reduction in water use) and waterless urinals, which typically achieve an additional 14% reduction.⁹⁹

All new construction and major renovations undertaken by state agencies in Massachusetts must meet the Massachusetts LEED Plus green building standard.¹⁰⁰ Massachusetts LEED Plus requires obtaining the basic LEED certification, as well as attainment of specific LEED credits, including the incorporation of strategies that will conserve 20% of building water use (*LEED-NC Version 2.2, Water Efficiency, Credit 3.1*).¹⁰¹

BENEFITS

Environmental Benefits

Water Savings

Most of the 8 to 9 million flush urinals in the U.S. average 3.0 gpf, although the newer models use 1.0 gpf or less. Therefore, most waterless urinals save 1 to 3 gallons of water per use, depending on the model of flush urinal being replaced. Water savings by building will vary depending on use. However, in a small office building with 2 urinals and 25 males working 260 days per year, assuming 3 urinal uses per male per day, water usage can be reduced by 19,500 gallons annually by substituting waterless urinals for 1.0 gpf units. Annual water usage can be reduced by 58,500 gallons by replacing 3.0 gpf units with waterless urinals.¹⁰² Waterless urinals also eliminate the possibility of water loss due to leaking flush valves.¹⁰³

Other Environmental Benefits

When cities and other water supply agencies do not have to pump and treat as much water and sewage, energy use is reduced.¹⁰⁴ If the use of waterless urinals is scaled up, they can reduce the amount of affluent flowing to sewer systems, thereby preventing water pollution by reducing the incidence of combined sewer overflows.

Economic Benefits

According to the U.S. Army Engineer Research and Development Center, simple payback time typically ranges from ½ to 3 years for new installation and retrofit with waterless urinals.¹⁰⁵

Overview: Costs and Savings

Several manufacturers' websites feature worksheets for calculating the costs, savings and payback times associated with waterless urinals. Sample worksheets can be found at <http://www.waterless.com/savings.php>, and http://www.zeroflush.com/savings_analysis.php. An overview of the costs and savings associated with waterless urinals is presented below. The overview is followed by sample figures for costs and savings associated with waterless urinals.

Up-Front Costs

Initial costs for waterless urinals vary depending on the price of the fixtures and the price of installation.

Up-Front Savings

In new construction, savings can result from the elimination of water supply lines, flush valves, sensors and, in some jurisdictions, drainage fixture hook up charges.^{106 107} However, proposed changes to the Massachusetts plumbing code will require water supply piping to be installed in new construction even in instances where waterless urinals are specified. While water supply piping is not used for waterless urinals, it is anticipated that it will be required in case a facility chooses to replace waterless urinals with flush urinals at a future date.¹⁰⁸

Annual Savings

Annual savings from installing waterless urinals vary depending on the flush volume of replaced urinals, the number of urinal uses per day, and water and sewer rates.¹⁰⁹ Additional savings can come from the elimination of parts and labor costs for repair and/or replacement of flush valves and sensors.

Annual Costs

Annual costs vary depending on the need for, price of and longevity of replaceable cartridge traps and need for, quantity required and price of liquid sealant and cleaning products.

Sample Costs and Savings

The following tables display sample costs and savings for waterless urinals.

Up-front Costs

Purchase prices for four waterless urinal brands and representative flush urinals were compiled by the US Army Corps of Engineers' Engineer Research and Development Center's Construction Engineering Research Laboratory in 2006. They are shown in Table 4 and do not include the cost of installation.

TABLE 4. PURCHASE PRICES FOR WATERLESS AND FLUSH URINALS

BRAND	DURAVIT	FALCON/ SLOAN	WATERLESS	ZEROFLUSH	REGULAR FLUSH URINAL - AMERICAN STANDARD INC.	AUTOMATIC FLUSH URINAL - AMERICAN STANDARD, INC.
Price of Urinal Fixture	\$626.50 (retail on web)	\$240	\$393 - 408	\$399	\$206.38	\$204.10
Price of Ancillary Parts and Equipment	\$104 ¹¹⁰ for high pressure flushing adaptor				\$83.56 ea Flush Valve: Sloan Valve 180-1 Royal Urinal Flushometer	\$278.37 ea Sloan Auto Flush Valve: Sloan Valve 8186 G2 Optima 1.5 gal
Total Purchase Price	\$730.50	\$240	\$393-\$408	\$399	\$289.94	\$482.47

Table 4 shows that up-front purchase prices for waterless urinals can be more or less than for flush urinals, depending on brand and type.

Annual Savings

The annual savings on water and sewer costs as a result of using waterless urinals are estimated in Table 5 for a small and a large office building. These scenarios assume that all urinals in the facility are converted to waterless versions. To estimate water savings, we multiplied together the office's male population, urinal uses per male per day (estimated at three for an office), the number of days per year that the facility is in use (estimated at 260 for an office), and the number of gallons per flush avoided (estimated at two, which is average). We then applied a local water and sewer rate to estimate cost savings. For a small office with 25 men, installing waterless urinals would save an estimated 39,000 gallons and \$500 in water and sewer costs per year. For a large office building with 1,000 men, installing waterless urinals would save an estimated 1.56 million gallons and \$21,000 in water and sewer costs per year.

TABLE 5. ANNUAL WATER AND SEWER COST SAVINGS

	SMALL OFFICE SCENARIO	LARGE OFFICE SCENARIO
Number of Males	25	1,000
Number of Urinal Uses/Male/Day	3	3
Number of Days of Urinal Use/Year	260	260
Number of Urinal Uses/Year	19,500	780,000
Gallons of Water Per Use (i.e. Per Flush) Avoided [1]	2	2
Gallons of Water Saved/Year	39,000	1.56 million
Estimated Water and Sewer Cost Savings/Year [2]	\$500	\$21,000
<p>[1] Most waterless urinals save one to three gallons of water per use, depending on the model of flush urinal being replaced. Two gallons per use was used as an average.</p> <p>[2] Water and sewer fees vary from community to community in Massachusetts. Further, some communities use a flat rate structure, some use an ascending rate structure and some use a flat fee. For simplicity, the combined water and sewer flat rate of \$9.95/hundred cubic feet charged by the Town of Brookline, MA was used to calculate cost savings.¹¹¹ There are 748 gallons per hundred cubic feet.</p> <p>Note: The number of urinals in the small office and large office scenarios are not listed in this table because the annual water and sewer cost savings do not depend explicitly upon the number of <i>urinals</i> present in the small office or in the large office. They depend upon the number of urinal <i>uses</i>, which is driven by the number of males in the office, by the number of urinal uses/male/day and by the number of days/year that the office is in use. Further, the number of urinals in a building may be influenced by the building configuration (e.g. number of floors, number of restrooms) as well as by the number of male occupants. Therefore, the number of urinals in a given building may not correlate precisely with usage.</p>		

Annual Costs

Costs for replaceable cartridge traps/inserts and for liquid sealant were compiled by the US Army Corps of Engineers' Engineer Research and Development Center's Construction Engineering Research Laboratory in 2006 for several brands of waterless urinals. They are shown in Table 6. The US Army Corp of Engineers did not record prices for daily surface cleaning products. Where applicable, these prices were obtained from vendors.

