BUILDING DESIGN+CONSTRUCTION
INSPIRING THE BUILDING TEAM
NOVEMBER 2009

Green Buildings + Water Performance

Seventh in a Series of Annual Reports on the Green Building Movement

What Building Teams and Home Builders Can Do To Confront the Pending Crisis in Water Scarcity

"People can't drink oil." That is what one respondent to our exclusive survey of AEC professionals said, to highlight the absolute necessity of water to our everyday lives.

Our seventh White Paper on Green Buildings focuses on the role of water in sustainable design and construction. The context for this discussion is shaped by the following:

- Virtually every region of the U.S. and parts of most states likely will experience water shortages in the next 10 years.
- More water is consumed outside buildings and homes—for landscape irrigation and cooling towers—than is used inside for toilets, faucets, and showers.
- Up to 20% of our purified water is lost to leaks in the nation's decaying infrastructure.
- There have been significant improvements in the efficiency of plumbing products in the last two decades, but saving too much water could lead to conditions that might impact the health of building occupants.
- Improving water performance can also help reduce energy use and greenhouse gas emissions.
- The reuse of water may be "the next big thing" in water conservation, efficiency, and performance.

The editors conclude with a set of 21 detailed recommendations—an Action Plan—for the consideration of Building Teams, home builders, developers, building owners, government officials, industry membership associations, NGOs, and the public with regard to water performance.

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1. Water Performance: Getting the Most from Every Drop

Since 2003, *Building Design+Construction* has produced a series of annual reports on the green building movement.[1] Our first two White Papers covered the early days of green building. In subsequent reports, we took on life cycle assessment of green building products (2005); analyzed the bottom line of green buildings (2006); and conducted groundbreaking studies of owner and user perceptions of green buildings (2007). Last year, we tackled climate change in an effort to help our audience of AEC professionals, building owners, and real estate developers understand the impact of global warming on their businesses.

Together, these White Papers encompass more than 225,000 words—enough for a decent-size book—and provide arguably the most sustained, objective analysis of the green building movement available to the AEC community. Four have been finalists for the Jesse H. Neal Award (called the "Pulitzer Prize of the Business Press"); two have won that award, along with national awards from the Construction Writers Association and the American Society of Business Publication Editors.

Now, in our seventh White Paper, we turn to water. Why water?

1 To download copies of past White Papers, go to: http://www.bdcnetwork.com/university/community/934/White+Papers/47492.html

2 "Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages," U.S. General Accounting Office, GAO-03-514, July 2003.

Principal Findings of the Water Performance White Paper

1. Virtually every region of the U.S. and parts of most states likely will experience water shortages in the next 10 years. Some are already feeling the effects of water scarcity.

2. More water is consumed outside buildings and homes—for landscape irrigation and cooling towers—than is used inside for toilets, faucets, showers, and the like.

3. Somewhere between 15% and 20% of the nation's water never makes it from the filtration plant to the property line, thanks to our decaying infrastructure.

4. Manufacturers have significantly improved the efficiency of plumbing, irrigation, and water reuse technologies in recent years, but long-term conservation also depends heavily on how people use these products.

5. There may be limits to water efficiency. In some cases, saving water can lead to "unintended consequences," such as pipeline drainage problems, health and safety concerns, and negative impacts on the environment.

6. Improvements in water performance can have a bonus: reducing energy use and greenhouse gas emissions.

7. The reuse of water may be "the next big thing" in water conservation, efficiency, and performance.

The availability of water is becoming an increasingly serious public issue. A 2003 survey by the General Accounting Office found that water managers in 36 states foresaw water shortages hitting their states to some extent over the next 10-year period under merely "average water conditions" (Figure 1.1). Colorado and South Carolina said their states would be entirely under drought; 16 states said one or more regions would be affected, while another 18 states saw localized water shortages.[2]

Two water-stressed states, California and New Mexico, did not complete the survey (along with Michigan). Georgia, which experienced a crippling drought in 2007, said in 2003 it would only experience "localized" water shortages.

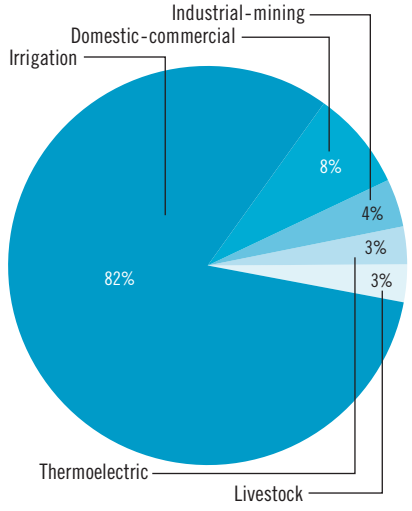
Water managers in 11 states told the GAO that their states were likely to experience water shortages "under drought conditions" in the following decade; 29 states said water shortages would be regional, and another six said it would be localized. Again, California and New Mexico did not participate.

On top of this, the U.S. will be adding another 100 million to its population over the next three decades, adding further to water stress.

Defining water performance. It is important to draw a distinction between water efficiency and water conservation, according to John Watson, water efficiency director for Sloan Valve Co. (a sponsor of this report). Water efficiency is driven by technology—how well a plumbing device such as a toilet or showerhead can operate effectively, using the least amount of water. Water conservation refers to the actual consumption of water by the end user. "You have the efficiency component and the conservation part of the formula. Together, they yield water performance"—a measure of how well the technology works and how well it meets the needs of the end user, says Watson.

For example, Watson points to plumbing industry research which showed that 95% of consumers were satisfied with a flow rate of 0.8 gallons per minute for high-efficiency lavatory faucets. For high-efficiency showerheads, the industry first modeled an optimal system, then built an apparatus to test the "ideal" model in the real world. "We

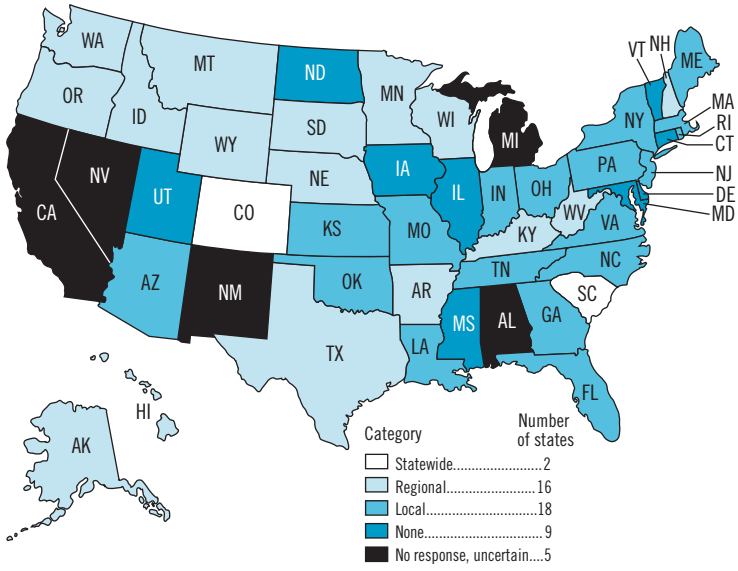
Chart 1.1
PERCENTAGE OF TOTAL WATER CONSUMED IN THE U.S., BY SECTOR



Source: Robert Goldstein, "EPRI's Water/Energy Sustainability Initiative," New York Regional Energy-Water Workshop, 20 April 2004. Data from USGS, NOAA, USDA, U.S. Census Bureau, USDOE, and USEPA (1995).

Although power plants withdraw large amounts of water, only a small percentage is evaporated; as a result, power plants consume only about 3% of the water in the U.S. Agricultural irrigation accounts for the greatest amount of actual water consumption, 82%.

Figure 1.1
EXTENT OF WATER SHORTAGES LIKELY OVER NEXT DECADE (2003-2013) (UNDER AVERAGE WATER CONDITIONS)



Source: "Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages," U.S. General Accounting Office, GAO-03-514, July 2003, p. 65.

In 2003 water managers in 36 states said they anticipated shortages in local areas, regions of their states, or statewide in the next 10 years under "average water conditions." Forty-six of 47 water managers said at least portions of their states were likely to experience water shortages "under drought conditions" in the next 10 years; 11 said such conditions would impact their entire state. California, New Mexico, and Michigan did not respond to the GAO survey.

actually proved that the data we came up with mathematically"—a flow rate of 2.0 gpm—"was a good shower" in most people's view, says Watson.

Kate McMordie, of the U.S. Energy Department's Pacific Northwest National Lab, frames "performance" another way. "It's not about everyone taking shorter showers" to save water, she says. "It's doing the same function with less water"—with no loss of end-user satisfaction.

How water is used. Buildings account for somewhere around 12% of water use in the U.S., according to the U.S. Geological Survey (or 14%, if you use the U.S. Green Building Council's figure). The preponderance of the water that is actually consumed in the U.S.—82%—is used for irrigation (Chart 1.1). About two-thirds of water use in urban areas goes to homes, apartment buildings, and condominiums (Chart 1.2). And nearly two-thirds of the water for single-family homes winds up on the lawn, or is lost to leaks (Chart 1.3).

This raises the question of how much water homeowners and building occupants can actually save.

"One of the real disconnects we have is that you 'know' what you 'see,' says Rob Zimmerman, a senior staff engineer for water conservation initiatives at Kohler Co. (a sponsor of this report). "People think the toilet wastes water, or the shower wastes water. But only about 4-5% of water use in U.S. goes through plumbing fixtures. When we talk about water shortages, there's only so much we can do on the plumbing side. If people think we're going to solve this problem with low-flow showerheads and faucets, that's not going to happen."

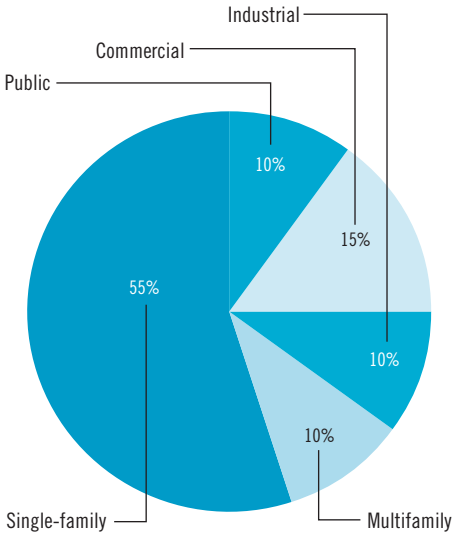
This is not to say that we shouldn't seek what Zimmerman calls "definite and attainable goals": an average 100 to 250 gallons per capita per day (GPCD) for single-family homes, about 55-70 GPCD for indoor use—possibly as low as 40 GPCD for indoor use in new green homes. Bill Gauley, a water engineering expert with Veritec Consulting, Mississauga, Ont., thinks 32 GPCD is feasible.

But indoor plumbing may not be the real culprit. As we shall see (Chapter 4), landscape irrigation uses a lot more water than is used inside buildings or homes.[3] "Using potable water for irrigation is a sin," says Toto USA's Gunnar Baldwin,

3 There is the further problem of "water gluttony." A study of residential water use in Dallas, in 2005, found that the top 10% of homeowners used 34% of the city's residential demand. The most gluttonous household used enough water to supply the indoor needs of 425 people. "Discussion: Are Water Managers Becoming Lawn Irrigation Managers?" Amy Vickers, Journal AWWA, February 2007.

Even the age of homes may be a factor. A U.S. Environmental Protection Agency WaterSense survey of 18,000 homes, half of them built before 2001 and half built in 2001 or later, found that new homes in seven of nine cities under study used 40% more water than older homes. Why? New homes had more bathrooms, and this seemed to encourage use. "Can water efficient technology save us from ourselves?" Doug Bennett, Landscape Management, 9 September 2008. wwww.landscapemanagement.net/landscape/Green%20Industry%20News/Can-water-effi cient-technology-save-us-from-oursel/ArticleStandard/Article/detail/548578?contextCategoryId=465

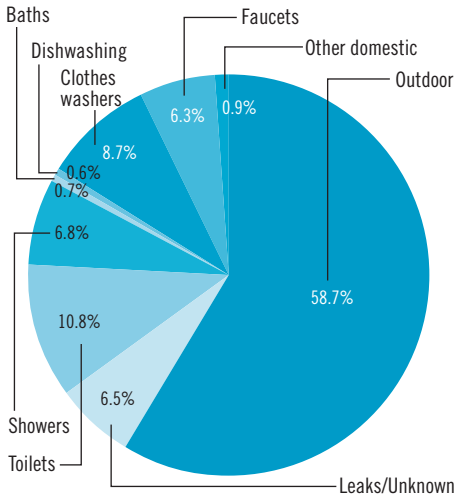
Chart 1.2
URBAN WATER CONSUMPTION, BY SECTOR



Source: "Graywater Treatment and Reuse Systems," John Koeller, Koeller & Associates, Linda Vista, Calif.

Residential uses account for nearly two-thirds of actual water consumption in the urban portions of the U.S.

Chart 1.3
TOTAL U.S. DOMESTIC WATER CONSUMPTION



Source: Data from Residential End Uses of Water. ©1999 AWWA Research Foundation and American Water Works Association. Copyright 1999 Aquacraft Inc. and AWWARF. All rights reserved. At: http://www.aquacraft.com/Publications/resident.htm

In the late 1990s, the AWWA Research Foundation commissioned Aquacraft Inc. to study the end uses of water in 100 single-family homes (statistically selected to be representative of all single-family homes) in 12 cities and water districts.* Indoor use, not counting leaks, accounted for about 35% of the total. The bulk of single-family water use occurred outdoors.

a charter board member of the Alliance for Water Efficiency. "It's totally unnecessary and should be banned completely."

In commercial buildings, cooling towers can account for a major chunk of water use, especially in hot, dry climates, says Texas-based water consultant H.W. (Bill) Hoffman. "In a typical office building in downtown Austin, cooling tower use typically would be 30-50% of total water use," he says. On a hot, dry day, an office building with 800-1,000 tons of A/C equipment can use 20,000-30,000 gallons a day, "even if the system is operating efficiently."

The true cost of water. In the U.S., water, like gasoline, is cheap. It is estimated that water used for agricultural irrigation is priced at only one-sixth of its true value. According to Jeff Kishel, PE, SVP and leader of A/E firm Stantec's environment business, agricultural users may pay about $10 an acre-foot for water, while residential users might pay hundreds of dollars for the same amount, depending on location.

Becoming more efficient also drives up the unit cost of water. "Los Angeles is using the same amount of water it used 20 or 30 years ago, but the cost per gallon has gone up, because your fixed costs are virtually the same," says Kishel.

In fact, water in the U.S. is so cheap that it makes it difficult to pay for much-needed improvements to the system. "The true *cost* of delivering clean water continues to creep slowly upwards, as does the average *price* of water, but not at the kind of rates that would seem to be required if we are going to upgrade and truly maintain our infrastructure on a sustainable basis," note the editors of *Environmental Business Journal* in their recent WaterView 2009 Report. "It seems clear that we still don't really recognize the true value of water—nor do we have to currently pay a price for water anywhere near what it is really worth to us."[4]

Hidden costs of water. One of the less well-understood aspects of water is its energy cost. In most parts of the country, however, water has to be pumped to its point of use, and that takes energy, usually in the form of electricity or natural gas.

Water processing and distribution, coupled with sewage treatment, consumes about 4% of electricity in the U.S., according to the Electric Power Research Institute (EPRI), Menlo Park, Calif.[5] A 2009 analysis by River Network, Portland, Ore., estimated U.S. water-related energy use—including heating water for homes and businesses—at 521 million MWh a year—equivalent to 13% of

*Boulder and Denver, Colo.; Eugene, Ore.; Las Virgenes (Calif.) Metropolitan Water District; Lompoc, Calif.; Phoenix; San Diego; Seattle; Tampa, Fla.; Tempe/Scottsdale, Ariz.; Walnut Valley (Calif.) Water District; and Waterloo/Cambridge, Ont.

Aquacraft's Peter Mayer: "The outdoor use component is strongly influenced by the the geography and climate of the cities that participated in the study. Outdoor use as a percent of the total ranged from 22-67% in this study. While the 58.7% outdoor use was the average for the participating agencies, these agencies are not representative of the entire U.S. It is an acknowledged weakness of the study."

4 "WaterView 2009 Report: Water & Wastewater Markets," Environmental Business Journal (published by ZweigWhite), Summer 2009.

5 "Water and Sustainability (Volume 4): Use Water Consumption for Water Supply and Treatment—The Next Half Century," Electric Power Research Institute, Topical Report, March 2002.

the nation's electricity consumption.[6] In California, water transport and treatment accounts for 19% of electricity used in the state. For many older municipal water systems, supplying fresh water to buildings and homes can account for 80% of the energy used by local water utilities, according to the Alliance for Water Efficiency

Crumbling infrastructure. The U.S. has about 700,000 miles of water and sewer pipe, of which an estimated 72,000 miles are 80 years of age or older. "The stuff's falling apart," says Stantec's Jeff Kishel. "A lot of it is owned by public agencies and they tend to leave it in the ground until it falls apart. A lot of this infrastructure is nearing or at or even beyond its useful life."

Greg Kail, public affairs director for the American Water Works Association, whose 60,000 members represent the nation's water utilities, says what the AWWA calls "non-revenue water" comes in part from such things as water lost due to fire hydrants being flushed. As for leaks, says Kail, "We've gotten away from what an average percent would be, because of the various ways it's measured" by the nation's 54,000 community water systems. A 1996 estimate said that a 10% loss would be "a good level," says Kail, but experts say it could be as much as 20-30% in older cities of the Northeast and Midwest.[7]

The nation's larger water utilities are spending billions on infrastructure improvements—$46 billion for water (in 2004), $36.4 billion for sewers (2005).[8] According to Jennifer Hoffner, of Portland, Ore.-based American Rivers, Atlanta has cut its leaks from 20% to about 14-15%. Chicago has made significant strides in relining and repairing miles and miles of its water pipes.

