Water and Wastewater Design in Buildings

An Online Continuing Education Course for Engineers

Course Number: BD-2005

Credit: 2 Hours / 2 PDH / 2 CPD

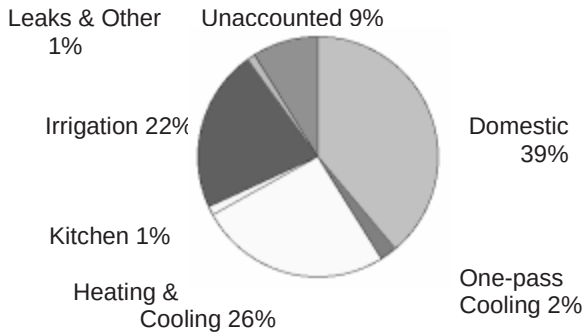
Introduction

The goal of effective water management is to reduce water consumption without compromising the performance of equipment and fixtures. Using water more efficiently is a green strategy for several reasons: it reduces pressure on sometimes-limited water resources, reduces the amount of energy and chemicals used for water and wastewater treatment, and, to the extent that the use of *hot* water is reduced, increases energy savings—with associated environmental benefits.

Minimizing water consumption should be the goal during the design of any new or renovated facility. Additionally, a comprehensive audit of water use should be performed for all existing buildings and landscapes. The water audit should be accompanied by an examination of available water management techniques and be followed by implementation and monitoring of appropriate measures.

These techniques include (1) reducing losses by repairing leaky faucets and pipes; (2) reducing the overall amount of water consumed (replacing toilets with low-flush models, for example); (3) finding more sustainable sources of fresh water (rainwater harvesting, for example); (4) managing water more responsibly after use (using graywater for irrigation, for example, and more responsible wastewater treatment); (5) where appropriate, enforcing conservation-based water pricing; and (6) forming partnerships with local utilities. Water management also involves emergency planning for droughts and implementation of those plans when conditions require. Most water management strategies can be implemented at any time, although a few—such as installation of an alternative wastewater treatment system—are far more easily done during major building renovations or as part of new construction. An important integration opportunity is to reduce hot water use, which both reduces overall water consumption and saves energy.

Water Use in Commercial Buildings



Technical Information

Water use in the United States has more than doubled in the past half-century—from about 180 billion gallons (680 billion liters) a day in 1950 to more than 410 billion gallons (1.5 trillion liters) a day in 2005.

Replacing old plumbing fixtures can save huge quantities of water. The standards established for water consumption by the Energy Policy Act restrict showerheads to 2.5 gallons (9.5 liters) per minute, urinals to 1 gallon (3.8 liters) per flush, faucets to 2.2 gallons (8.3 liters) per minute at 60 psi (410 kPa), and toilets to 1.6 gallons (6 liters) per flush at 80 psi (550 kPa).

Water management measures that are cost-effective—that is, with a payback of 10 years or less—can be implemented immediately. Note that the true cost of water must include costs to heat, cool, and pump it; costs of treatment before use (such as softening or filtration); and costs to treat or dispose of wastewater. Dollar savings from reduced water and energy use

as a result of water conservation projects can be substantial.

A successful water management program begins with the development of a comprehensive plan that includes a thorough analysis of water use throughout a facility (see "Eight Steps to a Successful Water Management Plan") and a review of the relationship between the facility and water supplier (typically, a municipal utility company).

EIGHT STEPS TO A SUCCESSFUL WATER MANAGEMENT PLAN

1. Gather information. Start with the facility floor plan, operating schedules, number of employees and visitors, and maintenance/janitorial schedules. List all fixtures and the manufacturers' data on rated flow rates. Determine outdoor water applications, quantity, and schedule. Obtain utility name and water/sewer bills for at least the past two years. Check meter calibration results to adjust quantities, if necessary.

2. Conduct a comprehensive facility survey. A basic water audit can be completed by qualified staff using published tools and fixture-use assumptions; a more complete audit may require assistance from water efficiency professionals.

3. Explore and evaluate water management options. With a water audit in hand, determine whether fixture replacement and changes in maintenance procedures are needed. Just a single constantly running toilet, for example, can waste 6,000 gallons (23,000 liters) per day!

4. Conduct life-cycle cost analyses and explore financing options. Total water cost must include water purchased from utilities, pumping energy, pretreating, water heating and cooling, chemical treatments (e.g., cooling towers), and sewer costs.

5. Develop a water management plan and work schedule. Set priorities for the changes to be made based on current water use, occupant needs, and life-cycle cost analysis. Determine the schedule of implementation and associated funding.

6. Inform building occupants about water management. Send a letter to everyone telling them about the plan. Post signs near equipment to make occupants aware of water savings initiatives. Set up a "hotline" to report leaks or other wastes of water.

7. Implement the water management plan. Check with contractors to ensure that work is going as planned. Check bills to verify consumption reductions as the program evolves. Immediately address problems that arise for users.

8. Monitor the water management plan. Carefully check to ensure that savings are occurring. Make regular contact with the operating and maintenance staff to insure their active participation.

The following sections of this course address more specific aspects of water conservation, as well as innovative water source and wastewater treatment options.

Waterless urinals like this use a lightweight biodegradable oil in an EcoTrap®, which allows urine to pass through while blocking odors from entering the restroom. The oil is replenished on a regular schedule based on usage.

Toilets and Urinals

There are three common varieties of toilets: gravity flow, (siphon-jet) flush valve, and pressurized tank systems. Similarly, there are four common varieties of urinals: the siphonic jet urinal, washout/wash-down urinals, blowout urinals, and waterless urinals. All of these must meet water efficiency standards, though waterless urinals go far beyond the conservation minimums. Composting toilets also use no water, but potential applications are generally limited.

