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# Water Innovations

# TOP 10 TRENDS of 2016

Expert Insight Into Today's Critical Water And Wastewater Issues

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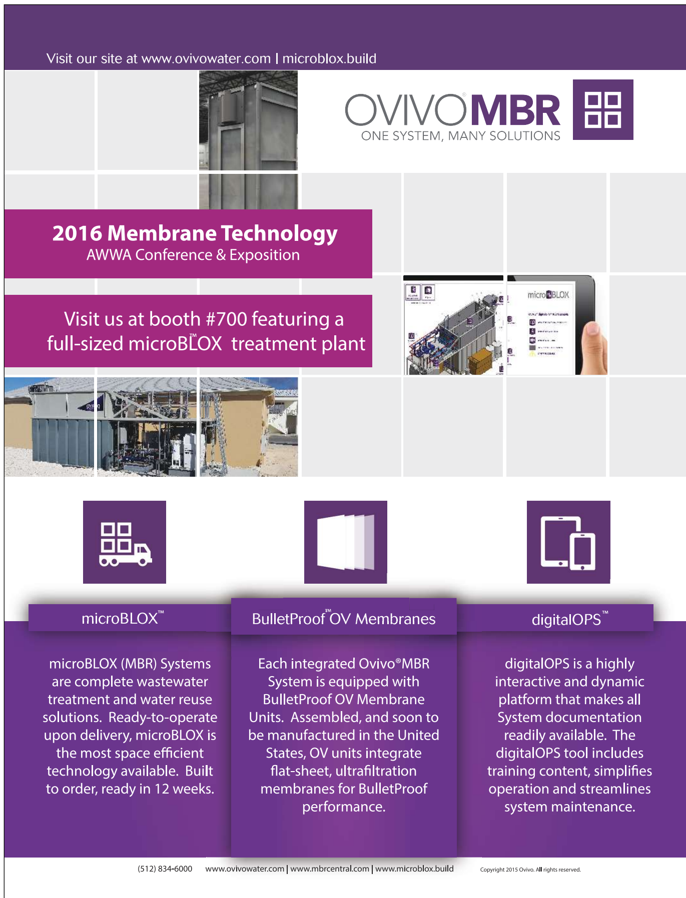




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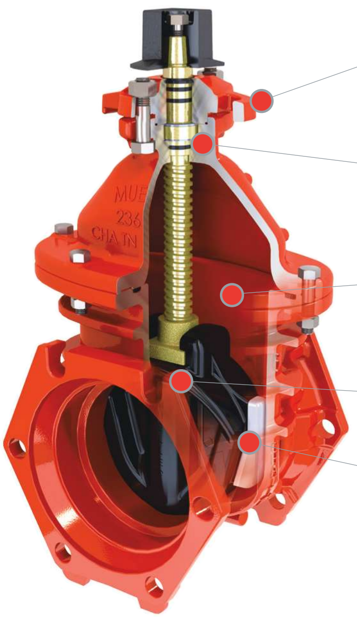

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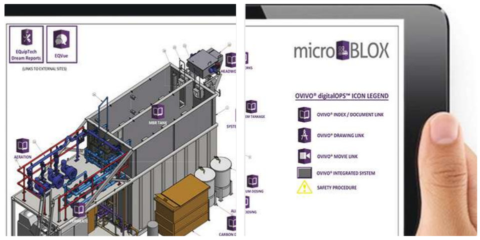


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# EDITOR'S LETTER

By Kevin Westerling
Chief Editor, editor@wateronline.com

# 3 Game Changers
## For Water And Wastewater

*Three key events from 2015 could reshape the water/wastewater industry in 2016 and for years to come.*

The annual "Top 10 Trends" edition of *Water Innovations* keeps you in tune with pressing issues currently facing the industry, presenting real-world examples and tips from your peers on how to solve them. In 2016, the topics include climate change, groundwater protection, nutrients, non-revenue water, and water reuse; we also introduce strategies and technologies for sustainability, regulatory compliance, funding, and labor. Bright spots abound in the solutions you'll find herein — very practical, actionable guidance — but I'd like to acknowledge some other bright spots, of a different type.

These are moments of change but unrelated to equipment or processes. The following events foreshadow a "new normal" on the horizon for the water and wastewater industry — the arrival date is indeterminate, but inevitable. And when it comes, we may look back and see these moments as turning points.

### When Congress Wised Up On WIFIA

The Water Infrastructure Finance and Innovation Act (WIFIA) was years in the making, seeming at times that it would never come to satisfactory fruition. Introduced in 2011, the funding initiative for water/wastewater capital improvement projects passed through the legislative process in a series of fits and starts. In its 2014 incarnation, the bill authorized financing of 49 percent of the cost of large plant improvements, but the other 51 percent could not be achieved through tax-exempt bonds — a non-starter for many projects. However, through the tireless efforts of lobbyists, including the American Water Works Association (AWWA), the Water Environment Federation (WEF), and many others, Congress passed a version of the bill in late 2015 that removed the tax-exempt bond restrictions on WIFIA, thus freeing financing options for sorely needed infrastructure renewal. Will it herald an age of new treatment plant construction and pipeline renewal? It certainly should.

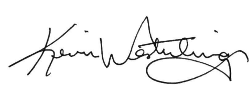
### When The World Coalesced On Climate Change Action

While skepticism, name-calling, and the cherry-picking and misrepresentation of data persist, the COP21 climate change conference in Paris proved at least one thing: World leaders and business magnates responsible for the long-term prosperity of nations and multibillion-dollar industries believe the threat is real. To protect their citizens, their businesses, and the Earth itself (in no specific priority order), these leaders are willing to undertake unprecedented investment and accountability. For municipalities and their constituents, the fear is primarily too much water (floods) or not enough (scarcity), while businesses are chiefly concerned with the latter. To avoid or mitigate such impacts, energy efficiency, emissions control, and reuse are destined to become the norm across the board (by choice or by mandate), and many businesses will choose to operate closed-loop water management systems. COP21, by unifying leaders and introducing reform and pledges on a grand scale, may have provided the momentum necessary to truly, finally, kick-start a new era of sustainability.

### When Bill Gates Drank Poop Water

You may have seen it on *The Tonight Show Starring Jimmy Fallon* or learned about it from *Forbes,* CNN, *Wired,* NPR, or *Popular Mechanics*. When Bill Gates drank water purified from sewage, promoting a new technology funded by the Gates Foundation, it blew people's minds. Of course, we in the water industry are familiar with potable water reuse and fully confident in the technologies that make it safe. The general public, however, is a different story, and squeamishness surrounding "toilet to tap" (a term advocates avoid) has been a major hurdle in getting this needed resource implemented. So when the common water consumer, tucked in bed awaiting Jimmy's next celebrity Lip Sync Battle, sees the world's richest man happily sip the product, it is a moment of impact. Direct and indirect potable reuse will need to be increasingly utilized as the stresses of population growth and drought converge, but it doesn't happen as easily or often as it should without public approval; indeed, politicians have even won elections by "safeguarding" the public and railing against it. Gates normalized the idea for millions overnight, creating waves of mainstream influence that continue to resonate and turn the tide toward widespread public acceptance.

So, 2016, what do you have in store?





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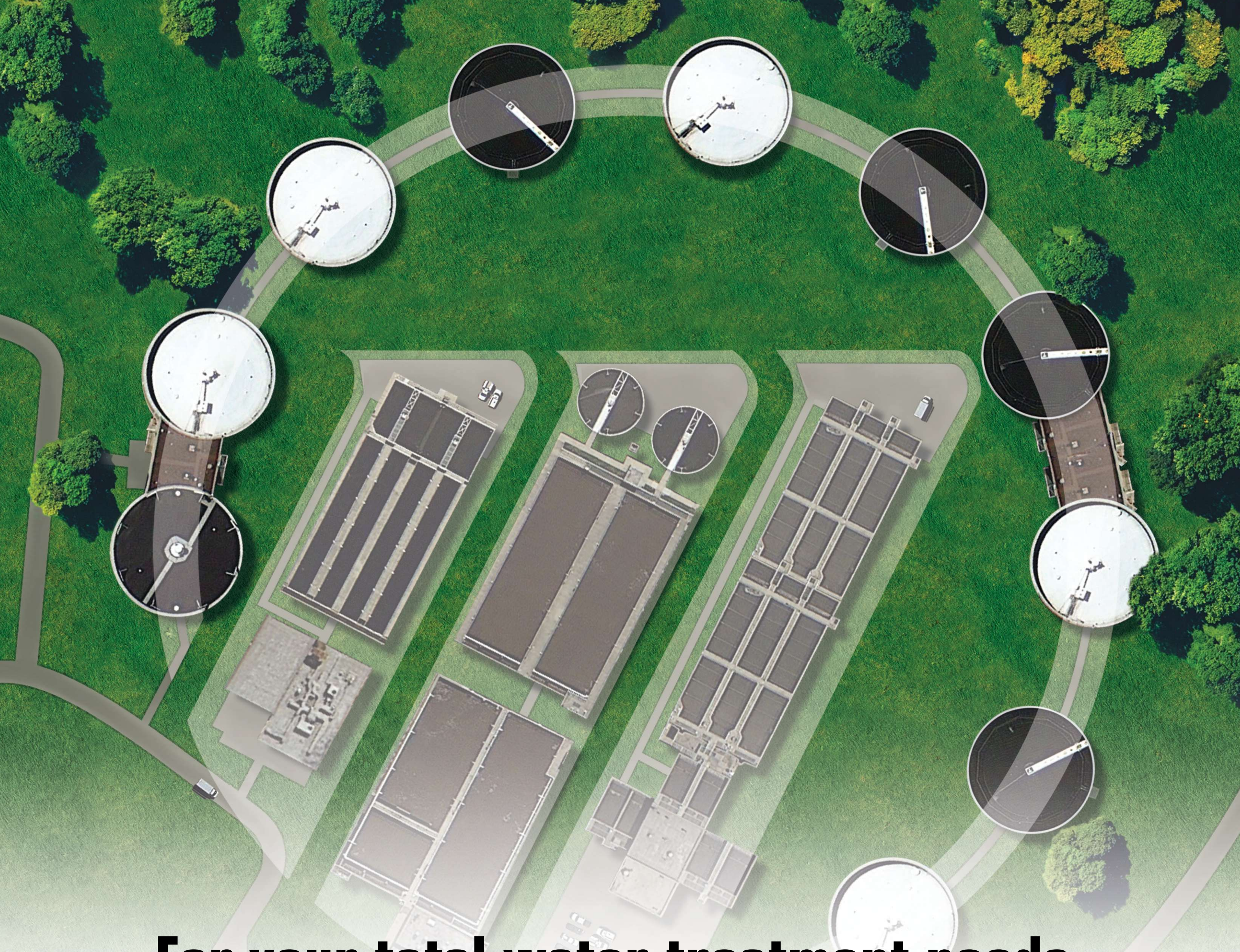

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# The Resilient Year: 7 Trends To Watch In 2016

Given the condition of our environment this year and beyond, it's possible that no other issue will be as critical in 2016 as planning for and protecting against catastrophic events. These seven emerging trends forecast how the water industry will cope.

By John Batten

As floods, drought, and other natural disasters unfold globally, resilience continues to top the world's headlines. The major change coming in 2016 will be the concept that resilience should shape public attitudes, policy, investment priorities, projects, and the status of water utilities as drivers for change. The year 2016 will be about how well cities and water utilities can become more resilient to disruptive events, from intense storms and drought to funding shortfalls and service demands.

### A Climate Of Change

Trends in resilience continue to emerge in cities across the U.S., so it's there that you find trends in action. Cities large and small seek to create an environment where people and businesses can thrive, yet they are also vulnerable to budget pressures, resource constraints, and natural disasters. Against these headwinds, the task of delivering safe and reliable water while protecting citizens from pollutants, disease, and flooding takes both strength of will and flexibility to adapt.

Fortunately, resilience solutions are trending along with these challenges and reflect new and exciting ideas. A global spirit of collaboration and sharing has produced a rich body of ideas and best practices that cities are making their own. Just as each city is dealt a different set of challenges, local conditions define individual resilience agendas.

Still, we can expect to see some core themes dominate in 2016, and many are unfolding now. It's critical for water industry professionals to keep up with these seven trends as they play out in the coming months.

### Trend #1: Cities Embrace Resilience

Just as the natural world has to adapt to survive, so too do our urban centers. Resilience matters in every way — not just for quick disaster recovery, but also for communities to feel confident that come flood, drought, or other water-related stresses, their city's future holds promise.

For these reasons, mayors, councils, utilities, and businesses are making resilience a top priority. The near-universality of urban resilience needs has led to a new global network pioneered by the Rockefeller Foundation called 100 Resilient Cities (100RC). The foundation provides resources to help cities hire chief resilience officers (CROs) and develop resilience strategies.

Resilience leaders have also broadened the definition of resilience to include the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what acute shocks and chronic stresses they experience. Seeing the city as a whole expands the scope of resilience to include social and economic factors as well as the physical.