The costs for cartridges/inserts and liquid sealant were used to calculate total annual waterless urinal maintenance supply costs for the same small and large office scenarios that were described in Table 5. The calculations are based upon the trap maintenance protocols shown in Table 1. However, adequate information was not available to assess the quantity of daily cleaner that might be used annually on those brands of urinals for which it is recommended. Therefore, the total annual maintenance supply costs in Table 6 do not include costs for daily cleaner, leading to an underestimate of annual costs for the Duravit and Falcon/Sloan brands. With this caveat, Table 6 shows that total annual maintenance supply costs for a small office with 25 males range from \$27 to \$105 across four waterless urinal technologies. For a large office building with 1,000 males, total annual maintenance supply costs range from \$1,222 - \$4,683 across the four technologies.

TABLE 6. ANNUAL MAINTENANCE SUPPLY COSTS FOR WATERLESS URINALS¹¹²

BRAND	DURAVIT		FALCON/SLOAN		WATERLESS		ZEROFLUSH	
Cost/Cartridge or Insert	Not Applicable		\$35		\$4.95		\$28.50	
Cost - Liquid Sealant	\$2/100 ml [1]		No charge - comes with cartridge		\$14.40/qt/15,000 - 20,000 uses		No charge - comes with drain insert	
Cost - Daily Surface Cleaner	\$6/19 oz bottle [2]		\$39 for 12 Surface Cleaner Refills [4]		Not applicable		Not applicable	
Total Annual Maintenance Supply Costs	Small Office [3]	Large Office [3]	Small Office [5]	Large Office [5]	Small Office [5]	Large Office [5]	Small Office [5]	Large Office [5]
	\$48	\$1,848	\$105	\$4,683	\$27	\$1,222	\$37	\$1,652
<p>[1] 100 ml of liquid sealant is used to refill the urinal trap each time it is flushed out. Duravit recommends flushing the trap every month or 3,000 uses, whichever comes first. In both the small office and large office scenarios, flushing traps every month would be appropriate, assuming all urinals get equal use.</p> <p>[2] The US Army Corp of Engineers did not record prices for daily surface cleaning products. This is a 2008 price obtained from Duravit USA.¹¹³ No information was available on how long a 19 oz. bottle of daily surface cleaner might last. Therefore, the annual cost of the recommended daily surface cleaner is NOT included in the Total Annual Maintenance Supply Costs for the Duravit urinal, leading to an underestimate of annual costs for this brand.</p> <p>[3] For the Duravit technology, the Total Annual Maintenance Supply Cost assumes that there are 2 urinals in the small office scenario and 77 urinals in the large office scenario (i.e. about 1 urinal for each 13 males in each case). Each urinal trap is flushed each month, and 100 ml (\$2 worth) of liquid sealant is used to refill the trap after flushing.</p> <p>[4] 2008 price obtained from Pokorny Associates, the Sloan Valve Co. representative for Massachusetts.¹¹⁴ Adequate information was not available on how long a Surface Cleaner Refill might last. Therefore, the annual cost of the recommended daily surface cleaner is NOT included in the Total Annual Maintenance Supply Costs for the Falcon/Sloan urinal, leading to an underestimate of annual costs for this brand.</p> <p>[5] For the Falcon/Sloan, Waterless and ZeroFlush technologies, the Total Annual Maintenance Supply Cost is not based upon the number of urinals in the small and large office scenarios. For these technologies, maintenance protocols call for cartridge replacement and/or the addition of liquid sealant after a certain number of urinal uses. Therefore, annual cartridge and liquid sealant costs are based upon the annual number of urinal uses expected in the small and large office scenarios.</p>								

Hygienic Benefits

In 2000, Falcon Waterfree Technologies requested that UCLA's Department of Civil and Environmental Engineering perform certain standardized tests on their waterless urinal in an independent manner. Among the analytical tests done was a comparison of bacterial cell counts on the surfaces of a Falcon Waterfree urinal to the cell counts on a typical flush urinal, under normal use. The investigators found that the bacterial count per unit area on the waterless urinal was about one-half of the count on the flush urinal. While there were not sufficient data to conclude that the waterless urinal would experience lower microbial growth rates under all conditions, the data appeared to support the conclusion that waterless urinals will not experience greater bacterial growth rates than flush urinals.¹¹⁵ The Shanghai Environment Project Design Institute found that bacteria concentrations were five times lower on the surfaces of waterless urinals compared to flush urinals.¹¹⁶

Water used by flush urinals gives bacteria the moist environment it needs to grow. The surfaces of waterless urinals are designed to dry out between uses. While urine itself is normally sterile, bacterial colonies are seeded by fecal matter carried in air-borne droplets and aerosols that are produced when the rest room's toilets are flushed. The likely explanation for the lower microbial counts on the waterless urinal is the lower incidence of damp surface areas that can provide a breeding ground for bacteria. When conventional urinals are flushed, they in turn create aerosols containing new-growth bacteria that grew on the wet surfaces of the urinal. Installing waterless urinals, therefore, is likely to reduce rest room visitor exposure to airborne bacteria due to drier fixture surfaces and no flushing action.¹¹⁷ In 2006, the St. Louis County Public Health and Human Services Department found over five times more airborne bacteria per cubic meter of air in a restroom outfitted with flush urinals compared to a restroom with waterless urinals and similar usage in the same building.¹¹⁸

Further, waterless urinals are touch-free, eliminating the exposure to disease-causing bacteria that can occur when users operate manual flush fixtures.

