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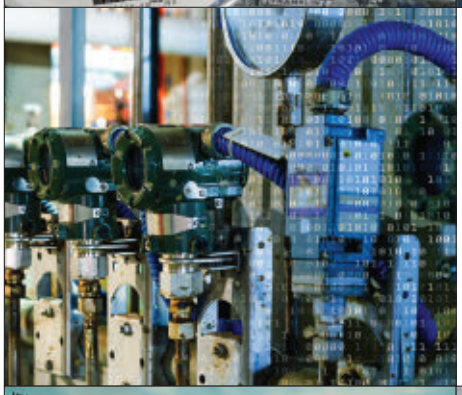
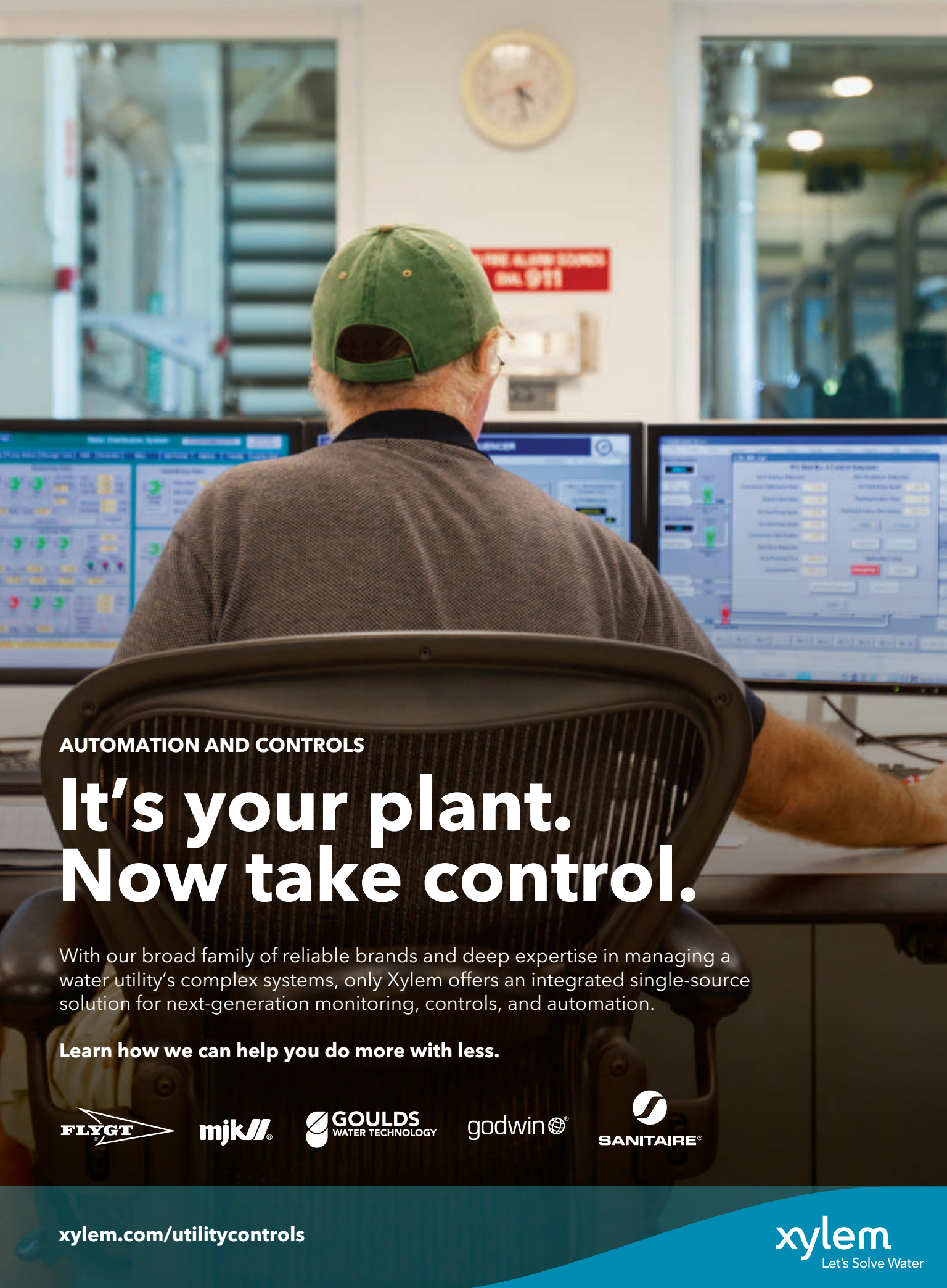


INTEGRATE

DIGITAL SOLUTIONS CONTINUE MAKING HEADWAY IN SECTOR



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ON THE COVER
The pandemic has sped the need to integrate digital solutions in every area of the water sector. The smart water trend has evolved to an integration movement. Each cover tile illustrates that momentum.