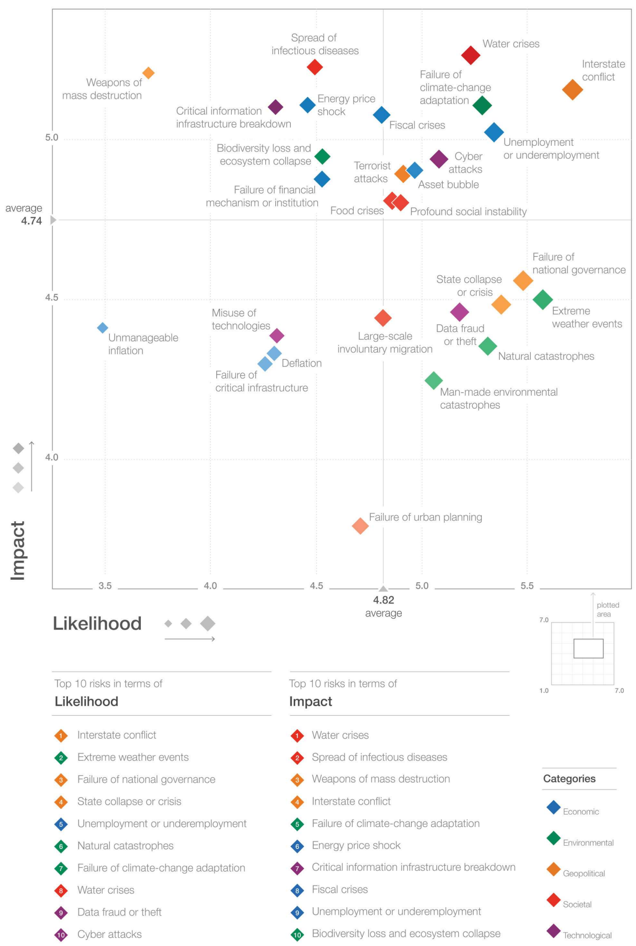
Perhaps the most important result of this trend is the recognition that a resilient city is a competitive city. Today, investors and businesses seek certainty that infrastructure will support their future growth and business interests. Water and wastewater system integrity as well as quick recovery from floods are no longer "nice to haves." Resilience is the core goal that connects economic and social priorities.

### Trend #2: Climate Redefines Risk

Increasingly, the world is recognizing that climate change is causing sea-level rise and more frequent and intense storms or drought. This one-two punch from climate change isn't restricted to emerging economies. Water and wastewater utilities from Florida to California are facing the need to make their systems resilient to too much or too little water and to saltwater intrusion from rising tides and sea levels.

In the U.S., flood threats create challenges across multiple fronts. In fact, according to a report from the International Organisation for Economic Co-operation and Development's "Studies on Water," by 2050 nearly 20 percent of the world's population will live at risk from floods. Until we adapt to climate change, we'll need to build systems to accommodate and hold back water.

Elsewhere, climate change has produced greater risk of water scarcity, as many communities in the Western U.S. know all too well. As if that weren't enough, a recent report from the World Economic Forum shows that water crises top the list of disasters in terms of impact.




Source: Global Risks 2015 report, World Economic Forum, Switzerland, 2015

### Water Crises Top The List Of Global Risks

In addition, the National Oceanic and Atmospheric Administration predicts more intense "El Niño effects" in 2016, which can be considered disasters in waiting. These include:

- Wetter-than-average conditions most likely in the Southern tier of the U.S., from central and southern California, across Texas, to Florida, and up the East Coast to southern New England. Above-average precipitation is also favored in southeastern Alaska.
- Drier-than-average conditions most likely for Hawaii, central and western Alaska, parts of the Pacific Northwest and northern Rockies, and for areas near the Great Lakes and Ohio Valley.
- Some improvement is likely in central and southern California but not drought removal. Drought is also likely to persist in the Pacific Northwest and northern Rockies, with drought development likely in Hawaii, parts of the northern Plains, and in the northern Great Lakes region.

While risk from climate change may often seem far off or someone else's problem, utilities can use these reports to create the urgency needed to galvanize public support for resilience measures.

### Trend #3: Cities Using Risk-Based Planning

In the aftermath of Hurricane Sandy, flooded subways and the disruption of essential services in New York City sounded a wake-up call to put resilience on the top of public agendas. In response to this crisis, Mayor Bill de Blasio and his team, through the Mayor's Office of Recovery and Resiliency, created a plan to improve the city's resilience to future trauma. The first priority of this risk-based resilience plan was to ensure that the city could recover and emerge stronger both economically and socially from another major natural disaster.

This plan assigns extra investment and high priority to critical and vulnerable public assets like hospitals, transportation, and telecommunications, plus water and wastewater facilities. Short-term solutions aim to provide flood protection for individual buildings. The end goal is business and social continuity, which also provides a foundation for recovery and rebuilding. Other cities will look at this model in 2016 as a way to rationalize resilience investment.

### Trend #4: Greater Acceptance of Alternative Sources And Reuse

Droughts challenge the ability to meet water demand year to year. Utilities are exploring ways to proactively address drought as part of broader sustainability planning. Los Angeles includes the following goals in its Sustainable City pLAn, the roadmap to a city that is environmentally healthy, economically prosperous, and equitable for all.

- Source 50 percent of water locally by 2025, using both potable and non-potable sources, including stormwater recharge and recycled water.
- Reduce average per capita potable water use by 20 percent by 2017.
- Improve disaster preparedness and resiliency for the city, so commercial activity can return to normal after a disaster as quickly as possible, with measurable targets.
- Reduce municipal water use by at least 20 percent by 2017.

L.A.'s plans to increase the diversity of its water supply will provide national inspiration, particularly as communities accept impaired supplies like treated seawater and wastewater.

For instance, the world's largest inland desalination plant, located in El Paso, Texas, produces up to 27.5 MGD from previously unusable brackish groundwater. The facility also removes more pathogens than required by public health regulations and helps protect fresh groundwater. Throughout drought-stricken regions, advanced reuse and desalination technologies are making these alternative sources more viable, both technically and financially. In 2016, the psychological barriers will be the last hurdles to fall.

### Trend #5: Creating Alternative Resiliency Funding

By now, the problems of aging infrastructure and the need to build more robust resilience defenses have provoked top leaders to pay attention. However, while there may be agreement on the need for resilient water and flood infrastructure, funding remains a challenge.

Water desalination plant construction in Carlsbad, CA

The year 2016 will see continued effort to build political will for water supply investment. Advocacy from the joint efforts of local and national leaders like the Value of Water Coalition and others is starting to open minds to the idea that investment in water infrastructure is essential, not just for drinking but also for economic, environmental, and social well-being.

While these debates continue, some utilities are using risk-based asset management strategies to squeeze additional performance from existing systems and set priorities. Risk analysis can lead to insights that put planning on solid ground, while enabling leaders to present choices to investors and the public. Recognizing risk and defining the level of tolerance for risk produces a stronger business case, whether support is public or private.

More practically, the data collected to measure risk also helps create a more useful picture of the entire lifecycle of a facility. Used for asset management, these strategies produce more efficiency and enable utilities to prolong the life of existing systems, which will remain essential in 2016 until more long-term projects get off the ground.

### Trend #6: Leading Cities Promote Resilience For Competitive Advantage

Cities compete to attract more jobs and to be recognized as thriving, vibrant, and desirable places to live and do business. The ability to rebound quickly and successfully from shocks and stresses is essential for a city to remain competitive, investable, and livable. Leading cities now promote water capacity and resilience as key levers for economic development and investment.

Increasingly, businesses look at cities' resiliency claims and assess potential risks when deciding where to locate. As a result, a reliable water supply and a reputation for managing flood risk are qualities on corporate relocation checklists. Water systems will need to find ways to leverage their capacity and system integrity in the competition for funding.

In addition, the more resilient the city, the greater its ability to attract investment. Investors want the same reassurances that businesses do. It's only a matter of years before bond investors develop indices for measuring resiliency to price the risks in and around cities. How well cities mitigate those risks will directly affect their perceived attractiveness and their ability to raise capital. Even today, more and more companies are developing environmental and social sustainability standards as a way to measure and communicate their sustainability to capital investors (e.g., the Dow Jones Sustainability Index).

### Trend #7: Building Resilient Destinations

As we move into 2016, cities will see the value in building resilient destinations that incorporate civil flood protection with green, low-impact design features, thereby enabling the creation of investable development zones that can generate revenues to offset the cost of the critical infrastructure while creating emotional attachment areas that raise civic pride. For example, the High Line in New York City, a repurposed, abandoned elevated train spur, has turned into a destination enjoyed by residents and tourists alike and has drawn further economic development along its corridor. In the same way, the proposed flood defenses for Manhattan, dubbed by some "The Dry Line," are being developed to protect the city from storm surge and sea-level rise, while also attracting people to a landscaped promenade with the potential for mixed-use real estate development.

Manhattan's East Side Coastal Resilience project concept combines storm surge defense and mixed use. *(Credit: Image Courtesy of BIG-Bjarke Ingels Group)*

Cities and utilities can be heartened that trends are pointing to more ways to cope with perennial resilience issues, from knowledge-sharing through platforms like 100 Resilient Cities, pioneered by the Rockefeller Foundation, to progress in risk-based planning. Investors and ratepayers alike are increasingly acknowledging the value of water. As resiliency becomes more of a mainstream issue, let's hope 2016 is the year when this momentum finally produces sustainable funding — in time to meet the next resiliency challenge. ■


### About The Author

John Batten is the Global Water and Cities Director for Arcadis, leading a global team dedicated to delivering outcomes that improve quality of life, safely and sustainably. As an industry thought leader on all aspects of resiliency, Batten's 30 years in the consultancy sphere include management of water utilities and public health facilities.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# The 3 Trillion-Gallon Leak – Where's Our Water?

The tipping point is here, and utilities are learning the best ways to prevent water loss and protect revenue.

By Will Jernigan

*May you live in interesting times.* Though widely purported to be Chinese, this phrase is of unknown origin. It is an ironic expression — intended as a curse rather than a blessing. Uninteresting times mean peace and tranquility.

In today's world of water — like it or not — we live in interesting times.

Access to enough safe water is a serious issue around the world, though we have historically been fortunate in this regard in North America. If we needed more water, we just added another supply line. Those days are largely gone, as the costs to develop the supply have gone up, and the availability of the supply has gone away. How we manage this precious resource is more important today than at any other point in history.

## The Tipping Point

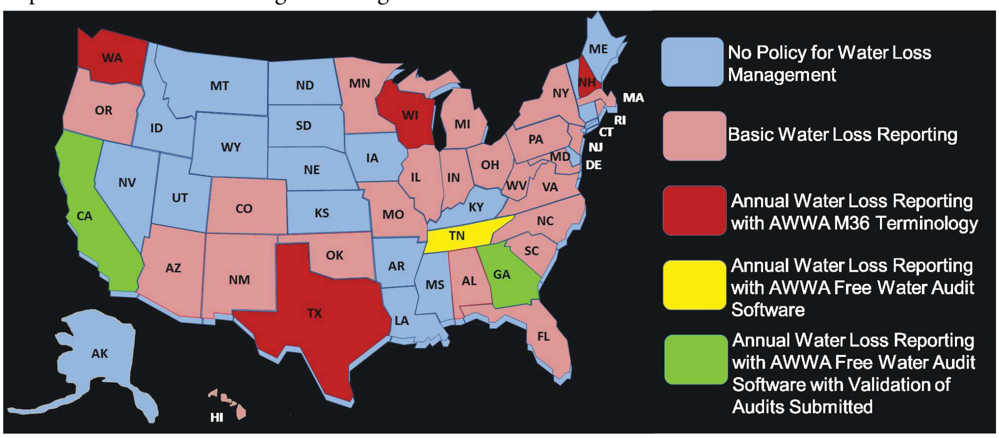
In October of 2015, the state of California passed landmark water loss legislation[1] that set into place requirements for all urban water systems to conduct American Water Works Association (AWWA) water audits, with formal validation of those audits. This puts California as the second state in the nation, after Georgia, with this requirement. Georgia steps forward with formalizing its existing water audit validation efforts by instituting a validation certification program — the first in the nation. Meanwhile, water loss control training initiatives are being launched in Colorado,[2] New Mexico,[3] Wisconsin,[4] and Oklahoma.[5]

In December of 2015, the inaugural North American Water Loss conference was held in Atlanta. This special event — the first-ever dedicated water loss conference and exhibition on American soil — brought together over 500 attendees from 40 states and provinces in the U.S. and Canada, and 15 countries around the world. Established international water loss companies are swarming the North American market, and new water loss companies are emerging. The divide between water and energy is closing: The U.S. EPA now supports water loss control as eligible for state energy-efficiency funding programs, with billions of dollars being made available.[6]

All of this points to the convergence of environmental, political, technological, and regulatory drivers for an explosion of adoption across North America for advanced water loss management practices. We are on the cusp of significant advancements in 1) the widespread adoption of established management practices, and 2) innovation in water loss technologies and management practices.

## System Optimization

Every pipe network leaks. Every metering system misses water. Every billing system has quirks. And every water system experiences theft. These are the components of water loss, and every system has them — all of them. Each of these water loss components exerts a tangible, measurable cost on the utility. These costs are often masked. Chemical and power costs were up last year? Perhaps due to more leakage that you treated and pumped. Revenues not keeping up with expenses? Perhaps a decline in meter performance. The truth is that water loss is an embedded cost, so it's easy to pretend that it's not there.



Landscape of water loss policy in the U.S. (2015)

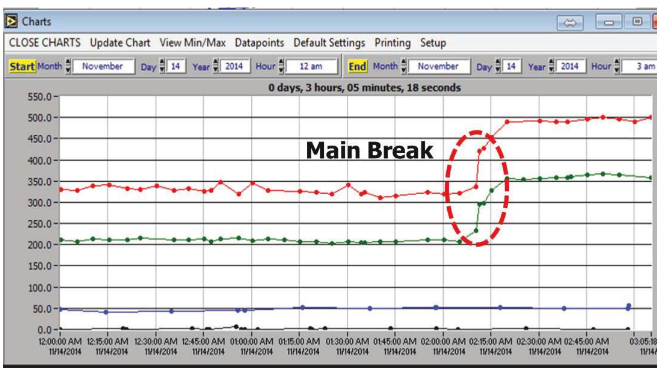
And the reality is that unmanaged water loss is the most expensive kind there is.

One-hundred-percent of water systems have a water loss program. When leaks show up, we fix them. When meters stop, we replace them. When we see people stealing water, we fine them. But few systems have a *proactive* water loss program, seeking out these issues before they happen, based on a sound business case for action. If we wait for issues to find us, we are overspending. It may not feel like it — because the cost of no action is embedded — but it is there. And just as every system has water loss, every system has an economically optimum level of water loss. Reactive programs will not get us to this economic optimum. The gap between our water loss today and our economic optimum represents our business case for action — and the business case against no action. The tipping point brings a mainstream awareness of these issues and pushes the methods and tools forward for solving our hidden problems.