IMPLEMENTATION EXPERIENCE

IEc conducted a series of interviews as the main source of information on waterless urinal implementation experience and performance. We initially focused our interviews on facilities that participated in the OSD waterless urinal pilot project. Pilot project participants included public facilities within the Commonwealth that installed waterless urinals at no or low cost for the purposes of testing the technology. To increase the volume of interviews, we expanded our contact list to other public and private facilities that had not participated in the OSD pilot project, but had independently installed waterless urinal technology.

At the facilities contacted, we interviewed individuals from two stakeholder groups: facility managers and custodians. We developed a specific set of interview questions for each group based on their experience with waterless urinal installation, maintenance, and repair. We asked a broad series of questions to facility managers covering general information about the facility (e.g., facility types, the number of waterless and conventional urinals, facility population, etc.), installation experience, and experience with use, maintenance and repair. In contrast, interview questions for custodians focused specifically on maintenance and repair of waterless urinals. Tables 7 and 8 present the interview guides developed for facility managers and custodians, respectively. Most of the interviews for this project were conducted over the phone; two were conducted on site (Beede Swim and Fitness, and the Massachusetts Maritime Academy).

OVERVIEW OF PARTICIPATING FACILITIES

IEc completed a total of 12 interviews: 11 interviews with facility managers (some of whom reported that they also function as custodians) and one interview with a custodian. Thus, with one exception, each interview represents a unique facility. All but one facility (Sarasota County) is located in the Commonwealth. To assess any correlation of facility type with waterless urinal performance, we interviewed individuals at a diversity of facility types, including:

- Office buildings;
- Dormitories;
- Prisons;
- Classrooms/labs; and
- Gyms/sports clubs.

TABLE 7. FACILITY MANAGER INTERVIEW GUIDE

TOPIC AREA	INTERVIEW QUESTIONS
Basic Information	<ol style="list-style-type: none"> 1. What is the approximate population of your facility (i.e., employees plus regular facility users)? Approximately what percentage of this population is male? 2. Does the facility receive a water and sewer bill? If so, what are the rates charged? 3. How many waterless urinals are installed? 4. How long have the waterless urinals been in use? 5. What is the manufacturer of the urinals? 6. How many, if any, conventional urinals are installed at the facility? What is the proximity of the conventional and waterless urinals in the facility (i.e., are conventional urinals installed in the same bathroom(s) as waterless urinals? In nearby bathrooms?)
Background Information	<ol style="list-style-type: none"> 1. How did your facility become aware of the option of installing waterless urinals? 2. Did you receive information from your vendor about installation and maintenance of urinals? <p>For public facilities only (including public colleges and universities):</p> <ol style="list-style-type: none"> 3. Did you participate in a pilot project with OSD to install the urinals? If so, describe the process and steps of participating in that pilot. 4. Did your facility receive any communication from OSD about installation and maintenance?
Installation	<ol style="list-style-type: none"> 1. Were waterless urinals installed during new construction or were they retrofitted? 2. What was the total cost of waterless urinal installation? Separate into cost of urinals and cost of installation, if possible. 3. Was there anything notable about the installation of the waterless urinals? Were there any problems?(e.g., maintaining ADA mounting heights in retrofits? 4. What type of urinal cartridge was originally installed? How does the price of the cartridge compare to that of conventional urinal cakes? How often do you replace this cartridge? 5. For retrofit projects, were drain lines routed before the waterless urinals were installed? 6. For retrofit projects, did you assess the slope of the drain lines towards the mainline before installing the waterless urinals? If so, what was the minimum degree of slope?
Use, Maintenance and Repair	<ol style="list-style-type: none"> 1. Please describe the cleaning protocol for your waterless urinals (e.g., specific products used, time required for cleaning, frequency of cleaning). How does this compare to conventional urinal cleaning procedures? 2. What cleaning products do you use for the waterless urinals (i.e., do they differ from the products used for conventional urinals? If so, how does the price of these products compare to the price of conventional urinal cleaning products?) 3. Have you switched the type of cartridge used since installation? If so, why? Were there cost implications? If so, explain. How long have you been using the new cartridge type? (If they have experience with more than one type of cartridge, would it be possible to get answers to the questions in this section for both types of cartridges?) 4. Was training on the cleaning/maintenance of waterless urinals provided to the maintenance staff? Were any written training materials used? If so, could you share them with us? 5. Are the maintenance staff employees or contractors? (If not ascertained in setup call) 6. What has your overall experience been with the waterless urinals?

TOPIC AREA	INTERVIEW QUESTIONS
	<ol style="list-style-type: none"> 7. What has your experience been with the maintenance of the waterless urinals? (If challenges noted, probe to the nature of the challenges: Are maintenance staff using water? Are protocols for flush and waterless urinals being confused?) 8. Have you received feedback from maintenance team on cleaning of the waterless urinals? Please explain. 9. Have there been odor problems associated with the waterless urinals? 10. For retrofit projects, have there been any changes, positive or negative, in the amount of sediment build up (encrustation) in drain pipes since you installed the waterless urinals? 11. What is the frequency of repair for waterless urinals compared to conventional urinals? 12. Do you have any signs posted warning users not to misuse the waterless urinals? 13. Have you received feedback from users of the waterless urinals? If so, please elaborate.

TABLE 8. CUSTODIAN INTERVIEW GUIDE

Maintenance and repair	<ol style="list-style-type: none"> 1. Are you a staff employee at the facility or a contractor? 2. Please describe the cleaning protocol for your waterless urinals (e.g., specific products used, time required for cleaning, frequency of cleaning). How does this compare to conventional urinal cleaning procedures? 3. What training was provided to you for the cleaning/maintenance of waterless urinals? 4. What has your experience been in maintaining the waterless urinals? (If they note challenges, probe). 5. Have there been odor problems or other issues associated with the waterless urinals? 6. What is the frequency of repair for waterless urinals compared to conventional urinals?
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Facility type and facility population, relative to the number of urinals, are two factors driving the load for waterless urinals. IEC wanted to assess the correlation of load and performance. To do so, for each facility type interviewed, IEC developed assumptions about the frequency of urinal use (per male, per day). We assume the average male will use a urinal in a daytime setting (i.e., at work or during the school day) an average of three times throughout the day. We further estimate that in a dormitory, a male student will use a urinal an average of four times per day (once in the morning, twice in between classes, and once at night). At a full-time residential facility, such as a prison, we assume six uses in a 24-hour period. Finally, at a gym or sports club, where the typical visit is in the range of 1-2 hours, we assume an average of one use per visit. These assumptions are presented in Table 9.