FEATURES

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▶ MARCH 2021

NEWS

▶ Rate Challenges

▶ Drinking Water Regulations

NOTABLE

▶ True Digitalization

▶ In Partnership with WateReuse

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The Water Environment Federation (WEF) is a not-for-profit technical and educational organization of 35,000 individual members and 75 affiliated Member Associations representing water quality professionals around the world. Since 1928, WEF and its members have protected public health and the environment.

WEF's Mission and Critical Objectives
Connect water professionals: WEF develops an engaged membership that is representative of the multiple practice areas of the water environment industry.

Enrich the expertise of water professionals: WEF provides a broad range of professional content and programming that is relevant and widely valued by the water sector worldwide.

Increase the awareness of the impact and value of water: WEF generates an increased public awareness of the value of water leading to increased funding to protect water quality through appropriate levels of infrastructure, management approaches, and services.

Provide a platform for water sector innovation: WEF establishes the conditions that promote accelerated development and implementation of innovative technologies and approaches in the water sector.

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Working Different and Harder

For a year now, we all have been operating either remotely or socially distanced. In both cases, two things have proven true. First, digital tools are incredibly useful and provide us all sorts of new options. Second, it takes effort, skill, and guts to adapt to new ways all the time. We feel lucky that our readers never quit and always make the most of the tools available.

While you are working harder to keep your utility moving forward, technology is working faster to help you achieve smart solutions. In particular, digital twin technology is emerging to help measure the present and predict the future.

If you are considering moving toward a fully digital instrumentation transformation, "Operational Edge" (p. 40) can give you some ideas. If you need to get some answers on how to handle automatic control valves — either basic or digitally advanced ones — check out "Sharp (Trouble) shooting" on p. 36. To see how it all can come together to prevent combined sewer overflows, "Double Vision" (p. 30) is the story you're looking for.

p. 40

p. 30

But we also cannot ignore the financial and safety challenges we are still facing. The debt left by shutoff moratoria cannot be ignored. People need water, but that need has a price. See some of the discussion in "Competing Crises" on p. 22. And staying healthy is always essential. That's why Operator Essentials (p. 52) reviews what every operator needs to know about protecting themself from COVID-19 and other biological hazards.

— The Editors

Errata

An unintentional line break in the January issue led to WEF President Lynn Broaddus' name being omitted on p. 28. We apologize for the error.

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True Digitalization

Driving productivity with predictive maintenance

James Chalmers

The water sector is leading the way in using digital technology as the basis for predictive maintenance that can extend the life of aging assets as well as helping to improve operational efficiency.

The extent of the digital ambition for some operators could be simply to control two or three pumps with a programmable logic controller (PLC) linked to a supervisory control and data acquisition (SCADA) system via a phone line. This approach can work well. However, the advent of Industry 4.0 makes it possible to fully embrace true digitalization. The result is operators in the water sector establishing a more holistic view of their critical assets that enables enhanced operational performance.

A good example is to consider a pump that abstracts water from a river for processing before it goes into the distribution network. When there is heavy rain, it often results in the increased ingress of dirt from the riverbanks, causing increased levels of turbidity in the river water. Historically, we would have kept this pump operating in all weather conditions. In contrast, thanks to digitalization, we can monitor both weather forecasts and changing turbidity levels. This enables operators to make fully informed decisions on how best to adjust the pump operation. Suitable actions might be to reduce speed or stop pumping. They might even decide to switch over to an alternative source to save on the higher treatment costs that result from increased turbidity.

Digital solutions that collect and analyze data enables users to make better decisions to optimize performance and predict maintenance needs. ABB

Proactive Processes

There are many other possibilities to utilize digitalization to optimize the water process. One approach is to install the new generation of wireless, battery-powered smart sensors on motors linked to pumps. This enables actionable real-time data to be gathered, aggregated, and analyzed via the cloud. Taking advantage of this "smart monitoring" technology is a key step for operators in making an effective transition from time-based monitoring regimes to predictive condition-based monitoring. These smart sensors have built-in algorithms that help detect the onset of vibrations in a pump that act as an early warning of a developing issue, such as bearing wear, cavitation, or a blockage. Armed with this information, operators can decide either to take immediate action or they might plan to manage the pump carefully until the next scheduled maintenance shutdown.

Using digital cloud-based condition monitoring solutions for the entire powertrain provides insight into the health of the system so actions can be taken before issues occur. ABB

Variable Speed Drives (VSDs)

VSDs control nearly one-third of the world's motors. While the main reason is generally to reduce energy usage, water and wastewater applications also can use drives for process control, reducing water hammer, or optimizing well operations. Drives can be used to control several pumps in a cascade system in water pumping applications to optimize pump operations. The new generation of VSDs also incorporate built-in applications, such as pump cleaning routines that put the

Predictive maintenance is driving productivity in the water sector. ABB

pump into repeated forward and reverse motion. This makes drives an important target for digitalization.

One way of implementing digitalization is to use a remote monitoring solution that gathers data from VSDs in a water facility and uploads it to the cloud. All the various data collected from drives, motors, and pumps can then be collated and analyzed. This allows the presentation of a detailed picture to provide insights on the health and performance of the complete powertrain.

