3. What Building Teams Are Doing To Conserve Water Inside Buildings

While hard data on total water use in buildings is somewhat difficult to come by, the U.S. Green Building Council estimates that buildings account for 14% of domestic water consumption in the U.S.[1] Other sources report 12%—a relatively small percentage compared with, say, agriculture, but it represents tens of billions of gallons of domestic water consumed every day.[2]

In addition to the millions of single-family homes in the U.S. and Canada, hospitals, laboratories, industrial facilities, apartment and condo complexes, commercial kitchens, sports arenas, hotels, and office developments are particularly large consumers of domestic water for interior uses. For instance, toilets in commercial buildings alone consume 1.2 billion gallons of water a day.[3]

There are also severe inefficiencies in the system. For example, EPA WaterSense estimates that 80% of the 12 million urinals in the U.S. use up to five times the federal standard of 1.0 gallons per flush and waste more than 150 billion gallons of fresh water a year, enough to supply 1.5 million homes.[4]

In the U.S., the Energy Policy Act of 1992 first brought the issue of water conservation to light by banning the installation of toilets that consume more than 1.6 gpf—a move that led to outcries from building owners and homeowners for awhile, until manufacturers, plumbers, and contractors could work out the mechanical problems of the early units. Since then, new regulations, the growth of the green building movement, and significant improvements in plumbing products have enabled Building Teams, homeowners, and property owners to drastically cut water use in buildings.

This past August, Los Angeles became the first U.S. city to mandate high-efficiency fixtures in all new buildings and major renovations. The ordinance, which kicks in December 1, limits toilets to 1.28 gallons per flush and urinals to 0.5 gpf. The regulation also requires high-efficiency faucets (2.2 gallons per minute), pre-rinse spray valves (1.6 gpm), showerheads (2.0 gpm), commercial dishwashers (0.62-1.16 gallons/rack), and, starting next year, pint-flush urinals (0.125 gpf).[5]

Other cities in California are expected to follow suit in light of the statewide drought.[4] And it's only a matter of time before jurisdictions throughout the U.S.—especially those in water-scarce regions like the Southwest—mandate the switch to high-efficiency water technology.[6]

Earlier this year, the U.S. Green Building Council raised the bar for green buildings with the release of LEED 2009. LEED now requires a 20% reduction in water use as a prerequisite and increases the number of Water Efficiency credits in its various programs. Even more drastic is a new requirement for LEED-certified projects to submit performance data on water (and energy) use for five years after certification.

These increasingly stringent standards and regulations—along with large-scale drought and water scarcity in a growing number of regions of the country—are driving demand for water-saving systems and technologies. Manufacturers have heeded the call by providing a slew of low- or no-flow products, sensor-activated devices, graywater recycling systems, and water submetering technology (Table 3.1).

And Building Teams are responding. According to the BD+C/Professional Builder 2009 White Paper Survey, most Nonresidential Survey respondents said their firms are already using an average of 9-10 water-saving technologies and expect their firms to make use of 13-14 such systems in the near future. High-efficiency lavatory faucets (1.5 gpm or less), sensor-activated faucets, and sensor-activated flush valves are the most commonly specified technologies, followed by high-efficiency showerheads (2.0 gpm or less), water

1 U.S. Green Building Council research, www.usgbc.org/DisplayPage.aspx?CMSPageID=1718

2 U.S. Geological Survey of estimated water consumption in 2000. http://pubs.usgs.gov/circ/2004/circ1268/htdocs/text-total.html

3 Environmental Building News, February 2008, www.buildinggreen.com/auth/article.cfm/2008/2/3/Water-Doing-More-With-Less

4 "Water-Efficiency Technologies for Mechanical Contractors," Jerry Yudelson, PE, for the Mechanical Contracting Education and Research Foundation, 2009.