Using these assumptions, IEC developed the metric of users/urinal/day. For example, as shown in Table 10 on the next page, Beede Swim and Fitness reports that 300 men visit its facility on a daily basis. Beede has a total of 5 urinals, all of them waterless. Thus, 300 men multiplied by one use, and divided by 5 urinals, results in an estimate of 60 uses/urinal, day.

TABLE 9. URINAL USE ASSUMPTIONS BY FACILITY TYPE

FACILITY TYPE	USES PER MALE, PER DAY
Office building	3
Classrooms/lab/school library	3
Dormitory	4
Prison	6
Gym/sports club	1

In addition to facility type and intensity of use, other important sources of variance in the facilities interviewed include facility size (as measured by population), the extent of waterless versus conventional urinal installation, and the number of waterless urinals installed new versus retrofit. Table 10 summarizes these statistics for participating facilities. As shown in Table 10, Cape Cod Community College and the MA Department of Corrections have the highest intensity of use, while the MA College of Art and Design and Dubuque State Park have the lowest. In addition, Beede Swim and Fitness, the Brookline Health Department, and Cape Cod Community College had all new installation of waterless urinals, while Longfellow Tennis Club, MA College of Art and Design, MA Department of Corrections, Dubuque State Park and Sarasota County retrofitted them into existing bathrooms. About half of all facilities interviewed had mixed installations, meaning that conventional urinals were installed in the same building or some bathroom as waterless urinals. One facility, Salem State College, ultimately did not install any waterless urinals due to plumbing constraints.

TABLE 10: SUMMARY OF FACILITIES INTERVIEWED

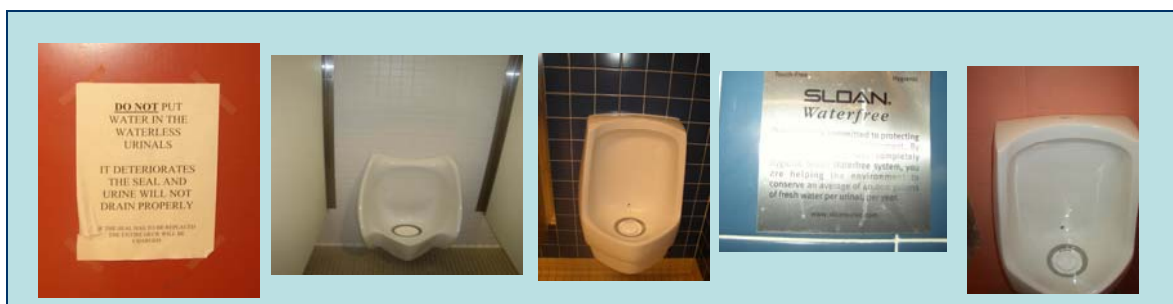
FACILITY NAME	BUILDING TYPE(S)	DAILY MALE POPULATION	WATERLESS URINALS			# FLUSH URINALS	# USERS/ URINAL/ DAY
			TOTAL #	# RETROFITS	# NEW INSTALLS		
Beede Swim and Fitness (Town of Concord)	Town Pool and Gym	300	5	0	5	0	60
Brookline Health Department	Office	15	1	0	1	0	45
Cape Cod Community College	Academic Building	34-93*	6	0	6	0	105-179
Harvard University	Dormitories and Classrooms	N/A	36	N/A	N/A	300	N/A
Longfellow Tennis Club	Private Gym	??	3	3	0	0	??
MA College of Art and Design	Classrooms	1,115	6	6	0	100	32
MA Department of Corrections	Prison	190	4	4	0	1	228
MA Maritime Academy	Dormitory	256	15	4	11	0	68
MA State Parks-DCR, Dubuque	Office	12	1	1	0	0	36

FACILITY NAME	BUILDING TYPE(S)	DAILY MALE POPULATION	WATERLESS URINALS			# FLUSH URINALS	# USERS/ URINAL/ DAY
			TOTAL #	# RETROFITS	# NEW INSTALLS		
State Park							
Salem State College	Unclear	N/A	0	0	0	N/A	N/A
Sarasota County (Various municipal buildings)	Various	Varies	151	151	0	57	N/A

* Estimated based on publicly available information.
N/A indicates that information was not available.

At the two interviews conducted onsite (Beede Swim and Fitness and MA Maritime Academy), IEC took photographs of the waterless urinals installed and the posted signage, as shown in Figure 6 below:

FIGURE 6. WATERLESS URINALS AND SIGNAGE AT PARTICIPATING FACILITIES



INTERVIEW FINDINGS

Of the ten facilities interviewed for this project that installed waterless urinals, seven reported an overall positive experience with waterless urinals, and a number of facilities emphatically recommend the technology. Two facilities—MA Department of Corrections and MA Maritime Academy—reported dissatisfaction with the technology. Harvard University provided a mixed appraisal.

Although the overall assessment of waterless urinals is positive, many facilities with positive impressions have experienced at least one problem with the technology. Temporary but severe odor problems caused by sewer gas leaking into the bathroom during cartridge checks and changes is a problem reported by most facilities. As discussed in the technology overview section, there are steps that facilities can take to mitigate this problem. However, facilities interviewed do not appear to be aware of them. A few facilities reported sediment buildup; one facility, Mass College of Art and Design, reported using screens to avoid such buildup. Harvard reported needing to remount waterless urinals to avoid leaks, and another facility reported increased splashback with waterless urinals.

As discussed in detail in forthcoming pages, a number of factors appear to be related to the degree of success a facility achieves with its waterless urinals. The type of facility and whether the urinal was installed as part of new construction or a retrofit seem to be highly correlated with success or discontent. Other factors, including maintenance vigilance and cartridge type, seem to be related but less strongly correlated than facility type and new construction versus retrofit. Table 11 on the next page presents a summary of factors assessed by IEC, and an overall assessment of implementation experience, by site.

Factors Strongly Correlated With Outcomes

Given that this project included interviews with a limited number of facilities that installed waterless urinals, we cannot comment definitely on causes that drive success with waterless urinals. With that said, a few factors appear to be strongly correlated with waterless urinals implementation experience: new construction, proper retrofits, and facility type.

New Construction and Proper Retrofits

Facilities that installed waterless urinals as part of new construction had uniformly positive experiences with waterless urinals, reporting only isolated problems. In contrast, retrofit projects posed additional challenges that need to be addressed at installation to ensure proper functioning.