Water companies normally monitor their piping networks on a continuous basis to check for any abnormal changes in pressures and flow that indicate problems, such as blockages and leakages. However, the first warning they sometimes receive is when a customer or highway authority informs them of a burst water pipe. The major benefit of digitalization is the increased sensitivity it provides in detecting adverse trends and using them to trigger an early warning. When treated water goes to waste before reaching the consumer, it is bad for the environment and an added cost for water utilities. The sooner they take action to prevent this waste, the higher the savings, and the lower the damage to customer confidence.

Smart Water Solution

With few natural water sources and limited landmass, water conservation is a top priority in Singapore, especially since demand is expected to double over the next four decades. Current consumption is more than 1.5 billion L/d (400 million gal/d). High operational costs, increasing energy usage, and a national skills shortage forced the city-state's water utility, the Public Utilities Board (PUB), to think beyond convention.

In conjunction with a consultant, the PUB conducted a successful pilot involving the installation of smart sensors on its pumps and motors. The real-time data obtained via the sensors resulted in reduced troubleshooting time, resources, and paperwork.

Following the pilot, the consultant installed an integrated solution with 22 smart sensors, remote condition monitoring, and augmented reality glasses to assist with maintenance and training. The solution also comprised six digital powertrains, which integrate sensor and drive data with cloud-based analytics along the complete range of facility equipment — from drives and motors to pumps and bearings.

Through the condition monitoring portal, the PUB can easily configure the powertrains and monitor critical health and operating parameters. In turn, the powertrains alert the utility to warning signs of imminent failure, which helps to reduce maintenance costs.

One of the biggest advantages of implementing this digitalization process is that there is no need to strip down existing hardware. Starting with a clear strategic plan, utilities can divide their water network into zones or districts and then identify how to address specific challenges in each. It is best to start small by adding to existing technology, which makes smart sensors the perfect starting point. They are inexpensive, easy to connect and use, and can be fitted to motors, pumps, bearings, and gearing.

Digitalization Growth

Digitalization is already helping the water sector to implement predictive maintenance, prevent water losses, and promote productivity. The arguments in its favor will only continue to grow increasingly powerful as the number of successful installations proliferates.

For further information: https://new.abb.com/drives/segments/water-and-wastewater.

***James Chalmers** is Vice President of Global Water & Wastewater Sales for ABB's Motion business.*

Smart Sensors can convert traditional motors into smart, wirelessly connected devices. ABB

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Resilience Redefined at the 36th Annual WateReuse Symposium

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What role does water reuse play in ensuring water security, safety, and supply? Recycled water has been used for decades in many regions to create a resilient and drought-proof water supply, but interest in water recycling also is growing dramatically in more water abundant communities as a strategy to protect sensitive waterways or alleviate over-burdened centralized treatment facilities.

The WateReuse Association (Alexandria, Virginia) will present two weeks of engaging and fully interactive live roundtables on water reuse policy, operations, research, and outreach, March 15 to 25, during the 36th Annual WateReuse Symposium. Organized around the theme, *Resilience Redefined* and presented in collaboration with The Water Research Foundation (Denver), the 2021 virtual WateReuse Symposium is designed to provide access to education in manageable blocks of time and maximize your ability to network with colleagues.

The format of one live roundtable discussion per day allows busy attendees to participate virtually around busy work schedules. Each roundtable panel will be followed by breakout discussions where attendees can turn on their cameras to engage with colleagues and panel presenters.

March 15: Water Reuse 101

The first live roundtable of the 36th Annual WateReuse Symposium, Water Reuse 101, will open with a panel discussion of the broad considerations for planning and operating a water recycling program. Panelists will explore water reuse drivers, financing options, technology adoption, research, public acceptance, and the biggest challenges of implementing water reuse projects. Following the panel discussion, attendees can enter breakout rooms to discuss the specifics of regulations, public education, operator training, innovative technologies, and more.

March 16: Water Recycling and Public Health

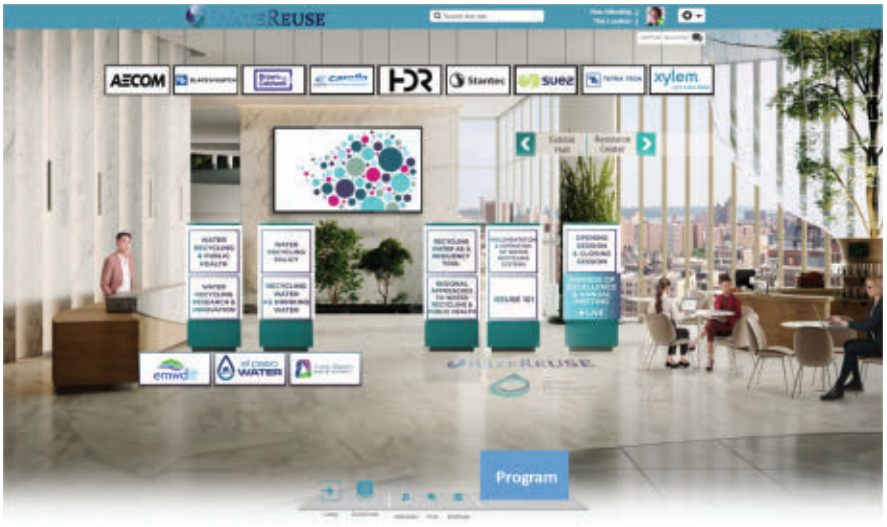
During the second roundtable, panelists from utilities, academia, and business will discuss the intersection of water reuse and public health. The panel will share best practices for communicating about public health and provide examples of how utility partnerships with medical professionals have increased local support for potable reuse. Attendees will join the individual panelists for breakout discussions of specific public health topics.