The AWWA says that an additional $250 billion spread over the next couple of decades is needed; the 2003 EPA Drinking Water Needs Survey put the cost at $276.8 billion over 20 years. But that kind of investment is unlikely to happen. Of the $787 billion in the economic stimulus, for example, only about $2 billion is set aside for drinking water improvements and about $4 billion for wastewater—"a drop in the bucket," according to Kail.

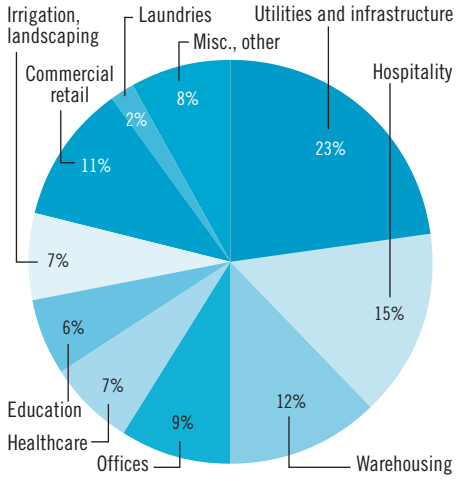
In the meantime, billions of gallons of fresh water will be lost en route to homes or buildings, building owners will be charged for sewer services for wastewater that never reached the treatment plant, huge amounts of energy will be consumed, and untold tons of greenhouse gases will be generated.

'Unintended consequences.' When it comes to water performance, sometimes doing the right thing creates "unintended consequences," to use the phrase *du jour*. Manufacturers are getting so good at making toilets efficient that we may be in danger of not having enough wastewater to flush the sewer lines properly—the so-called "drain line transport problem."

In the U.S., five organizations—the Alliance for Water Efficiency (AWE), the Plumbing Manufacturers Institute (PMI), the International Association of Plumbing and Mechanical Organizations (IAPMO), the International Code Council (ICC), and the Plumbing-Heating-Cooling Contractors Association (PHCC)—have formed the Plumbing Efficiency Research Coalition. PERC's first initiative: a research study on the drain line carry problem, which will seek to determine the minimum amount of water necessary to safely flush drain lines.

Another "unintended consequence" is what Gary Nuss, managing principal for water resources at Jacobs, calls "regulatory drought." This occurs when protecting the environment trumps

Chart 1.4
COMMERCIAL AND INSTITUTIONAL WATER USE IN THE U.S., 1995



Source: Dziegielewski, B., et al.,"Commercial and Institutional End Uses of Water," American Water Works Association and AWWA Research Foundation, 2000, and EPA WaterSense, "Water Efficiency in the Commercial and Institutional Sector: Considerations for a WaterSense Program," 20 August 2009.

Hospitality (restaurants and lodging), office buildings, hospitals, and schools and university buildings represent good opportunities for water performance improvements. These figures are based on the EPA's "Study of Potential Water Efficiency Improvements in Commercial Businesses (1997) and, according to the EPA, "represent the largest national data sample to date, and are consistent with other available studies regarding subsector water usage" in commercial and institutional buildings.

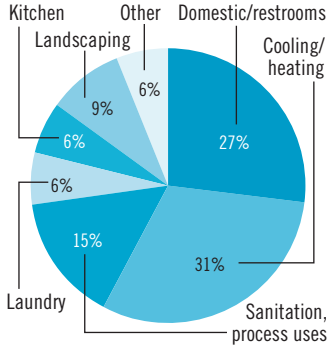
6 "The Carbon Footprint of Water," Bevan Griffiths-Sattenspiel and Wendy Wilson, River Network, May 2009. www.rivernetwork.org The authors note further: "While this appears to be a conservative estimate of water-related energy use, our findings suggest that the carbon footprint currently associated with moving, treating, and heating water in the U.S. is at least 290 million metric tons a year. The CO_2 embedded in the nation's water represents 5% of all U.S. carbon emissions and is equivalent to the emissions of over 62 coal-fired power plants."

7 The Infrastructure Leakage Index provides a measure of how a water system is performing vs. best practices. An ILI of 3 would mean that the system is three times "leakier" than it should be. Presumably, new systems should have low ILIs; older systems, high indexes. ILI was first published by the International Water Association in 1999 and is in use in 50 countries.

8 "Financing Water Infrastructure: A Water Infrastructure Bank and Other Innovations," American Water Works Association, 26 February 2009, page 3.

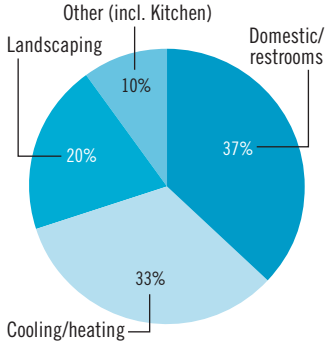
This water consumption breakdown for key building types indicates a wide range of patterns in how much water occupants and systems use. Note: While these charts represent best available data, the studies are at least a decade old and are based on limited geographical, climatic, and building-type differences and may not reflect improvements in water-efficient plumbing, irrigation, and cooling tower technologies.

Chart 1.5
END USES OF WATER IN HOSPITALS



Source: Dziegielewski, B., et al.,"Commercial and Institutional End Uses of Water," American Water Works Association and AWWA Research Foundation, 2000.

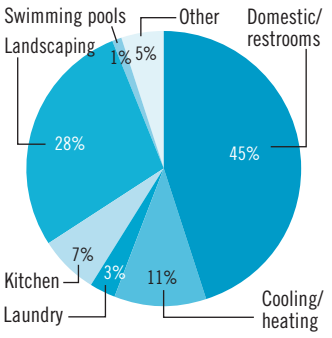
Chart 1.6
END USES OF WATER IN OFFICE BUILDINGS



Source: Dziegielewski, B., et al., "Commercial and Institutional End Uses of Water," American Water Works Association and AWWA Research Foundation, 2000.

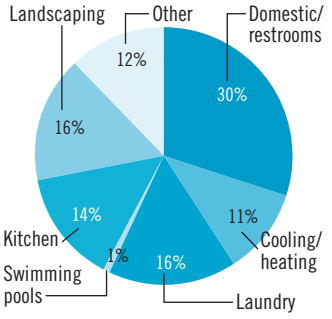
9 Of course, all water is "reused" in some sense. Much of the water in the Colorado River, which supplies drinking water to the Los Angeles region, comes from the discharge from 180 wastewater treatment plants along its route. Thousands of treatment plants discharge their treated wastewater into the Hudson, Ohio, and mighty Mississippi, thus supplying a source of potable water (following further treatment and purification, of course) to populations downstream.

Chart 1.7
END USES OF WATER IN SCHOOLS



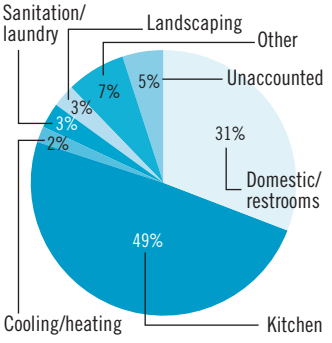
Source: EPA WaterSense, "Water Efficiency in the Commercial and Institutional Sector: Considerations for a WaterSense Program," 20 August 2009, p. 8. Based on Dziegielewski et al., 2000.

Chart 1.8
END USES OF WATER IN HOTELS AND MOTELS



Source: EPA WaterSense,"Water Efficiency in the Commercial and Institutional Sector: Considerations for a WaterSense Program," 20 August 2009, p. 9. Based on Dziegielewski et al., Commercial and Institutional End Uses of Water, 2000.

Chart 1.9
END USES OF WATER IN RESTAURANTS



Source: Dziegielewski, B., et al.,"Commercial and Institutional End Uses of Water,"American Water Works Association and AWWA Research Foundation, 2000.

human need for water. This past July, a U.S. District Court judge ruled against the U.S. Army Corps of Engineers in favor of Florida, which said it was entitled to water from federally controlled Lake Lanier, Atlanta's main reservoir, to maintain marine life in the Chattahoochee River on its side of the Georgia-Florida state line.

WATER REUSE: 'THE NEXT BIG THING'

"One thing that's quickly gaining momentum is water reuse," says Sloan Valve's John Watson. "This is the next big thing."

Water reuse involves both graywater and rainwater. In the case of graywater, why not collect the wastewater from sinks, clothes washers, and showers, give it a moderate level of filtering and disinfecting, and use it to flush toilets in a house or building? Why not give this valuable resource a second life, so to speak? It may seem logical, but plumbing, building, and health regulations in many jurisdictions prohibit this practice as a potential danger to the health of building occupants.

Likewise, it would seem to make sense to use roof runoff for other useful purposes. "We're using fresh domestic drinking water to irrigate grass and replenish cooling towers," says Rick Reinders, president of Watertronics, Hartland, Wis., a manufacturer of rainwater harvesting systems (and a sponsor of this report). "By harvesting rainwater, you're reusing that water, and it's not going into the treatment system. That relieves pressure on sewer and septic systems."

Yet many states and local jurisdictions prohibit the indoor use of graywater and rainwater and limit their use at most to underground drip irrigation. NSF International, a product testing organization based in Ann Arbor, Mich., is drafting a standard on the water quality and O&M aspects of graywater to help clarify the health and safety aspects associated with reused water.[9]

In the following chapters we expand on the points hinted at here. Chapter 2 presents the results of two exclusive surveys. Chapter 3 explores what Building Teams are doing about indoor water performance; Chapter 4 looks at the exterior of buildings. Chapter 5 surveys the water components of the green building certification programs. Chapter 6 delves into water and energy.

We conclude with our Action Plan—21 specific recommendations on what AEC professionals, home builders, government agencies, trade associations, and the public can do to improve water performance.

2. AEC Professionals and Home Builders Voice Their Opinions on Issues Related to Water Performance

Methodology

In September 2009, *Building Design+Construction* conducted an online survey among 10,000 of its subscribers to determine their opinions, perceptions, and actions relative to water issues. The Nonresidential Survey sample was selected from all qualified recipients of the magazine who had provided email addresses when subscribing. Each of the first 50 respondents received a $25 Amazon gift certificate.

Of the 748 who completed the survey, 442 (59%) work for design firms, 171 (23%) work for build firms, and 109 (15%) work for owning firms (3% "other"). For questions in which all 748 responded, the margin of error is 3.58% (at the 95% confidence level) and 3.01% (at the 90% confidence level).

A similar survey was conducted among subscribers of our sister publication, *Professional Builder*. The margin of error for the Residential Survey is 7.21% (at the 95% confidence level) and 6.05% (90% confidence level) for questions answered by all 185 respondents.

Respondents to *Building Design+Construction's* "Nonresidential Survey" expressed a wide variety of viewpoints concerning water in the built environment. "This is a very important issue for the world," said the head of an engineering firm in North Carolina. An electrical designer in Texas said, "Water availability is critical for both economic development and sustaining the present as well as for providing for future population growth." A retail developer in the western U.S. warned that stewardship over potentially finite water resources "should be constantly in our thoughts and consideration." And the president/CEO of a New York-area development firm summed up these issues with this remark: "People can't drink oil."

Economic factors in client decisions. Several respondents were worried about added costs for water in light of current economic conditions (the survey was distributed in September 2009). "Greater costs to clients plus the economic downturn will cause additional hardship on clients, subcontractors, and suppliers," said one California architect.

"Clients usually don't want to spend the money for futuristic ideas," said an engineer in California. The president of an engineering firm in Georgia brought up the link to future development: "Water supply is critical to health and essential for development of new facilities. Growth will be severely hindered if water is not in adequate supply." But this respondent also added a cautionary coda: "Conservation is essential."

Principal Findings of the Nonresidential Survey

1.Water efficiency in projects. The majority of respondents said their firms had used water-efficient technologies, products, or systems in at least a quarter of all projects in the past two years; more than a fourth of respondents stated that their firms had used such systems in more than 75% of all projects. More importantly, respondents said they expect their firms to increase adoption of water-efficient technologies in the next two years.

2.Water-efficient products. Respondents said their firms are already using a broad array of water-saving products, technologies, or systems—an average 9-10 such technologies for indoor use (high-efficiency lavatory faucets, sensor-activated faucets and flush valves, high-efficiency showerheads, etc.) and an average 6-7 "exterior" systems (stormwater management, retention ponds, native plantings, drip irrigation). Moreover, they expect their firms to make even greater use of such technologies or systems in the next couple of years (Table 3.2, page WP20; and Table 4.1, page WP27).

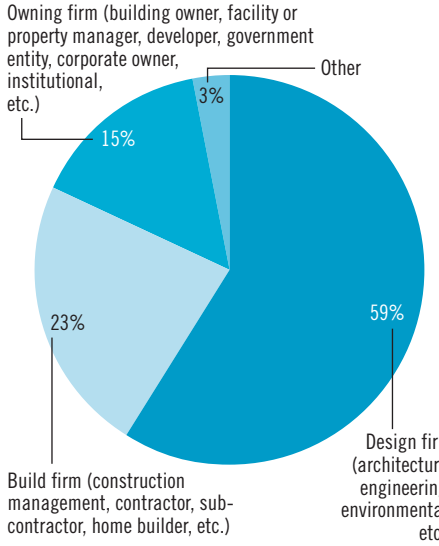
3.Water-related problems. Of respondents who said their firms had experienced water-related problems in the past few years (an average of one or two such instances), nearly half cited restrictions on water use as the chief problem, followed closely by "legislative or regulatory action." "Increased project costs" was cited as the principal impact of these factors by the majority of respondents.

4.Water costs. Half of all respondents said they expect water costs to "increase somewhat" in the next 2-3 years, with another 21% expecting "significant" increases.

5.Code issues. More than three-fourths of respondents identified "code restrictions or requirements" as the factor having the greatest water-related impact on their firms' building projects.

6.Water-energy nexus. With regard to the energy requirements of water, respondents were pretty much in the middle (3.12 on a 5-point scale), although one-fourth of them said they saw "significant" energy costs related to water (Chart 6.1, page WP39).

Chart 2.1
WHERE NONRESIDENTIAL SURVEY RESPONDENTS WORK



Base: 747
Source: BD+C 2009 White Paper Survey

Nearly three of every five Nonresidential Survey respondents (59%) work for architectural, engineering, or environmental design firms. Build firms (23%) and owning firms (15%) were also well represented among respondents, providing a representative overview of the U.S./Canada noncommercial design and construction sector. (A small group of design/build firms (<1% of total) are included in Other.) The large sample size (748) results in a margin of error of 3.58% (at the 95% confidence level) and 3.01% (at the 90% confidence levels) for questions in which the entire group has responded.

Table 2.1
NONRESIDENTIAL RESPONDENTS' PRIMARY JOB FUNCTION

Architect	40%
Engineer (civil, environmental, MEP, structural)	19%
Construction manager	12%
Construction professional, subcontractor	12%
Real estate developer	5%
Building owner	3%
Consultant (environmental, green building, other)	1%
Government official or staff	1%
Home builder	1%
Interior designer	1%
Facility director, manager	1%
Other	4%

Base: 748
Source: BD+C/Professional Builder 2009 White Paper Survey

Architects and engineers of all kinds constitute the bulk of Nonresidential Survey respondents (59%), with construction managers, construction professionals, and home builders forming the next largest group (25%). Developers, building owners, facilities personnel, and government representatives (10%) were also represented in the study, which drew on the experience of 748 professionals derived from the audience base of Building Design+Construction.

One respondent said his firm was blessed with clients with progressive attitudes on water. "We are seeing many of our clients request the development of natural systems to handle stormwater issues." Forward-thinking design for such clients leads to projects that not only protect water quality, but also enhance public open space and lower overall maintenance costs for government, said this Georgia land developer.

But "selling" water efficiency to clients is not always easy. "The issues surrounding water are very long-term, and long-term is difficult to sell," said one respondent. "We need to start programs that can build to a solution over a period of years." The owner of a design firm in Minneapolis predicted that the "big effects" of water shortages are "five to 10 years down the road, and most clients aren't at all aware of how serious those effects could be."

Code and regulation worries. One group of respondents was vocal about the regulatory aspects of water. "Any additional regulations or restrictions will increase construction costs," said one. An owner/architect in New York City said the most significant issue related to water in his projects was the supply of drinking water, "which is being increasingly regulated."

"Artificially decreasing supply through excessive environmental regulations and land restrictions,"

More Survey Results

For additional survey results, please visit: http://www.BDCnetwork.com/article/CA6702093.html.