Two issues in particular appear to plague retrofits: the need to 1) assess drain slope and 2) clean drain lines prior to installation. For example, the biggest problem that the MA Department of Correction encountered with its retrofit waterless urinals was an excess of what the facility manager refers to as “salt buildup” around the top of the cartridge and in the drain lines. This buildup has led to drain flow problems and difficulty removing the cartridges. However, the correctional facility did not route the drain line with a sewer snake prior to installation, nor did they assess the slope of the drain line towards the mainline. Therefore, the drain lines may have had previous buildup prior to installation or the slope of the drain line may have been too gradual to move urine towards the mainline. Either of these scenarios leads to increased sediment buildup in the pipes.

At MA Maritime Academy, 11 waterless urinals were installed as part of a new construction and four as part of a retrofit. The onsite plumber at MA Maritime reports that problems have been much more frequent with the urinals installed as a retrofit. Like the MA Department of Corrections, MA Maritime Academy did not route the drain line or assess the slope of the drain line towards the mainline for its retrofit urinals. The plumber believes that if the college had performed both of these jobs prior to the retrofit, he would not have experienced as many problems with the retrofit waterless urinals.

MA Maritime Academy and MA Department of Correction are the only two facilities interviewed that did not perform either of these recommended measures, and they have had the most difficulty with their retrofit waterless urinals. In contrast, both MA College of Art and Design and Sarasota County assessed the slope and routed the drain line prior to their retrofits. These facilities have experienced far fewer problems.

TABLE 11. INTERVIEW FINDINGS SUMMARY

FACILITY NAME	BUILDING TYPE(S)	NEW OR RETROFIT	MIXED INSTALLATION	BRAND	CARTRIDGE TYPE [1]	MAINTENANCE AVAILABILITY	USERS/ URINAL/ DAY	OVERALL EXPERIENCE
Beede Swim and Fitness (Town of Concord)	Town Pool and Gym	New	No	Zeroflush	Disposable	High	60	Positive
Brookline Health Department	Office	New	No	N/A	N/A	N/A	45	Positive
Cape Cod Community College	Academic Building	New	No	N/A	Disposable	Medium	105-179	Positive
Harvard University	Dormitories and Classrooms	Both	Yes	Sloan and Waterless	Hybrid & Disposable	N/A	N/A	Mixed
Longfellow Tennis Club	Private Gym	Retrofit	No	N/A	Hybrid	High	N/A	Positive
MA College of Art and Design	Classrooms	Retrofit	Yes	Sloan	Disposable	Medium	32	Positive
MA Department of Corrections	Prison	Retrofit	Yes	Sloan	Disposable	Medium	228	Negative
MA Maritime Academy	Dormitory	Both	No	Sloan	Disposable	Medium	68	Negative
MA State Parks-DCR, Dubuque State Parks	Office	Retrofit	No	Waterless	Hybrid	Low	36	Positive
Sarasota County (Various municipal buildings)	Various	Retrofit	N/A	mostly Ecotech	Permanent	N/A	N/A	Positive

Note: N/A indicates that information was not available.

[1] Table 11 displays the terminology used by facility managers and custodians to describe cartridge types. It is slightly different than the terminology used in the Technology Overview section. In Table 11, “Disposable” refers to a replaceable trap cartridge or insert of the type shown in Figure 1 that is removed and disposed of after a certain number of uses. Liquid sealant can be added to the new trap cartridge or insert only at the time of replacement. They cannot be refilled in between replacements. “Hybrid” refers to a removable, disposable cartridge of the type shown in Figure 1 that can be refilled with liquid sealant in between cartridge replacements. “Permanent” refers to a long lasting cartridge with a permanent self-sealing valve that does not utilize a liquid sealant. The valve and cartridge are shown in Figures 3 and 4.

Facility Type

A diversity of facilities reported positive experiences with waterless urinals, including offices, academic buildings, and recreational facilities.

The two facilities interviewed that have had negative experiences with waterless urinals are a dormitory (MA Maritime Academy) and a prison (MA Department of Corrections). In addition to the retrofit issues discussed above, it appears that problems experienced at these facilities are exacerbated by 1) the relatively high, constant use that these urinals receive and 2) the potential for misuse and unmet needs for more frequent cartridge changes.

If high user load were an independent cause of the problems experienced at MA Maritime and the MA Department of Corrections, we would see similar problems at facilities with a high number of users/urinal/day. Although the prison had the highest users/urinal/day, Cape Cod Community College had the second highest level and did not report significant problems. In addition, the Beede

Fitness Center has a similar level of use as MA Maritime Academy and has had no problems with their waterless urinals. Thus, high use alone does not appear to be a cause for concern.

While urinals in office or classroom buildings may have similar use to institutional residencies at peak hours, they experience little or no traffic during nights and weekends. Therefore, residential buildings may require that the cartridges be refilled, changed, or cleaned (depending on what type of urinal is installed), 4-5 times more often than non-residential buildings with the same populations. It is possible that facilities that experienced problems did not change the cartridge as frequently as needed.

In addition, the resident plumber at MA Maritime Academy indicated that the problems he has experienced with waterless urinals are directly related to the inherent irresponsibility of college dormitory residents. Examples of poor treatment of the waterless urinals at MA Maritime Academy include residents emptying fish tanks and soup containers into the urinals. In both instances, the cartridge needed to be changed prematurely. For this reason, the MA Maritime plumber supports the installation of waterless urinals in any building other than a dormitory. Interestingly, Harvard did not report problems with waterless urinals, despite installation in dorms as well as classrooms.

Factors That May Influence Outcomes

Maintenance protocol and cartridge type appear to relate to implementation experience at some facilities.

Maintenance Protocol

All manufacturers of waterless urinals instruct facilities to wipe them down daily, and some manufacturers recommend special cleansers. Not surprisingly, facilities that clean the urinals more frequently and do not use water-based cleaning products tend to experience fewer odor problems. For example, the Beede Swim and Fitness Center and the Longfellow Tennis Club both clean the urinals several times per day with a cleaning solution recommended by the waterless urinal manufacturer. Neither facility reports any odor problems in day-to-day use.

Similarly, at Cape Cod Community College, the maintenance staff uses a specialized cleaner on the waterless urinals, and cleans them daily. According to staff, the urinals have no odor problems as long as the cartridge is functioning properly. However, on days when the normal maintenance staff is out, maintenance workers from another college building that have little experience with waterless urinals are responsible for cleaning. Despite the training that was provided these substitute workers, they tend to use traditional, water-based cleaners on the waterless urinals, which has led to bacteria growth and odor problems. The director of maintenance claims that every odor incidence has been the result of poor cleaning by substitute workers.