March 17: Recycled Water as Drinking Water

In this roundtable, experts and attendees will share challenges and solutions to potable reuse implementation from enhanced source control programs to artificial intelligence in water reuse. The breakout discussions will center on regulatory development, carbon-based advanced treatment, incorporation of membrane bioreactors into advanced treatment trains, and more.

March 18: Recycled Water as a Resiliency Tool

The fourth live roundtable will explore how communities can use reuse water to strengthen the resiliency of water systems. From early planning to the metrics for success, the roundtable will explore the benefits of water recycling for resiliency. Breakout topics include utility resilience and risk management, innovation and technology, and opportunities to implement change.



March 19: Regional Approaches to Water Recycling

The drivers and even technology for water reuse can vary dramatically in different regions. This roundtable explores how and why regional approaches differ. The breakout sessions will be focused discussions on specific U.S. regions or internationally.

March 22: Implementation and Operation of Water Recycling Systems

The second week of live roundtables begins with an in-depth discussion of

implementing and operating a water reuse program. Utility leaders will share successes and challenges of starting up a new program and maintaining a smooth operation. Breakout topics include public acceptance, pilot project development, funding and pricing, and operator training.

March 23: Water Recycling Research and Innovation

The Water Research Foundation will lead a panel of researchers in a discussion of the latest research on pathogens, quantitative microbial risk assessment, chemical peaks and source control, and the use of research results to support regulatory development. Attendees can join breakout discussions on specific research areas.

March 24: Water Recycling and Policy

This live policy roundtable will examine how policies and regulations can support water recycling as a resiliency tool. Panelists will discuss where and how polices and regulations are succeeding and where there are gaps and shortcomings. Specific examples will be given at the federal, state, and local levels. The session concludes with an opportunity for attendees to join breakout groups to discuss specific policy topics.

March 25: The Future of Water Reuse

The live portions of the WateReuse Symposium will close with a panel presentation focusing on water recycling in the future. The panel will examine expanding applications of water recycling across the globe and national involvement in those expansions.

On-Demand Technical Sessions and Opening General Session

To prepare attendees to fully engage in the live roundtables, the 36th Annual WateReuse Symposium has planned to release more than two dozen pre-recorded technical sessions on March 1. The on-demand technical presentations provide valuable background on water reuse research and policy, as well as insights into water reuse management strategies that include potable reuse, ecological restoration, decentralized systems, stormwater capture, and agricultural reuse. The on-demand sessions will be made available in conjunction with a live opening general session featuring a panel discussion on the challenges and opportunity of integrating public health and water reuse.

The full program, including recordings of live roundtables and events, will be available to registrants through April 23, 2021. Experience the WateReuse Symposium from the comfort of your own office, connect with colleagues, and earn professional development hours. For more information and to register, visit www.watereuse.org/symposium.