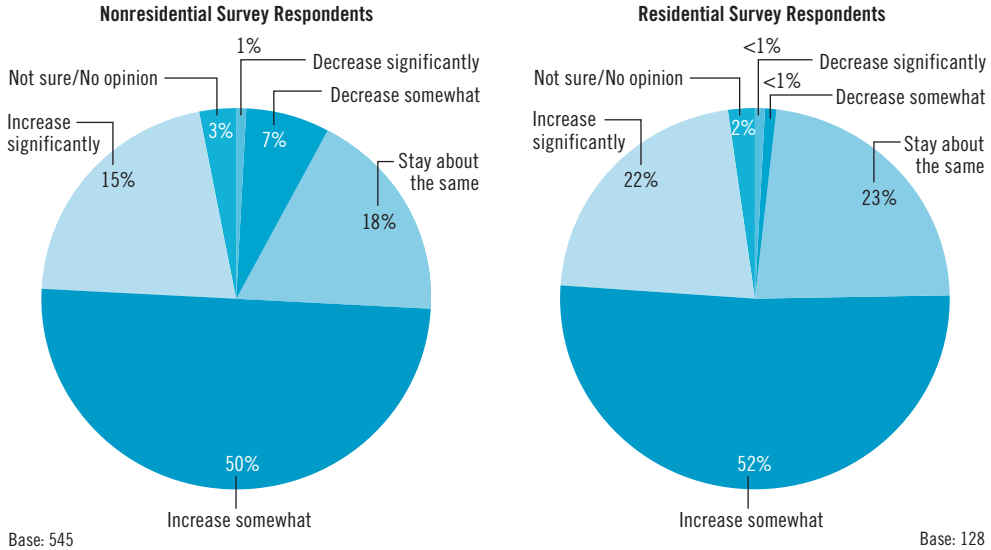
Table 2.2
USE OF WATER-EFFICIENT TECHNOLOGIES IN PROJECTS
In the last 18-24 months, approximately what percentage of your firm's building projects or major renovations employed water-efficient technologies, products, or systems? What percentage of your firm's projects will employ or plan to employ water-efficient technologies, products, or systems?

	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
None	10%	4%	17%	9%
Less than 10% of projects	14%	8%	17%	11%
10% to 25% of projects	19%	12%	10%	7%
26% to 50% of projects	13%	15%	14%	12%
51% to 75% of projects	12%	14%	5%	15%
More than 75% of projects	26%	38%	30%	38%
Don't know/Can't estimate	6%	9%	8%	8%

Base: Nonresidential, 679; Residential, 161
Source: BD+C/Professional Builder 2009 White Paper Survey

Based on the results of both surveys, prospects are good for increased adoption of water-efficient technologies, products, and systems in both the residential and nonresidential construction over the next two years. Both groups said they expect their companies to increase their adoption of water-efficient tools in the majority of projects, to the point where the majority in each survey (Nonresidential, 52%; Residential, 53%) said they expect more than half their firms' projects to be using water-saving systems in the next two years.

Chart 2.2
TOTAL COST OF WATER
From your professional experience and what you have read or heard, do you think the total cost of water for your firm's new building projects and major renovations will decrease, increase, or stay about the same over the next 2-3 years?



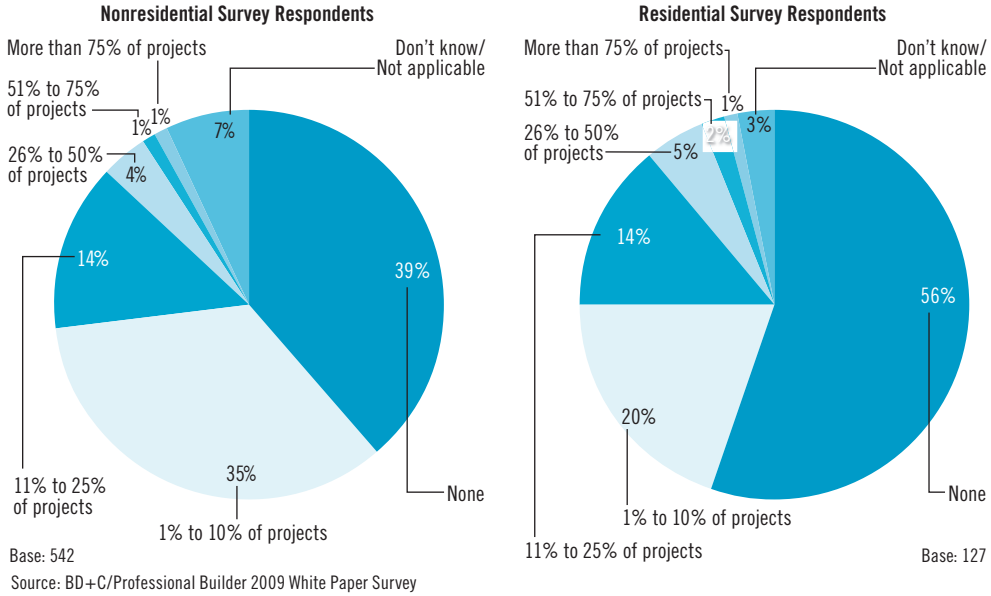
Base: 545

Base: 128

Source: BD+C/Professional Builder 2009 White Paper Survey

The majority of respondents to both surveys (Nonresidential, 50%; Residential, 52%) said they believe the total cost of water for their firms' projects will "increase somewhat," with more than one-fifth of each group (Nonresidential, 21%; Residential, 22%) predicting it would "increase significantly."

Chart 2.3
EXTENT OF WATER-RELATED PROBLEMS IN BUILDING PROJECTS
To the best of your knowledge, approximately what percentage of your firm's new building projects or major renovations experienced water-related problems in the past 2-3 years?



Base: 542

Base: 127

Source: BD+C/Professional Builder 2009 White Paper Survey

The majority of Residential Survey respondents (56%) and a fairly large representation of Nonresidential Survey respondents (39%) said their companies had experienced no water-related problems in projects over the last few years. Among Nonresidential Survey respondents reporting problems, nearly half (49%) reported problems in up to one-fourth of their firms' projects, while more than a third (345) of Residential Survey respondents reported problems in up to one-fourth of their companies' projects.

as well as poor regional and local planning development regulations, are "the major contributors to the increased cost of water resources" cited by one California architect. Greater regulation of water is "not warranted at this time," said a design firm principal in Oklahoma. "We are not at the point that it is necessary to legislate this," he said.

On the flip side of the codes issue, a VP at a multidisciplinary A/E firm in Maryland said, "Code mandates drive change the most, as owners tend to vote with their wallets." Even more sanguine as to the benefits of codes was a principal of a New Jersey architecture firm: "Revisions to the building codes which restrict water usage and reduce waste water will have the single greatest positive effect" on water consumption and wastewater reduction. "I believe this to be so more than LEED certification."

A project executive with a West Coast construction services firm called for "a push for code requirements to ensure more cost-effective and high-quality water systems." A Florida-based AEC professional cried out for "badly needed" regulations to permit rainwater harvesting in the Sunshine State. "It needs to be incorporated into the Florida Building Code so that counties and municipalities will readily allow the use of rainwater cisterns and other harvesting systems." And a designer in California hailed his state's recent adoption of "more progressive" graywater provisions in the state plumbing code as "very good news"—but noted that "municipalities are lagging far behind in forming coherent regulatory positions with respect to rainwater catchment."

Regional dimensions of water. If it is true that all politics is local, so, too, are all water issues. "The U.S. has such diverse water issues, it's hard to arrive at an omnibus policy," said a respondent from Wisconsin. "Regional solutions are going to be the practical solution."

While water issues are of lesser concern in areas of relative water abundance—for example, an architect in New York City said water issues were "at the lower end" of his concerns—those in the thick of water-stressed areas were much more focused on the problem. "In working in Maricopa County, Ariz., we use thousands of gallons of water a day to keep a crust on the soil to keep dust particles down," reported a project superintendent for a construction company in Phoenix. "How can we conserve water when this is a requirement for construction?"

Another Phoenix-based respondent cited differentials in cost by jurisdiction: "Impact fees for water and sewer service for commercial developments can be astronomical based upon the jurisdiction that delivers the service." One project's impact fees were so high that this architecture firm principal found it more feasible to dig a well and put in a septic system rather than to tap into the municipal services. Bottom line: "The client saved hundreds of thousands of dollars."

Water's green component. A number of respondents took the opportunity to air their views on green building. The owner of a construction and development firm in Austin, Texas, criticized the green building movement as "substantially oversold," citing "experimental products with unproven track records," notably with regard to maintenance costs, life span, and recovery costs. A facilities architect at a medical center in Louisiana expressed concern that, "in many cases," certified

Table 2.3
TYPES OF WATER-RELATED PROBLEMS IN BUILDING PROJECTS
Which of the following water-related problems did your firm or company experience in the last 2-3 years in any new building projects or major renovations? What was the impact of these problems on your projects?

Type of Problem Encountered	Nonresidential	Residential
Restrictions on water use or service	49%	46%
Legislative or regulatory action related to water	33%	36%
Significant increase in water rates	30%	48%
Water scarcity or drought	21%	27%
Unreliable water supply	14%	9%
Contamination of drinking water	9%	11%
Denial of water service	9%	13%
Other	13%	11%
Base: 328		
Impact of Problem on Project	**Nonresidential**	**Residential**
Increased projects costs	55%	64%
Had minimal impact; problem was readily resolved	27%	29%
Delayed the project	21%	30%
Resulted in significant changes in the project	17%	13%
Contributed to the termination of the project	3%	4%
Other/Don't know/No opinion	13%	11%

Base: Nonresidential, 327; Residential, 56
Source: BD+C/Professional Builder 2009 White Paper Survey

Nonresidential Survey respondents who reported water problems said their companies experienced 1-2 water-related events over the last three years (mean: 1.77). The average number of events for Residential respondents was two (mean: 2.00). "Other" problems cited by the Nonresidential Survey group included "low pressure for fire sprinkler systems," "leaks," "inadequate detention capacity," "clogged filters," "storm control," "old utility piping," and "containment" (presumably of stormwater or runoff). Residential Survey respondents mentioned "stormwater regulations," "infiltration" from nearby vacant lots, and "increased cost of new meters." In terms of impact, both groups cited "increased project costs" as the biggest negative (Nonresidential, 55%; Residential, 64%), followed by project delays (Nonresidential, 21%; Residential, 30%). However, more than a quarter of respondents said the problems were minor and had been resolved quickly. Note: The response rate to these questions among Residential Survey respondents is low, with a margin of error >14%.

buildings may not be performing as designed. He recommended a two-year waiting period for verification before certification would be bestowed.

"Potable water resources and stormwater mitigation are economic issues apart from but co-opted by 'green' marketing," said the owner of a design firm in Washington State. "The real question is not whether a policy or strategy is 'green' but whether it is practical and within the budget."

Greater sophistication about green building issues was suggested by the co-owner of a specialty development firm in the Twin Cities: "Designers and [property] owners need to make good decisions without chasing certifications and points." The director of sustainable design for an architecture firm called her fellow building designers to task for having "little knowledge of the relationship [between] energy and water" and for failing, in her opinion, to "understand the global issues of water scarcity." But an operations manager for a major construction services firm commended green certification programs, specifically LEED, for "making more folks aware of the need to conserve water resources." And, as one respondent put it, "Green building is our future."

New technologies, new opportunities. Many AEC firms are already adopting water-efficiency technologies—and intend to employ them at an even greater rate in the next couple of years. "We have been using waterless urinals for years," reported an interior designer and LEED AP. The vice president of a design firm in Phoenix said his firm "uses water-reduction strategies in every building project." An estimator with a construction company in Tennessee said his firm was using native vegetation for landscaping, rather than "some generic type of grassing," to stabilize soil.

At a larger scale, the chair of an engineering firm in Chicago questioned the wisdom of encouraging—or even allowing—further development in water-scarce areas like Las Vegas or Phoenix: "If water is limited, so should the population be limited. We should not burden areas [that] have no water." And a building systems manager for a construction firm in the Upper Midwest said it would take a "significant water shortage, distribution issue, or increase in the value of water" to get people in his part of the country energized about water issues. Economic factors, he said, "must drive the need for conservation and efficiency."

"We need to quit wasting our environment," said the president of a design firm in the Houston area. "Our society needs to understand the future of our world and develop a mind[set] around SAVING what we have" (emphasis in original)."

The last word goes to a principal of a multidisciplinary design firm in suburban Boston. "People in the U.S. don't know how lucky they are to have so much drinkable water available to them," she said. "Unless they have experienced water restrictions personally for some reason, they don't think about how vital and precious clean water is.

Principal Findings of the Residential Survey

1. Nearly half of respondents said their companies had used water-efficient technologies, products, or systems in 26% or more of their home building projects in the last two years, with 30% stating that their firms had done so in more than three-fourths of their projects. (Table 3.2, page WP20).

2. Nearly two-thirds said their firms plan to use water-efficient systems in the next couple of years, with 38% forecasting their companies would do so in more than three-fourths of projects.

3. Like their nonresidential counterparts, home builders were most concerned about the possible impact code restrictions or regulations, as well as general economic conditions, might have on their businesses.

4. The majority of respondents said they expect water costs to increase somewhat over the next 2-3 years, with 22% expecting significant increases.

5. More than a third of Residential Survey respondents reported problems in as many as one-fourth of their companies' projects.

The economic downturn of 2008-09 has home builders and residential developers' heads spinning, to the point where many of them can't think about anything else. "Can you help me with the economy?" was the rhetorical question posed by the CEO of a home building firm in Utah. "Water is the second most important resource! Customers are first. Without customers, we don't need water." As one residential developer put it, "We are conscious of environmental factors when

The International Association of Plumbing and Mechanical Officials continues to lead in code development related to Green Plumbing. IAPMO's involvement in sustainable initiatives predates current trends as the Uniform Codes have long included provisions for water efficient plumbing products, grey water and reclaimed water systems, solar energy systems and environmentally friendly refrigerants. You may not recognize our name, but you know our UPC Shield marks mean the plumbing products throughout your home and office are safe and reliable.

Our most recent efforts include the development of the Green Plumbing and Mechanical Code Supplement. This unique, comprehensive document spells out the best sustainable residential and commercial plumbing and mechanical systems and practices in simple, straightforward code language. It is not a point system for determining "greenness," but rather an actual code document from which any jurisdiction can work toward increased sustainability.

The Green Supplement will complement IAPMO's Uniform Codes — or any other adopted state, regional or model plumbing and mechanical code — by introducing additional language pertaining to:

- Water and energy efficiency and conservation, including:
- High efficiency fixtures, fixture fittings and appliances
- High efficiency plumbing fittings, fixtures and appliances
- Water softening equipment
- Cooling towers and evaporative coolers
- Alternate Water Source Usage, including gray water, rainwater and recycled water
- Water heating systems, including equipment efficiency, insulation, recirculation, design and system controls
- Energy efficiency for HVAC systems and commissioning and increased indoor environmental quality.

The Green Supplement is not a "greener" version of the Uniform Codes, but rather a separate document establishing requirements for sustainable building and water efficiency applicable to safe, reliable plumbing and mechanical systems. It serves as an invaluable resource for code officials, plumbers, contractors, engineers and manufacturers in designing, installing and approving more sustainable plumbing and mechanical systems. The Green Supplement:

- Provides the most comprehensive collection of plumbing and mechanical provisions available toward increased water and energy efficiency
- All provisions contained in the Green Supplement are proven safe and reliable
- Provides related installation and maintenance requirements
- Where possible, the Green Supplement provides commentary detailing the water and energy savings associated with the provisions detailed within its language

For more information about the Green Supplement and/or IAPMO's commitment to facilitating a more sustainable environment through innovative plumbing and mechanical systems, please contact Dave Viola, IAPMO director of Special Services, at (708) 995-3004 or dave.viola@iapmo.org.

Russ Chaney
Executive Director, The IAPMO Group

we develop, but we also must balance the costs of the projects with the costs of the green features we want to use. It ain't easy."

In the residential sector, the home buyer is all about price, several respondents noted. "People aren't very interested in anything that costs them more initially," said the president of a building company in Wyoming. "Almost all efforts at conservation or efficiency take a sales effort." Said the CEO of a Missouri home building company, "Rarely have we found that people are motivated to 'do the right thing' unless it affects their pocketbook."

This seems to be especially the case in home builders' efforts to "sell" green houses. "Home buyers are interested only if going green reduces costs, either initial costs or operating costs," said a property developer in Florida. Only a "very small percentage, 5% or so, want to incorporate green regardless of cost." Another respondent said his customer base is interested in green components, but not in a "total green home," adding, "Some of this is price-driven, some of it is comfort-driven."

"We have employed water-, sewer-, and energy-saving products for 30 years," said an experienced construction company president. "All of the 'green' and 'climate' issues are going to do nothing except increase costs. What we need now is price reduction solutions to get the economy going again."

"The current economy is going to have an impact on the green movement," said the head of a building company in Maine. "Customers cannot afford to make the necessary upgrades. Green building will move on but at a slower pace than what I would like to see."

"While green building sounds great, ultimately local municipalities will remove the incentives and make the guidelines mandatory, thereby increasing the cost to developer and builder and ultimately the homeowner," said another respondent. "Ironically, they will be the same people who cry about the lack of affordable housing stock."

The owner of a custom home building firm in Maryland who had completed a LEED Platinum home expressed concern about the "excessive" cost of certification under LEED for Homes. His bottom line: "NAHB Green Certification is more applicable to residential."

Both builders and buyers are drowning in greenwash, according to several respondents, making it difficult to choose products that are both cost-effective and functional. "Due to our current economy, selling a home that costs 20% [more] due to the implementation of so-called 'green' products is a difficult sale," said one. "I strongly believe that some organization needs to honestly evaluate and certify all of these 'green' products."

But not all Residential Survey respondents were down on green. "Green home building is here to

Table 2.4
RESIDENTIAL RESPONDENTS' primary job function

Home builder, construction manager, contractor	61%
Land developer, real estate developer	12%
Designer of homes (architect, landscape architect, interior designer, etc.)	10%
Specialty trade contractor	(5%)
Engineer (mechanical, electrical, plumbing)	2%
Government or code official	1%
Other	8%

Base: 185
Source: BD+C/Professional Builder 2009 White Paper Survey

More than three-fifths (61%) of Residential Survey respondents identified themselves as home builders, accompanied by a spread of developers (12%) and designers (10%). Note: Based on the sample size (185), the margin of error is 7.21% (at the 95% confidence level) and 6.05% (90% confidence level) for questions answered by all respondents. The sample was derived from the audience of BD+C's sister publication, Professional Builder.