This point is further supported by MA Department of Correction's reported odor problems. Although the correctional facility uses a specialized cleaner on the waterless urinals, they are only cleaned once a day. Since we estimate each urinal at the facility is used an average of 200 times per day, these urinals may have more uses between cleanings than any other facility interviewed. The high frequency of uses between cleanings likely plays a role in the odor problems experienced by the facility.

However, there are exceptions to the rule that higher maintenance vigilance affects outcomes, the most notable being MA State Parks/Dubuque Park (DCR). The MA State Parks/DCR office uses a general “green” cleaning solution on its lone waterless urinal only once per week. Despite this infrequent cleaning schedule with a non-specialized cleaning solution, the office reports a universally positive experience with its urinal. However, their urinal likely gets far less use than most, as only twelve males are employed in the office. If each male uses the urinals three times per day and works five days per week, the urinal is only used 180 times between cleanings, less frequently than at the prison. Similarly, the Brookline Public Health building uses a traditional cleaner on their one waterless urinal and has not reported any problems.

Cartridge Type

A second factor that seems to have an impact on success at some facilities is the type of urinal cartridge used. All three types of cartridges were reported to be in use at the facilities interviewed for this report: hybrid liquid seal (which can be refilled), disposable liquid seal, and permanent/non-liquid seal. Most of the individuals interviewed indicated that they have not switched cartridge types since installation because they believe that their waterless urinals can use only cartridges produced by the manufacturer of the urinal. At least one facility appeared to be unaware of the option to switch to refillable or permanent cartridges.

Most facilities interviewed use liquid sealant cartridges, either hybrid or disposable. Facilities that have urinals with either hybrid cartridges or non-liquid sealants seem to prefer these cartridges to disposable cartridges. For example, Harvard University, which installed both hybrid and disposable cartridges, prefers hybrid cartridges for cost reasons. Sarasota County, FL has installed 151 waterless urinals, the vast majority of which have permanent, non-liquid cartridges. Given Sarasota’s experience with both permanent and liquid seal cartridges, the operations supervisor will only buy permanent cartridges in the future, citing the unpredictability and cost of liquid seal cartridges.

Furthermore, the MA Maritime Academy interviewee that maintains waterless urinals with disposable cartridges reported that he would like to be able to refill the liquid sealant without changing the entire cartridge. He added that purchasing only the liquid sealant would dramatically cut down on cost and reduce waste, because the vast majority of the cartridge replacements for the urinals at MA Maritime Academy have been because the cartridge was out of sealant because of misuse; since the cartridge is not refillable, the entire cartridge had to be replaced.

Several facilities with disposable cartridges, however, report wholly positive results, and did not indicate dissatisfaction with their cartridges. Cape Cod Community College and MA College of Art and Design are two examples of such facilities.

Factors that Do Not Influence Outcomes

IEc identified three factors that do not appear to influence waterless urinal outcomes: lack of maintenance staff training, mixed installation, and urinal age.

Lack of Maintenance Staff Training

MA Department of Corrections reported the most unsuccessful experience with waterless urinals, but it does not seem to be related to untrained workers. Maintenance workers at the prison were trained according to manufacturer instructions. Similarly, at Cape Cod Community College, maintenance problems seem to be related to employees without significant experience dealing with the urinals, rather than lack of training. All employees at the college were trained equally when they were first installed, but only certain employees have maintained the waterless urinals frequently since installation. None of the facilities personnel interviewed for this report indicated concerns with improperly or inadequately trained employees.

Mixed Installation

Harvard University, the MA College of Art and Design, and the MA Department of Corrections have a mixed installation of waterless and conventional urinals in the same building; the Department of Corrections also has mixed installation in the same bathrooms. We investigated the potential for mixed installation to cause confusion regarding cleaning protocols for waterless and conventional urinals, and in particular the potential for cleaning staff to use water to clean waterless urinals, causing odor or other maintenance problems. This discussed as a potential issue in the Technology Overview, but interestingly, interviewees did not identify problems with mixed installation.

Several factors discussed above, including inadequate cleaning, have contributed to the prison's unsatisfactory experience, but confusion regarding cleaning protocol is not one of them: waterless urinals are not cleaned with water at the prison. The MA College of Art and Design had only positive feedback on waterless urinals. Harvard reported an overall mixed assessment but mixed installation was not a factor cited. The facilities manager noted that the university initially encountered this confusion and odor problems resulted from improper cleaning, but the issue was quickly remedied and is not a factor driving Harvard's mixed review of the technology. Interestingly, CCCC may explore future mixed installation with the goal of regularly exposing all of the campus' maintenance staff to waterless urinals; the facilities manager thinks that mixed installation may address the problem of improper cleaning by substitute maintenance staff.

Urinal Age

We were not able to draw any correlation between increased urinal age and increased repair, as no facility reported any waterless urinals needing repair. In addition, we did not identify any cases where facilities were initially pleased with waterless urinal performance, only to experience problems after some time of use. From the interviews with facilities that manage both conventional and waterless urinals, it appears repairs on conventional urinals are usually due to problems with the flush handle, the automatic flush sensor, or leaking pipes. Since waterless urinals do not flush and inherently have fewer pipes, it appears that waterless urinals do not need frequent repair.

WRITE-UPS OF INDIVIDUAL FACILITIES

MA Department of Corrections

The MA Department of Corrections installed four Sloan waterless urinals as part of a retrofit project at one of its correctional centers in 2005. The urinals cost roughly \$250 each. There was no additional labor cost for installation as the retrofit was done by in-house plumbers. The facility has a population of 190, 95% of whom are male. The center still has one conventional urinal, which is installed in the same bathroom as a waterless urinal.

The facility manager reported an extremely negative experience with the urinals to date. The facility has experienced numerous problems with the urinals including sediment buildup, difficulty removing cartridges, and frequent odor problems. The facility manager has received several complaints from both users and maintenance staff regarding these issues. As discussed earlier in this section, these problems are likely a result of the unfortunate combination of poor planning, installation, and maintenance at a high use facility. Drain lines were not routed prior to installation, nor did the facility assess the slope of the drain line towards the mainline. Furthermore, the urinals are only cleaned once per day, which may be inadequate given that they are used 24 hours per day.