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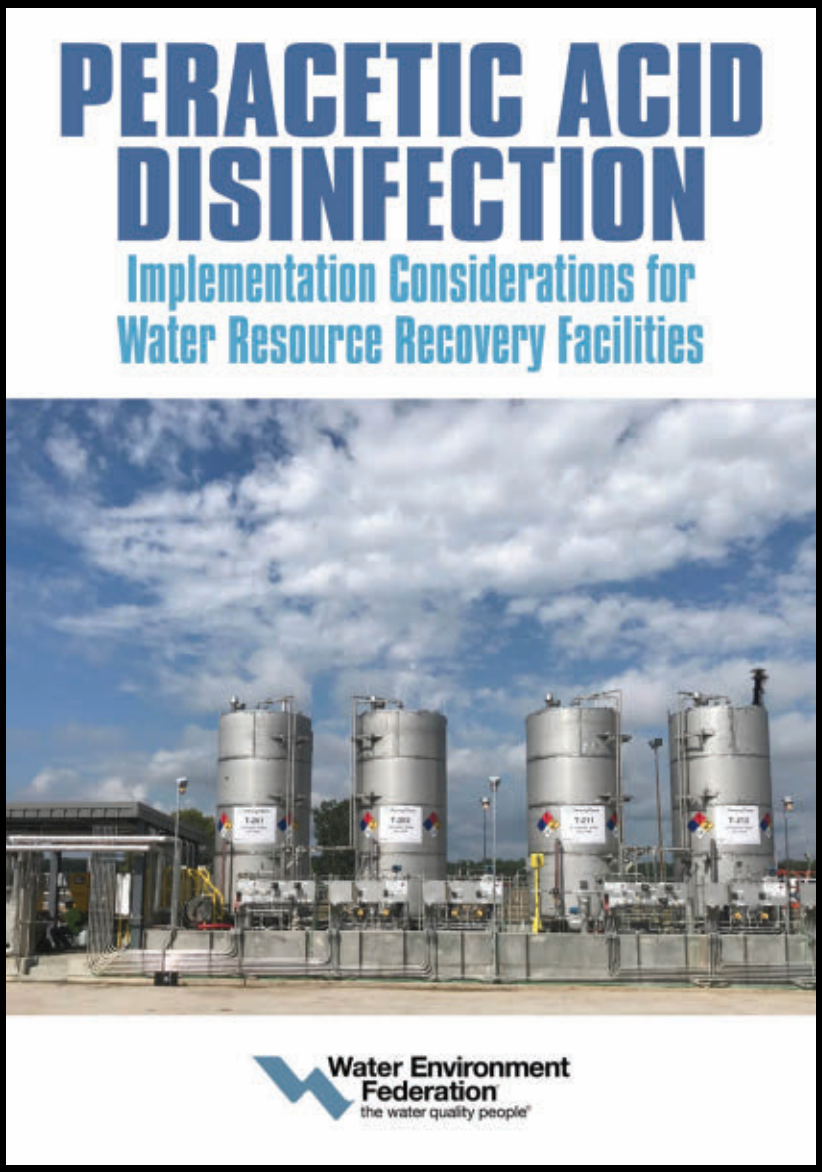

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Estimating Microbes Living on Ocean Debris

On the surface of each of the several trillion pieces of plastic debris in the world's oceans grow diverse colonies of microbes and bacteria that do not naturally occur in the marine environment. These invasive microrganisms have the potential to disrupt the ocean's normal nutrient-flow patterns and affect biodiversity.

For the first time, researchers in Florida and the Netherlands have estimated that approximately 1% of all microbial cells on the ocean's surface — or between 1,500 and 11,000 tons of carbon biomass — inhabit marine plastic-and-glass wastes.

The research team performed confocal laser scanning microscopy to examine the microbes living on several common types of ocean waste, including polypropylene, polystyrene, polyethylene, and glass. Documenting the amount, size, and cellular carbon mass of these microbes enabled the researchers to develop cellular profiles for each type of debris. Using the team's profiles alongside existing estimates of the world's current volume of marine debris yielded the first documented, global estimate of the volume of invasive microbes living on the ocean's surface.

Much of the team's study, which appeared in the *Multidisciplinary Journal of Microbial Ecology*, focuses on the potential effects of these invasive cells on the microalgae and other photosynthetic cells that underpin several marine food chains. By consuming nitrogen, phosphorus, and other ocean nutrients, microbes on ocean waste likely take resources from microalgae and affect biodiversity, described lead author Tracy Mincer from Florida Atlantic University (Fort Pierce) in an October 2020 release.

"With the advantage of a surface, which concentrates nutrients, organisms colonizing plastics in the ocean are taking up those limiting nutrients that normally would have been consumed or out-competed by free-living microbes," Mincer said. "So essentially, these microbes on plastics are taking habitat space away and represent the beginning of a regime shift for these habitats."

WHO: Florida Atlantic University (Fort Pierce) and Royal Netherlands Institute for Sea Research (Texel, Netherlands)

WHAT: First global estimate of microbial biomass living on anthropogenic ocean debris.

HIGHLIGHTS:

- Between 1,500 and 11,000 tons of carbon biomass are estimated to inhabit marine plastic-and-glass wastes.
- Researchers used results from confocal laser scanning microscopy alongside global estimates of ocean waste volumes to estimate total microbial biomass.
- Microbes colonizing marine debris take away resources from the microalgae that underpin marine biodiversity.

RESEARCH: "Microbial carrying capacity and carbon biomass of plastic marine debris," *Multidisciplinary Journal of Microbial Ecology,* Vol. 15, bit.ly/ocean-microbes.

A research team from Florida Atlantic University (Fort Pierce) and the Royal Netherlands Institute for Sea Research (Texel, Netherlands) has estimated the total volume of microbes living on plastic-and-glass waste across the world's oceans. Image courtesy of Monica Volpin/Pixabay

Adsorbing Pharmaceuticals with Agricultural Waste

Biochar created from two previously untested agricultural waste products — cotton-gin waste and pulp from the guayule plant native to the southwest U.S. — have proven to be efficient adsorbents for the removal of common pharmaceuticals from treated wastewater.

The research team synthesized biochar from the two waste products by heating them to extreme temperatures in an anoxic environment. Then, they deposited the resultant rigid, charcoal-like substance into aqueous solutions containing 10 mg/L of three common pharmaceuticals: sulfapyridine, docusate, and erythromycin.