Table 2.5
IMPACTS OF WATER ISSUES ON BUILDING PROJECTS In your opinion, to what extent will each of the following affect water factors (supply, quality, security, cost) for your new building projects or major renovations over the next 2-3 years? (1 = No effect at all, 5 = Substantial effect)

	Nonresidential		Residential	
	Mean	Mean top 2 (score = 4 or 5)	Mean	Mean top 2 (score = 4 or 5)
Code requirements or restrictions	4.25	76%	4.03	60%
General negative economic conditions	3.74	54%	3.67	48%
Higher sewer/water treatment rates	3.72	57%	3.68	53%
Infrastructure problems	3.72	56%	3.65	50%
Water service or supply restrictions	3.72	56%	3.63	55%
Higher water rates	3.71	57%	3.60	50%
Competition for water resources (e.g., agricultural irrigation, industrial use, etc.)	3.71	54%	3.12	36%
Infrastructure capacity	3.70	58%	3.58	51%
Total cost of water	3.68	56%	3.72	53%
Drought or near-drought conditions	3.68	55%	3.37	42%
Pollution or contamination	3.49	47%	3.09	34%
Climate change	3.23	37%	2.63	17%
Terrorist acts	2.65	19%	2.58	14%

Base: Nonresidential, 539-543; Residential, 125-128
Source: BD+C/Professional Builder 2009 White Paper Survey

Code requirements or restrictions as they affect water were definitely on the minds of respondents to both surveys: a mean score of 4.25 for Nonresidential Survey respondents is considered a very strong indicator, especially combined with more than three-fourths (76%) rating "codes" in their Top 2 responses. Neither group expressed much concern about the impact of climate change on water or possible terrorist acts threatening the water supply.

stay," said the president of a Texas home building company. "High-performance houses help the environment as well as the end user of the home."

Among the problems cited by some home builders was the occasional difficulty of tapping into the available water supply. "Most of my units are supplied by wells, drilling has gotten very expensive, and the quality of the water has been getting worse," said a builder in the Northeast. "My costs for drilling have doubled in the last six years."

An Ohio builder said he has run into problems when he builds away from Lake Erie and has to drill for water. "Sometimes it is difficult to find water, depending on the area," he said. A home builder in Alaska said the problem there was water quality, not quantity.

Water issues can hit builders even in water-surfeited New England, according to a respondent from suburban Boston. "The government regulatory agency has already restricted use of water, particularly for irrigation on new projects," he stated. "This has impacted us directly and forced us to reduce [the use of] turf and increase [the use of] native species that will not require irrigation water after they take hold." And a designer in suburban Chicago noted that his problem was stormwater management, not water supply.

Seeking solutions. There are home builders who see opportunity in water-related consumer issues. Noting that water heating is the second-largest use of energy in most homes (after HVAC), this builder cited water efficiency as "critical to energy-efficiency improvements that will lower the homeowner's operational costs."

A Wisconsin builder noted that one of her company's condominium projects is entirely free of storm sewers, thanks to the use of pervious pavement (made from recycled glass, no less). "It works extremely well," she reported, but the cost is two-and-a-half times that of concrete. "So we are limited by [the home buyer's] budget as to how frequently we can use it."

Home builder alliances have a special role in assuring the supply of water in their regions, said a South Dakota construction firm head. "It's really important that we keep lobbying for our current and future water projects or we will see some possibly severe water restrictions in the very near future," he said. "It is our responsibility as HBA leaders to see that these projects are built, not so much for our own benefit but for our grandchildren and great-grandchildren."

Table 2.6
IMPACT OF WATER-RELATED PROBLEMS ON BUILDING PROJECTS
What was the impact of water-related issues on projects that experienced problems? (Multiple answers permitted.)

	Nonresidential	Residential
Increased project costs	55%	64%
Had minimal impact, problem was readily resolved	27%	29%
Delayed the project	21%	30%
Resulted in significant changes in the project	17%	13%
Contributed to termination of the project	3%	4%
Other	2%	4%
Don't know/Not applicable	13%	7%

Base: Nonresidential, 327; Residential, 52
Source: BD+C/Professional Builder 2009 White Paper Survey

Among respondents reporting water-related problems on their firms' projects, a majority of each group (Nonresidential, 55%; Residential, 64%) said the biggest impact was a bump in project costs. Respondents who had experienced water-related problems on projects reported an average of one or two such incidents (Nonresidential mean, 1.44; Residential mean, 1.54). It is important to note, however, that more than a quarter of respondents of each survey (Nonresidential, 27%; Residential, 29%) reported at least one incident that had resulted in minimal impact on the project. Caution: Sample size for Residential respondents is small.

Table 2.7
REASONS FOR EMPLOYING WATER-EFFICIENT TECHNOLOGIES
Based on your professional experience, what reasons do clients give for employing water-efficient technologies, products, or systems in building projects? (Multiple responses permitted.)

	Nonresidential	Residential
Code restrictions or requirements	72%	38%
Reduce water costs	65%	66%
Green building/green home certification	65%	33%
Reduce energy costs	64%	66%
Reduce total building operating costs	60%	39%
Environmental stewardship	56%	54%
Government regulations or standards	56%	30%
Client/owner requirement or request	52%	-
Reduce sewer/wastewater charges	47%	42%
Corporate sustainability requirements	42%	-
Avoid current or future water shortage	39%	34%
Utility or tax rebates	34%	26%
Branding or positioning	30%	-
Competitive advantage	27%	-
Optimize design and construction quality	25%	23%
Climate change impacts	18%	22%
Water quality improvement	16%	18%
Reduce risk of water supply contamination	11%	11%
Other	<1%	3%
Don't know/Not applicable	4%	3%

Base: Nonresidential, 531; Residential, 125
Source: BD+C/Professional Builder 2009 White Paper Survey

There seems to be a wide difference of opinion between respondent groups over how their clients view code restrictions or requirements. The Nonresidential Survey group gave this factor high marks (72%) in terms of influencing clients to adopt water-efficient technologies or systems, whereas the Residential Survey group gave it relatively low consideration (38%) compared to such factors as reducing water and energy costs (both 66%). The majority of respondents to both surveys (Nonresidential, 56%; Residential, 54%) cited "environmental stewardship" as a factor in their clients' decisions about water efficiency.

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

Underwriters Laboratories

Dear Building Professionals,

Underwriters Laboratories (UL) is pleased to sponsor *Building Design+Construction's* 2009 White Paper, "Green Buildings + Water Performance." The important work of protecting our environment and water supplies requires consumers, businesses and public service institutions to work together.

Water has been defined as a critical global issue for this century. Builders have experienced the impact of water shortages including increases in the cost of water. Buildings account for 40 percent of the world's energy use and consume 20 percent of the world's available water (sourced from The World Business Council for Sustainable Development and UN Environment Program respectively). Reduction of energy and water use will help protect this resource.

As industry leaders, you have responded to this challenge by taking steps both to stay informed and embrace both green building design and water efficient technologies. However, there are many considerations in the design and construction of buildings including code requirements, competition for water resources and cost of water and energy use.

UL understands the complex challenges faced each day in designing and constructing buildings that are not only environmentally sound but also meet strict code requirements for overall public safety. For 115 years, we have been a trusted partner in product testing and standards development. Today, environmental and water safety are essential platforms to our public safety mission.

We were one of the first certification bodies to be accredited under EPA's WaterSense[SM] program, helping consumers identify water efficient plumbing products. In 2009, UL launched UL Environment, Inc., a new business unit focused on verification of green products and development of green standards across several industries. Providing clarity in the marketplace, ULE has already validated claims of building material manufacturers and begun developing environmental standards for the industry.

This is just the beginning. We will continue to work closely with manufacturers, regulatory authorities and other stakeholders to provide industry solutions.

Sincerely,

Keith Williams
President and CEO
Underwriters Laboratories

laboratory mockup tests of cast iron and PVC piping in three diameter sizes, and 3) field test actual plumbing systems.

PERC hopes the research findings will help designers on new projects or retrofits to take into account both current—and future—levels of wastewater flow when designing drain lines. This may involve adding more pitch to pipe runs, avoiding long, horizontal drain lines, and reducing the number of elbows.[12, 13]

Waterless Urinals: The Debate Rages On

Eighteen years after the first commercial water-free urinals were released to the U.S. building market, debate over their efficacy keeps rumbling on.

Manufacturers of waterless systems successfully addressed early concerns about potential cleanliness and odor problems by educating the AEC industry and improving methods for trapping odors. Today, few jurisdictions flat out ban the installation of these systems. The consensus among industry experts is that the most appropriate building types for waterless urinals are places of congregation, such as airports, stadiums, arenas, museums, and convention centers, because they have a high level of use and generally more reliable maintenance, which is the real key.

"The success of a waterless urinal installation completely depends on maintenance," says Heath Baxa, manager of sustainable design with M-E Engineers, who has specified waterless urinals in sports facilities. He says it's up to the facility staff to follow the manufacturer's instructions on cleaning the units and replacing the trapping solution on schedule. Even then, something as innocent as accidentally dumping water into certain types of waterless units can break the liquid seal, possibly leading to odor problems. (Some systems are designed to allow a small amount of water to be poured into the system to flush the lines on a periodic basis.)

There's also the question of the potential for blockage of drain lines following years of exposure to non-diluted urine. Without water to help flush urine deposits through the urinal and drain pipe, deposits can accumulate, potentially leading to waste backup and odor build-up.[14] There are documented cases where drain lines clogged completely just six months after installation.[15]

"We're really concerned about the long-term performance, not so much with the unit itself, but with the waste lines," says Jeffrey Gaines, AIA, sustainable design leader with Albert Kahn Associates. "Are these pipes going to corrode over time? We could end up with a tremendous problem that nobody anticipated."

In its forthcoming Green Plumbing and Mechanical Code Supplement, IAPMO strongly recommends that local plumbing codes require water supply lines to be installed behind the water-free fixtures in case the units ever have to be replaced with water-fed urinals. The IAPMO document will also call for water-fed sinks or other fixtures to be placed upstream of waterless urinals to wash the drain lines of urine deposits—a practice that is mandatory in drought-ravaged Australia.

One alternative to waterless urinals that is catching the eye of AEC professionals is the one-eighth-gallon urinal. While pint-flush technology is relatively new and unproven, proponents say these systems can deliver up to 90% water savings compared to standard urinals.

Another option that is starting to gain attention, especially in the retrofit market, is the so-called "blue cube"—a small dissolvable urinal block that is capable of converting standard urinals into virtually water-free units. The cubes last up to 1,000 uses and utilize a mix of bacteria, water softeners, and biodegradable surfactants that works to dissolve uric scale from pipes, eliminate odor, and reduce water use by up to 99%.[16] "You just put it in and turn off the urinals, and then you flush once a day—effectively turning a flushing urinal into a waterless unit," says John Koeller, PE, a Yorba Linda, Calif.-based water conservation consultant who has tracked the technology closely. "Every report coming back is that these things do the job."

Despite some pushback, many experts stress that waterless urinals have their place, especially since each one can save upwards of 40,000 gallons of water a year. Once again, these systems work best in buildings with high urinal use rates—sports facilities being the obvious example—where a strict maintenance regimen is adhered to.

12 On another research topic, consultants Bill Gauley and John Koeller have questioned the adequacy of the current ASME/CSA drain line carry testing protocol. The consultants, who conducted extensive drain line tests for the Canada Mortgage and Housing Corporation in 2005, claim that the ASME/CSA testing method uses "non-realistic" test media (¾-inch plastic balls) and requires the same testing procedure for both residential and commercial installations.

"We know that there is a clear difference between ¾-inch balls and 'real' waste and that there are significant differences between residential and commercial toilet installations," they stated in a January 2009 technical brief.[13] Gauley and Koeller are calling for replacing plastic balls with a soybean paste mixture, a method known as MaP testing (maximum performance testing), which they helped develop.

13 "High-Efficiency Flushometer Toilets in Non-Residential Applications: A caution for water-efficiency practitioners, design professionals, and facilities managers," Alliance for Water Efficiency, January 2009, www.allianceforwaterefficiency.org/CAUTION_-_Non-Residential_HETs_and_Drainline_Carry.aspx

14 "Application of Dry Urinals," by Mete Demiriz, Gelsenkirchen University of Applied Sciences, 2004, www.a4we.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=934

15 "Straight Green: Adventures in Waterless Urinals," by Chris Dixon, Walls and Ceilings, July 28, 2008, www.wconline.com

16 EcoBlue website, www.ecobluecorp.com

U.S. Federal Building
San Francisco, CA

U.S. General Services Administration

As one of the largest public real estate organizations in the world, the U.S. General Services Administration's Public Buildings Service is a leader in sustainability and green design. GSA is the landlord for the federal civilian government, and its portfolio of more than 8,600 owned and leased properties total 352 million rentable square feet of workspace. In managing these assets, GSA is committed to excellence in energy conservation and sustainable design.

Consider these facts:

- GSA's first green roof was installed in 1975
- The first renewable energy purchase occurred in 1991
- GSA's first LEED certified building dates back to 2002
- In 2007, GSA saved $46 million through recycling
- Today, GSA has 25 LEED certified buildings in its inventory
- Today, GSA has 118 Energy Star buildings
- GSA has reduced energy use by 8 percent since 2003
- That is on top of a 30 percent reduction since 1985!

Energy conservation and environmental stewardship are among the agency's highest priorities. All new GSA construction and major renovation projects must be LEED certified, ideally at the LEED Silver level or better. This is also the case for lease construction projects. The Energy Independence and Security Act of 2007 requires all federal agencies in leased space to be in Energy Star-labeled buildings by 2010. It also stipulates a fossil-fuel generated energy reduction of 55 percent in federal buildings in 2010 with further reductions in five-year increments so that by 2030, federal buildings no longer use fossil fuels. The private sector design and construction industry will play a key role in helping the government meet these goals.

Recent projects demonstrate GSA's success in sustainability and green design:

- The San Francisco Federal Building is a model of sustainable design with natural light in 85 percent of the offices and natural ventilation cooling the 18 story tower from the sixth floor up.
- The Environmental Protection Agency's Regional Headquarters in Denver uses one third less energy and water than buildings of comparable size and boasts downtown Denver's first green roof.
- As part of the $ 5.5 billion appropriated to GSA under the Recovery Act, the agency is rapidly working to convert federal buildings into high-performance green buildings and build new energy-efficient federal buildings.

4. What Building Teams Are Doing To Conserve Water Outside Buildings

While significant progress in water conservation has been made inside buildings—primarily with the widespread adoption of high-efficiency plumbing fixtures—much of the water consumption in buildings actually occurs outside the structure itself. In a typical hospital or office building, for instance, landscape irrigation and cooling tower makeup water can account for more than half of total water consumption.[1] In warm regions like the Southeast, cooling towers alone can consume more than half of total water use in large buildings.[2] Schools, college and university campuses, museums, suburban office complexes, stadiums, and single-family homes can often use massive amounts of water for irrigation to maintain green space.

In recent years, the building community has made great strides in improving water performance outside buildings. Some measures, like stormwater management planning and installation of retention ponds, are mandated by local codes or permit requirements. Other approaches, such as water-efficient irrigation systems and low-water-use landscaping, are gaining popularity because of relatively short payback periods and contribution toward green building certification.

Building Teams are implementing a broad range of exterior water-efficiency measures to achieve water reduction goals, according to the 2009 BD+C/Professional Builder 2009 White Paper Survey. Survey respondents that work on nonresidential building projects said they have implemented 6-7 exterior water-efficiency technologies or systems on projects in the last 18-24 months. Moreover, respondents said they expect to use 9-10 measures within the next two years (Table 4.2). Among the most popular measures are stormwater management plans, retention ponds, low-water-use landscaping/indigenous planting, drip irrigation systems, and pervious pavement.

Similarly, nearly half of our Residential Survey respondents (48%) said they're already using drip irrigation, and 40% said their companies are using automated irrigation systems. Many more are already employing stormwater management plans (73%) and retention ponds (55%) (Table 4.2).

Applying one or more of these design practices and technologies can save building owners thousands and even millions of gallons of water annually. Take the LEED Platinum One Bryant Park tower in New York City for example. Stormwater harvesting and cooling tower condensate recovery alone are saving an estimated 5.8 million gallons of water a year, resulting in net annual savings of $12,750 on water costs.[3]

WATER-EFFICIENT LANDSCAPE AND IRRIGATION

Landscape irrigation represents a significant portion of overall water use in both residential and commercial buildings. In Phoenix, for example, irrigation accounts for about two-thirds of total residential water use, and even in water-rich areas like Seattle and Tampa, irrigation represents more than a third of total household water use.[4]

"Landscape irrigation can be as much as 60% of water use in homes, especially in arid climates," says Jennifer Riley-Chetwynd, with Rain Bird, Azusa, Calif., a manufacturer of residential and commercial irrigation systems. "Even in commercial settings, you should be asking how well you are managing your water use."

Newer technologies are helping building owners reduce water use for landscape irrigation functions. One particularly promising technology is weather-based irrigation. Instead of watering according to a preset schedule, these "smart" systems take into account prevailing weather conditions, current and historic evapotranspiration, and soil moisture levels to provide the ideal amount of water based on the needs of the plants. By watering based on need, property owners have been able to achieve immediate water usage reductions of 5-7%, according to a four-year study of 2,294 smart controller installations across California.[5]

The study found that 53% of locations were over-irrigating their property before installation of the smart controllers, based on a theoretical irrigation requirement (TIR) for each property. Forty-

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

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

3 "Water Conservation Protocols," Robert Benazzi, Buildings, October 2009.