Beede Swim and Fitness Center

The Beede Swim and Fitness Center in Concord, MA was completed in April 2006. All of the facility's five urinals are ZeroFlush waterless urinals installed as part of the new construction. The urinals were a donation from the owner of Conservation Solutions, which is also based in Concord. Approximately 300 males visit the center each day. The employee responsible for maintaining the urinals reports very few problems. He cleans them several times per day with an alcohol-based cleaner, and reports that the urinals only take a few seconds to clean. The only problem reported is occasional odor problems when the cartridge needs to be checked and severe odor problems when changing the cartridge. However, when the cartridge is in place, the urinals are odorless. There were no problems installing the urinals at the facility and none of the urinals have needed repair since the facility opened. Beede has received only positive feedback from facility members that use the urinals.

MA Maritime Academy

MA Maritime Academy installed fifteen Sloan waterless urinals in a dormitory in the spring of 2007, 11 during new construction on the top floor and four as retrofits in older bathrooms. The resident plumber at the college reports numerous problems with the urinals, including misuse, lint buildup in the holes of the cartridge, and significant sediment buildup in the drains of the retrofit urinals. The plumber attributes sediment buildup to the fact that the drain lines were not routed and the drain slope to the mainline was not assessed prior to installation. The student residents of the dormitory have also misused the urinals by emptying a fish tank, pouring in juice and soup, and depositing sand into the waterless urinals. All of these events have resulted in the need for premature cartridge change. The resident plumber believes that misuse is the primary source of the problems and remains a supporter of waterless urinal installation in any state-owned building except dormitories.

Harvard University

Harvard University began looking into waterless urinals in 2005 and has been installing them continuously in both retrofit and new construction projects. Harvard installed several dozen waterless urinals by two different manufacturers, Sloan and Waterless. Harvard's plumbing inspector reported a strong preference for Waterless over Sloan for a number of reasons. He reported that Sloan urinals have three points where leaks can occur compared to one point in Waterless models. Although Harvard has not experienced any leakage from either model, ensuring that each of Sloan's three potential leakage areas is closed created problems with installation. The inspector reported that Harvard needed to remount Sloan waterless urinals several times to make certain that urinals will not leak in the future. Additionally, staff indicated that Waterless urinals are cheaper and easier to maintain than Sloan, because Waterless cartridges are refillable. Sloan cartridges must be completely replaced when the sealant expires. Harvard has experienced a slight increase in pipe stoppages since installing waterless urinals. The inspector believes that this results from less water washing solids down the pipes, and that the solution is to ensure conventional toilets and showers are installed on floors above the waterless urinals to wash solids away. Harvard was not able to provide data to estimate daily urinal loads.

Cape Cod Community College

The Lyndon P. Lorusso Applied Technology Building at Cape Cod Community College ("CCCC") opened in the summer of 2006. The building contains six waterless urinals and no conventional urinals. The facilities manager at CCCC reports that the college's overall experience with waterless urinals has been excellent. He has seen fewer problems with the waterless urinals as staff become more aware of how to maintain them. CCCC uses a specialized alcohol-based cleaner on its waterless urinals and a water-based cleaner on its conventional urinals. The facilities manager reported that the regular maintenance staff clean and maintain the urinals at the new building perfectly. However, problems develop when one of these employees is out, and an inexperienced maintenance employee acts as a substitute. Despite training, these maintenance substitutes frequently use the water-based cleaner on the waterless urinals, allowing bacteria to grow and resulting in odor. The facilities manager would like to install one waterless urinal in every building as a retrofit so all of his employees are comfortable maintaining them.

The facilities manager previously received several complaints from staff about using a different cleaner and having to change the waterless urinal cartridges, but he no longer receives such complaints. The only complaint he continues to receive from his staff pertains to sediment buildup in the base of the urinal that makes changing the cartridge difficult.

Salem State College

Salem State College looked into installing waterless urinals from three different manufactures as a retrofit project. The college eventually decided not to perform the retrofit because ADA rules state that the rim must be 17" above the floor. Installing the urinals according to ADA rules would have been very expensive, involving ripping out walls and drains. The sustainability manager at Salem State believes that any building that is over 20 years old may experience similar problems with drain heights. He reported however, that Salem State plans to gradually install the waterless urinals as they

renovate their bathrooms in the coming years. In the interim, the college is installing ultra-low-flush, 1-pint urinals manufactured by Zurn.

Longfellow Tennis Club

The Longfellow Tennis Club has a membership of approximately 3,500 individuals. Three waterless urinals have been installed at the club for approximately a year, replacing all conventional urinals at the club.

The waterless units were installed as retrofits of the existing conventional urinals. Installation was challenging since the existing drain pipe did not align with the pipe height on the waterless unit. The plumbing at the club had to be redone to install the waterless urinals. Prior to installation, the drain slope was also measured and found to be insufficient for a waterless unit; the slope was adjusted during installation. The club did not route the drain lines before installation. The total cost of installation for each unit was \$1400, \$400 of which was for the waterless unit and materials, and \$1000 of which was for installation labor.

The waterless urinals are cleaned twice per day. A cleaning solution recommended by the manufacturer is sprayed into the urinal. There is not a significant cost differential between the waterless cleaning product and the cleaning product used for the conventional urinals. In addition to cleaning, the trap containing gel sealant is refilled approximately once per week. The custodial staff who clean the urinals are club employees who were given a hands-on maintenance training and provided with printed manufacturer instructions. There have been no maintenance issues to date. Repair of the waterless units has been significantly less frequent than for the conventional urinals. With conventional urinals, repairs were often related to the water-control valves, but since the waterless urinal eliminates this, repairs have been minimal.

Some users of the waterless urinals at the club feel there is more “splashback” than with conventional urinals, but the response has been otherwise favorable. Instructional signs are posted above each waterless unit that warn users not to pour water down the urinals.

Massachusetts College of Art and Design

The Massachusetts College of Art and Design has a total population of approximately 1,900 individuals, of which approximately 1,115 are males. Six Sloan WES-1000 waterless urinals have been installed at the college since February 2008; installation of 15 more waterless urinals is planned for summer 2008. In addition to the waterless urinals, approximately 100 conventional urinals are installed on campus.