While both biochar products adsorbed and removed large proportions of the pharmaceuticals, biochar from cotton-gin waste proved far more efficient. It achieved 70% sulfapyridine removal, 98% docusate removal, and 74% erythromycin removal. Guayule-pulp biochar removed 50% of docusate and erythromycin, and only 5% of sulfapyridine.

In addition to identifying the two agricultural waste products as promising candidates for use in pharmaceutical remediation, the study also documents a way to create more effective biochar adsorbents. Doubling typical pyrolysis temperatures from 350°C to 700°C (650°F to 1,300°F) yielded biochar with higher pH, larger specific surface areas, and greater surface hydrophobicity, which are qualities that improve their effectiveness when attracting and capturing pharmaceuticals.

The discovery could help researchers develop new, biochar-based wastewater treatment solutions that would target pharmaceuticals and other difficult contaminants in treated effluent before their discharge into waterways, according to lead researcher Marlene Ndoun of Pennsylvania State University (University Park) in a November 2020 release.

WHO: Pennsylvania State University (University Park) and U.S. Department of Agriculture

WHAT: Biochar made from cotton-gin waste and guayule bagasse remove up to 98% of common pharmaceuticals from aqueous solution.

HIGHLIGHTS:

- Researchers pyrolyze cotton-gin waste and pulp from guayule plant (bagasse) at 350°C, 500°C, and 700°C.
- Biochar made from cotton-gin waste successfully adsorbs between 70% and 98% of tested pharmaceuticals.
- Biochar made from guayule bagasse adsorbs between 5% and 50% of tested pharmaceuticals.
- Biochar synthesized at higher temperatures perform better as adsorbents because of their higher pH and greater surface area and hydrophobicity.

RESEARCH: "Adsorption of pharmaceuticals from aqueous solutions using biochar derived from cotton gin waste and guayule bagasse," *Biochar,* 2020, http://bit.ly/biochar-WET

"Beyond removing emerging contaminants such as pharmaceuticals, I am interested in blending biochar materials so that we have low-cost filters able to remove the typical contaminants we find in water, such as bacteria and organic matter," Ndoun said.

New research illustrates the potential of two agricultural waste products — cotton-gin waste and pulp from the guayule plant — as adsorbents to remove pharmaceuticals from treated wastewater. Image courtesy of bobbycrim/Pixabay

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Small-Footprint Filtration System Removes up to 98% of Common Antibiotics

A prototype filtration system promises to remove common antibiotics from treated wastewater effluent at a lower cost and with a smaller footprint than conventional approaches.

The column-shaped filter features four distinct layers: gravel, sand, soil, and a mixture of soil and biochar. Water enters the filter through the bottom of the column and progresses upward through each layer via a pump before discharging from the top of the column.

The development team, consisting of researchers from the U.S. Department of Agriculture (USDA) and the University of California–Irvine, tested the column on simulated wastewater containing 10 ppb of four of the most common antibiotics. Tests demonstrated removal rates of as high as 98% for tetracycline, 91% for cefalexin, 81% for amoxicillin, and 51% for sulfadiazine.

According to the team's research, maximizing contact time between influent and each layer of filtration media improved antibiotic removal efficiency, particularly for amoxicillin and cefalexin. On the other hand, it was generally more difficult to purge antibiotics from water containing dissolved organic matter.

The prototype, intended as a scale model, measures 50 cm in height and 12 cm in diameter. The full-scale model for municipal use would be approximately four times that size, described USDA microbiologist Mark Ibekwe in a November 2020 statement.

"These results show the importance of using layers of different materials to target different antibiotics rather than expecting one layer and material will be able to do the job," Ibekwe said.

WHO: U.S. Department of Agriculture (USDA) and University of California–Irvine

WHAT: Prototype filtration system featuring natural media demonstrates cost-effective antibiotic removal.

HIGHLIGHTS:

- Column-shaped filtration system features layers of gravel, sand, soil, and soil mixed with biochar.
- Researchers test filtration columns on simulated wastewater containing 10 ppb of amoxicillin, cefalexin, sulfadiazine, and tetracycline.
- System removes between 51% and 98% of each antibiotic, with better results with greater hydraulic retention times.

RESEARCH: "System of multi-layered environmental media for the removal of antibiotics from wastewater," *Journal of Environmental Chemical Engineering*, Vol. 8, No. 5, bit.ly/antibiotic-column.