### Tomorrow's Toolbox

Sectorization of pipe networks into leakage management zones, commonly known as district metered areas (DMAs), is certainly an established practice around the world. There are some utilities in the U.S. that have been employing this practice for many years. On the whole, however, DMAs are not an established practice in the U.S. But this is changing. Utilities without DMAs are leveraging existing pressure zone configurations as a foray into leakage management zones.[7] And utilities with DMAs are pushing the boundaries of technology to achieve one-man step testing and pushing the boundaries of the technical minimum leakage levels.[8] DMAs represent a tool in the toolbox for leakage management. Like acoustic leak surveys, DMAs fall under "active leakage control" — proactively localizing, pinpointing, and repairing leaks before they find you.

Another underutilized tool in the leakage toolbox that is beginning to take hold in the U.S. is pressure optimization. Traditionally, our pipe networks have been designed with full consideration for the occurrence of *minimum* pressures but little or no consideration for the occurrence of maximum pressures.




Flow analysis from DMA gives immediate alert for main break *(Credit: Water & Wastewater Authority of Wilson County)*

The relationship between lower pressures and lower leakage rates has been well understood for nearly two decades. More recently, the relationship between lower pressure and fewer breaks has become well understood. Beyond these very tangible benefits, the impacts of pressure on energy costs and pipe replacement costs are now coming into full view. Just as with the car we drive, how we operate our water networks has a direct impact on operating costs and the effective life of the pipes. It turns out that these impacts, when aggregated, can be tremendous. Utilities and even state agencies[9] are beginning to recognize the potential in these advanced optimization practices.

On the revenue side, some interesting case studies are emerging where utilities are moving to optimize revenue losses on their large customer meter populations. Conventional wisdom[10] suggests a large meter testing should be dictated by meter size. Utilities are beginning to employ a benefit-cost approach[11] to these programs, looking at the probable gain based on consumptive revenue and how this stacks up against testing and remediation costs. What they are seeing from this is a meter-specific testing plan that identifies which of their nonresidential meters are economically justified for testing very often and which should not be tested at all. And the results are compelling.

What will 2016 bring? Web traffic statistics tracked by AWWA[12] support what we are generally observing in the media and at conference events: The issue of water loss is mainstreaming. With this comes a broader adoption of entry-level practices — standard AWWA water auditing. But it also brings the continued adoption and innovation of advanced practices for leakage and revenue management that propel the industry forward. ■

1. Senate Bill 555, signed October 9th, 2015.
2. Colorado Water Wise M36 training program – http://coloradowaterwise.org/WaterLossAuditTraining
3. New Mexico Environment Department Water Loss Training Program – https://southwestefc.unm.edu/waterloss/registration.html
4. Wisconsin Water Association & Public Services Commission – Pilot Water Loss Training – Sept 2015 – Feb 2016.
5. Oklahoma DEQ – Pilot Water Audit Program Presentation. Proceedings from ASDWA Annual Conference 2015, Fort Worth, TX.
6. EPA Clean Power Plan – http://water.epa.gov/infrastructure/sustain/energyefficiency.cfm
7. City of Asheville, NC – Case Study Presentation. Proceedings from AWWA Water Infrastructure Conference 2014, Atlanta, GA.
8. Water & Wastewater Authority of Wilson County – Case Study Presentation. Proceedings from AWWA Annual Conference 2015, Anaheim, CA.
9. Georgia Environmental Finance Authority – Water Loss Technical Assistance Program including DMAs & Pressure Optimization – 2015-2016
10. AWWA M6 Manual – Water Meters-Selection, Installation, Testing & Maintenance.
11. New York City DEP and Asheville, NC – Large Meter Economic Optimization Program. Proceedings from the North American Water Loss 2015, Atlanta, GA.
12. Minutes from AWWA Water Loss Control Committee meeting, October 2015, Bethesda, MD.

### About The Author

Will Jernigan, PE, is a director with Cavanaugh and a nationally recognized leader in water loss management and bioenergy. Will has 15 years in the industry, and is active with AWWA in several ways, including vice chair of the AWWA Water Loss Control Committee, principle author on the *M36 Manual for Water Loss Control, 4th Edition,* chair of the inaugural North American Water Loss Conference (December 2015 in Atlanta), and member of the IWA Water Loss Specialist Group.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# The Age Of Peracetic Acid – A Solution To Increasingly Challenging Regulations

While chlorination has long dominated water disinfection, new approaches and technologies have emerged in the wake of disinfection byproduct (DBP) regulations. Could peracetic acid (PAA) be the option that dethrones the king?

By Kati Bell and Varsha Wylie

Chlorination became the standard for disinfecting treated wastewater in the 20th century and has been key to successfully protecting public health. However, awareness of environmental impacts associated with wastewater chlorination raised concerns regarding how to effectively balance destruction of pathogenic microorganisms against effects of disinfection byproducts (DBPs) that have both environmental and public health consequences. This issue prompted governments in North America[1] to reduce levels of chlorine and its byproducts in disinfected wastewater.[2] These regulatory actions prompted significant research into alternative disinfection, advancing implementation of technologies such as UV and ozone. Today, more than a quarter of all municipal wastewater treatment facilities are utilizing UV disinfection; and while there is interest in ozone disinfection for wastewater, challenges of early technologies stunted development of this market.

### New Regulatory Challenges

2015 was a year of significant challenges for chlorine disinfection. The U.S. EPA updated its ambient water quality criteria (AWQC) for human health. This update provided relief for concentrations of trihalomethanes (THMs); however, criteria for cyanide were lowered by nearly an order of magnitude — from 140 microns per liter (ug/L) to 4 ug/L for "Consumption of Water and Organisms."[3] Cyanide commonly occurs in municipal wastewaters, and a growing number of wastewater treatment plants (WWTPs) across the U.S. are detecting cyanide in chlorinated effluents at levels exceeding influent concentrations. This is particularly important as regulatory requirements for nutrient removal are being implemented across the country; related changes in effluent characteristics may increase cyanide formation potential, which has been the subject of several studies.[4] Additionally, it is anticipated that the EPA will eventually revisit other disinfection products such as nitrosamines and dioxins because it did not update human health criteria for these chemicals due to outstanding technical issues at the time of criteria update.

In Canada, Environment Canada began work on a national strategy to manage wastewater effluents under the direction of the Canadian Council of Ministers of the Environment (CCME) in 2006. In 2007, CCME released a "Draft Canada-wide Strategy for the Management of Municipal Wastewater Effluent." At the same time, Environment Canada published a "Proposed Regulatory Framework for Wastewater" to explain how the Canada-wide Strategy would be implemented. A draft regulation based on the CCME strategy was released for comment in 2010, and on July 28, 2012, the Wastewater Systems Effluent Regulations were published in the *Canada Gazette*. The regulations, which went into effect in January 2015, are made under the Fisheries Act, which prohibits unauthorized deterioration, disruption, and destruction of fish habitat. The new regulations are the first federal regulations that specifically address municipal WWTP effluents not previously regulated by the provincial authorities and impose strict limits for final effluent quality related to un-ionized ammonia, acute lethality testing, and total residual chlorine (TRC). Thus, many Canadian facilities that have historically used chlorination are faced with these new requirements.

Further, recent research has uncovered additional findings related to reactions of chlorine with constituents commonly found in treated wastewater, such as pharmaceuticals and personal care products (PPCPs) and other high-volume production chemicals. Many of these compounds are transformed during chlorine disinfection and can result in compounds that are more toxic than the parent chemical — and these DBPs are not eliminated by dechlorination. For example, chlorination of triclosan, an antimicrobial widely used in soaps, leads to substitution of the aromatic ring and cleavage reactions resulting in chloroform and related THMs, which are regulated DBPs. And, in surface waters downstream of WWTPs, where wastewater is disinfected with chlorine, the chlorinated triclosan derivatives undergo photochemical transformation to form di-, tri-, and tetrachlorinated dioxins that accumulate in downstream sediments.[5]

The DBP formation potential from disinfection is only part of the challenge of chlorine. From 1965 through 2007, 788 railcars were involved in accidents with 11 instances of catastrophic loss (i.e., a loss of all, or nearly all) of the chlorine lading.[6] While these losses resulted in only four fatalities, it is clear that additional federal regulations and programs under the U.S. Department of Homeland Security and the U.S. Department of Transportation will be implemented to address the security of chemical production, transportation, and use of chlorine.

Chlorine-associated DBPs and additional potential hazards from handling chlorine gas have prompted utilities to switch to UV disinfection. While UV disinfection eliminates formation of toxic DBPs, it also eliminates the beneficial chemical oxidation step that transforms endocrine-disrupting compounds (EDCs).[7] The EDCs most often implicated in the feminization of fish — 17β-estradiol, 17α-ethinylestradiol, estrone, and nonylphenol[8] — are transformed during chlorine disinfection.[9] This unexpected consequence raises new challenges. Thus, some researchers call for more effective methods of removing DBP precursors and applying disinfectants other than chlorine. However, to avoid DBP formation, while still disinfecting and removing EDCs, a disinfectant with oxidizing capacity will be required. Ozone can meet these needs from a process standpoint, but challenges of high capital costs, even in light of advances in ozone generation technologies, can make implementation of this technology for wastewater disinfection unfeasible.

### An Alternative Disinfectant

Peroxyacetic acid or peracetic acid (PAA) is a chemical gaining a great deal of interest due to its ability to provide bacterial inactivation performance at costs competitive with other mature disinfection technologies. PAA is a chemical oxidant that has been applied to the food, beverage, medical, and pharmaceutical industries as a disinfectant for many years; and, because of its oxidizing power, it can address at least some constituents of emerging concern. PAA has the chemical formula $CH_3CO_3H$ and is produced as an equilibrium solution as shown in Figure 1. Commercial preparation includes reacting acetic acid with hydrogen peroxide in the presence of a catalyst; specific grades of PAA are formulated by controlling the concentration and amounts of reagents during the manufacturing process.

The oxidation potential of PAA is higher than other chemicals used in water and wastewater treatment, nearly as high as ozone (Figure 2), which accounts for its ability to both disinfect and oxidize organic chemicals. Because of its reactivity, PAA does not persist in the environment and breaks down into acetic acid (vinegar) and hydrogen peroxide, which subsequently decomposes to oxygen and water. This is an important consideration in selection of a PAA product for wastewater applications, because each formulation introduces a slightly different amount of acetic acid (Table 1), which has an associated biological oxygen demand (BOD) for each mg/L of PAA dosed. Peracetic acid, hydrogen peroxide, and acetic acid have low octanol-water partition coefficients ($K_{OW}$) (0.3, 0.4, and 0.68, respectively) and low sediment adsorption coefficients, so bioaccumulation in aquatic organisms or in sediments is highly unlikely.

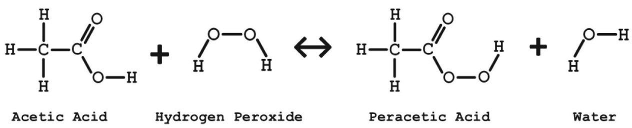


Figure 1. PAA is commercially available in an equilibrium solution

In addition to the facts that PAA does not produce halogenated DBPs and has low aquatic toxicity relative to chlorine, its use on-site does not require special risk management plans (RMPs), as required by the EPA when handling certain toxic chemicals.

According to the *Code of Federal Regulations*, if "the partial pressure of the regulated substance in the mixture (solution) under handling or storage conditions in any portion of the process is less than 10 millimeters of mercury (mm Hg), the amount of the substance in the mixture in that portion of the process need not be considered when determining whether more than a threshold quantity is present at a stationary source."

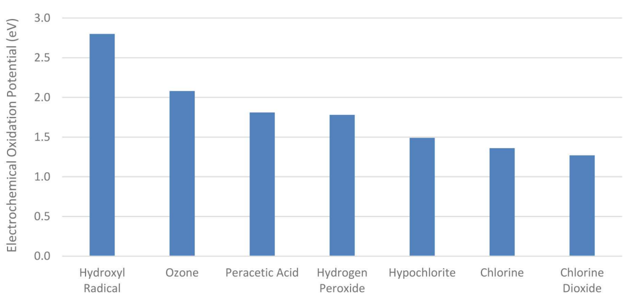


Figure 2. Electrochemical oxidation potential (EOP) for several disinfectants

The commercial products used for wastewater disinfection have low vapor pressures of PAA in the mixture, and PAA may be excluded from the RMP; facilities are required only to adhere to the general duty clause. This is similar to the requirements for the E2 regulations in Canada.

### PAA Applications In Municipal Wastewater

PAA has been demonstrated to be an effective wastewater disinfectant over a wide range of effluent qualities, requiring low doses of chemical to achieve bacterial inactivation. PAA has fast kinetics, requiring short contact times for disinfection. Capital costs for retrofit of existing chlorine facilities are very low, and PAA is able to provide treatment for challenging effluent while meeting stringent limits for halogenated DBPs such as THMs, cyanide, and dioxins. There are a handful of full-scale installations that have been implemented where PAA was selected for its benefits; some of these facilities are listed here:

- NW Langley WWTP in Metro Vancouver, British Columbia
- St. Augustine WWTP in St. Augustine, FL
- City of Steubenville WWTP in Steubenville, OH
- Mayport Naval Facility in Jacksonville, FL
- Greenville WWTP in Greenville, KY
- Whitehouse WWTP in Whitehouse, TN
- Flagler Beach WWTP in Flagler Beach, FL
- Three Rivers Regional WWTP in Longview, WA
- Tri Cities WWTP in Clackamas, OR

Figure 3. Temporary bulk PAA tank installation used for full-scale pilot testing at the Stiles WWTP in Memphis, TN. *(Credit: PeroxyChem)*

Further, the Stiles WWTP in Memphis, TN is currently under design for implementation of a PAA disinfection system after a full-scale study conducted in 2014 (Figure 3). This facility, when completed, will be the largest municipal PAA disinfection system globally, with a peak hour treatment capacity of 250 MGD, exceeding the capacity of the Nosedo WWTP in Milan, Italy with a capacity of approximately 110 MGD. Typical PAA installations are simple chemical storage tanks and pump skids, as shown in Figures 3 and 4.