5 IAPMO Green Newsletter, August 2009, p.1, www.iapmo.org/Green%20Issues/2009-08%20Green%20Newsletter%20August.pdf

6 U.S. General Accounting Office, 2003 report, as cited in Environmental Building News, "Water: Doing More with Less," February 1, 2008, 17:2

metering devices, tankless water heaters, and high-efficiency urinals. Waterless urinals, dual-flush toilets and flush valves, and high-efficiency dishwashers are also gaining popularity with Building Teams (Table 3.2).

In certain building types, such as offices and schools, implementation of these interior water-saving technologies alone can cut overall water consumption by 30% or more, with payback periods as short as three years on certain technologies. High-efficiency toilets and faucet spray aerators can have the quickest payback, especially in retrofit projects.[4]

A case in point: The Parc 55 Union Square Hotel in San Francisco is saving $170,000 a year on water and sewer charges after replacing more than a thousand 3.5-gpf toilets with pressure-assist 1.0-gpf units, according to a third-party research report. The hotel is saving nearly a million gallons of water every month, and its toilet-related maintenance calls have been cut in half.[7]

"When it comes to conserving water in buildings, the first step is to look at the plumbing fixtures," says Heath Baxa, PE, LEED AP, a project manager and head of sustainable design with

7 *"Evaluation of Water Use Reduction Achieved Through Hotel Guest Room Toilet Fixture Replacements," Koeller and Co. and Veritec Consulting Inc., September 2009, www.flushmate.com/DocumentLibrary/pdf/parc-55-hotel-fixture-replacements-sept-2009.pdf*

Table 3.1
WATER-EFFICIENT TECHNOLOGY BASELINES

Technology	Current base	Most efficient	Future possible	Comments
Toilets	1.6 gpf	0.8 gpf (pressure-assist and dual-flush units)	Water-free composting toilets (niche technology: remote buildings, demonstration green projects)	• Progressive jurisdictions are moving toward 1.28 gpf as the standard • Dual-flush is gaining share in women's restrooms
Urinals	1.0 gpf	0 gpf	"Blue cube" converts installed, standard-flush urinals into 99% water-free units	• Pint-flush (0.125 gpf) units quickly gaining market share • New WaterSense label defines high-efficiency as 0.5 gpf
Showerheads	2.5 gpm	1.5 gpm	Innovations in performance and user experience by maximizing droplet size and spray force with less water	• WaterSense label defines high-efficiency as 2.0 gpf • Hotels slow to adopt low-flow (due to guest complaints)
Faucets	2.5 gpm at 80 psi; 2.2 gpm at 60 psi; 1.5 gpm at 60 psi (residential lavatory faucets)	0.5 gpm	• Innovations in faucet/aerator design to create perception of strong flow • Improvements in sensor technology	Studies show that sensors may increase water use by activating unnecessarily and operating longer than needed
Pre-rinse spray valves (commercial kitchens)	1.6 gpm	1.28 gpm		These devices typically use more water in commercial kitchens than dishwashers
Hot water circulation systems	Continuous-circulation systems (maintain a loop of circulating hot water, reducing wait time)	Demand-controlled hot water circulators (improved energy efficiency by delivering hot water only when needed)		• Save water, but increase energy use • Common in hotels and residential • Alternative: greater hot water pipe insulation
Commercial clothes washers	1.26 MEF (modified energy factor); 9.5 WF (water factor)	1.72 MEF; 8.0 WF (Energy Star threshold)	Huge potential for graywater capture and reuse	Large commercial washing systems used in hotels and hospitals not addressed by Energy Star or other federal standards
Commercial dishwashers	1-1.7 gal/rack (under counter); 0.95-1.18 gal/r (stationary single-tank door); 0.7-0.79 (single-tank conveyor); 0.54 (multi-tank conveyor)	0.28 gal/rack	Innovations in spray nozzle design, chemical additives, and water temperature to speed washing time	Water use varies widely based on model type

Sources: *Environmental Building News*, February 2008; U.S. EPA

M-E Engineers Inc., Wheat Ridge, Colo. The next step, says Baxa, is to look at the feasibility of reusing water on the site, and "that's where things get more complex."