Opportunities

The vast majority of toilets and urinals were installed at a time when there was little or no regard for using water efficiently. Consequently, there are ample opportunities to make significant savings in water usage. Complete replacement is the desired option. Retrofit of existing toilets and urinals is a second choice that may be more attractive if there are budget constraints. While retrofits reduce the amount of water used per flush, most fixtures were not designed to use reduced amounts of water and their performance may suffer. Only complete replacement of porcelain fixtures ensures that, even with less water, they can still perform efficiently and effectively.

Technical Information

Toilets account for almost half of a typical building's water consumption. Americans flush about 4.8 billion gallons (18.2 billion liters) of water down toilets each day, according to the U.S. Environmental Protection Agency. According to the Plumbing Foundation, replacing all existing toilets with 1.6 gallons (6 liters) per flush, ultra-low-flow (ULF) models would save almost 5,500 gallons (25,000 liters) of water per person each year. A widespread toilet replacement program in New York City apartment buildings found an average 29% reduction in total water use for the buildings studied. The entire program, in which 1.3 million toilets were replaced, is estimated to be saving 60-80 million gallons (230-300 million liters) per day.

There is a common perception that ULF toilets do not perform adequately. A number of early 1.6-gallons-per-flush (gpf) (6-liter) gravity-flush toilets that were simply adapted from 3.5-gpf (16-liter) models—rather than being designed from the ground up to operate effectively with the ULF volume—performed very poorly, and some low-cost toilets today still suffer from that problem. But studies show that most 1.6-gpf (6-liter) toilets work very well. Where flush performance is a particular concern, or water conservation beyond that of a 1.6-gpf (6-liter) model is required, pressurized-tank toilets, vacuum toilets, and dual-flush toilets should be considered. Carefully choose toilet models based on recommendations from industry surveys or experienced plumbers and facility managers. You may also want to contact some managers of facilities that have already installed the toilets under consideration.

While some retrofit options for toilets reduce water use, none of these modifications will perform as effectively or use as little water as quality toilets manufactured after January 1, 1994. These retrofits will merely allow the fixture to operate using less water until it is replaced.

Even greater water conservation can be achieved in certain (limited) applications with composting toilets. Because of the size of composting tanks, lack of knowledge about performance, local regulatory restrictions, and higher first-costs,

composting toilets are rarely an option except in certain unique applications, such as national park facilities. Composting toilets are being used very successfully, for example, at Grand Canyon National Park.

With urinals, water conservation well beyond the standard 1.0-gpf (4.5-liter) performance for new products can be obtained using waterless urinals. These products, available from The Waterless Company, use a special trap with a lightweight biodegradable oil that lets urine and water pass through but prevents odors from escaping into the restroom; there are no valves to fail, and clogging does not cause flooding. Three Waterless urinals at the Bureau of Recreation's Glen Canyon Visitor Center are saving an estimated 225,000 gallons (850,000 liters) of water per year, according to *Environmental Building News*. Furthermore, installing those urinals enabled the Bureau to avoid spending $600,000 to expand its on-site sewage treatment capacity. Projected water savings from waterless urinals in different types of facilities are shown in the table below—both for retrofits and new construction.

TOILET AND URINAL RETROFITS

Adjust the flush valve to reduce the water used per flush without impeding waste removal or violating the manufacturer's requirements.

Regularly check for leaks and periodically replace valves and ballcocks. Use toilet cleaners that are not highly corrosive to flapper valves.

Check water pressure to ensure that the pressure is proper for optimal toilet or urinal operation.

Early closure devices can save 1 to 2 gallons (4.5 to 9 liters) per flush. These devices cause the same force to be exerted with each flush but with half the water.

Dual-flush adapters can be used with some toilets; these allow two types of flushes, saving up to 1.2 gallons (5.5 liters) per flush. One flush is standard and removes solids; the second is smaller and removes paper and liquids.

Toilet refill diverters are extremely low-cost devices that balance the flow of refill water in gravity-flush toilets. With most toilets, the bowl fills a lot faster than the tank, and excess water in the bowl simply flows down the drain—this occurs even in 1.6-gpf (6-liter) toilets. Products made by the Fuller Group of Marietta, Georgia, and Niagara Conservation Corp. of Cedar Knolls, New Jersey, divert most of the bowl-refill water into the tank, typically saving

PROJECTED WATER SAVINGS FROM INSTALLING WATERLESS URINALS

Building Type	No. Males	No. Urinals	Uses/ Day	Gal/ Flush	Days / Year	Ann. Water Savings/Urinal Gallons	Liters
Small Office	25	1	3	3.0	260	58,500	220,000
New const.	25	1	3	1.0	260	19,500	73,800
Restaurant	150	3	1	3.0	360	54,000	204,000
New const.	150	3	1	1.0	360	18,000	68,100
School	300	10	2	3.0	185	33,300	126,000
New const.	300	10	2	1.0	185	11,100	42,000

1/2 to 1 gallon (2 to 4 liters) per flush on an older toilet and about 1/4 gallon (1 liter) on a new toilet. *Environmental Building News* reported that the Marriott Corporation has installed the Fuller AquaSaver product on 280,000 of their 480,000 toilets and is saving $3.4 million per year in water bills.

For siphonic jet urinals, retrofit with infrared sensors to eliminate double flushing, or replace. Choose 0.5-gpf (1.9-liter) models instead of 1.0-gpf (3.8-liter) models for greater savings.

Blowout urinals, w
intervals as the water t
level, can be modified
function only when
occupied.

**Displacement devices,
bottles, and toilet
recommended for 5-g
3.5-gpf (16-liter) toilet
can compromise
performance, resultin
flushing or increase
cleaning. Early-closure
better but must
calibrated.**