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

5 "Evaluation of California Weather-Based 'Smart' Irrigation Controller Programs," Aquacraft Inc., July 1, 2009, www.aquacraft.com/Download_Reports/Evaluation_of_California_Smart_Controller_Programs_-_Final_Report.pdf

seven percent of locations were at or under the TIR threshold; in fact, according to Peter Mayer, a consultant with Aquacraft Inc., a good portion of these properties were actually using too little water on their grounds. (This resulted in an average increase in water use of 1.49 kgal, or 0.43%, for those locations. But as Fiona Sanchez, conservation director for the Irvine Ranch [Calif.] Water District, noted at the October 2009 WaterSmart Innovations Conference in Las Vegas, "If smart controllers deliver to the theoretical requirement, that's what the controllers were supposed to do." In other words, the controllers did their job.)

The study concluded that while weather-based

Table 4.1
RECLAIMED WATER SOURCES FOR EXTERIOR APPLICATIONS

Source	Definition	Typical uses	Requirements	Pluses and minuses
Graywater	Wastewater collected in buildings from showers, bathtubs, clothes washers, and lavatory faucets	Nonpotable: usually used for subsurface irrigation	Separate wastewater drainage lines for graywater and blackwater, a flitration system, and usually storage; sometimes fed directly into subsurface irrigation piping	+ Reduces freshwater demand + Water volumes can be large + Emergency irrigation source – Difficulties with permits – Cost of dual piping – Risk of smell, O+M issues
Rooftop rainwater harvesting	Rainfall collected from a roof surface	Nonpotable: toilet flushing, irrigation, makeup water for cooling equipment; potable if adequately treated	A gutter system to channel rainwater into a cistern; often first-flush and filtration systems; treatment for potable uses.	+ Reduces freshwater demand + Rainwater is generally softer than well water + Avoided energy for pumping (if gravity-fed from a cistern) – Rainwater volume can vary
Landscape-scale stormwater harvesting	Stormwater collected on parking areas or other low-permeability landscape surfaces and stored in retention ponds	Nonpotable: toilet flushing, makeup water for cooling equipment	Topography that channels stormwater into retention ponds and a mechanism for withdrawl and use	+ Reduces freshwater demand + Fairly low cost – Difficult to manage stored water due to evaporation, vegetation
Air-conditioner condensate	Condensate captured from the evaporator coils of AC equipment or dehumidifiers	Nonpotable: toilet flushing, irrigation, makeup water for cooling equipment	Drainage of condensate lines into storage for reuse; only feasible in areas with adequate indoor humidity levels	+ Reduces freshwater demand + As distilled water, condensate is initially very pure + Water volumes can be large – Potential for contamination of stored condensate and lines
Mechanical equipment blowdown	Water bled from cooling towers and other mechanical equipment	Nonpotable: irrigation	Collection and storage components integrated with cooling towers and other sources of blowdown	+ Reduces freshwater demand + Water volumes can be large – Most blowdown water has high mineral content or other contaminants
Treat wastewater (building-scale)	Onsite treated wastewater (graywater or blackwater), producing nonpotable water	Nonpotable: toilet flushing, irrigation, makeup water for cooling equipment	On-site treatment system employing biological action, microfiltration, and sometimes reverse osmosis, UV, or chemical purification	+ Reduces freshwater demand – High installaion cost – Sludge disposal remains – Can be energy-intensive
Treat wastewater (municipal-supplied)	Outflow from a sewage treatment plant after tertiary treatment and purification; distributed from water utility through separate piping (purple pipe)	Nonpotable: toilet flushing, irrigation, makeup water for cooling equipment	Separate supply plumbing for potable and nonpotable water; some water utilities provide such piping, most commonly tied to dedicated irrigation systems	+ Reduces freshwater demand + Energy savings compared with potable water use – Perception that treated wastewater is unsanitary
Desalinated water	Freshwater produced by removing salts from seawater or brackish water	Potable	Most desalination plants use reverse osmosis, forcing salt water through a specialized membrane that excludes salts	+ Reduces freshwater demand + Virtually unlimited supply – Energy-intensive

Source: Environmental Building News, 1 May 2008

controllers are an important piece of the puzzle, they're not the single solution for achieving perfect irrigation control and water savings. "Even the best, most water-efficient controller cannot make up for poor system design, installation, and maintenance," the authors stated.

The authors stress the need for a holistic approach to irrigation and landscape design. Given the complexity of site design, landscape architects and related professionals deserve a seat at the design table on projects—a rare occurrence even for the most fully integrated Building Team. Speaking at the WaterSmart Innovation conference, Kerry Blind, FASLA, LEED AP, president of Ecos Environmental Design, Atlanta, said that landscape architects can bring sustainable design practices involving the use of techniques like bioswales, rainwater harvesting, vegetated roofs, porous pavement, ideal plant life selection, and retention ponds to improve water management.

RAINWATER REUSE: A VIABLE WATER SUPPLY

The bulk of building projects in the U.S. miss out on one of the most potentially significant water conservation opportunities by failing to consider one key tool: rainwater catchment and reuse.

Consider these facts: For every inch of rain that falls on a thousand square feet of roof area, 600

6 Rainwater Committee Final Report, Texas Water Development Board 2006.

7 "The Legalities of Rainwater Harvesting," Leora Broydo Vestel, New York Times, June 29, 2009.

Packed Rainwater Catchment Systems

While many rainwater harvesting systems are custom engineered from various components, there are several packaged systems available to the U.S. market.[2]

Product	Size	Performance data	Manufacturer
Brac Greywater Recycling System Model CGW- 19800	4,590-gallon capacity	All-in-one graywater system can be used to capture rainwater. The system includes an in-ground holding tank, in-ground lift station, above-ground dual pressure filters, a water management processor with a dedicated pump, a VFD 15-hp constant pressure pumping system, pressure filter alarms, and an integrated monitoring and controller processor with built-in BMS functionality.	BRAC Systems www.bracsystems.com/home.html info@bracsystems.com
BRAE Rainwater Systems	10 possible packages, up to 6,000-gallon systems	Offer custom commercial designs up to 500,000-gallon storage. Packaged systems include everything needed to build and maintain a rainwater system: tank, tank liner, basket filter sign kit, flex couplers, pump, and screens.	Blue Ridge Atlantic Enterprises www.braewater.com (800) 772-1958
Bushman RW Systems	Three packages, the largest at 620 gallons	Offer tanks up to 6,500 gallons and equipment for larger systems, but no package for larger systems.	Bushman, www.bushmanusa.com (866) 920-8265
Jay R. Smith Rainwater Harvesting System Packages	Seven possible packages	Largest package is for a 5,500-sf roof. Offer components that can serve roofs up to 32,000 sf. Packages include vortex rainwater filter, overflow device, smoothing inlet, suction pump, float switch, floating filter, and a purification kit is optional. Tank not included.	Jay R. Smith Mfg. Co. www.jrsmith.com (334) 277-8520
ReWater models RWAF4 and RWAF5	200-gallon surge tank; no large storage tank included	Commercial system for irrigation only. Can be engineered to back itself up with pressurized fresh water in case it runs out of stored rain.	ReWater Systems Inc. www.rewater.com support@rewater.com
Watertronics Sky Harvester Water Conservation System	20,000-gallon capacity	Large commercial package with tank, pump, tank level controls, vortex filter, UL control panel, irrigation controller, replenishment water control and measurement, remote data logging and control, premium efficient pumps and motors, custom PLC controls and logic, auto-flushing filter for clean irrigation water, multiple replenishment source control, integration with building automation systems.	Watertronics www.watertronics.com (262) 367-5000

Source: "Water-Efficiency Technologies for Mechanical Contractors," August 20, 2009

gallons of water can be collected for harvesting. In central Texas, a home or commercial building that size could expect to collect upwards of 20,000 gallons a year.[6] In rain-heavy regions like the Northwest and Southeast, the same-sized structure could collect up to five times that amount annually. The numbers are staggering when extrapolated over large areas or regions. For instance, if just 10% of the roof area in Texas were used for rainwater harvesting, an estimated 38 billion gallons of water would be conserved each year—water that would otherwise run off site, taxing storm sewer systems and contributing to erosion.

Compared with graywater reuse systems, rainwater harvesting is relatively simple to execute, especially for irrigation and cooling tower makeup applications, which don't require costly, complicated dual piping systems and oftentimes call for only minimal water treatment. Moreover, the emergence of "packaged" rainwater harvesting systems is making it easier for building owners and even homeowners to implement the technology (see sidebar).

"This is such a simple and obvious thing to do in much of the country that one wonders why it has taken so long to be considered as a viable new water supply," said green building consultant Jerry Yudelson, PE, LEED AP, in his recent report on water-efficiency technologies for the Mechanical Contracting Education and Research Foundation.[2] "In addition to providing onsite water supply and reducing the need to use potable water for lower-quality water uses, rainwater harvesting can help reduce stormwater runoff from building sites."

Yet, despite the huge potential for water savings, rainwater reuse is still relatively rare in U.S. building projects. Only about a third (34%) of AEC respondents to the 2009 White Paper Survey said they specified rainwater harvesting or retention systems for outdoor use in nonresidential projects in the past 18-24 months. Even fewer residential building respondents (26%) said their companies had implemented such systems within the past two years.

In some areas of the country, like parts of Utah and Washington and, until recently, the entire state of Colorado, rainwater collection is restricted—and even illegal—without special permits from the local authorities. Opponents of rainwater harvesting see it as a water rights issue: If too many building owners adopt the practice, it will greatly reduce water flow to streams and aquifers where it is needed for wells and springs. They see this as being akin to stealing water from downstream users who are legally entitled to the water.[7]

By contrast, states and jurisdictions in water-

Table 4.2
EXTERIOR WATER-EFFICIENT SYSTEMS USED
Which of the following exterior technologies or strategies has your firm or company used in new projects or major renovations in the last 18-24 months? Which do you intend 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
Stormwater management plans	71%	77%	73%	77%
Retention ponds	64%	70%	55%	58%
Low-water-use landscaping, indigenous planting	55%	70%	45%	60%
Drip irrigation systems	48%	59%	48%	55%
Pervious pavement (parking, walkways, etc.)	45%	68%	40%	56%
Automated irrigation systems (including evapotranspiration sensors, soil moisture sensors, weather-based systems, etc.)	42%	54%	40%	55%
Pressure-reducing valves (for landscape irrigation)	41%	54%	36%	45%
Bioswales	38%	49%	23%	33%
High-efficiency irrigation systems	37%	54%	30%	49%
Rainwater harvesting/retention systems (for outdoor use, e.g., landscape irrigation)	34%	59%	26%	45%
Green (vegetated) roofs	30%	54%	11%	20%
Turf reduction programs	28%	43%	22%	37%
Cooling tower condensate recovery systems	27%	40%	-	-
Low-impact development ("LID")	27%	46%	23%	31%
Rain gardens	24%	40%	16%	33%
On-site wastewater treatment systems	22%	32%	22%	26%
Rainwater reuse systems (for indoor use, e.g., flushing toilets)	17%	38%	5%	20%
Artificial turf	15%	22%	9%	16%
Municipally provided recycled water systems ("purple pipe")	13%	24%	8%	19%
Desalination systems	6%	11%	-	-

Base: Nonresidential, 557; Residential, 131-132
Source: BD+C/Professional Builder 2009 White Paper Survey

Respondents to the Nonresidential Survey used 6-7 "exterior" technologies or systems in the last two years (mean: 6.85) and expect to use 9-10 in the next 18-24 months (mean: 9.64), an indication of fairly widespread acceptance of water-efficiency techniques for dealing with stormwater and runoff problems and landscape irrigation. Among respondents to both surveys, stormwater management plans (Nonresidential, 71%; Residential, 73%) and retention ponds (Nonresidential, 64%; Residential, 55%) scored highest; these are often mandated by local codes or permit requirements. Planting low-impact vegetation and using more-efficient landscape irrigation systems also did well with both groups.

scarce regions like the Southwest are offering incentives for the installation of rainwater collection systems. Texas offers rebates of up to $40,000 for building owners that install collection and reuse systems. Santa Fe County, N.M., and Tucson, Ariz., actually require these systems on certain new building projects.[7]

"Rainwater collection for irrigation or even fixture flushing is something that we could use on almost every one of our projects," says Dave Plasschaert, a mechanical designer with KJWW Engineering Consultants, Rock Island, Ill. "But cost and upkeep of this type of system are typically why it does not remain in projects very long."

First cost remains a major concern with budget-conscious building owners. System costs can range from $20,000 to more than $50,000, with payback periods of a few years to well over a decade. In addition, because rainfall can vary greatly season to season, a supplemental potable water supply is typically required to meet supply demands, adding to both initial and ongoing costs.

However, in cases where buildings are designed to achieve 100% rainwater collection, the payback for collection and treatment systems can be almost immediate by eliminating costs associated with storm-drain hookups and related infrastructure and fees. This was the case at a California university project, where the cost to install two 20,000-gallon storage tanks and related collection, treatment, and distribution systems was less than the cost of tapping into the town's storm drains.[2]

Another issue impeding the adoption of rainwater harvesting is the lack of standards and regulations governing the design, installation, and maintenance of these systems, and allowed uses for the reclaimed water. This leaves local code officials and jurisdictions to interpret system design based on the current code, which can delay projects and result in higher first costs. For instance, some jurisdictions treat rainwater as graywater, limiting applications for reuse and requiring more-stringent treatment and storage measures. "That's where rainwater harvesting can get expensive because graywater oftentimes has special requirements," says David C. Smith, PE, LEED AP, manager of plumbing and fire protection with Bala Consulting Engineers, King of Prussia, Pa.

Georgia, Texas, and Virginia are among a handful of states and cities that have published guidelines for the implementation of rainwater catchment systems. This past August, the American Rainwater Catchment Systems Association published a revised draft of its Rainwater Catchment Design and Installation Standards, which were developed in a joint effort with the American Society of Plumbing Engineers to be a national standards document. Next February, the International Association of Plumbing and Mechanical Officials (in cooperation with the International Code Council) will issue its Green Plumbing and Mechanical Code Supplement that introduces language that plumbing and building code officials can use to allow for rainwater harvesting in their jurisdictions. The hope is that these authoritative documents will help speed the code review and approval process for rainwater harvesting systems.

The growing demand for rainwater harvesting is spurring interest in siphonic roof drainage technology, which utilizes the principle of negative pressure to help draw water along horizontal piping and into the vertical drain. Unlike traditional gravity-based systems, which require multiple downpipes and ideal surface pitch to transport water off a roof, siphonic systems typically require just a few downpipes, reducing first costs and aiding in rainwater collection for reuse.

"We advise our clients to consider siphonic roof drainage for any roof project larger than 40,000 square feet," says Randy Pool, PE, LEED AP, managing principal with architecture/engineering firm Stantec, Edmonton, Alb. At this threshold, says Pool, siphonic systems typically cost no more than traditional drainage approaches.

COOLING TOWER WATER RECOVERY: A LARGELY UNTAPPED SOURCE

Cooling towers for chillers often are the largest consumers of water in buildings. Because these systems rely on water evaporation as part of the air conditioning process, they churn through thousands of gallons of water every minute. Considering that the average cooling tower uses three gallons of water per minute for every ton of cooling, a large commercial building with 1,000 tons of refrigeration will use 3,000 gallons of water per minute—10 times the amount of water used in the average household each day.[2]

Despite being water hogs, cooling towers are the predominant air cooling technology in the commercial building sector because of the significant energy savings they offer over alternative approaches. Newer "dry" cooling

technologies like variable refrigeration volume systems show promise for reducing both water and energy use, but first cost is an obstacle to adoption of these systems.[2]

One obvious way to reduce cooling tower water use is to slim down the size of the cooling system through energy-efficient building design. By tightening the building envelope and implementing energy-efficient technologies like lighting controls, Building Teams can reduce overall cooling load required for a building, allowing for the mechanical systems like cooling towers to be downsized. Taking just 10 tons of required refrigeration out of a building can cut water use by 43,200 gallons a day.

Use of cooling tower water management techniques, such as conductivity meters and automatic controls, is another approach to conserving water. This is especially true with regard to blowdown, the process whereby water is removed from the system to reduce mineral concentration and scaling that occurs as a result of the evaporation process. Through real-time tracking and adjusting of blowdown water bleed rates based on evaporation rates, makeup water consumption can be reduced by 20% or more.[6]

Some progressive jurisdictions have instituted strict rules related to blowdown water usage. As part of its recently enacted water conservation ordinance, which goes into effect 1 December 2009, Los Angeles will mandate that cooling towers operate at a minimum of 5.5 cycles of concentration for blowdown use. The ordinance also outlaws use of single-pass cooling towers—systems that use 100% fresh water as the cooling medium—for air conditioning.[8]

Water treatment technologies, such as the Dolphin WaterCare system, help building owners achieve greater recirculation rates before requiring a blowdown to occur, according to John P. Cole, PE, LEED AP, a principal and assistant director of mechanical engineering with Albert Kahn Associates, Detroit. "The newer technologies are chemical-free and can greatly reduce water makeup requirements."

Another potential opportunity for whole building water savings is the reuse of wastewater—including both blowdown and condensate—from cooling towers and other mechanical equipment for irrigation, and, in some cases, cooling tower makeup water and flushing water. Likewise, harvested rainwater and municipal-supplied reclaimed wastewater (so-called "purple pipe" water) can be used as makeup water for cooling tower equipment, reducing reliance on potable water (Table 4.1).