### Work To Be Done

This list of PAA installations in North America is not comprehensive, and there are a number of ongoing pilots that are providing scientific data to deepen the industry understanding of this technology. While the roles of factors such as suspended solids, temperature, pH, and

| Table 1. Chemical Information for PAA Products Registered for Wastewater Disinfection | | | | |
|---|---|---|---|---|
| | Proxitane® WW-12 | VigorOx® WWT II | BioSide™ HS 15% | Peragreen® 22WW |
| EPA Registration (date of registration) | 68660-1 (2013) | 65402-3 (2008) | 63838-2 (2015) | 63838-20 (2015) |
| Application Rate and Allowable Residual | Apply 0.5 – 10 ppm Residual <1.0 ppm | Apply 0.5 – 15 ppm Residual <1.0 ppm, if DF>12, 0.09*DF | Apply 0.5 – 10 ppm Residual <1.0 ppm | Apply 0.5 – 10 ppm Residual <1.0 ppm |
| Peracetic Acid ($CH_3COOOH$) | 12% | 15% | 15% | 22% |
| Hydrogen Peroxide ($H_2O_2$) | 18.5% | 23% | 23% | 5% |
| Acetic Acid ($CH_3COOH$) | 20% | 16% | 16% | 45% |
| Sulfuric Acid ($H_2SO_4$) | -- | <1% | -- | -- |
| Water (free) | balance | 45% | 45% | balance |
| Freezing point | -40.3 to -42.0C (-40.5 to -43.6°F) | -49C (-56°F) | -49C (-56°F) | < -18C (< 0°F) |

Table 1. Chemical Information for PAA Products Registered for Wastewater Disinfection

other site-specific characteristics are important considerations in determining dosing requirements for various wastewater types, in general, results of studies are demonstrating that, for secondary effluent, initial design dosing is 1.5 to 2 mg/L of PAA. And with the fast disinfection kinetics of PAA, there are case study projects being implemented with peak flow contact times significantly shorter than what is required for achieving bacterial inactivation compliance for chlorine.

While PAA is seemingly a success story, PAA still faces a hurdle of limited use when compared to other more mature disinfection technologies such as chlorination, ozone, and UV disinfection. Though the EPA has approved four PAA products for use as a wastewater disinfectant, state regulatory agencies are struggling with how to address permitting. Some of these challenges are related to the fact that the EPA has yet to publish an "approved" method for PAA monitoring in the *Code of Federal Regulations*. Even considering the EPA has approved registration labels on allowable residuals for discharge, the office that is responsible for environmental toxicity decisions is not necessarily coordinated with the Office of Wastewater, making it difficult for states to obtain technical support to implement PAA projects.


Figure 4. Typical pump skid used for PAA feed.
*(Credit: PeroxyChem)*

The information presented herein is intended to be a cursory overview of PAA disinfection. There is a tremendous amount of literature and experience with wastewater disinfection using PAA. To respond to the growing interest in this technology, it will be necessary to develop regulatory and design guidance to aid decision-makers in understanding the cost of compliance of using PAA as well as obtaining local regulatory support for implementation. Thus, when an individual facility is evaluating disinfection options, it is important to consider site-specific factors such as compliance goals, O&M (operations and maintenance), the willingness of a particular facility to take on risks associated with implementation of a new technology, and costs. If considering PAA for disinfection, utilities are advised to discuss this option with their consulting engineer, local regulatory authorities, and local PAA sales representatives to obtain more information on how this alternative compares to other mature disinfection technologies. ■


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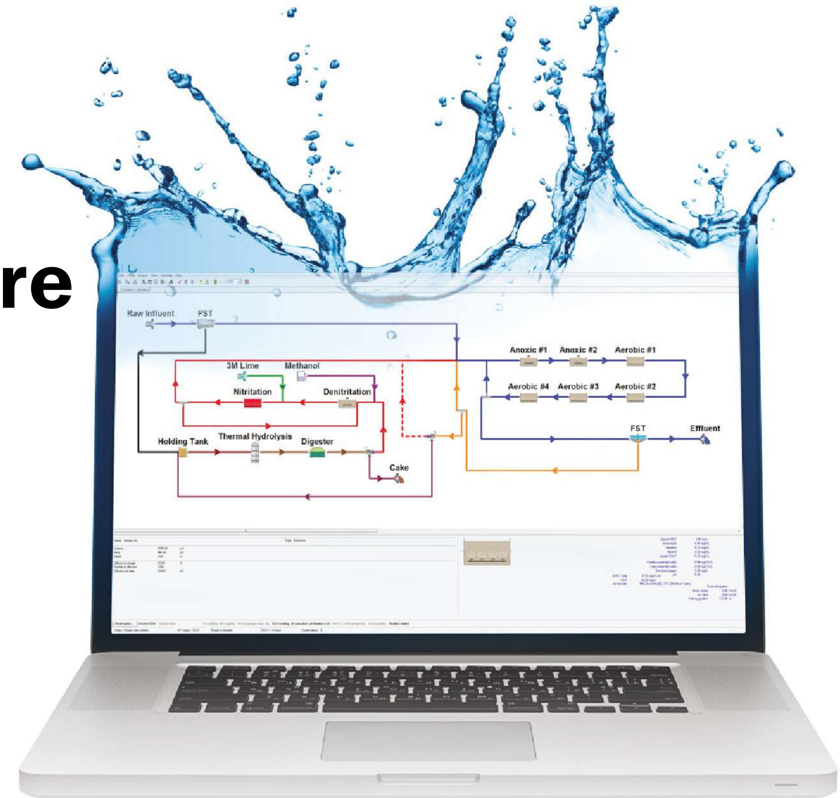
## About The Authors

Dr. Kati Bell, PhD, PE, BCEE, is the Water Reuse Global Practice Leader for MWH Global. She is a registered engineer in four states with 20 years of experience in research, selection, design, and optimization of water/wastewater processes. Highlights of her work include chairing the recently published WEF/IUVA Ultraviolet Disinfection Wastewater, as well as directing over 2 BGD of disinfection projects.

Varsha Wylie is a Project Technical Lead for MWH Global. She is a process engineer with 13 years of international experience in the water industry. She has a strong design-build background and has designed and commissioned a number of water/wastewater treatment facilities in the UK and the U.S.

# Simulating A Cure For Brain Drain




By Peter Chawaga

Much has been made of the gap in knowledge to come when the water industry's aging workforce reaches retirement. With advances in simulation training software capable of getting new employees familiar with plant processes, it may be an analog fear in the digital world.

As members of the baby boomer generation retire, industries across the country are facing the challenge of substituting them with a motivated and skilled force of younger replacements. In the water sector, the Water Research Foundation (WRF) and the American Water Works Association (AWWA) have been the vanguard for this looming need. The two jointly sponsored a public report released in 2010, the *Water Sector Workforce Sustainability Initiative*, which took a deep dive into labor statistics as they existed then and remains the most comprehensive forecast of the issue.

Per the report, the average age of a water utility worker five years ago was 44.7 and the average wastewater worker was 45.4. Workers in both sectors typically retire at 56. By 2020, the researchers predicted, between 30 and 50 percent of the water workforce could be retired.

**In a field as sensitive and precise as wastewater treatment, simulators provide the room for error necessary for novices to refine their skills.**

There's a lot of speculation about how best to fill the labor gaps and prepare young talent for taking on water jobs. A major concern in such a specialized field is that as tenured workers leave, knowledge of operations leaves with them, a phenomenon known as "brain drain." But there may be hope for bringing the newbies up to speed by making use of one rapidly advancing digital field.

### A Solution In Demand

EnviroSim Associates, based in Ontario, Canada, provides simulation software for wastewater process engineers. Its software suite includes BioWin, a wastewater process simulator that mimics the procedures of an entire plant; PetWin, a simulator customized for petroleum wastewater treatment that includes an industrial activated sludge digestion model, four biomass components acting on sulfide and sulfate, and four adaptable components modeled on processes using ethylbenzene, phenol, benzene, and toulene; and BW Controller, which packages the other two models with the chance to experience a range of advanced process control scenarios such as the need to set dissolved oxygen based on reactor ammonia concentration or to use pH measurements to adjust air flow.

Christopher Bye, senior process engineer with EnviroSim, has seen interest in the company's wares trend up as plant processes become harder to grasp.

"Demand has increased steadily over the years, driven by wastewater treatment plants becoming more and more complex," he said. "With this increased treatment complexity come more interactions between different components of a treatment plant. BioWin enables designers to be aware of these interactions and

**"[Our software] allows students and young professionals to see the complex cause-and-effect relationships in wastewater treatment, and that type of learning is highly appealing."**

Christopher Bye, senior process engineer, EnviroSim

look at options and strategies for dealing with them. Over the years, we have seen BioWin move from a tool used by early adopters to something that now is considered to be a necessary component in every process engineer's toolkit."

There's also Hydromantis, another simulation software provider headquartered down the street from EnviroSim (which, I'm assured, is purely a geographical coincidence). Its tools address both the drinking and wastewater side of the industry. There are WatPro, which predicts water quality to simulate plant operation; ODM, for online disinfection management; GPS-X, a wastewater treatment plant simulator that can aid design and optimization efforts; CapdetWorks, which can project capital and operating costs; Toxchem, for odor emission reporting and modeling; and SimuWorks, the "flight simulator for water and wastewater treatment plants."

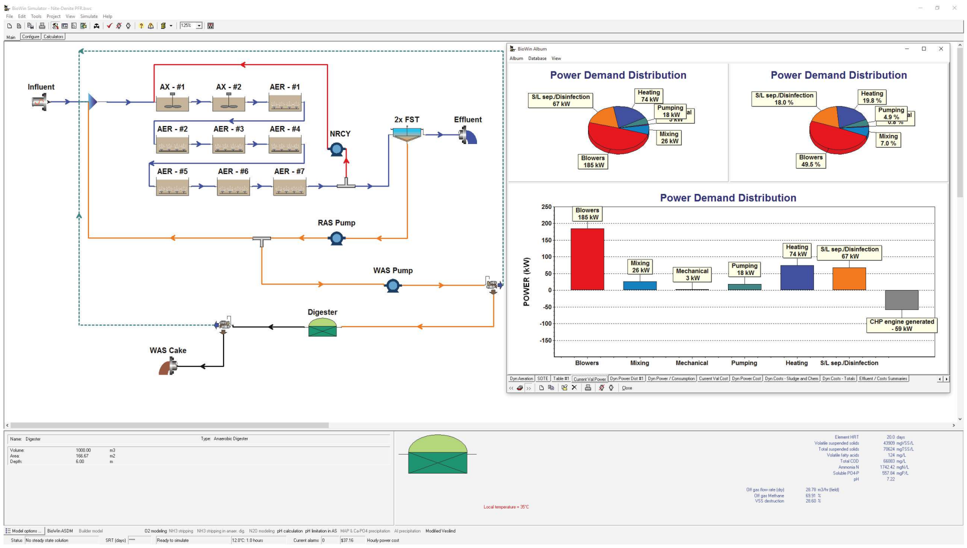
"Our SimuWorks platform was designed specifically to provide operators with a realistic training platform," Robert Beres, executive vice president of sales and marketing for Hydromantis, said. "It can be deployed as a complete life-sized replica of a specific control room, set up for regional training with a library of various plant models used in more traditional, multistation classroom environments or loaded on individual workstations."

In a field as sensitive and precise as wastewater treatment, simulators provide the room for error necessary for novices to refine their skills.

"BioWin allows new staff to play with the plant process in a safe environment," Bye said. "For example, changing a dissolved oxygen setpoint or a wasting rate and then observing how the process responds is a fantastic way to reinforce important concepts that play a role in the knowledge base of a wastewater professional."

### Enlisting The Future

When it comes to the retiring workforce, WRF and AWWA may be more concerned with enticing new labor than training it. The two, along with the U.S. EPA, launched a recruiting website, WorkForWater.org, to encourage young people to pursue careers in the water sector. The *Water Sector Workforce Sustainability Initiative* report includes recommendations for connecting with




Screenshot from the BioWin wastewater process simulator

schools and workforce investment boards.

Simulation software can serve as a recruiting tool, too, offering new workers a realistic and engaging experience with the tasks that are offered by the field.

"[Our software] allows students and young professionals to see the complex cause-and-effect relationships in wastewater treatment, and that type of learning is highly appealing," said Bye.

Beres added that working with simulators may clear up some misconceptions about the industry held by inexperienced workers.

"Simulation tools are dispensing with the prevailing notion that careers in water or wastewater treatment do not offer opportunities for engaging digital tools," he said. "Platforms such as SCADA and process models are making it obvious that while the challenges have been with us for a long time, there is an exciting evolution in the sophistication of the tools that we are using to address the challenges. This exposes the younger generation of professionals to the use of these tools early in their training and careers. They are realizing that the challenges in water and wastewater treatment are as complex, as exciting, and as worthy of their focus as those in other fields of engineering."

## An Image Of What's To Come

Simulation software mimics plant processes as the operator would see them on the job, as gridded displays resembling flowcharts. But imagining the future of computer simulation can take the mind in a thousand digitally painted directions. As the ability to display controls in more detailed and intuitive ways expands, simulators will have to keep up to continue delivering a realistic training experience.

Both EnviroSim and Hydromantis are working on programs that will keep simulation software in line with how most of us are beginning to engage with technology: on the go.

"We see simulation training becoming more and more mobile," Bye said. "Simulators could move to the cloud as many other software solutions have done. This could allow wastewater professionals to access the knowledge repository encapsulated in simulators as they walk around the plant, not just when they are sitting behind a computer in an office."

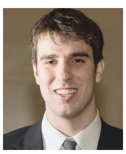
Exploring the outer limits of mainstream technology, equipment provider Ovivo developed a virtual reality app that can take customers directly into the product.