The waterless urinals were installed as retrofits of previous, conventional urinals. Prior to installation, and per manufacturer instructions, the drain lines were routed. In addition, a product that came with the waterless urinals was used to quickly test the slope of the drain lines. Each waterless urinal comes complete with all necessary retrofit materials at a cost of \$500 per unit. The installation costs are difficult to estimate because the college used its full-time plumbing crew to conduct the retrofits. In general, the retrofit process was not problematic. The only installation issue was that the water supply in the building is oddly configured, which made it difficult to cap the water supply.

The waterless urinals are cleaned daily using a disinfectant spray supplied by Sloan. The Sloan product is comparable in cost to the cleaning solution used on the conventional urinals. The waterless cartridges are also manufactured by Sloan; they were installed with the urinals in February and have yet to be replaced. The college uses screens over the drains in the waterless urinals that help prevent sediment buildup. Thus far, there have not been any maintenance issues with the waterless units. The custodial staff, who are college employees, were given the manufacturer's printed instructions in the way of training on waterless urinal maintenance. There have also been few, if any, repairs necessary for the waterless units. Based on work orders submitted, conventional urinals require far more repairs than the waterless urinals. An instructional sign provided by Sloan is posted above each waterless unit, warning against misuse of the urinal.

Users of the waterless urinals have had only positive feedback thus far, and the college estimates that they have saved approximately 20,000 gallons of water per unit, annually.

Brookline Health Department Building

The Brookline Health Department building has a total population of 45 individuals, approximately 15 of whom are men. One waterless urinal has been installed in the building for a year and a half; there are no conventional urinals in the building.

The waterless urinal was installed at the suggestion of the architect responsible for recent renovations to the building. The waterless urinal was a new installation and no problems were encountered during installation.

Maintenance staff in the building are a mix of Health Department employees and contract workers. They clean the waterless urinal according to the manufacturer instructions, as they were trained to do. Cleaning entails use of the same cleaning solution as would be used for conventional urinals. In addition, the urinal cartridge (manufacturer unknown) is replaced approximately once per month and the liquid sealant in the cartridge is changed weekly. The same type of cartridge has been used since the waterless urinal was installed. The waterless urinal has not required any repairs since installation.

Initially, users of the waterless urinal in the Brookline Health Department had concerns about cleanliness, but these concerns have been overcome and most users have had only positive feedback about waterless technology. No odor issues were reported.

DCR - MA State Parks/Dubuque Heritage State Park

This facility has one waterless urinal (manufactured by Waterless New England) and no conventional urinals. The total facility population is 28 individuals, about 12 of whom are male. The single waterless urinal has been installed for approximately four years. The waterless urinal at this facility was a retrofit project; no problems were encountered during installation.

A "green" cleaning solution is used to clean the waterless urinal weekly. This is the same solution that was used to clean the conventional urinal before the retrofit. The same urinal cartridge (manufactured by Waterless New England) has been used since the waterless urinal was installed. The custodial staff who clean the waterless urinal are employees of the facility. In the way of training, the custodian was given the manufacturer's pamphlet on the appropriate cleaning of the urinal. The facility's experience with the use and maintenance of the waterless urinal has been wholly positive; the interviewee noted that maintenance is minimal and easy.

Sarasota County

The Sarasota County government includes a diversity of buildings and parks. A total of 151 waterless urinals have been installed at various facilities beginning in 2006. An additional 112 waterless units are currently being installed, fully replacing the remaining conventional urinals. All but two of the urinals are manufactured by Ecotech; the other two are manufactured by Falcon. Two types of cartridges have been used in the waterless urinals: liquid seal, and non-liquid seal. All of the liquid seal cartridges have now been phased out because of problems with the adhesive that bonds the rubber seal to the cartridge.

The waterless urinals were primarily retrofits of existing conventional urinals. The total installation cost of each waterless unit is \$810: \$290 for the waterless urinal, \$130 for the cartridge, and \$390 for contractor labor. The drain lines were routed prior to installation to remove sediment and the drain slope was measured. During installation, the height of the drain pipe in the wall had to be lowered to match the new urinals' discharge pipe.

The waterless urinals are cleaned with the same solution as is used on conventional urinals. Drain lines are flushed once per month by pouring water directly into the urinal without removing the cartridge. The cartridges are cleaned every three, six, or nine months (depending on user load) by running the cartridge valve under water while massaging the valve end. Waterless urinals have required fewer repairs than conventional urinals, which are prone to water leaks. Thus far, there have not been any problems with sediment buildup.

Waterless technology is a new concept to most, which requires educating staff and the public. Any negative feedback usually occurs within 2-3 days of the installation, and it almost always comes from staff. Occasionally, odor problems arise – typically as a result of a poor seal at the waste pipe or when a cartridge is overdue for servicing. The county now uses wax seals to remedy this problem.

RECOMMENDATIONS

IEc and Aceti Associates developed the following recommendations for waterless urinal diffusion based on the research and analysis conducted for this project:

- Waterless urinals appear to work well in most settings. The Commonwealth should continue to support their diffusion given the significant water conservation and water cost savings provided by the technology.
- Installation of waterless urinals is more straightforward during new construction. Retrofitting waterless urinals in existing bathrooms without renovation poses some challenges but can be accomplished successfully. Prior to a retrofit project, it is imperative that facilities 1) ensure that the slope of the drain line is ample, and 2) route drain lines to avoid problems such as sediment build up and 3) check that drain heights are appropriate to the brand to be purchased. Facilities are far less likely to encounter problems with retrofit projects if they make these preparations.
- Waterless urinals are being used successfully at stadiums, airports, offices, academic buildings, gyms, and a wide variety of other settings, and we recommend widespread diffusion of the technology. However, we do not recommend continued installation in dorms or prisons, which have experienced significant problems with waterless urinals. These problems appear to be due in part to resident misuse and limited availability of maintenance. Availability of maintenance staff is important for both daily cleaning and frequent cartridge changes/refills at facilities with high user loads.
- Facilities exploring the installation of waterless urinals should conduct cost, savings, and payback calculations. These calculations should include: unit cost, installation cost, cartridge replacement cost, cleaning supply cost, and water savings. These calculations should be based on facility-specific information including the number of conventional urinals to be replaced, the number of men at the facility, and water rate. In addition, calculations should be based on brand-specific information because cleaning supply and cartridge costs vary significantly by brand.
- Checking and changing waterless urinals cartridges often leads to escape of sewer gas in the bathroom, causing a temporary but significant odor problem. To avoid unpleasantness of sewer gas escape during cartridge changes, OSD or its vendors should communicate a flushing maintenance protocol to waterless urinal customers.

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