USGBC's LEED-EBOM program stresses these water reuse approaches by offering up to two Water Efficiency credits for supplying at least 95% of cooling tower makeup water from reclaimed sources, as well as an additional possible credit for cooling tower water management.[2]

To date, however, condensate recovery has not caught on all that well with commercial, institutional, and industrial design and construction firms. For instance, just 27% of AEC respondents to the 2009 White Paper Nonresidential Survey said that their firms had specified cooling tower condensate recovery systems in the past 18-24 months. And while 40% said they plan to specify cooling tower condensate recovery in the next couple of years, the adoption rate seems low considering the significant potential of this technology.

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

9 "WaterView 2009 Report: Water & Wastewater Markets – Overview of Markets and Competition," Environmental Business Journal, ZweigWhite, August 3, 2009, www.zweigwhite.com/zw-830.aspx?mtn=F3581A

Will groundwater replenishment ease fear of wastewater recycling?

In early 2008, the world's largest indirect potable water recycling system went online in Orange County, Calif. The $485 million facility treats up to 130 million gallons of wastewater a day and runs the recycled water back to aquifers that serve the residential, commercial, and agricultural needs of several communities.[9] It's a process that many municipal water districts have been using for years, only the OC facility takes wastewater recycling to a grand scale.

Water experts believe that, despite the public's squeamishness over consumption of water that was once wastewater (no matter how far from upstream it came), these systems will become more common in the near future as water supply concerns mount.

"It's important to remember that large portions of the country are essentially drinking wastewater—stuff that's treated in one place and then sent down into the aquifer or into a river or stream, extracted downstream, treated, and then used as potable water," says Gunnar Baldwin, water efficiency specialist with Toto USA Inc. "So wastewater is not really waste."

5. Certification Programs + Water Performance

Water factors into all national green building certification programs, and while it may account for only a small piece of the overall sustainability pie, there are points to be earned by targeting water use reduction and increasing water efficiency. This chapter looks at how and where water factors into commercial and residential green building certification programs.

EPA WATERSENSE

In 2006, the U.S. Environmental Protection Agency, in partnership with manufacturers, retailers, distributors, and utility companies, established the WaterSense program. The program adds labels to such products as faucets, toilets, and showerheads that meet EPA water-efficiency and performance standards—typically 20-30% more efficient than standard products.

The EPA's goal for the WaterSense label is to have it achieve the same level of recognition among consumers as its Energy Star label, which rates the energy efficiency of products and buildings. The signs are encouraging. "WaterSense has had a big leap in market share," says Stephanie Tanner, lead engineer for WaterSense. "In 2007, our rated toilets had only 2% of the market, and in 2008 we had 8.8%. We also had 11.7% of the faucet market and 24.6% of all faucet aerators." Tanner says there are 300 different toilets and 800 faucets and aerators available with the WaterSense label.

The WaterSense Commercial and Institutional Certification Program is still in the planning and comment stage, but the broad outlines of the program are beginning to take shape.

PROPOSED WATER EFFICIENCY IN THE COMMERCIAL AND INSTITUTIONAL SECTOR

The EPA is defining the CI sector as including any building with a use other than residential, and figures these building types to account for 17% of water drawn from public supplies.

The EPA homed in on six commercial property types that it determined accounted for the largest consumption of water. The WaterSense CI program stipulates a potential 40% reduction in water use: office buildings, 43,338,240 gal/yr; schools, 37,798,766 gal/yr; restaurants, 15,640,869 gal/yr; laundries, 4,887,771 gal/yr; healthcare facilities,

The U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating program in its various manifestations scored big with respondents to the Nonresidential Survey, while the NAHB's National Green Building Standard drew the largest response among respondents to the Residential Survey (29% "have used," 66% "expect to use"). At this writing, the WaterSense New Home Specification had not been published, but both groups (25% Nonresidential, 45% Residential) expressed interest in using it as it becomes available. Note: The Green Guide for Health Care, Labs21, and CHPS do not apply to the residential market and were not included in the Residential Survey.

Table 5.1
USE OF GREEN-BUILDING CERTIFICATION PROGRAMS
Which of the following green building certification or specification programs have you or your firm employed in building projects 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
LEED (USGBC) [New Construction, Commercial Interiors, Core & Shell, Retail, Existing Buildings O&M, Schools, Neighborhood Development, etc.]	64%	82%	10%*	29%*
WaterSense Product Labeling Program (EPA)	26%	46%	17%	47%
LEED for Homes (USGBC)	19%	41%	22%	46%
Green Globes (Green Building Initiative)	17%	40%	10%**	32%**
National Green Building Standard (NAHB)	14%	33%	29%	66%
Green Guide for Health Care (GGHC)	14%	29%	-	-
Labs21 (U.S. EPA and USDOE)	10%	20%	-	-
WaterSense Water-Efficient Single-Family New Home Specification (EPA)-	25%	-	45%	
CHPS (Collaborative for High Performance Schools)	7%	18%	-	-
Environments for Living (Masco)	2%	10%	5%	16%
GreenPlumbers Accreditation	2%	8%	1%	11%

Base: Nonresidential, 667-674; Residential, 156-158
*LEED for Neighborhood Development only.
**Green Globes (New Construction) only.
Source: BD+C/Professional Builder 2009 White Paper Survey

4,877,771 gal/yr; hospitality, 3,258,514 gal/yr.

WaterSense targets include:

- Indoor domestic water use (restrooms, washing machines, dishwashers)
- Cooling and heating (cooling towers, single-pass cooling)
- Outdoor water use (irrigation, native plantings)

Implementing a WaterSense CI program will present the EPA with several challenges, among them whether to roll out a broad program that includes all commercial and institutional sectors or to focus on one sector at a time. The large-scale rollout allows WaterSense to capture economies of scale. However, the-one-size-fits-all program might not work because different types of commercial and institutional buildings have technology and operating procedures specific to their needs.

Choosing the single building type option would enable WaterSense to target those commercial sectors with the greatest potential for improvement in water efficiency first. However, such an approach might mean that the EPA would miss

IAPMO Green Plumbing and Mechanical Code Supplement

"The building and plumbing codes are perhaps the biggest hindrance to the adoption of green buildings," says David Viola, director of special services for the International Association of Plumbing and Mechanical Officials (a sponsor of this White Paper). To bridge the gap between existing mechanical and plumbing codes and green building programs, IAPMO has produced the Green Plumbing and Mechanical Code Supplement. "There's so little information about how to do green systems properly and safely within existing building codes, so we're rolling out a document that shows how it's done," says Viola. A draft was released in August for peer review; the final version is due February 2010.

The five most important areas covered in the Green Plumbing and Mechanical Code Supplement, according to Viola:

1. Using alternate water sources

"The biggest void in the industry is how to safely use alternate water sources," says Viola. "Inspectors and code officials think it's best to avoid using graywater because they're very conservative and feel it's best to avoid the risk of something bad happening," particularly any health hazard, he says. However, many green building rating systems already give points for using alternate water sources, but they don't prescribe how to use the graywater correctly. "That's where the supplement fits in," says Viola. "We show you how to replace potable water, earn your points, and do it safely."

2. Proper use of high-efficiency plumbing products

With water conservation comes the potential for drain line clogging. For IAPMO, it's important to identify code provisions and testing methods to ensure waste flushes out correctly and efficiently. Dry drains, like those for waterless urinals, are especially tricky, according to Viola, who says the supplement states that jurisdictions should require an upstream fixture that discharges past a waterless urinal to clean the drain and minimize potential for build-up. The document also recommends a requirement to rough in a water supply in the wall in case the waterless urinal ever has to be replaced with a water-fed unit.

Another hot-button issue: multi-headed showers, which have become "the poster child for anti-green," says Viola. Installing two showerheads flowing at 2.5 gpm in a single shower stall doubles the amount of water used, even though the individual low showerheads still meet the guidelines of most green building rating programs. Viola says IAPMO is giving product manufacturers an opportunity to work out a solution. "It's an interesting debate and I like where things are heading," says Viola. "They're getting creative, which may bring us into the realm where we're using more recycled water. It's forcing the industry to think outside the box."

3. Conserving hot water

"Every bit of hot water that's conserved is energy saved," says Viola. IAPMO considers hot water systems a key part of the supplement. Energy savings can be captured by designing systems that bring hot water to the tap more quickly, by insulating pipes to mitigate heat loss as water moves through the pipes, and by right-sizing pipes and shortening runs of pipe to reduce the need to re-heat the water flowing through them.

4. Energy conservation in HVAC systems

Water conservation is one of the most important things the supplement is accomplishing, because water has so much embedded energy," says Viola. "When you save water you're getting inherent energy savings."

Viola calls energy conservation codes and standards "probably one of the most mature green areas," says Viola, pointing to ASHRAE 90.1, which serves as an energy conservation document that covers HVAC. IAPMO partnered with ASHRAE to bridge the gap between green standards and existing codes. As a result, the IAPMO supplement has essentially integrated the ASHRAE standards as its backbone.

5. Training and education in green plumbing systems

"The existing infrastructure for training professionals lacks the green element," says Viola. IAPMO recommends that jurisdictions look for examples of specific competency from professionals involved in designing, installing, and inspecting green systems. The document shies away from specifying types of training, instead recommending that industry sectors be involved in training professionals. Viola points to the complex solar and geothermal sectors. "A lot of people came up through the system without getting training in those technologies," he says.

out on water savings opportunities for non-targeted sectors.

The EPA is still accepting comments on its proposed WaterSense program for the commercial and institutional sector. Review the proposal at: http://www.epa.gov/watersense/docs/ci_whitepaper.pdf

http://www.epa.gov/WaterSense

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (U.S. GREEN BUILDING COUNCIL)

LEED has several green building rating "products," as the USGBC calls its rating programs, all with a Water Efficiency (WE) component. LEED for New Construction, Commercial Interiors, Core & Shell, Neighborhood Development, and Schools all have a prerequisite of a minimum 20% water use reduction compared to a baseline building. LEED-NC, LEED-CI, LEED-CS, LEED-ND, and LEED for Schools water use reduction excludes commercial steam cookers, commercial dishwashers, automatic ice makers, commercial and residential clothes washers, and residential dishwashers.

LEED FOR NEW CONSTRUCTION (WE CREDITS: 10)

LEED for New Construction addresses design and construction for both new buildings and major renovations of existing buildings.

In addition to the 20% prerequisite, additional credits are: water-efficient landscaping, 2-4 credits; innovative wastewater technologies, 2 credits; water use reduction, 2-4 credits.

LEED FOR COMMERCIAL INTERIORS (WE CREDITS: 11)

LEED for Commercial Interiors addresses tenant spaces in office, retail, and institutional buildings. In addition to the 20% prerequisite, additional reductions in water use can yield the following: 30% reduction, 6 credits; 35%, 8 credits; 40%, 11 credits.

LEED FOR CORE & SHELL (WE CREDITS: 10)

LEED for Core & Shell is used for projects where developers control design and construction of the core and shell base building but have no control over tenant fit-out. Additional credits beyond the 20% prerequisite: water efficient landscaping, 2-4 credits; innovative wastewater technologies, 2 credits; additional water use reduction, 2-4.

LEED FOR EXISTING BUILDINGS OPERATIONS & MAINTENANCE (WE CREDITS: 14)

LEED-EBOM certifies sustainability of ongoing operations within existing commercial and institutional buildings.

The prerequisite here is for a minimum 20% water use reduction compared with a building with plumbing systems substantially completed after 1992, and a 60% water use reduction compared with a baseline calculated for a building with plumbing system substantially completed before 1993. Additional credits include: water performance measurement, 1-2 credits; additional indoor plumbing fixture and fitting efficiency, 1-5 credits; water-efficient landscaping, 1-5 credits; cooling tower water management, 1-5 credits.

LEED FOR SCHOOLS (WE CREDITS: 11)

LEED for Schools addresses new schools and major renovations to existing schools. Beyond the 20% prerequisite, additional credits include: water-efficient landscaping, 2-4 credits; innovative wastewater technologies, 2 credits; water use reduction, 2-4 credits; process water use reduction, 1 credit.

LEED FOR NEIGHBORHOOD DEVELOPMENT—DRAFT (WE CREDITS: 8)

LEED for Neighborhood Development integrates smart growth, urbanism, and green building into the first national system for neighborhood design.

The Brouhaha over Purple Pipes

Purple pipes remain one of the most contentious sources of controversy in the green plumbing field because of changes in the types of water carried by them.

Utilities that sell reclaimed water have used purple pipes for years, and they claim that purple is their trade color and part of their brand. However, organizations such as IAPMO and the International Plumbing Code insist that all non-potable water, not just reclaimed water being sold by utilities, be carried in purple pipes; the pipes would be labeled to distinguish what type of water each is carrying.

The for-profit reclaimed water industry argues that purple pipes will be used to carry inferior water, which they feel will dilute their brand (so to speak) and cause confusion in the marketplace. "This has been the biggest obstacle moving green to the forefront," says IAPMO's David Viola. "We don't want to dismiss their concerns, so we're in the process of looking for a solution."

However, the 2009 Uniform Plumbing Code is already on the street and many jurisdictions are in the process of adopting it. In addition, pipe manufacturers are already churning out purple pipe and "once manufacturers commit to something, they'll fight like hell to avoid having to incur costs to redo it," says Viola.

In addition to the 20% prerequisite, additional credits include: building water efficiency, 1 credit; water-efficient landscaping, 1 credit; stormwater management, 1-4 credits; wastewater management, 1-2 credits.

LEED FOR RETAIL—DRAFT (WE CREDITS: CI, 11; NC, 10)

The LEED for Retail pilot has two ratings systems: LEED for Retail New Construction and LEED for Retail Commercial Interiors.

Both LEED for Retail programs require the 20% minimum reduction for the tenant space (for the CI program) and the building (for the NC program). LEED for Retail CI adds a second prerequisite: 20% water use reduction for commercial equipment performance.

Additional CI credits include: water use reduction of 30%, 6 credits; 35%, 8 credits; 40%, 11 credits. Additional NC credits: water-efficient landscaping, 2-4 credits; innovative wastewater technologies, 2 credits; water use reduction, 2-4 credits.

www.usgbc.org/leed

GREEN BUILDING INITIATIVE'S GREEN GLOBES

The Green Building Initiative's proposed American National Standard 01-200XP: Green Building Assessment Protocol for Commercial Buildings is aimed at new commercial construction, major commercial renovations, and multifamily buildings taller than three stories. The program is currently in draft form.

The standard proposes four levels of achievement and a possible total 1,000 points: Level 1, 35-45% of points; Level 2, 55-69%; Level 3, 70-84%; Level 4, 85-100%. Water assessment accounts for 130 possible points (13%).

Water assessment includes 10 categories:

1. Plumbing fixtures, fittings, appliances, and equipment, 46 points
2. Cooling towers, 18 points
3. Boilers and water heaters, 3 points
4. Commercial food service operations, 12 points
5. Medical, dental, and laboratory facilities, 11 points
6. Commercial/institutional laundries, 10 points
7. Special water features. 4 points
8. Water treatment, 5 points
9. Alternate sources of water, 15 points
10. Metering, 6 points

http://www.thegbi.org/assets/pdfs/GBI-01-200XP-August-2009-Red-line%2010-1-v10.pdf

COLLABORATIVE FOR HIGH PERFORMANCE SCHOOLS

The Collaborative for High Performance Schools was founded in 1999 to improve energy efficiency in schools. Eleven states have developed CHPS high-performance criteria, and there are 46 completed CHPS schools across the country. Recognition is either by third-party verification or self-certification.

Water efficiency, one of seven categories, maxes out at nine points—less than 8% of total possible points, although there is a prerequisite for a water use budget. The nine available points: reduce potable water for non-recreational landscaping areas (2), reduce potable water for recreational area landscaping (1), irrigation system testing and training (1), reduce sewage conveyance from toilets (2), and reduce indoor potable water use (2), and water management systems (1).

http://www.chps.net.

GREEN GUIDE FOR HEALTH CARE

The Green Guide for Health Care gives healthcare designers, owners, and operators a voluntary, self-certifying program they can use to evaluate green design, construction, and operating practices. The Green Guide offers two programs, Construction and Operations, in a single document.

1. Construction: 97 points, with a prerequisite for eliminating potable water use for medical equipment cooling. Water efficiency accounts for six points (6%).

2. Operations (for existing buildings): 72 points, with a prerequisite for a minimum 20% water use reduction compared with a baseline building. Water conservation accounts for eight points (11%).

http://www.gghc.org.

Water Considerations in Residential Programs

NAHB GREEN HOME BUILDING PROGRAMS

The National Association of Home Builders offers two green homes programs whose water-efficiency guidelines can be incorporated into new home construction or significant remodeling projects.

The Model Green Home Building Guidelines program (launched 2005) applies to new single-family homes and detached multifamily dwellings. The program offers three levels of green building certification: Bronze (minimum 6 WE points of 237 possible), Silver (minimum 13 WE of 311), and Gold (minimum 19 WE of 395).

The National Green Building Standard, launched in 2007, developed in partnership with the International Code Council (ICC), is the first residential green building rating system to receive full ANSI approval. Four certification levels are offered: Bronze (minimum 14 WE points of 222 possible), Silver (minimum 26 WE of 406), Gold (minimum 41 WE of 558), and Emerald (minimum 60 WE of 697). As of October 2009, 500 homes have earned certification.

Both programs exclude additions of any size to existing multifamily buildings, additions greater than 75% of the original conditioned area of an existing single-family home that do not involve renovation of the original building, and developments that do not contain any residential uses.

http://www.nahbgreen.org.