"This is one of the requests we had from some of the customers: to be able to understand the mechanics and the issues to fix the equipment, or to modify, or to improve it, how to operate it better," Elena Bailey, Ovivo's business development director for North America, told *Water Online* during WEFTEC 2015. "To train their new people who are coming into utilities, this is one of the ways we thought to demonstrate the equipment in operation."

At this point, the app is little more than an exciting way to explore 3D models of Ovivo equipment, without much to offer in terms of lessons for operating it. But it does set the table for possibilities at the intersection of digital advancement and simulation training.

Some may argue that certain aspects of plant operation can't be passed down through simulation and that offline pieces of knowledge will inevitably be lost as the current generation of workers retires. Simulation software is capable of becoming as wide and varied as any plant process, training new workers on the tasks that take place on a computer and, maybe one day, beyond. With so much on the digital horizon still unknown and still possible, fear of brain drain might just be a lack of imagination. ■

## About The Author

Peter Chawaga is the associate editor for *Water Online*. He creates and manages engaging and relevant content on a variety of water and wastewater industry topics. Chawaga has worked as a reporter and editor in newsrooms throughout the country and holds a bachelor's degree in English and a minor in journalism. He can be reached at pchawaga@wateronline.com.

# Leading The (Re)Charge: How The SFPUC Is Protecting San Francisco Bay Area Groundwater

The Hetch Hetchy Regional Water System is vulnerable to both drought and earthquakes, but innovative resiliency efforts by the San Francisco Public Utilities Commission (SFPUC) will keep the water flowing.

By Greg Bartow

Since the 1930's, the San Francisco Public Utilities Commission (SFPUC) has been largely reliant upon the iconic Hetch Hetchy reservoir and its water, originating in the Tuolumne River Watershed.

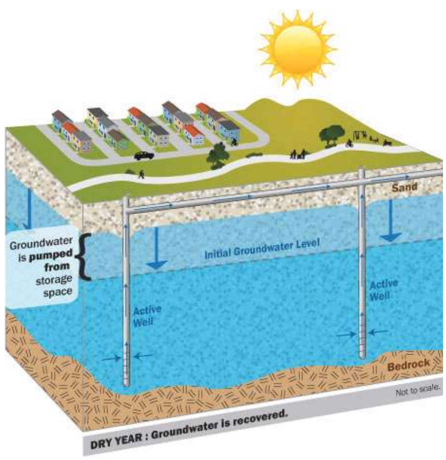
Much of the Hetch Hetchy Regional Water System's supplies travel the width of the state of California to reach Bay Area taps and cross three active earthquake faults. In 2008, the SFPUC's Commission charted the current water-supply strategy and included direction to diversify its water supply by developing additional groundwater and recycled water supplies. Amidst California's historic drought, building the infrastructure to diversify the SFPUC's water supply, specifically during a severe drought or emergency, is critical now more than ever.

Leading the charge to naturally recharge groundwater in the San Francisco Bay Area, the SFPUC's Regional Groundwater Storage and Recovery Project (Project) is the first of its kind by the SFPUC to form a partnership for storing water underground during dry years. The Project accomplished this by using an In-Lieu Conjunctive Use Agreement developed as a regional partnership between the SFPUC and three of its wholesale customers: the City of Daly City, the City of San Bruno, and the California Water Service Company. These agencies operate their own groundwater wells in addition to distributing SFPUC surface water to their customers. This is the first new water storage that the SFPUC has developed since 1965, and it is one of more than 80 projects that are a part of the SFPUC's $4.8 billion Water System Improvement Program to repair, replace, and seismically upgrade the Hetch Hetchy Regional Water System.


The blue star represents the Regional Groundwater Storage and Recovery Project within the Hetch Hetchy Regional Water System.

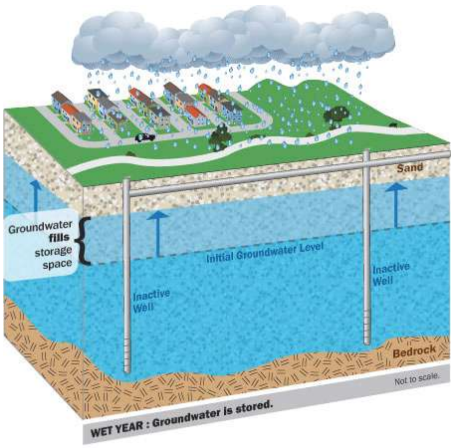
The SFPUC began the planning, environmental review, and design for this Project over 10 years ago. Now in construction, the Project will provide the SFPUC with dry-year storage in San Mateo County and a backup water supply after an emergency. The Project's new regional dry-year water supply will be able to provide approximately 7.2 MGD from the South Westside Groundwater Basin (San Mateo County, CA). This Project balances the use of groundwater and surface water to increase dry-year water supplies.

During years of normal or above-average rainfall,




In dry years, groundwater is pumped from storage — the "water savings account".

## The SFPUC will only pump groundwater that has been previously stored – thus ensuring the sustainability of the project.




In wet years, municipal pumping is decreased and groundwater fills the available aquifer storage space.

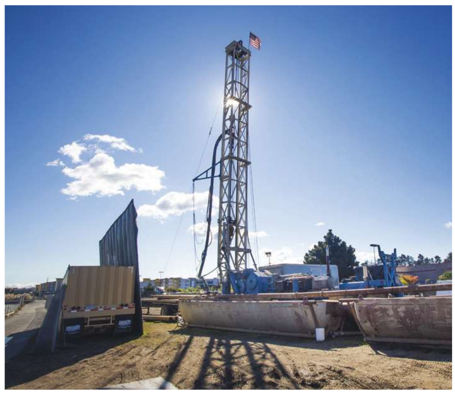
the SFPUC will provide up to 5.5 MGD of additional surface water to the Project's partner agencies in lieu of their groundwater pumping. Over time, the reduced pumping will result in the storage of up to 60,500 acre-feet or 20 billion gallons of water. The SFPUC will only pump groundwater that has been previously stored — thus ensuring the sustainability of the project.

The Project is currently installing up to 16 new groundwater wells and well stations, including chemical treatment equipment, tanks, pumping systems, and associated pipelines to extract, treat, and distribute stored groundwater in dry years. It is designed to help meet water demands during a 7.5-year-long drought (i.e., recovery of 8,050 acre-feet per year), thereby stretching the SFPUC's regional water resources. This dry-year supply will benefit all 2.6 million customers who depend on the SFPUC for all or part of their water supply.

The construction team is now on the second phase of work, which includes the well facility development. Each well facility will have various rooms to monitor, test, and pump water if needed.

Two types of well stations are being built — wells housed inside buildings with separate rooms for the well and chemical treatment and wells housed in outdoor, fenced enclosures without chemical treatment. Wells housed indoors will have vertical turbine deep well pumps and variable frequency drives. Wells housed outdoors have submersible pumps to avoid noise impacts. The water from these wells will be pumped to the indoor well stations or partner facilities for treatment. All of the groundwater will be chlorinated and, depending on the location, water quality, and point of connection, groundwater may also be adjusted for pH, fluoridated, and filtered for manganese.

The Project's wells and well pumps are designed to operate in a range of changing groundwater water levels — i.e., to accommodate higher water levels during the initial years of recovery and lower water levels following multiple dry years. Over a 7.5-year drought recovery period, existing water levels could decline by up to 100 feet, and pumping water levels could decline by 180 feet.



The drill rig was a critical part to the flow and function of this project. At each site, our construction teams drilled between 400 to 900 feet deep to develop new groundwater wells.

The SFPUC's ability to deliver high-quality water every day requires proactive planning and infrastructure investment. This is especially true as California faces some of the driest years on record. This Project will help increase San Francisco's water supply resilience, diversify its water supply portfolio, and reduce dependence on surface water, making the SFPUC's Hetch Hetchy Regional Water System less vulnerable to natural disasters such as droughts and earthquakes. ■

**About The Author**

Greg Bartow is the groundwater program manager for the San Francisco Public Utilities Commission and project manager for the SFPUC's Regional Groundwater Storage and Recovery Project.

# Design-Build Delivery In The Water Sector – A Trend Whose Time Has Come

The traditional project delivery model of design-bid-build is starting to give way to an alternative that often saves time and money while advancing innovation. Could design-build soon be the dominant delivery method for water/wastewater projects?

By John A. Giachino

Water sector interest in non-traditional construction procurement methods has grown substantially over the past decade. Aging systems, regulatory issues, and capacity demands are requiring public and private water utility owners to employ delivery methods that provide quicker delivery times and higher quality solutions and results, as well as earlier knowledge of construction costs. Owners are more often turning to alternative delivery approaches, including design-build.

Design-build is not new. History's earliest projects were designed and built by master builders. Industrialization brought about the specialization of engineering/design and separation of design from construction. But the trend in water and wastewater utility capital project execution is moving once again toward the "master builder" concept where one party is completely responsible for design and construction under a single contract. The key aspect of design-build is that the owner has a single point of responsibility for design and construction, which speeds project delivery, saves time and money, and reduces litigation and claims.

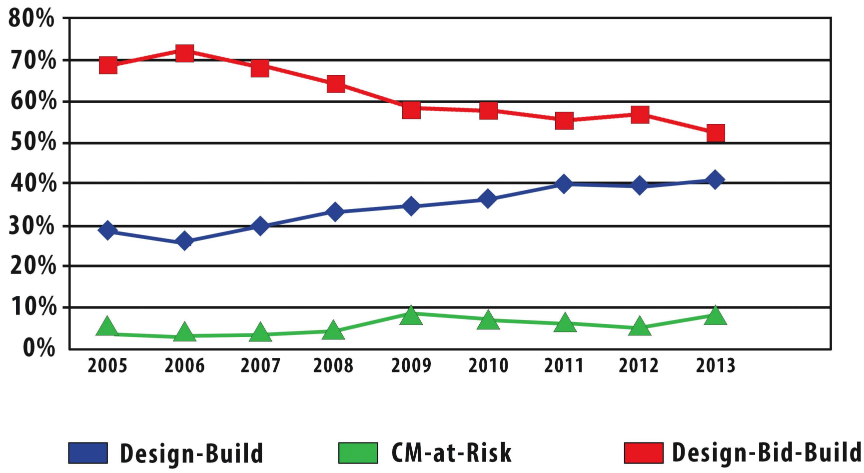
## Trending Up

As utility owners use design-build to deliver water and wastewater projects, the Design-Build Institute of America (DBIA) is seeing an increasing demand for specific training and materials. In response, DBIA has released best practices for design-build in the water/wastewater sector (available at www.dbia.org) and is working with industry partners like the American Water Works Association (AWWA), the Water Environment Federation (WEF), and the Water Design-Build Council (WDBC) to continue the ever-popular Design-Build for Water/Wastewater Conference.

Design-build has shown significant growth in the U.S. market. RSMeans, a part of The Gordian Group, recently published a report showing design-build market share has been holding steady at 40 percent since 2011. This represents an increase of 10 percent in the use of design-build since RSMeans first captured the data in 2005.

The use of design-build in the water sector is lagging behind other infrastructure sectors such as transportation. The Florida Department of Transportation District 7 worked with the Federal Highway Administration Florida Division and developed a design-

**Project Delivery Method Market Share for Non-Residential Construction**




*Analysis by RSMeans, a part of The Gordian Group* build framework for using federal highway safety funds. Ultimately, the design-build framework allowed the district to reduce the time it takes to deliver simple or low-cost safety improvements from 3 to 5 years down to just 3 to 9 months.

In the water sector, progressive design-build is a delivery method that is gaining in popularity and is a trending topic today. In this delivery method, the design-builder is selected based on qualifications. The proposer's experience, expertise, resources, and understanding of the project are evaluated. Price is not considered in the initial selection of the design-builder. Once the design-builder is selected, the project proceeds in two phases. Phase one involves developing the design in collaboration with the owner and advancing it to a point where the guaranteed maximum price can be agreed upon. During the second phase, the design is completed, buy out bids are solicited and received, and construction takes place. Progressive delivery is being used more and more by water and wastewater agencies because it provides owners with more control over the design and assures that owners get what they want.

We are seeing a shift in how the construction industry is organized. There are now large, integrated design-build firms that are aggressively pursuing projects in the U.S. and abroad. General contractors are retooling their capabilities to provide design-build services. Engineering firms are enhancing their capabilities on the construction side.

**The key aspect of design-build is that the owner has a single point of responsibility for design and construction, which speeds project delivery, saves time and money, and reduces litigation and claims.**

The firms delivering design-build services today focus on innovative technology and out-of-the-box thinking to generate solutions that can differentiate them. In design-build, solutions are not limited to traditional ideas. The best solution for the project at hand is always first and foremost. As ideas are generated, teams work as one to scrutinize them so owners are ensured the best design, means and methods, materials, costs, schedule, and more. With a Guaranteed Maximum Price (GMP) approach, this is all accomplished with open-book, full transparency. Owners will see more options, make better-informed decisions, and obtain better value.

## Successful Applications

An example of innovative technology application using design-build delivery is DC Water's Blue Plains Advanced Wastewater Treatment Plant biosolids reuse program. Originally, the utility pursued a design that used anaerobic digestion — a process that would have required 10 large, egg-shaped digesters, which would be an expensive, energy-intensive solution. After thorough evaluation, DC Water settled on a design-build approach to reduce the likelihood of unexpected costs. Using a thermal hydrolysis process (THP) would also reduce the size of the digesters needed by 50 percent, lowering construction costs and making the project more affordable. Obtaining a fixed price for the $215 million project gave DC Water the certainty to move forward with the detailed design and construction. The design-build team also developed an alternate approach to design and construction of the digester building, which shaved several months from the delivery schedule. Reduced biosolids hauling and onsite power production are expected to reduce the facility's greenhouse gas emissions by 40 percent. In addition to reducing waste, generating energy, and improving air quality, the project will save ratepayers an estimated $20 million annually — $10 million in power savings and $10 million in reduced sludge disposal costs.