New research from the U.S. Department of Agriculture and University of California–Irvine describes a new approach to remediating antibiotics from treated wastewater. Image courtesy of Heung Soon/Pixabay

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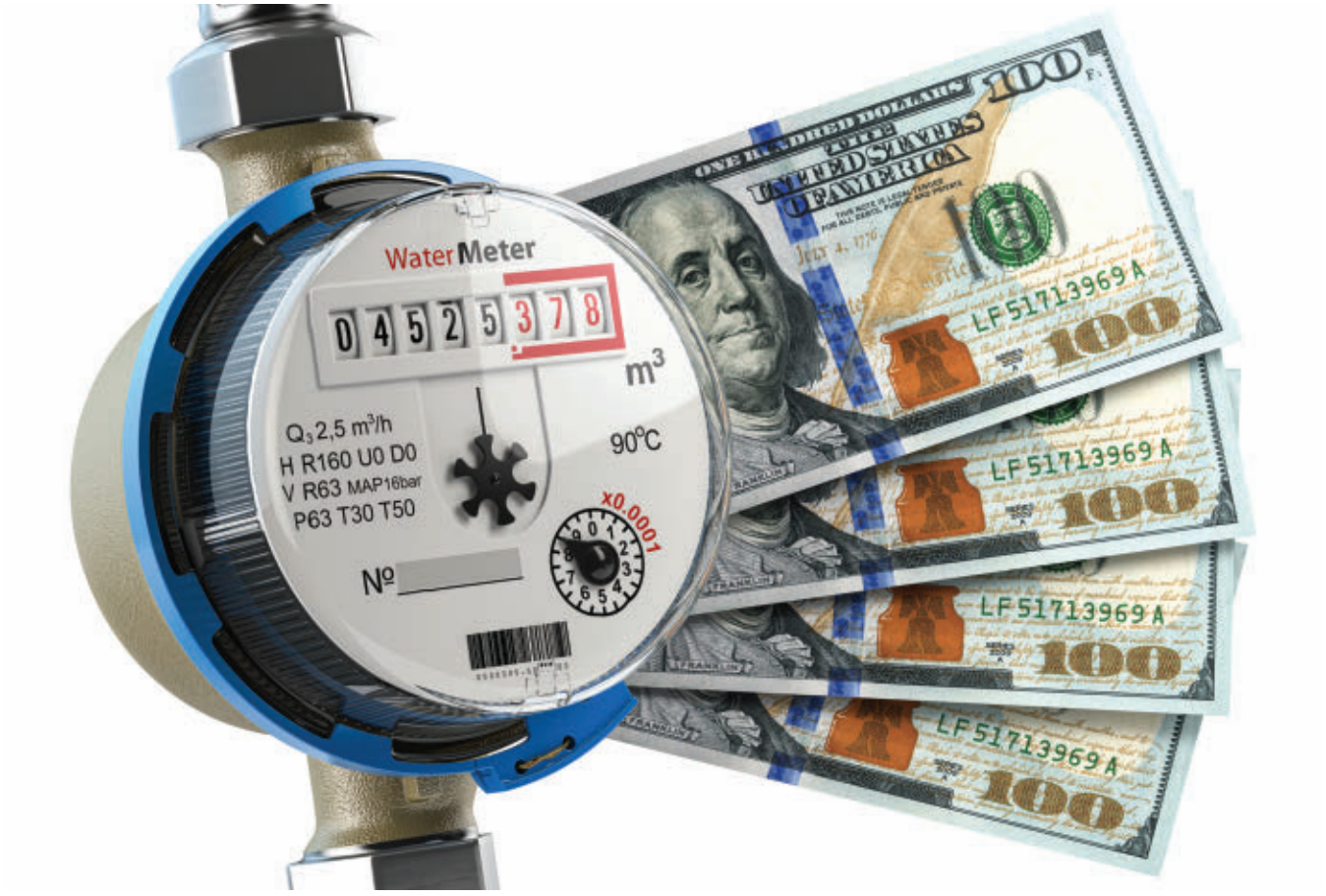
Competing Crises

With billions of dollars in unpaid water bills, U.S. citizens and utilities are coming up short on cash and ideas

By Will Fowler



U.S. utilities and consumers are facing tough decisions as bills pile up amid the pandemic.

In the fleeting hours of 2020, former U.S. President Donald Trump signed a second coronavirus relief plan into law. Among other things, it promised a program to help low-income families pay their water and wastewater utility bills. The amount allotted to the promised program is $638 million. Of that, nearly $20 million will go to tribal nations.

"While communities and utilities work to offer customer assistance and flexibility to those in need, the scope of the public health and economic crisis requires a federal hand," said a group of clean water organizations, including the Water Environment Federation (WEF; Alexandria, Virginia), in a joint statement on December 21.

The need for funds was highlighted earlier in 2020 when an investigation by the water news organization *Circle of Blue* found that "more than 1.5 million households in a dozen major U.S. cities with publicly operated water utilities owe $1.1 billion in past-due water bills."

Due to continued shutoff moratoriums, those bills have continued to grow since

Circle of Blue's August 2020 reporting. Although some states have set early 2021 expirations for their moratoriums, questions remain and pressure builds about how bills will be paid during a pandemic in which clean water has taken center stage as a public-health necessity.

Consumer Crisis

Terra Atkins was facing a $600 utility bill when she had an epiphany.

Having lost her job in the restaurant industry during the coronavirus shutdown, the grandmother from Tulsa County, Oklahoma, was behind on rent and her other bills, too. She had applied for rent assistance programs made available during the pandemic, but her applications were denied.