ENVIRONMENTS FOR LIVING

Masco's Environments for Living and Environments for Living Certified Green are national turn-key programs designed to help builders construct green homes. More than 130,000 homes have been certified under the programs.

Environments for Living Certified Green's water-efficiency features are designed to provide a minimum 20% indoor water savings.

http://www.environmentsforliving.com

LEED FOR HOMES (WE CREDITS: 15)

LEED for Homes targets the top 25% of new homes. Of 15 possible Water Efficiency credits, a minimum of three must be achieved in the water efficiency category. Credits include: water reuse (3-5 possible); irrigation system (1-4), and indoor water use (1-6). A total 3,050 homes are LEED certified, and more than 19,000 are registered.

http://www.usgbc.org

WATERSENSE NEW HOME CERTIFICATION

The WaterSense New Home Certification program, which is expected to go into effect by the end of the year, will apply to new single-family homes and townhouses up to three stories.

To comply, builders must construct homes where water usage is at least 20% less than that of standard homes. Their homes must then be examined by EPA-approved, third-party certification providers and inspectors who will evaluate individual properties.

WaterSense Requirements

INDOOR WATER USE

Static service pressure: Maximum 60 psi.

Hot water distribution system: No more than 0.6 gallons of water storage in any piping/manifold between hot water source and fixture.

Toilets and bathroom faucets: WaterSense-labeled high-efficiency fixtures.

Kitchen faucets: Maximum flow rate, 2.2 gpm.

Showerheads: Maximum flow rate of 2.5 gpm at 80 psi. Total allowable flow rate for all showerheads flowing at a given time limited to 2.5 gpm in a single shower compartment. The WaterSense draft specification for showerheads sets the maximum flow rate at 2.0 gpm at 80 psi.

Appliances: Energy Star-rated units.

Evaporative cooling systems: Maximum 3.5 gallons per ton-hour of cooling.

Water softeners: Must meet NSF/ANSI Standard 44.

OUTDOOR WATER EFFICIENCY

Landscaping: Option 1 allows the use of turfgrass, not to exceed 40% of the landscape. Option 2 allows sustainable plantings with specific water allowances based on a 70% evapotranspiration adjustment factor.

Pools/spas: Must have a cover.

Irrigation system: Must be designed to sustain landscape without creating runoff or direct overspray, achieve a lower-quarter distribution uniformity of 70% or greater, and be equipped with rain sensors to prevent operation during rainfall.

Irrigation controls: Must have multiple programming capabilities and allow for variable scheduling.

http://www.epa.gov/watersense/docs/comments_revised_draft_spec_508.pdf

Other Programs Targeting Water Efficiency

ASHRAE 189: http://aec.ihs.com/news/ashrae-sustainable-buildings.htm

Build It Green: http://www.builditgreen.org

GreenPlumbers: http://www.greenplumbersusa.com

International Green Construction Code: http://www.iccsafe.org/cs/IGCC/Pages/default.aspx

Labs21: http://www.epa.gov/lab21gov/about/approach.htm

6. The Water-Energy Nexus

Water and energy in buildings are intertwined, not only at the point of consumption, but also at the point of generation. Four percent of electricity use in the U.S., or 75 billion kWh annually, is attributable to the supply, conveyance, and treatment of water and wastewater. Moving water from place to place accounts for nearly 80% of that electricity use.[1]

Water weighs more than eight pounds a gallon, which is why moving water primarily with electric pumps consumes large quantities of electricity every year. The amount of electricity used by the nation's 54,000 water utilities varies depending on the size and design of the water system and the elevation and distance needed to pump water, but none of that transportation is cheap in electricity terms.

Utilities also withdraw large amounts of water from rivers and other sources to create energy—although only about 3% of that water is actually consumed in the process. Even though there are several different methods to produce electricity, all require lots of water for cooling. Eighty-nine percent of electricity created in power plants for use by buildings in the U.S. is produced with thermally driven, water-cooled energy conversion cycles, which evaporate water during the cooling of condenser water. Hydroelectric power represents around 9% of the total power generated in the U.S.[2]

Once at its destination buildings, water is also used heavily in managing heating and cooling loads. Most green buildings utilize evaporative cooling for air conditioning. With direct evaporative cooling, outside air is blown through a water-saturated medium (usually cellulose) and cooled by evaporation. The cooled air is circulated by a blower. Direct evaporative cooling adds moisture to the air stream until the air stream is close to saturation, so water is a key coolant in the process.

With indirect evaporative cooling, a secondary air stream is cooled by water. The cooled secondary air stream goes through a heat exchanger, where it cools the primary air stream, which is then circulated by a blower. Indirect evaporative cooling does not add moisture to the primary air stream. Unfortunately, there is not sufficient data available to gauge the water savings available through technologies such as indirect cooling. There is, however, ample evidence to show reducing water use reduces energy use, which has a direct impact on reducing greenhouse gas emissions, improves waterways by leaving more water in their river systems, and creates a more reliable water supply for agriculture, people, and wildlife.[5]

WATER CONSUMPTION FOR ENERGY GENERATION

As has been noted, most building energy use does not directly impact water, yet the water impact of energy production is substantial due to the cooling requirements of generating plants. Thermoelectric power withdrawals from bodies of water accounted for 48% of total water use, 39% of total freshwater withdrawals, and 52% of fresh surface-water withdrawals.[3]

Electricity demand is expected to follow Census Bureau population growth projections of 50% by 2050, with the exception of irrigation and industrial uses, which are expected to triple over that period.[1] So while energy demands should remain relatively flat (a 0.5% increase over current generation demand), water managers in 36 states in 2003 said they anticipate water shortages in the next decade under "average water conditions."[4] All 45 state water managers who responded to the GAO predicted water shortages could be accompanied by "severe economic, environmental, and social impacts." Moreover, median decreases in annual water supply from runoff are estimated at 67-96% loss of water in all of the western states by 2050.[5]

Constraints on the ability to withdraw water have a negative impact on utility operations and restrain energy production. Several nuclear power plants in the Southeast were threatened by drought conditions in 2008. In 2007, the reactor at a nuclear plant in Brown's Ferry, Ala., had to be temporarily shut down because of high Tennessee River water temperatures, even as a heat wave increased the demand for electricity.

1 "Water and Sustainability (Volume 4): Use Water Consumption for Water Supply and Treatment—The Next Half Century," Electric Power Research Institute, Topical Report, March 2002.

A 2009 study puts the figure at an estimated 13%, including energy for heating water in homes and buildings. See "The Carbon Footprint of Water," Bevan Griffiths-Sattenspiel and Wendy Wilson, River Network, May 2009. www.rivernetwork.org

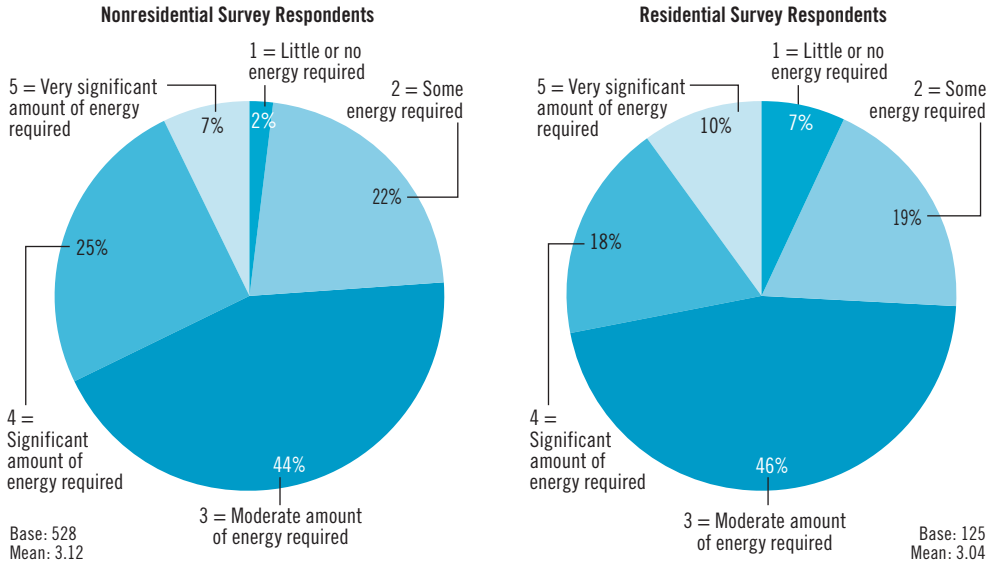
2 "Consumptive Water Use for US Power Production," National Renewable Energy Laboratory, December 2003.

3 "Water Use: Thermoelectric Power Use," U.S. Geological Survey, 2000 http://ga.water.usgs.gov/edu/wupt.html

4 "EPRI's Water/Energy Sustainability Initiative," Electric Power Research Institute, April 2004.

5 "Energy Down the Drain: The Water-Energy Climate Nexus," Natural Resources Defense Council, April 2009.

Chart 6.1
EVALUATING THE WATER-ENERGY NEXUS
Based on your professional experience or what you have read or heard, what is your sense of the amount of energy employed in supplying drinking water to buildings and homes and treating wastewater from buildings and homes?



Source: BD+C/Professional Builder 2009 White Paper Survey

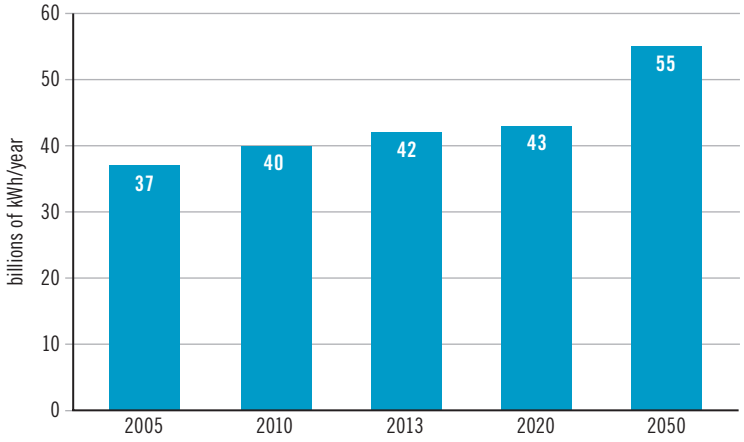
Respondents to both the Nonresidential and Residential Surveys came out pretty much the same—dead center—on the question of the energy component of water supply and treatment (Residential mean: 3.12, Nonresidential mean: 3.04). Yet nearly a third of Nonresidential Survey respondents (32%) saw a "significant" or "very significant" connection between water supply and treatment and energy use, while 28% of Residential Survey respondents also saw the nexus between water and energy.

All this begins to illustrate the water-energy nexus. Reducing energy consumption in buildings can have a positive impact in reducing the size and number of electricity-generating power plants, which themselves require huge amounts of water.

One way to look at the potential for significant reductions of building energy use—and therefore total water use—is through modeling. The Pacific Northwest National Laboratory's software tool, Building Energy Analysis and Modeling System (BEAMS), provides estimates of future energy costs and emissions savings resulting from lighting and equipment upgrades, improvements to the building envelope, and energy-oriented design of the whole building.

Using BEAMS, PNNL researchers estimated that avoided water consumption from the widespread use of green building technology could total 25 billion gallons by 2015. The DOE researchers estimated 78 billion gallons of water from building upgrades and new green construction could be saved by 2025. The avoided freshwater consumption indicated by BEAMS in terms of

Chart 6.2
BASELINE ENERGY CONSUMPTION FOR WATER SUPPLY PROVIDED FROM PUBLIC AGENCIES, 2005-2050



Source: Water & Sustainability: US Electricity Consumption for Water Supply & Treatment-The Next Half-Century, EPRI, 2002

Energy consumption for public water supply is expected to rise steadily through the year 2050. This tracks Census Bureau population growth projections of 50% over the same period.

a single person's daily water use (annual domestic freshwater use in 2000 was 33,600 gallons per person) could offset 517,521 persons by 2015 and 1.9 million persons by 2030.

But achieving the BEAMS estimates is not easy, either. To do so would require nearly 1.7 million older toilets to be replaced with 1.6 gpf toilets by 2015 and 5.3 million toilet retrofits by 2025, as well as more than six million top-loading clothes washers. To meet the goals of the BEAMS projection, $950 million would have to be spent by 2030 on efficient toilets alone.[6]

ENERGY COST OF TRANSPORTING AND CLEANING WATER

Whether it's surface water held in reservoirs or bringing up groundwater from aquifers, moving water is neither inexpensive nor particularly efficient in energy terms at delivering all the necessary water. Supplying water from groundwater sources requires 30% more electricity than supplying water from surface sources, due to the energy needed to lift raw water out of aquifers. Surface water, while cheaper to move than groundwater, can experience a high rate of evaporation before reaching its destination; this is especially true in arid regions such as the West, where it's needed the most. Add to that the inevitable loss of stored water through evaporation from surface water reservoirs. There is currently little guidance regarding the allowance for evaporation losses during reservoir planning.

As has been noted throughout this report, California, one of the states most dependent on outside water sources, devotes about 19% of all its electricity to the distribution and treatment of water. Pumping water over 300 miles from northern to southern California and raising it 2,000 feet over the Tehachapi Mountains alone uses 2-3% of all the electricity consumed in the state. Surface water utilities typically use 1.8 kWh per 1,000 gallons of electricity produced.[7] California also annually consumes four million acre-feet of the Colorado River's water.

"The most cost-effective way to save energy in California would be to reduce water use, because they wouldn't have to pump the water," says Doug Elliott, research economist in the Portland, Ore., office of the U.S. Department of Energy's Pacific Northwest National Laboratory.

Desalination also provides the Golden State with 50,000 acre-feet of water annually, or 10% of its water needs. However, desalination costs as much or more than transporting freshwater, and while technologies such as reverse osmosis are making it cleaner and less energy intensive, the cost of desalination is still prohibitive under most conditions—unless that's the only way you can get drinking water.

There are a couple of reasons why it is difficult to estimate the cost to maintain a desalination facility. First, the choice of desalination method is a crucial factor. Reverse osmosis uses fine membranes and pressure to separate salts from water, whereas multistage flash and multi-effect distillation— processes where condensed steam is used to evaporate freshwater from seawater—use thermal and electrical energy. Multistage flash and multi-effect distillation plants lag quite a bit behind reverse osmosis in terms of energy efficiency. The other problem with making generalizations about the cost of desalination is that regional energy prices are not easy to compare.

A more promising option for desalination of salt water, known as co-location, has been recognized as a versatile, effective solution by the American Academy of Environmental Engineers. Co-location partners desalination plants with power plants, which then share energy and water. Approximately

6 *"Quantifying Water Impacts of Buildings' Energy Usage: Presentation to the Buildings Technology Research And Development Subcommittee of the National Science and Technology Council," Elliott, Doug, and Dirks, Jim, Pacific Northwest National Laboratory, May 2009.*

7 *"Energy Down the Drain: The Hidden Cost of California's Water Supply," Natural Resources Defense Council, August 2004.*

Water heating and water conservation

Gary Klein, managing partner of Affiliated International Management, Newport Beach, Calif., knows about hot water. For nearly two decades, Klein studied the connection between water, energy, and the creation of greenhouse gases as a project manager for the California Energy Commission.

He knows what it costs the average homeowner annually to heat water in the home (about 15-30% of the house's total energy pie), how much water should be wasted while waiting for hot water to come out of the tap (no more than one cup), and how hot water should be delivered (through pipes with a smaller diameter and shorter length than are currently used in most homes and buildings).[8]

"If we could save half the water we used in buildings we'd save 2-3% of the electricity we need to generate," says Klein. "The low-flow showerhead doesn't really do anything, though, if you leave it on twice as long waiting for hot water. Letting your faucet run for five minutes uses about as much energy as letting a 60-watt light bulb run for 14 hours."

Klein has been working with Craig Selover, head of Masco's "Environments for Living" green homes program, on hot water. They have been advocating recycling of heat from water in homes via heat exchangers that send heat from spent shower or faucet water back to your water heater. They're also pushing for smaller pipes and individual water heaters for each fixture.

Klein says Building Teams can design plumbing systems that save half of the water used in residential and multifamily buildings. He remains convinced that energy efficiency is just as important to conserving water as water performance in buildings.

"The compact fluorescent light bulb saves water," he said. "It just saves it at the power plant because it doesn't need as much energy to run."

18% of desalinated water is already used by power plants. Desalination could be a viable alternative to damming and rerouting rivers to provide water if innovations in technology can bring the cost of building and maintaining facilities down.[8]

Nonetheless, the better path to conserving the output of overstretched bodies of water like the Colorado River is to reduce demand through good water design strategies in green buildings.

CONSERVING WATER IN BUILDINGS

For commercial buildings, the biggest opportunity to conserve water supply is in the mechanical systems. High-efficiency plumbing fixtures such as high-efficiency toilets can only do so much, and they can be defeated by inappropriate consumer use. Electric chillers represent the single largest electrical load in most commercial, institutional, and industrial buildings, accounting for 35-50% of a building's annual electricity use. Retrofitting existing buildings and new ones with efficient chillers, boilers, and other HVAC equipment will have the greatest effect on conserving water.

The most dramatic improvement in operating efficiency can be achieved by replacing an older chiller with a new high-efficiency unit. Centrifugal chillers that are 15-20 years old had a peak efficiency of 0.75-0.85 kW/ton when new, while those that are 10-15 years old had a peak efficiency of 0.60-0.70 kW/ton out of the carton. Newer centrifugal chillers offer peak efficiencies of 0.50 kW/ton or higher. When coupled with variable-frequency drives, they can deliver higher efficiency over a wide range of cooling loads.