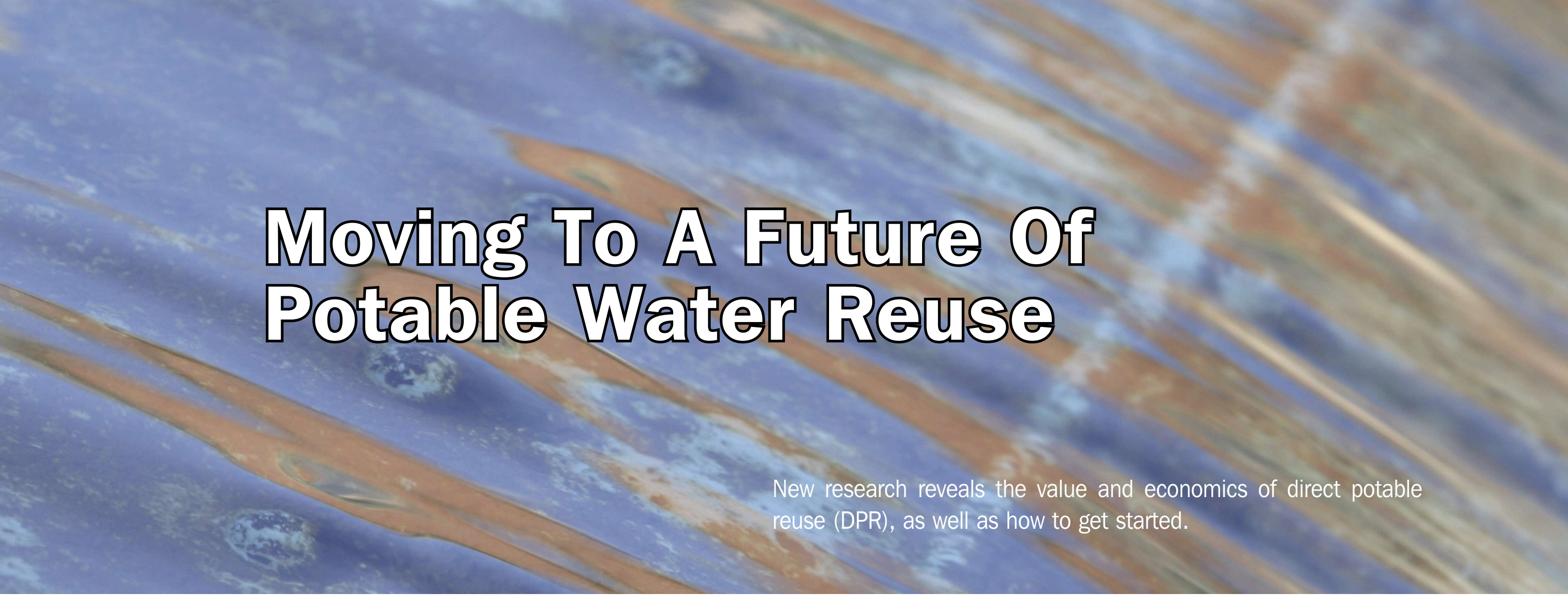
Innovative thinking is also a design-build derivative. The effluent filter upgrade and expansion project recently completed by the Charlotte-Mecklenburg Utilities Department (CMUD) at its McAlpine Creek Wastewater Management Facility, winner of the DBIA 2015 Design-Build Project/Team Award, is a good example of out-of-the-box thinking. CMUD desired to have greater control by being an involved and integral part of the design-build team through collaboration, communication, and development of technical solutions. Throughout the development of the GMP, the owner wanted to add scope to the project, thereby adding cost. Increased collaboration through the design-build process allowed the contractor to present each item in an à la carte list so CMUD could decide what was critical and what could be cut. Using the strategy of open collaboration, the project was completed under the GMP, allowing CMUD to include additional scope items. In short, all parties were partners on this project, and challenges and issues were dealt with as partners.

## Future Prospects

Certain questions arise as the popularity and use of design-build delivery continues to grow in the water space. Should design-build dominate the construction market? Will distinct design and construction companies become the exception, not the rule? As evidenced by the growing number of design firms that are creating construction holdings, there is already a consolidation of design and construction firms to provide integrated design-build services. Will state and local legislation fully support the use of design-build? Time will tell, but it appears that design-build is a sustainable trend into 2016 and beyond. ■

## About The Author

John A. Giachino, DBIA, is co-chair of the Design-Build Institute of America Water/Wastewater Markets Committee. He has served twice as president of the DBIA Florida Region and currently serves as Director of Business Development for PC Construction Company, a leading design-build construction firm.



# Moving To A Future Of Potable Water Reuse

New research reveals the value and economics of direct potable reuse (DPR), as well as how to get started.

By Justin Mattingly

The prolonged and ongoing drought in California and other regions in the Southwest has made water supplies increasingly scarce, highlighting the need to secure new and sustainable sources of potable water. One such option is to more effectively utilize existing wastewater resources through water reuse, and direct potable reuse (DPR) in particular, to supplement existing water supplies. Through a joint effort between WateReuse, the American Water Works Association (AWWA), and the Water Environment Federation (WEF), the report "Framework for Direct Potable Reuse" was developed by an independent advisory panel administered by the National Water Research Institute (NWRI) to provide information about the value of DPR as a water supply option and what is needed to implement a DPR program. Communities can find numerous advantages — including enhanced water supply reliability, decreased energy usage, greater value from limited natural water supplies, and controlled increases to the cost of water — by considering DPR as part of their water supply portfolios.

In California alone, there is great potential for the expansion of potable water reuse. A 2014 study from WateReuse estimated that by 2020, over 2,300 MGD in treated wastewater will be discharged to surface waters or the ocean. Of this amount, over 1,000 MGD could be used for either indirect potable reuse or DPR. This amount would meet the residential, commercial, and industrial water needs for eight million people, or more than 20 percent of the projected population of California in 2020. There is also significant potential in other regions of the country, including Big Spring, TX, which has a DPR facility currently in operation. The framework document is aimed at making this potential a reality throughout the country by paving the way for a sustainable source of drinking water that is protective of public health and resilient in the face of drought and climate change.

### What Is Direct Potable Reuse?

Although not often acknowledged, communities throughout the U.S. currently engage in potable water reuse, where downstream surface waters used as a source of drinking water are subject to upstream wastewater discharges. This is commonly referred to as unplanned or *de facto* potable reuse. Conversely, planned potable reuse can take the form either of indirect potable reuse, where an environmental buffer such as an aquifer or reservoir is present, or direct potable reuse, where no such environmental buffer is present.

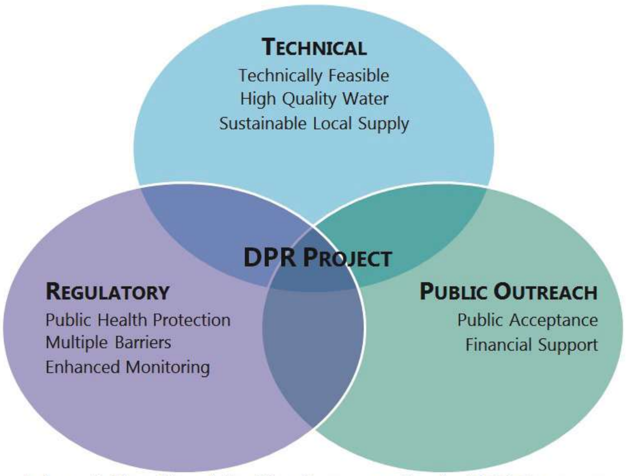
Direct potable reuse can be implemented in two ways:

1. Advanced treated water is introduced with or without the use of an engineered storage buffer (ESB) into the raw water supply immediately upstream of a drinking water treatment facility (DWTF). To date, permitted operational DPR facilities in the U.S. involve this form of DPR.
2. Finished water is directly introduced — with or without the use of an ESB — into a drinking water supply distribution system, either downstream of a DWTF or within the distribution system. Although a finished water DPR facility has been in operation at Windhoek, Namibia since 1967, the production of finished water is not the focus of the framework document.

A number of communities throughout the country are currently considering implementing a DPR program to supplement their current potable water supply. To ensure that these projects protect public health, decision-makers need to understand the regulatory and operational components that must be part of a DPR program. While such a program will resemble existing drinking water and wastewater programs, there are some distinct differences and unique characteristics to DPR where further guidance is needed. The framework document sponsored by WateReuse, AWWA, and WEF details these important issues with information on the following topics:

- Public health and regulatory aspects
- Source control programs
- Wastewater treatment

- Advanced water treatment
- Management of advanced treated water in a drinking water system
- Process monitoring
- Residuals management including brine disposal
- Facility operation
- Public outreach
- Future developments.



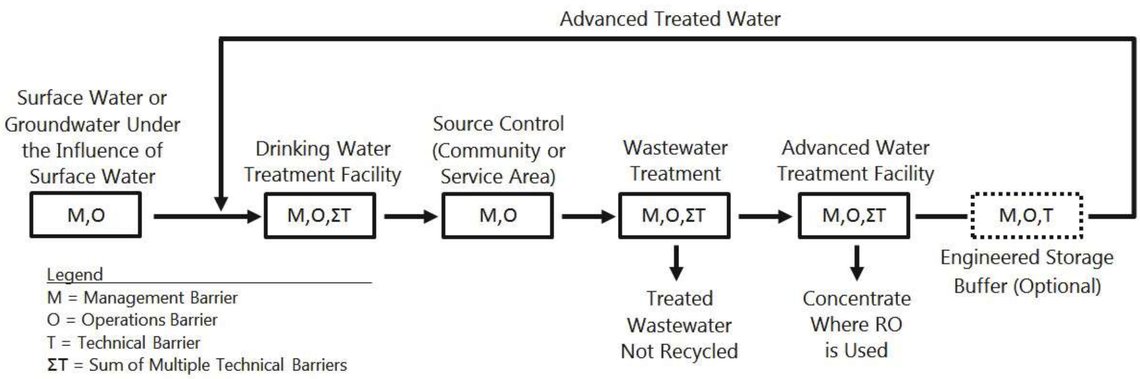
Inter-relationship of the Key Components of a DPR Program

Paramount among these topics is the implementation of a multi-barrier approach to removing pathogens and chemical constituents. These barriers can include management barriers such as pretreatment policies and proper operations and maintenance procedures, operational barriers such as monitoring and response plans, and the technical barriers of the physical treatment processes. When taken together, these barriers form the foundation of a robust and resilient DPR system.

**Mapping The Complete DPR Process**

A primary theme of the framework document is that DPR does not include just the treatment processes associated with an advanced treatment facility but also source control programs, traditional wastewater treatment, and the integration of advanced treated water into a drinking water treatment facility. Understanding that the performance of upstream processes can have an effect on downstream processes can go a long way to ensuring that a DPR system is performing properly.

A properly implemented source control program can help eliminate the discharge of constituents into wastewater that can be difficult to treat or impair the final quality of secondary effluent intended for DPR. This can be especially important in communities with large commercial and industrial discharges. There are several important elements to a source control program, including the legal authority to develop source




control measures, monitoring discharges within a service area, investigating and maintaining a current inventory of chemical constituents, an effective public outreach plan, and a response plan to be used in case of water quality deviations. Creating a source control program is an important step in DPR because the easiest way to remove chemical constituents from wastewater is to prevent them from entering the wastewater stream in the first place.

Following source control, the next step is the wastewater treatment process. Traditionally, the focus of wastewater treatment has been to produce an effluent suitable for discharge into the environment. However, for DPR there is additional optimization that can be done that has the potential to benefit and increase the efficiency of advanced treatment processes. In the context of DPR, the goal of wastewater treatment should be to provide a consistent and high-quality effluent while recognizing that certain contaminants such as pathogens and constituents of emerging concern may be removed more cost effectively than in advanced water treatment. As an example, the Orange County Sanitation District (OCSD) provides secondary effluent to the Orange County Water District (OCWD) for potable reuse. After completing operational changes to enable OCSD to produce a nitrified effluent, the microfiltration system at OCWD was able to significantly reduce membrane fouling, resulting in cost savings.

**Understanding that the performance of upstream processes can have an effect on downstream processes can go a long way to ensuring that a DPR system is performing properly.**

The advanced water treatment process is what separates potable reuse from traditional wastewater treatment. This is the process that takes secondary effluent and treats it further to meet potable water quality standards. This process can take various forms, but for DPR the process used at OCWD in its Groundwater Replenishment System (GWRS) has been shown to be effective at producing high-quality product water. This process includes several steps highlighted by microfiltration followed by reverse osmosis (RO) and an advanced oxidation step with UV and hydrogen peroxide. However, for inland communities, there are potential options not requiring RO, including processes with ozonation and biologically active filtration. Indirect potable reuse facilities in Gwinnett County, GA, and Fairfax County, VA, currently operate in this fashion.

Following the production of advanced treated water (ATW), it then must be integrated into the drinking water treatment and distribution system. Typically, ATW will be blended with raw water at the intake of a drinking water treatment facility. However, there are some potential issues that may arise from this process including effects on the coagulation process through reduced alkalinity or turbidity, as well as effects on aesthetics. WateReuse and the Water Research Foundation are currently looking into these issues closely to provide facilities with the best information to seamlessly integrate DPR into their water supply. It is important for all the facilities and agencies involved in each step of this process to work together with the understanding that each step is critical to the successful implementation of DPR.

### Economics Of DPR

When comparing DPR to other water supply options, cost is often one of main issues taken into consideration. While precise costs are difficult to generalize, comparing DPR to options like desalination shows DPR often to be the less expensive option, and DPR is also competitive in cost with imported water in California. A 2014 study from the WateReuse Research Foundation estimated the cost of DPR at a range of $820 to $2,000 per acre-foot of water. The range in cost for DPR is based on the cost of treatment, distribution, and brine disposal — if applicable.