Graywater for flushing: The next wave?

Installing water-efficient fixtures, industry experts say, will only take water conservation so far, perhaps to a 20-30% reduction in use. Shooting for a reduction of 40% or more will most likely require Building Teams to look at ways to reuse water. Inside buildings, that means using graywater—primarily the wastewater from bathroom sinks, showers, and clothes washers—to flush toilets and urinals.

To date, the use of graywater for flushing has been pretty rare. Only 21% of AEC respondents to the 2009 White Paper survey said their firms had specified graywater reuse systems in the past two years, even though the potential for water savings using graywater is significant, especially in office buildings, schools, hotels, and multifamily developments. And, unlike rainwater harvesting, where the water supply depends on the whim of Mother Nature, commercial and multifamily buildings provide a relatively constant source of graywater. "In a large of-

Table 3.2
INTERIOR WATER-EFFICIENT SYSTEMS USED
Which of the following indoor products, technologies, or services has your firm or company used in new projects or major renovations in the last 18-24 months? Which do you expect to use in the next 18-24 months?

	Nonresidential		Residential	
	Used in last 18-24 months	Expect to use in next 18-24 months	Used in last 18-24 months	Expect to use in next 18-24 months
High-efficiency lavatory faucets (1.5 gal/min or less)	65%	78%	46%	67%
Sensor-activated faucets	65%	75%	-	-
Sensor-activated flush valves	63%	74%	-	-
High-efficiency showerheads (2.0 gal/min or less)	62%	72%	70%	81%
Water metering	58%	66%	42%	51%
Tankless water heaters	57%	73%	52%	71%
High-efficiency urinals	56%	73%	-	-
High-efficiency single-flush gravity toilets (1.28 gal/flush or less)	51%	68%	43%	64%
High-efficiency flushometer toilets (1.28 gal/flush or less)	48%	67%	26%	42%
Low-flow kitchen faucets (2.2 gal/min or less)	42%	58%	47%	68%
Demand-activated recirculating hot water systems	40%	60%	-	-
Dual-flush flush valves	40%	64%	26%	48%
High-efficiency dual-flush toilets	38%	65%	29%	58%
High-efficiency dishwashers (10 gal or less/load)	35%	51%	55%	79%
High-efficiency pressure-assisted toilets	34%	48%	32%	39%
Non-water fixtures (sanitizer dispensers, UV disinfectant, etc.)	34%	49%	16%	31%
Water submetering	33%	46%	19%	33%
High-efficiency clothes washers (water factor of 7.5 or less)	31%	45%	49%	65%
Waterless (flush-free) urinals	27%	45%	-	-
Graywater reuse systems (for flushing toilets, etc.)	21%	50%	9%	24%
High-efficiency pre-rinse spray valves for commercial kitchens	21%	37%	-	-
Water use audits	21%	37%	11%	24%
Mechanical metering faucets	17%	28%	-	-

Base: Nonresidential, 583-585, Residential, 139-140
Source: BD+C/Professional Builder 2009 White Paper Survey

The majority of Nonresidential Survey respondents said their firms are already using a fairly broad array of water-saving products, technologies, or systems—on average, between nine and 10 of the technologies listed in the table (mean: 9.54). Moreover, they expect their companies to make use of 13-14 such technologies or systems in the next couple of years (mean: 13.22). Residential Survey respondents exhibited strong adoption rates for high-efficiency showerheads (70%), dishwashers (55%), tankless water heaters (52%), and clothes washers (49%), with even greater use expected in the next 18-24 months. Note: Certain technologies not normally used in residential projects (e.g., waterless urinals, pre-rinse spray valves) were not asked in the Residential Survey.

fice building, just the water from sinks can be significant on a daily basis, certainly enough to flush many toilets and urinals," notes green building consultant Jerry Yudelson, PE, MBA, LEED AP in his August 2009 report to the Mechanical Contractors Association of America Research Foundation.[4]

Despite growing demand and unrealized potential for graywater reuse in buildings, however, plenty of hurdles remain for those looking to implement graywater systems for toilet flushing.