Another approach that can help is energy modeling of new buildings. Software programs such as Integrated Environmental Systems' Virtual Environment-GAIA, Autodesk's Ecotect, Graphisoft's EcoDesigner, and Bentley's Hevacomp give Building Teams an unprecedented capability to design for whole building energy efficiency for new designs. Done properly, this can result in significant downsizing of buildings in the early stages of design, opening up the opportunity to downsize the project's chiller capacity—and its water consumption.

To get a better view of its water and energy consumption, the General Services Administration, the property manager of almost all federal office buildings and courthouses, last year asked the Department of Energy to investigate 12 GSA buildings and compare the performance of its green buildings to industry standard performance of energy, water, and other criteria. Eight of the 12 buildings were LEED-certified. All were designed with some LEED points available, even when the GSA had not pursued certification for them. Facility managers provided utility bills and maintenance budgets, and DOE researchers conducted an occupant survey for key data points. Twelve consecutive months of data were collected for each performance metric and normalized using building and site characteristics.

On average, the office buildings in the study performed 29% better on energy use than the Commercial Buildings Energy Consumption Survey national, regional, and GSA national averages. They performed 14% better than GSA's national goal for energy performance.[9]

"Some of the observations confirmed 'common beliefs,' such as [the belief that] buildings that intentionally incorporate energy considerations into design have better energy performance," wrote Kim Fowler and Emily Rauch, the two analysts from the Pacific Northwest National Laboratory who conducted the study. "The data show that half the change in the Energy Star score [of a building] can be explained by the change in the LEED Energy and Atmosphere 'Optimize Energy Performance' credits (EAc1). That is, buildings that received more EAc1 points tended to receive higher Energy Star scores."

Determining water use per occupant in the buildings, though, was not as clear-cut. The water use data provided for eight of the buildings included process and irrigation water, so the domestic use of water in those buildings had to be estimated. For all the buildings domestic water was estimated as the base water load revealed from monthly water use data.

In the end, the researchers found that the average water use of the buildings in the study was only 3% less than the calculated water use indices baseline. Not surprisingly, courthouses and office buildings in the arid and semi-arid West used more water than their counterparts back east.

The authors recommended sub-metering and more detailed information about each of the buildings' water use before water use could be compared to a relevant baseline.

What emerges from these various data points is that one of the best opportunities for conserving water is to use less energy. That's how the water-energy nexus plays out.

8 "Accounting for the Water –Energy-Greenhouse Gas Relationship," Klein, Gary, Affiliated International Management, October 2009.

9 "A Post Occupancy Evaluation of 12 GSA Office Buildings," Pacific Northwest National Laboratory, Fowler, Kim M., and Rauch, Emily M., July 2008.

7. Water Performance Action Plan

WHAT BUILDING TEAMS CAN DO

1. Design buildings to reduce cooling load. One of the most cost-effective ways to save water in new commercial, institutional, and industrial buildings is to design them to reduce the HVAC load as much as possible. This means paying strict attention to site orientation, building envelope tightness, daylighting, ventilation—that is, using all the powers of sustainable design you can muster to slim down those cooling towers, which are the biggest consumer of water in CII building projects.

2. Take advantage of cooling tower management technology. The use of conductivity meters and automatic controls to conserve cooling tower water is becoming fairly routine for many Building Teams. Every effort should be made to maximize blowdown water usage, with a minimum target of 5-6 cycles of concentration for blowdown use. Single-pass systems should be anathema. Where available, purple-pipe water should be used for condensate replenishment. "A well-run tower will only return 15% of the water to the sewer," says H.W. (Bill) Hoffman, a highly respected water consultant.

3. Consider alternatives to cooling towers. Groundwater systems, underfloor air distribution, and so-called dry systems like variable refrigeration volume systems are options that should be considered for every project. First-cost issues must be evaluated, but these systems may prove cost-effective over the long term, especially for owner-occupied buildings. Groundwater systems in particular are becoming increasingly popular with smart-thinking building owners and developers.

4. Design water and drain lines for optimal performance. In new construction, drain lines that are not properly sloped, have too many elbows, or are not properly sized can result in drain line clogging, especially as plumbing fixtures use less and less water. This is important in spread-out projects like malls and suburban office campuses, and in one-story single-family homes, where there is less verticality to the pipes.

Hot water lines should be designed for efficient transport of hot water from the heating source to the sink or shower. This is especially true in new home construction, where plumbing design is often an afterthought.

In retrofits of high-efficiency fixtures, especially toilets, make sure existing drain lines can function properly with the reduced volume of wastewater flow.

5. Get the landscape architect involved early in the job. Landscape architects are more than just "plant people." They can enhance the water performance of your project through the innovative design of rainwater harvesting systems, stormwater retention, rain gardens, vegetated roofs, bioswales, pervious pavement, structural soils, turf reduction, even so-called "green streets" (a requirement in Portland, Ore.) Don't wait to bring in the landscape architect as an "add-on" after the basic form of the building has been set. The landscape architect should be a charter member of the Building Team, charged with optimizing the performance of the site —especially its water performance—within the overall program of the building.

6. Become the expert on water rebates and incentives. AEC firms and home builders should make themselves the knowledge source regarding rebates, incentives, and grants for water conservation on behalf of their clients. Example: Rain Bird, a maker of high-efficiency sprinkler systems, has a link to a dozen state incentive programs for water-related rebates (http://www.rainbird.com/iuow/resources/watersavingsrebates.htm).

Here's how it can work: A few years back, HDR Architecture was able to convince client Banner Bank to install a massive storage tank for rainwater harvesting, thanks largely to a 60% grant from the EPA. HDR's David Gibney found out about the grant program through a Google search. The rainwater system contributed to the Boise, Idaho, project achieving LEED Platinum.

WHAT BUILDING OWNERS CAN DO

7. Engage in water management planning. Water management planning involves taking a comprehensive look at how water is used in buildings, especially for large corporate complexes, military bases, university campuses, hospital complexes, and the like. The basic idea, according to consultant Kate McMordie, is to compare the amount of incoming water supply with the pro-

jected actual use for each building, based on such factors as the number and kinds of toilets, urinals, sinks, and cooling towers, as well as landscape irrigation requirements.

There can be a substantial difference between the theoretical use and the actual amount of supply to a large campus—a 10-20% difference is not unusual, although McMordie has found one as great as 50%. Owners whose buildings are using substantially more water than the theoretical amount should go to the next step.

8. Conduct water audits. Water audits can yield detailed information about problems with mechanical and plumbing systems that can save money fairly quickly. As in the case of building commissioning, a water audit can reveal anything from a minor problem—a loose connection in a pipe system—to major flaws in, say, the building's cooling towers. A water audit for a 10-story office building would run about $5,000, according to consultant Bill Hoffman. In some localities, a WASCO, or water service company, may perform the audit at a lower cost and get compensated based on the savings it produces, much as an ESCO does for an energy audit.

WHAT GOVERNMENT CAN DO

9. Harmonize plumbing codes for water reuse. This is a biggie. In most jurisdictions, plumbing and building codes make it difficult to impossible to use innovative rainwater harvesting and graywater reuse, especially for indoor use. NSF International is conducting research on the health, safety, and public welfare of reused water, and IAPMO's new green supplement offers language for states and cities to use if they choose to permit this technology.

What is needed are case studies, data, and research to demonstrate the feasibility—and value—of graywater reuse in large commercial buildings and rainwater harvesting in both homes and commercial buildings. It's too inefficient for Building Teams and home builders to be trying to implement graywater and rainwater reuse in their projects on a case-by-case basis. However, local and state governments could encourage carefully supervised pilot projects to experiment with different systems or designs. The plumbing industry and government need to nail down the science and clinical aspects, see what really works, and then overlay the technical design and construction details onto building and plumbing codes to make this "next big thing" happen.

10. Consider water-use labeling on sale or transfer. Water-use labeling is a system whereby property owners would be required to have their buildings or homes audited for water performance at the time of sale, transfer, rental, or lease. Such a system has been in use for energy labeling in the U.K. and Europe for a number of years, and ASHRAE has recommended the use of energy labeling in the U.S.[1]

Water-use labeling would give prospective purchasers, renters, and lessees information that could be used to determine the sales or rental value of the property. Presumably, a highly efficient building or home with up-to-date plumbing and irrigation systems would bring more in the market than one with out-of-date equipment or poor water performance.

However—and this is important—with water-use labeling, the seller would not be required to make upgrades; that would become part of the sale or lease negotiation. This factor makes water-use labeling different from a "replacement on transfer" requirement, versions of which are already in effect in several cities in California (including Los Angeles, San Diego, and San Francisco) and which is being proposed for statewide adoption in California. Under proposed SB 407, starting in 2014 homeowners and apartment building owners making improvements to their properties would have to replace all noncompliant plumbing fixtures; multifamily and commercial properties up for sale would have to replace noncompliant fixtures before a final permit would be granted.

The gravity of the situation in California may give "replacement on transfer" some validity, but we think it advisable for other states and localities to start with market-based mechanisms like water-use labeling. If the jurisdiction finds that the more "voluntary" approach doesn't work, it could move up the scale to stricter regulation.

However, public officials should heed the warning of water consultant John Koeller, who has cautioned that mandating high-efficiency fixtures in retrofits without careful evaluation of the ability of plumbing and drain lines to function with less water in the system could lead to major problems, especially in older buildings and homes.

11. Use IAPMO's green plumbing supplement as a guide. The IAPMO Green Plumbing and Mechanical Code Supplement provides a consensus-based vehicle for states and local

1 See "Energy labels for buildings may be key to energy savings," Robert Cassidy, Building Design+Construction, April 2009. www.BDCnetwork.com/article/CA6647948.html

jurisdictions to resolve several of the most nettlesome conflicts between sustainable design and existing building, plumbing, and health codes. The document: 1) provides guidance to state and local officials on reusing water (notably graywater, rainwater harvesting, and purple pipe) to supplement the potable water supply; 2) describes best practices for avoiding problems like drain line clogging; 3) supplies language and standards for the use of high-efficiency plumbing and mechanical products; 4) shows how to achieve optimal results in hot water systems, thereby saving both water and energy; and 5) provides practical advice on the water-performance aspects of cooling systems in commercial, industrial, and institutional buildings.

The IAPMO code supplement will be available in February 2010. State and local plumbing and building officials should give it priority consideration.

12. Address the infrastructure problem. If you laid the water pipes that are more than 80 years old in this country end to end, you could circle the planet nearly three times. Because much of this ancient pipe is falling apart, at least 10-20% of the nation's potable water (and more in older cities) simply never makes it to its intended point of use. And as we have noted, considerable energy is also wasted pumping water that leaks from the system.

The American Water Works Association says an investment of $250 billion over 30 years is needed to repair or replace worn-out water pipes, valves, fittings, and so on. To meet these costs, AWWA recommends that the federal government do two things: 1) increase funding to the State Revolving Fund programs, which provide low-interest loans to local utilities for such improvements, and 2) create a "Federal Water Infrastructure Bank." The FWIB would provide financial assistance for large water infrastructure projects of national or regional importance ($75 million or more) with loans at the U.S. Treasury bond rate. In addition, the FWIB would purchase or guarantee State Revolving Fund bonds, thereby lowering the interest rates on these bonds.

Whether such a water infrastructure bank is merited is somewhat beyond our brief in this White Paper. Regrettably, the most likely scenario is that our ever-decaying water infrastructure will not get its due until some cataclysmic event grabs the headlines. Until then, the nation's 54,000 water utilities will have to plug along with business as usual.

WHAT WATER UTILITIES CAN DO

13. Be more creative in pricing water. Water is cheap—too cheap, in the view of many experts in the field, especially for potable water that is not used for drinking, washing, or other direct human use. Because water is relatively so cheap, it's hard to get property owners to reduce their use, especially for landscape irrigation (and, to some extent, for cooling towers in commercial buildings). Moreover, homeowners and building owners are used to water rates being subsidized. There's the further complication that most utilities charge based on volume, so reducing water use may be seen as not in their best interests.

For these reasons, a tiered system—a basic service fee for a pre-established floor of indoor water consumption per occupant, followed by higher fees for use above the base—may be the best pricing mechanism to encourage water conservation.

Nine years ago, Greensboro, N.C., established a four-tiered price system, coupled with a billing and availability fee for fixed costs. Households that saved water were rewarded with a lower rate and lower bills; others paid the price for water gluttony. Over the first seven years of the program, household consumption fell 22%.[2]

Tiered pricing should also be linked to wastewater treatment fees, so that buildings and homes that saved water and thereby sent less wastewater back to the treatment plant should also reap the benefit of lower sewage treatment bills.

14. Provide incentives for water audits. Water utilities rely on volume to stay afloat, so it may seem against their best interests to encourage water audits, which would result in less water usage. However, with the prospect of drought or water scarcity throughout most of the U.S. in coming years (not to mention the stressful impact of climate change and population growth on water resources), utilities need to offer these incentives to building owners and homeowners before a crisis hits.

15. Implement metering innovations. One of the problems with water is that a lot of it seems to disappear, and nobody knows how or why. Metering and submetering commercial and institutional buildings, apartments/condos, and single-family homes can help alleviate this problem by influencing end-user behavior and overcoming the "out of

2 "Hidden Reservoir: Why Water Efficiency Is the Best Solution for the Southeast," American Rivers, October 2008, page 16.

sight, out of mind" problem.

And it works. Austin, Texas, has found that submetered apartments use 15.3% less water than master-metered multifamily properties. In 2008, it required submetering in all multifamily buildings.[3]

Another technology, automated meter reading, uses radio-frequency technology to read water meters from the street. The advantage of AMR is that it can pick up anomalies—for example, a home with minimal landscaping and an unusually high water bill might have an undetected leak. Both New York City and the District of Columbia Water and Sewer Authority have implemented AMR systems, with good results.

WHAT MANUFACTURERS CAN DO

16. Support research on water performance issues. Plumbing fixture makers have played a valuable role in partnership with EPA WaterSense and other organizations in the development of high-efficiency faucets and showerheads. The industry has set up the Plumbing Efficiency Research Coalition to study the drain line transport problem. It is in the best interests of groups like the Plumbing Manufacturers Institute, the plumbing trade unions, and related associations to support research that will remove roadblocks to innovation and progress in sustainable design and construction.

17. Support the growth of green plumbing jobs. GreenPlumbers USA is making headway in its efforts to retrain 40,000 plumbers to make more efficient and effective sustainable plumbing systems in homes and buildings. Plumbers' unions and the United Association of Plumbers and Pipe Fitters should be in the forefront of the water performance movement, not only out of self-interest but as a demonstration of their leadership and public service. Manufacturers can play an important role in providing technical expertise, product samples, demonstration sites, and financial support for local, state, and national green plumbing training programs.

WHAT COMMUNITY COLLEGES CAN DO

18. Create a "pre-apprentice water auditor" certification program. Last year, we recommended the creation of an associate's degree in building commissioning as a way to enable more buildings to be commissioned.

So that more water audits can be performed, we support the proposal put forth by Steve Lehtonen of GreenPlumbers USA for community colleges to create a curriculum for "pre-apprentice water auditors." Graduates would be trained to assist professional water auditors, thus "stretching" the workforce and possibly reducing the cost of water audits. This certification will become even more valuable when the WaterSense New Homes program goes into effect.

If we can have Certified Energy Managers, LEED Accredited Professionals, and, now, Green Globes Assessors and Professionals, why not pre-apprentice water auditors and other water-related professional certifications? Here's another excellent opportunity to create interesting and well-paid green jobs.

WHAT THE PUBLIC CAN DO

19. Use less turfgrass, more native landscaping. This will require a major shift in the aesthetic mindset of the majority of American homeowners and commercial-institutional property owners. The well-groomed lawn has taken on a symbolic image that will be hard to erase from the American psyche. Nonetheless, efforts like the prairie restoration movement in the Midwest and various forms of native and Xeriscape landscaping have shown that the use of indigenous plants can be both beautiful and ecologically sound, especially with regard to water use.

20. Irrigate sensibly. If irrigation is still required, homeowners and property managers need to consider the use of high-efficiency irrigation systems that are based on the regional climate, local weather and soil conditions, the types of plantings, and so on. These systems can prevent the most egregious errors, such as watering during a rain storm.

21. Understand the energy cost of water. The public needs to appreciate more fully the energy cost of transporting and treating water and wastewater, and the resultant impact on greenhouse gas emissions and climate change.

With climate change adding to water scarcity and drought, the coming decade will demand our attention to water performance. "Water restrictions, mandates, rationing—Australia, Israel, and other parts of the world have already faced these issues," says Sean McGuire, staff liaison with the Mechanical Contractors Association of America. Their experience is "a preview of what may happen here in five or 10 years." The time for action is now.

3 "Hidden Reservoir," page 17.

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Environmental Business Journal's WaterView Report 2009, published by ZweigWhite, is a comprehensive manual and market research document for water and wastewater. The 811-page report maps out the water industry by sector, with market data breakdowns and forecasts, trends, and strategies derived from hundreds of executive interviews. More at: **www.zweigwhite.com/go/waterv09**

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The editors of *Building Design+Construction* would be glad to meet with Greenbuild attendees from Tuesday evening, Nov. 10, to Friday morning, Nov. 13, at our "Experimental Patient Room 3.0" display on the 3rd Floor of the Phoenix Convention Center. To schedule a meeting, contact: Robert Cassidy, rcassidy@reedbusiness.com; 630-288-8153 office; 773-844-0018 mobile.

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