Depending on the treatment train used, the cost of treatment can be expected to be relatively uniform. As an example, the GWRS in Orange County has costs of approximately $700 per acre-foot. On the other hand, costs for distribution and brine disposal are largely site-specific and vary based on the distance that water must be conveyed. Siting an advanced treatment facility close to a drinking water facility can dramatically reduce conveyance costs compared to facilities that are located far apart, especially if there is a large change in elevation. The same is true for residuals disposal from facilities utilizing RO. In that case, facilities located on a coastline may have lower costs due to easy access to an ocean outfall.

When determining whether to pursue DPR, economic and social factors should also be considered. Such factors could include energy use and carbon footprint, impact on wastewater discharges and pollution, and the economic benefit of having a local and sustainable water supply. Further detail on the economics of DPR and other water supply options can be found in the framework document, as well as the 2014 report from WateReuse, *The Economics and Opportunities of Direct Potable Reuse*.

### About Framework For Direct Potable Reuse

The report "Framework for Direct Potable Reuse" is available free of charge at www.watereuse.org. The document represents a consensus among the panel, while taking into consideration input from a project advisory committee composed of technical experts in water and wastewater treatment, as well as state and federal regulators. Members of the panel included Panel Chair Dr. George Tchobanoglous of the University of California, Davis; Dr. Joseph Cotruvo of Joseph Cotruvo & Associates; environmental engineering consultant Dr. James Crook; Dr. Ellen McDonald of Alan Plummer Associates; Dr. Adam Olivieri of EOA, Inc.; Andrew Salveson of Carollo Engineers; and Dr. R. Shane Trussell of Trussell Technologies, Inc. The panel was managed by Jeff Mosher of NWRI. ■

### About The Author

Justin Mattingly is a research manager with the WateReuse Association and Research Foundation. WateReuse is internationally recognized as a thought-leader on alternative water supply development. It is the go-to organization for applied research, policy guidance, and educational tools on water reuse, as well as the principal influencer of public opinion, lawmakers, and policymakers on policy and projects related to water reuse.

United Utilities doubled digester throughput and electricity production at the Davyhulme Wastewater Treatment Works in Manchester, U.K., by adding thermal hydrolysis.

# Warming Up To Thermal Hydrolysis

By Greg Knight, Scott Carr, and Andrew Shaw

Thermal hydrolysis is an innovative wastewater solids conditioning process that boasts many advantages – financial, environmental, and otherwise. Is your plant a good candidate?

The thermal hydrolysis process (THP) has been compared to a pressure cooker. It conditions wastewater solids at a high temperature and pressure to improve digestibility. Injected steam heats the solids and maintains them at a temperature of approximately 165°C and a gauge pressure of 600 kilopascals (kPA), or 87 psi, for 20 to 30 minutes, after which the pressure is released. The combination of high temperature and rapid depressurization makes the material more biodegradable for the anaerobic digestion that follows. An additional benefit is that the resulting biosolids are pathogen-free, achieving "Class A" status.

A number of configurations are available, including batch and continuous processes. The Cambi Group AS developed THP technology approximately 20 years ago, but other European and U.S. suppliers also now offer versions of this technology.

### The Benefits Of THP

Increased biodegradability of wastewater residuals yields increased digester-loading rates, production of cake with higher solids content, a biosolids product that meets the top standards for land application, and increased biogas production. Because it improves digestibility and the solids are easier to mix and pump at higher solids concentrations, THP can be used to increase digester loading rates. This makes it appealing to facilities that need to process more solids in existing systems or need to minimize the size and number of new digesters.

Improved conversion of volatile solids in the digestion process leads to other benefits, including better dewaterability and a drier cake product. Treating solids at a high temperature also yields a Class A biosolids product for fertilizer use according to U.S. EPA regulations for land application. The cake product from THP facilities also has fewer odors than that from conventional digestion facilities, which makes it more appealing for beneficial reuse.

Farmers spend a lot of money on fertilizer that is rich in nitrogen and phosphorus. Biosolids are also rich in nitrogen and phosphorus, so reusing very stable biosolids as a fertilizer reduces fertilization costs for farmers, reduces management costs for utilities, and provides a very real environmental benefit through sustainable reuse. We also know that, globally, our phosphorus resources are limited, so reusing phosphorus through land application of biosolids is an environmentally sustainable practice.

It is important to understand that THP doesn't necessarily increase energy recovery from a given quantity of solids because of the need to provide process steam. However, adding THP allows facilities with existing digesters to more than double their throughput capacity, which results in a significant increase in net biogas production. This can result in an equivalent increase in energy production for facilities with combined heat and power (CHP) or those producing renewable natural gas (RNG).

**Utilities with relatively high residuals management costs can benefit from a process that reduces biosolids mass and volume.**

New CHP facilities at the Blue Plains Advanced Wastewater Treatment Plant in Washington, D.C. enable DC Water to maximize energy recovery while also producing steam needed to drive THP.

Incorporating THP isn't a panacea, and it's not right in every situation. But where plants are at capacity and need to accommodate future growth, THP enables owners and operators to increase the treatment capacity of existing anaerobic digesters. Utilities with relatively high residuals management costs can benefit from a process that reduces biosolids mass and volume. And generating a better, more valuable end product can increase beneficial reuse and reduce management costs.

## A Deeper Dive

Experience with THP in the UK and the U.S. has revealed some important considerations for retrofitting THP to existing facilities. For one, solids need to be screened prior to entering THP facilities. Approximately 5-mm screening is required to prevent problems with buildup of rags and other debris in downstream equipment.

Whereas conventional digestion requires thickening prior to the process, thermal hydrolysis requires upstream dewatering; THP therefore requires two stages of dewatering — one stage before THP and digestion, and another stage afterwards. Cake storage is also required upstream of THP to provide a steady throughput and operational flexibility.

Because thermal hydrolysis requires steam, plants that add THP generally must replace their water boilers with steam boilers. Those with CHP will want to generate steam rather than hot water from the CHP waste heat to power THP operations.

It's necessary to cool the biosolids material following thermal hydrolysis and prior to digestion. Another consideration when upgrading existing digesters is that the gas piping may not be large enough for the increased biogas production per digester with THP.

Adding THP improves gas production by improving conversion of the energy in the biosolids into biogas. However, the process requires steam, so some of the biogas that is generated typically is used for steam production.

While a lot of existing THP facilities also have CHP, this technology does not always go hand-in-hand with THP. Where electricity costs are high and green energy credits are available — as in Europe and some regions of the U.S. — the generation of additional biogas offers a significant benefit. CHP can be a very good fit for THP because CHP generates a hot exhaust gas that can be used to generate steam. For this reason, it is quite common in Europe to use CHP with THP, where the average price of electricity is higher than in the U.S. More recently, production of RNG is also being carefully considered as an alternative use of the biogas (e.g., for pipeline injection or for vehicle fuel). It is important to examine the economics of biogas utilization options on a case-by-case basis to work out the best and highest use of the gas in a given situation.

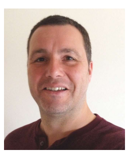
## Recent THP Innovations

In most applications today, thermal hydrolysis has been used upstream of anaerobic digestion, but there is now a process that allows for use of thermal hydrolysis downstream of anaerobic digestion. The solubilized material leaving the THP is dewatered to 40 percent solids concentration or greater. The sidestream from dewatering, which has a high biodegradable chemical oxygen demand, is sent back to the digesters, which leads to improved gas production and improved conversion of volatile solids. A system like this offers the potential for an easier retrofit of THP to existing processes.

Another new option is intermediate thermal hydrolysis. It entails inserting thermal hydrolysis between two stages of digestion. Owners would process residuals through conventional digestion, then THP, then another stage of digestion to maximize solids conversion and energy recovery.

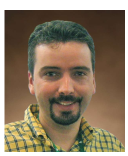
Both of these emerging approaches could potentially be favorable for facilities with plenty of existing digester capacity. In these situations, owners aren't driven to get more solids through a limited number of digesters but can reap other benefits. They can benefit from improved digestion performance through better solids conversion and greater gas production, construction and maintenance of a smaller THP facility, and production of a better-quality cake for beneficial use. ■


## About The Authors



Greg Knight serves as the Black & Veatch thermal hydrolysis technical lead in the U.S. and has led process engineering for anaerobic digestion and THP projects on both sides of the Atlantic. He has 14 years of process engineering experience in water, wastewater, and biosolids management.

Scott Carr is Black & Veatch's Global Practice and Technology Leader for biosolids and residuals management. With 30 years of experience, he has focused his career on all aspects of biosolids and residuals management, including processing and beneficial use of biosolids.



Andrew Shaw is a Global Practice and Technology Leader in wastewater and sustainability for Black & Veatch, as well as an associate vice president. He holds a PhD in environmental engineering and has 20 years of experience of wastewater treatment around the world.

# The True Impact Of Various Nutrient Species And The Best Ways To Manage Them

The Water Environment Research Foundation (WERF) has conducted a host of studies, summarized here, to help utilities evaluate and solve their nutrient-related problems.

By WERF staff

Excessive amounts of nutrients in receiving waters can cause environmental problems such as harmful algal blooms, hypoxia, and fish kills resulting from biomass decay. Current technology is making it easier to detect nitrogen (N) and phosphorus (P) in our waterways down to the smallest amounts. Many watershed protection plans (e.g., Total Maximum Daily Loads [TMDLs]) use total phosphorus (TP) for setting limits because P is one of the two key macro-nutrients (the other is N) that algae need to grow. It is very expensive to research and implement advanced treatment technologies to remove nutrients to very low levels from wastewater effluent. It often requires significant amounts of energy and chemicals, but operators often have very little understanding of whether the results will actually reduce algae growth. WERF has recently completed a series of research projects that can help the water quality community more accurately determine the true impact of various nutrient species and the best ways to manage them.

## WERF Nutrients Research

Because advanced biological nutrient removal (BNR) systems do a thorough job of eliminating most inorganic N and suspended solids, the result is often effluent that is heavy in dissolved organic nitrogen (DON). And while DON can account for upwards of half of the total nitrogen (TN) coming out of these systems, little is known about how much of this is actually contributing to algae growth. Recently completed WERF research, *Uptake by Algae of Dissolved Organic Nitrogen from BNR Treatment Plant Effluents (NUTR1R06e),* developed a simple and effective method for measuring bioavailable DON, as well as other forms that are not readily taken up by algae. As a first step, researchers developed a process for separating out different forms of N using various resins. This allowed them to isolate the hydrophilic forms of DON, and in these samples researchers saw very little consumption of DON or algal growth, suggesting that they are not actually bioavailable. Knowing which nutrient fractions are really contributing to algal blooms can help tailor treatment towards the real causes.

Another of WERF's recently completed research projects sought further fundamental understanding of effluent P chemical species to interpret and improve technologies for P removal to very low limits. This research looked for insights into the removal efficiency and mechanisms of different P fractions through various treatment technologies. Twenty processes were evaluated at 12 water resource recovery facilities (WRRFs). The P composition in the influent and the secondary and tertiary effluents from the processes were characterized using standard methods, as well as sequential chemical extraction for metal-bound P analysis and molecular cutoff for distribution analysis. Wastewater characterization and fingerprinting were also performed to reveal the association of organic P with identifiable effluent organic fractions. Then, changes in P fractions along the treatment train in each WRRF were evaluated and compared to measured concentrations. The results from this study, *Phosphorus Fractionation and Removal in Wastewater Treatment: Implications for Minimizing Effluent Phosphorus (NUTR1R06l),* suggest that advanced tertiary treatment processes may achieve low effluent TP levels. Technologies and multistage treatments that target the effective elimination of fine and colloidal particulates, as well as non-reactive P fractions will be required.

The next team of WERF researchers looked at the effluent from advanced P removal processes at work across the U.S. and measured the bioavailability of P. What they found was that different removal processes produced different P species compositions, and in most cases, more than half of this P was not contributing to algal growth. They also found a strong correlation between total reactive P and bioavailability — meaning measuring for P that reacts to analyte could serve as a quicker, cheaper, and easier way to measure bioavailability. This research, *The Bioavailable Phosphorus Fraction in Effluent from Advanced Secondary and Tertiary Treatment (NUTR1R06m),* could aid in the development of watershed protection plans, many of which use TP as a benchmark. Plans that identify and more effectively target those P fractions that are actually bioavailable could help avoid unnecessarily high chemical use and reduce operational costs, sludge production, and greenhouse gas emissions. Because many TMDLs use TP for setting limits without considering the possibility that P fractions may differ in bioavailability, when establishing regulations on TP, the results from this study could be helpful in setting limits.

Although meeting lower nutrient levels has become a high priority for many facilities, the benefits of reaching these lower limits can sometimes be offset by the negative impacts that it takes to meet them. Achieving lower limits can necessitate excessive chemical additives and require significant amounts of extra pumping, mixing, and aerating, which require huge amounts of energy. WERF's recently completed research, *Striking the Balance Between Nutrient Removal in Wastewater Treatment and Sustainability (NUTR1R06n),* suggests that a point of diminishing returns might be reached after enhanced nutrient removal. The additional chemicals and energy needed beyond that point caused a 70 percent spike in greenhouse gas emissions — and resulted in only a one percent drop in nutrient levels. Operational costs also increased more than five times to get to these higher levels of treatment. Researchers found that a more effective solution might be managing these nutrients before they even arrive at the facilities. Integrating best management practices for controlling nonpoint sources, such as the runoff that carries nutrients into our waterways, is a more sustainable solution for protecting our environment as a whole.

Another WERF research study took a step back to first assess the impact of various forms of P to help inform regulations and target the P species that are the real offenders. Preliminary studies point to dissolved organic phosphorus (DOP), present after advanced treatment, as a major contributor. Using a newly established test that is based on measures of fluorescence and enzymatic analysis, researchers found a significant portion of lingering DOP could be bioavailable to algae — potentially impacting receiving waters. Finding ways to remove these residual nutrients could be key to meeting future stringent nutrient regulations. In this case, removal of DOP would mean integrating processes that remove hydrophobic organic matter, such as adsorption. This research, *Bioavailability and Characteristics of Dissolved Organic Nutrients in Wastewater Effluents (NUTR1R06o),* provides valuable information for engineers and facility operators that can help them manage investments on processes to eliminate bioavailable P and N more effectively.