First, there's the *cost hurdle*, both the cost of the systems themselves and the cost of the space associated with tanks, pumps, and treatment, not to mention the need for dual-piping to separate graywater from potable water. "Those are the biggest obstacles," says Julie Paquette, PE, LEED AP, an associate with the Green Integration Group, R.G. Vanderweil Engineers, Boston. Even in Boston, where water rates are well above the national average, Paquette says owners balk at the long payback and O&M requirements of water reuse systems.

The next hurdle: *building and plumbing codes*. Many jurisdictions simply have not caught up with the technology, forcing Building Teams to invest a lot of time asking for special approval for alternative approaches. "Even the mere threat of a construction delay or additional preparation costs frightens many owners from pursuing established alternative water-conservation strategies," says Jeffrey Gaines, AIA, LEED AP, a senior associate, manager of programming and planning, and sustainable design committee leader with Albert Kahn Associates, Detroit.

Some states and localities make it really hard to use graywater. Until recently, for example, Oregon required applicants to obtain a water quality permit comparable to that for a municipal wastewater treatment plant. Coupled with high permit fees, this requirement effectively killed graywater reuse in the state. This past June, Oregon changed its law to allow graywater to be used for "beneficial uses," such as flushing toilets and urinals and irrigating certain trees and plants.[8]

Code officials and plumbing boards justify their position by saying that their first responsibility is to protect the public's health and safety and that graywater, if not treated properly, could become a breeding ground for microorgan-

8 Oregon Department of Environmental Quality, Gray Water Fact Sheet, June 30, 2009, www.deq.state.or.us/wq/pubs/factsheets/reuse/WQgraywaterFactsheet.pdf

Packaged Graywater Systems

In the past, building owners or homeowners who wanted to use recycled graywater had but one option: a custom-engineered solution tailored to the specific project. While custom systems are still the choice in most big building projects, a growing number of packaged graywater recycling systems, complete with pumps, storage tanks, treatment solutions, and piping, are now available for commercial and residential use. Prices range from $300 for a single sink/toilet system to $75,000 or more for bigger commercial buildings. Here's a rundown of the systems available in the U.S.*:

Product	Function	Comments	Manufacturer
AquaCycle	Recycles graywater from lavatory sinks, showers, tubs, and laundry machines for use in toilet flushing, clothes washing, cleaning, and landscaping	Numerous existing installations in small and large residential and institutional applications in Europe	Pontos, subsidiary of Hansgrohe AG, www.pontos-aquacycle.com/pontos/en/company/pontos.html, info@pontos-aquacycle.com
Aqus Water Reuse System	Recycles graywater from lavatory sinks for use in toilet flushing	Uniform Plumbing Code listed product; Production and deliveries began in 2006	WaterSaver Technologies, www.watersavertech.com, info@watersavertech.com
BRAC Graywater Recycling System	Recycles graywater from lavatory sinks, showers, tubs, and laundry machines for use in toilet flushing	Uniform Plumbing Code listed product; in production	BRAC Systems, www.bracsystems.com/home.html, info@bracsystems.com
ReWater	Captures, filters, and reuses water from showers, tubs, lavatory sinks, and laundry machines for landscape irrigation	Available since 1990; numerous existing installations with a proven track record	ReWater Systems Inc., www.rewater.com, support@rewater.com

Source: Alliance for Water Efficiency

* Ecoplay, from CME Sanitary Systems (www.ecoplay.nl/en/index.html, info@ecoplay.nl), and Catchment 720L, from Perpetual Water (www.perpetualwater.com.au sales@perpetualwater.com.au), are not readily available in the U.S.

isms and other potential health hazards. In the absence of science-based quality standards for graywater reuse (something several plumbing manufacturers are trying to develop), they say, graywater reuse should be limited to underground drip irrigation at best.