**Although meeting lower nutrient levels has become a high priority for many facilities, the benefits of reaching these lower limits can sometimes be offset by the negative impacts that it takes to meet them.**

Direct determination of P mineralization kinetics in advanced wastewater treatment facility effluents is crucial for developing protective strategies for minimizing eutrophication in receiving surface waters. The research project *Mineralization Kinetics of Soluble Phosphorus and Soluble Organic Nitrogen in Advanced Nutrient Removal Effluents (NUTR1R06p)* looked at the dissolved P uptake kinetics characterization for five treatment facilities in the Spokane River/Long Lake System in Washington and Idaho and also tested samples from five other facilities. The researchers tested whether nutrient co-limitation and/or effluent toxicity artificially depressed the percent of bioavailable phosphorus (BAP) estimates for the effluent samples. As it is very expensive to manage dissolved P in effluents using current detection methods, a simpler and less expensive bioassay uptake measurement tool was developed. The research report also presents a general approach for improving models used in managing nutrient impacted waterbodies.

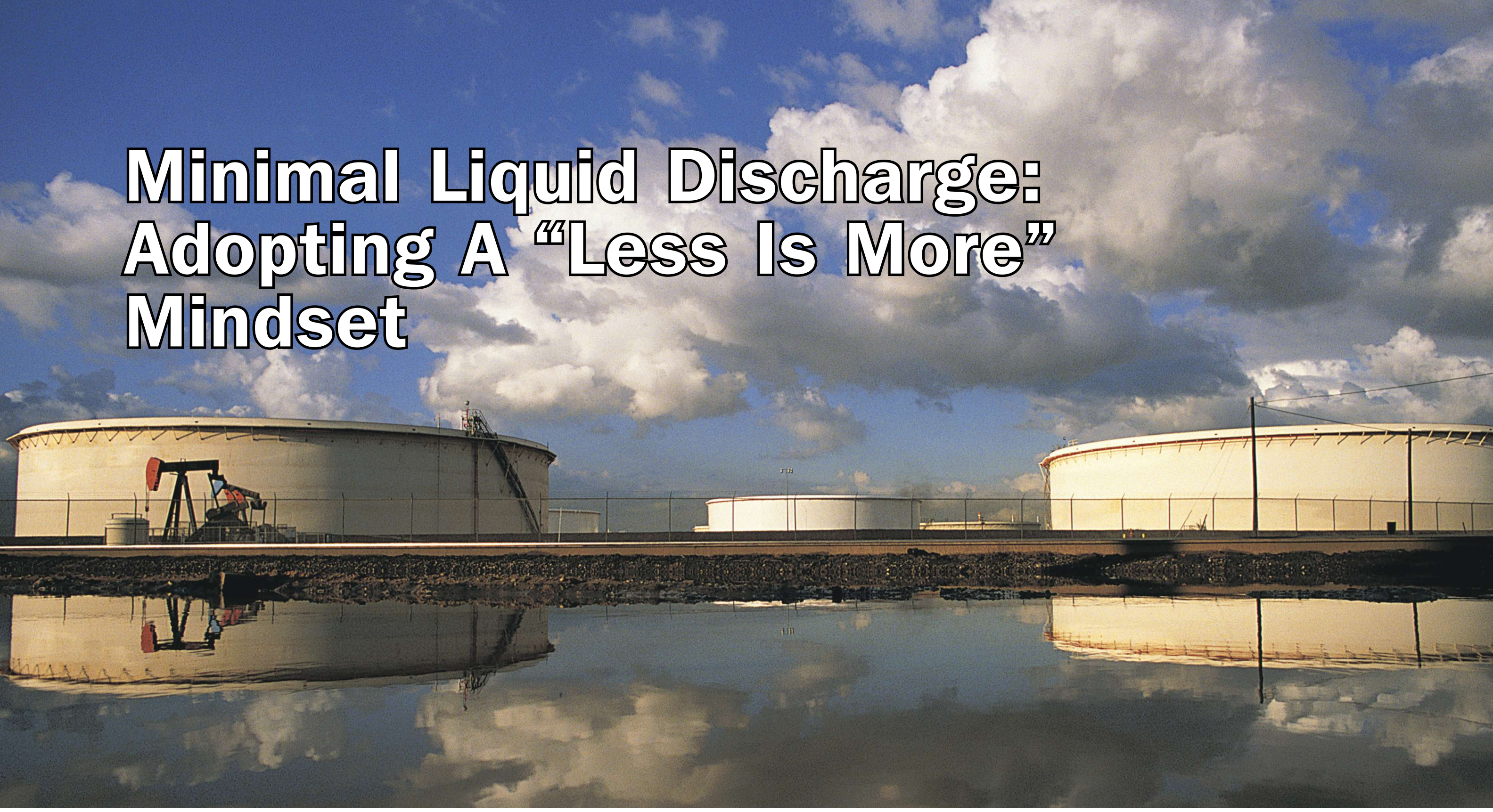
Removing P beyond enhanced biological processes usually requires adding chemical coagulants, most often alum. Although this can do a good job of producing effluent with fairly low nutrient levels, it also produces a sizable amount of chemical sludge, which up until now has been largely thought of as waste. However, innovative science is reimagining this product as a useful additive that can be plugged back into upstream treatment processes, resulting in even lower P levels. Researchers for this WERF project, *Solids Role in Tertiary Chemical Phosphorus Removal by Alum (NUTR1R06t),* found that the most effective points of reentry for sludge in the treatment train took advantage of existing solids separation processes, such as primary clarification, aeration, or secondary clarification. New process flows that take advantage of the sorptive capacity of this sludge could lead to ultra-low P levels while decreasing alum levels.

Turning to the importance of real-time information, the WERF research project *BNR Process Monitoring and Control with Online Nitrogen Analyzers for Nitrogen Credit Exchange Program in Connecticut (NUTR1R06y)* summarizes the use, performance, and reliability of online analyzers by water pollution control facilities in Connecticut. It also considers their use for automated process control to optimize BNR performance. The research report includes case studies which describe practical approaches towards automated online process control for the improvement of BNR process performance. The researchers found that while there is an increasing interest in online N analyzers, their use for automated process control is not typical, that the implementation of automated process control is easier when the treatment facility undergoes an upgrade, and that it is dependent on the facility's existing processes.

Looking toward the models that are used to set nutrient limits, the final project, *Can TMDL Models Reproduce the Nutrient Loading-Hypoxia Relationship? (U4R09),* addressed uncertainty regarding whether current eutrophication models used to determine TMDLs and to forecast the impact of TMDLs on water quality are accurate over longer time periods. The research team sought to calibrate a 55-year watershed simulation in the Chesapeake Bay watershed using several models by constructing a long-term time series (1950 to present) of nutrient loading for that area from nutrient loading observations in the Susquehanna, Potomac, and Patuxent Rivers, as well as proxies for other non-tidal rivers, long-term records of point sources, and proxies for changes in atmospheric loading. They found that there is good agreement between models and measurable results, except in the wet month (July). Based on the findings of this research, regulatory agencies may want to evaluate the agreement between modeled and observed hypoxic volume in future TMDL re-evaluations.

## Conclusions

Although begun several years ago, these recently completed WERF studies illustrate the depth of additional knowledge that is needed to inform the process of setting and meeting nutrient limits. Ultimately, they build the case for WERF's newest research portfolio on the harvesting and recovery of these valuable nutrients. Results from WERF's nutrient recovery research will begin to become available this year. For more information, please visit www.werf.org. ■



# Minimal Liquid Discharge: Adopting A "Less Is More" Mindset

If zero liquid discharge (ZLD) is too costly, water reuse and sustainability can still be prioritized and realized through minimal liquid discharge (MLD).

By Snehal Desai, Steve Rosenberg, and Nanette Hermsen

As we move toward a circular economy based on virtually no waste, with raw materials continually recycled and reused, the crucial role water plays is top of mind for corporate leaders across the globe.

Conversations around water supply challenges have penetrated the boardroom level in 62 percent of large companies, according to the Carbon Disclosure Project (CDP), unlike in years past when sustainable practices were relegated to mid-level management. Moreover, almost a quarter of the 830 companies surveyed by the CDP said that water-related issues could limit the growth of their businesses.[1]

Manufacturing is one of the sectors most vulnerable to water shortages. With global water demand for manufacturing anticipated to increase by 400 percent from 2000 to 2050,[2] maximizing the efficient use of water by industry is a critical step in the right direction — for both the environment and the bottom line.

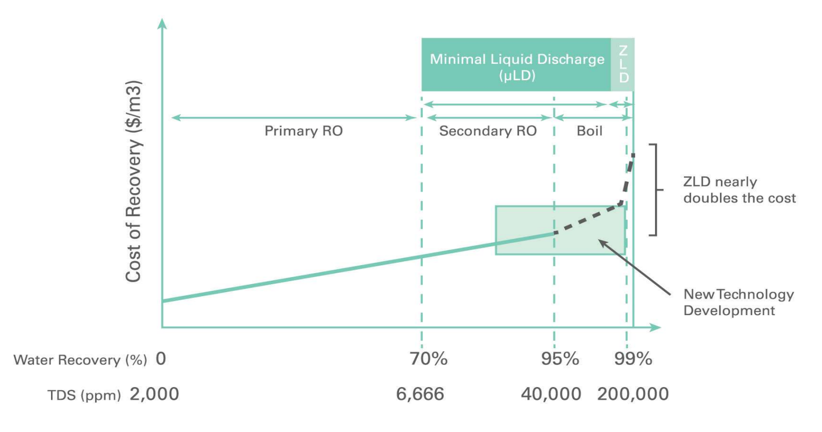
## Adopting A Minimal Liquid Discharge Mindset

Business value is at risk if companies don't take capital considerations surrounding water use into account and adjust their operations accordingly. Companies must strike a balance between meeting their objectives and what is practical or reasonable in terms of costs.

While zero liquid discharge (ZLD) — a water treatment process in which all wastewater produced is purified and recycled, leaving zero liquid discharge at the end of the treatment cycle — is a viable solution for some companies, it's not the most realistic solution for all, given the steep price tag.

When facing significant discharge mitigation costs, businesses often wonder, "What are my other options besides ZLD?" One solution is minimal liquid discharge (MLD), an approach adopted by brand names like General Motors and Frito-Lay. MLD is a more cost-effective and sustainable way for companies to improve their water footprint, enabling up

COST COMPARISON OF MINIMAL LIQUID DISCHARGE (MLD) VS ZERO LIQUID DISCHARGE (ZLD)




Source: Dow Water & Process Solutions

to 95 percent liquid discharge recovery at a fraction of ZLD's costs.

Coined by Dow, the term MLD might be new, but the processes on which it is based rely on proven water filtration technologies such as ultrafiltration, reverse osmosis (RO), and nanofiltration — with a host of improvements.

Depending on individual regulatory and environmental needs and requirements, as well as the capital and operating budget, MLD can be a good fit for many industrial and municipal sites. By conducting a water audit to match waste streams and appropriate water requirements, companies can better identify how much wastewater requires processing and the approach that will most economically and sustainably match their plant's needs.

**Traditional water treatment technologies have advanced, and now companies can achieve a better water footprint without going to the extreme – all while staying within their budget.**

An excellent example of an "MLD mindset" in action can be found at the General Motors (GM) vehicle assembly plant in San Luis Potosi, Mexico, outside of Mexico City, which opened in 2008.[3] The plant, which employs up to 1,800 and has an annual capacity of 160,000 cars, is located in an arid, remote area with no receiving stream or municipal sewer available to discharge wastewater.

Yet by using a combination of RO technology, a proprietary high-rate chemical softening process, and other technologies, the plant can convert up to 90 percent of its tertiary wastewater into reusable water, leaving less than 10 percent of liquid waste for discharge into adjacent solar ponds for evaporation.

Clearly, GM has determined 90 percent to be the optimal economic number for its wastewater conversion. That's what MLD is all about — providing users with a variety of options to achieve the results most optimal for a particular plant, based on a variety of factors.

And it's important to point out that an MLD approach still significantly benefits the environment and surrounding community.

In arid Casa Grande, AZ, for example, Frito-Lay North America, a division of PepsiCo, is using a membrane bioreactor (MBR) and activated carbon/low-pressure RO system to achieve 70 to 75 percent water recovery, saving more than 100 million gallons of fresh water annually. The plant is the first in the U.S. to convert food process water into drinking water quality for direct reuse in production.[4]

## It's A Journey, Not A Destination

The big challenge lies in adopting this new mindset of "We can achieve significant gains without breaking the bank." More companies must realize they don't have to wait for the perfect ZLD solution when an MLD strategy will put them on a path toward higher recovery today. Traditional water treatment technologies have advanced, and now companies can achieve a better water footprint without going to the extreme — all while staying within their budget. By adopting this mindset and evaluating current systems for areas of improvement, companies can take significant steps towards a circular economy without breaking the bank. We are on a journey to zero, but the major steps along that path are what can ultimately help us make significant progress along the way. ■

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## About The Authors

As the global business director for Dow Water & Process Solutions, Snehal Desai is responsible for implementing business growth strategy and leading the 1,700 people who work in the business. He is an expert on key industry and global issues such as water scarcity, quality, and safety, along with the interdependencies of water and energy.

Steve Rosenberg is a research fellow for Dow Water & Process Solutions with more than 30 years of industrial experience in the development of advanced materials. His main focus is on developing breakthrough innovations for water treatment technologies such as ultrafiltration, reverse osmosis, and ion exchange.

Nanette Hermsen is the global marketing director for reverse osmosis at Dow Water & Process Solutions. In this role, she is responsible for setting the marketing strategy for the business unit, driving regional marketing programs, and working closely with research to identify market aligned innovation targets for reverse osmosis.