Code officials also point to potential maintenance problems with graywater systems, especially in homes. They argue that if many homeowners have trouble maintaining simple things like water heaters, how can they be expected to maintain complex graywater treatment systems? In response, the Alliance for Water Efficiency suggests that manufacturers could offer lifetime maintenance programs, or local jurisdictions could require periodic inspections of such systems.[9] Either way, there would be added costs.

The International Code Council and IAPMO are working on the problem. For example, IAPMO's Green Plumbing and Mechanical Code Supplement, due out next February, introduces language pertaining to the use of graywater recycling and rainwater harvesting, with the goal of speeding the code review and approval process for these new technologies (more on this in Chapter 5, page WP33).

California's Department of Water Resources is in the process of adopting statewide standards for installing dual plumbing systems—one for potable water, the other for recycled water—within virtually any commercial and institutional building type. If adopted in January, the code would allow recycled water to be used in toilets and urinals, air-conditioning devices, cooling towers, and floor trap priming. Building owners would have to implement health and safety measures, such as cross-connection testing, installation of purple-colored pipes, and posting of signage in rooms that utilize recycled water or house recycled water equipment.[10]

Despite the obstacles, demand for graywater recycling is expected to grow as code bodies and jurisdictions become more accepting of these technologies and costs for implementation come down. Half of the respondents to our Nonresidential Survey and nearly a quarter respondents to the Residential Survey said they plan to install these systems within the next two years. One sign of a budding graywater market is the growing number of off-the-shelf solutions being developed by manufacturers (see sidebar, page WP21).

Drain line transport issue: How low can we go?

One huge concern among plumbing engineers and contractors is the possibility of clogging that could occur in drain lines when new water-efficient fixtures are installed. Greater efficiency leads to less water in the drain lines, meaning that there may not be enough water to flush waste down the pipes.

"When the industry went from 3.5 gallons per flush to 1.6 in the 1990s, there was a lot of talk about drain lines drying up; now we're going to 1.28 and even lower to one gallon per flush," says Pete DeMarco, IAPMO's director of special programs. "We know that somewhere between 1.6 and zero gallons per flush, building owners are going to have problems with clogging because there won't be enough wastewater in the system."

This problem can be especially nettlesome in large commercial projects such as shopping malls, office complexes, and warehouses that have long, horizontal drainage lines to the sewer. A 2005 study of nine high-efficiency toilets using four drain line diameters and slope configurations found greater potential for waste remnant and potential blocking with drain lines as short as 50 feet (with four-inch-diameter pipe at a 1% slope) if no supplemental flows are present.[11]

While there have been no major cases of drain line clogging involving high-efficiency fixtures in the U.S., building owners in Europe and Australia have recently reported problems. Last year, the city of Tucson, Ariz., was so concerned with possible backup in its sewer lines (which can lead to dangerous and malodorous hydrogen sulfide concentrations) that it suspended its program of retrofitting low-flow toilets in older neighborhoods.

Concerned that manufacturers may be reaching a "tipping point" in how low they can go in water efficiency, five plumbing industry groups have formed the Plumbing Efficiency Research Coalition with the goal of sponsoring an extensive research study on drain line carry. According to IAPMO's DeMarco, who is coordinating the project for PERC, the study will 1) use computational fluid dynamics to model how far waste will travel under various guidelines, 2) conduct

9 "Package Graywater Recovery and Treatment Systems Introduction," Alliance for Water Efficiency, June 8, 2009, www.allianceforwaterefficiency.org/Package_Graywater_Recovery_and_Treatment_Systems.aspx

10 California Department of Water Resources, July 2009, www.water.ca.gov/recycling/plumb/Flyer.pdf

11 "Evaluation of Water-Efficient Toilet Technologies to Carry Waste in Drainlines," Bill Gauley and John Koeller for the Canada Mortgage and Housing Corporation, April 2005, p. 30, www.cwwa.ca/pdf_files/Drainline%20Report%20Revision-Apr%201.pdf