"When I lost my job, they shut down any portal that had access to employment records, paystubs, financial papers, anything," Atkins said. "When I applied for the rental assistance program, I couldn't access those documents. I couldn't prove COVID impact, so they denied me."

However, Atkins and others were able to find help from a utility assistance program. The group Allied Communities of Tulsa Inspiring Our Neighborhood (ACTION) offered a program more accessible than the rental assistance programs. Atkins is a community organizer for ACTION.

While Tulsa tenants might struggle with rent assistance programs, paying off utility debt could free up money to pay rent. To provide this assistance, ACTION has used federal funding from the first pandemic relief package — the Coronavirus Aid, Relief, and Economic Security Act (CARES) Act that was passed in March 2020. These funds have strict use limitations.

As of January 2021, the Tulsa program has distributed relief to more than 1,400 households and paid out nearly $350,000. Many more have applied, and ACTION organizers say that more help is on the way.

Utility Crisis

According to the Chicago Bar Association's *@The Bar* blog, seven states have opted against shutoff moratoriums. Other states have a range of expiring shutoff moratoriums. Some expirations, the blog states, begin to expire this month.

California is among the states with a shutoff moratorium in place. The California Boards (CWB) estimates households across the state owe $1 billion in back-due drinking water, wastewater, and stormwater bills.

"The Board estimates that at least 1.6 million households have water debt. This means at least 12% of households in the state have water debt," a CWB representative said during a January 19 meeting. "The average debt amount is

roughly $500 per household."

Additionally, CWB scored the financial vulnerability of small- to medium-sized water systems statewide based on three indicators: number of months before financial assistance is required; days of unrestricted cash on hand; and revenue-to-expense ratio. Based on those indicators, CWB estimated 270 small- to medium-sized systems across California showed a high financial vulnerability risk, meaning they met two of the three indicators. An additional 25 small- to medium-sized systems met all three indicators, which CWB scored as an extreme financial vulnerability.

CWB noted that several utilities they contacted reported that they were able to postpone capital improvements to help with lost revenue.

"These would be things like main line replacements they had planned for this year, well rehabilitations, maybe some tank rehabilitations," said Sean McCarthy of the State Water Resources Control Board during the meeting. "In the short term, they can put it off, but in the long-term, water infrastructure exceeds its useful service life and it will have to be replaced."

McCarthy also noted that some of the systems reported increased expenses due to the pandemic. These include buying personal protective equipment or supplying employees with equipment to work remotely.

"Overall, I think water systems are very resilient and robust," McCarthy said. "But it is a short-term issue, a short-term resiliency. Long-term, the loss in revenue and the increase in household debt … is going to delay capital improvements, and the water systems will have many needs."

> "Many people will not pay their utility bill to be able to pay their rent. And people will go without food or medicine to keep their lights on or the water running. There is a ripple effect that happens. These kinds of choices keep you up at night."
>
> Terra Atkins
> Tulsa County, Oklahoma

Weighing Options

There are a few options for water systems with rising needs. One approach is to simply charge the debt to the customers who incurred it, an idea called the *cost causality principle*. While in some cases this is possible, Dr. Ted Kury of the University of Florida (Gainesville) Public Utility Research Center says it is often more complicated than it sounds.

"The problem is that it just won't be enough to cover all the debt," he said. "You're going to have customers who still can't pay their bills and get disconnected from the system and now generate no revenue at all."

That leaves a few options, Kury said. The first, *regulatory asset management*, involves turning the debt into an asset for the utility and paying it off over time by increasing rates. This puts the burden on ratepayers who use the service.

The second, *securitization*, involves larger government entities taking on the debt and paying for it by issuing bonds, then paying those bonds back in the long-term with taxpayer dollars. This puts the burden on all taxpayers.

For private utilities, the third and likely most controversial option is to pay the debt with money that would otherwise be paid to investors for their contributions to utility services.

"The trouble with that is that investors provide money with the understanding that they're getting a payout commensurate with the risk they're taking on," Kury said. "If the investor perceives that they are being asked to take on more risk than they expected, they'll pull their capital out and invest in something else. Customers might not pay for it in the short run, but if that capital is absent, the utility can't maintain itself and they end up paying in the long run."

Paying with investor money, of course, is not an option for systems that are wholly municipal and don't have investors or shareholders. However, putting the burden on wealthy investors who may be able to take the additional risk can be appealing to a public unwilling or unable to pay the debt.

Kury said that who ends up paying depends on how big the debt gets.

"The total debt load is looking like it's about 25% of what was earned in 2019," Kury said. "If you charge that to ratepayers, then people are going to be upset. That's probably the cleanest solution, but if the price tag is high enough securitization looks more attractive to policymakers because it kind of hides the cost. Government debt is a big thing, and the securitization of this debt would just become a small part of the larger debt. What happens depends on the magnitude."

Unwilling or Unable?

One of the hottest points of contention about the debt is whether those responsible for it are merely unwilling to pay it off, or genuinely unable.

"We had to do something, and these moratoria were an important first step to prevent people from losing essential services. But then you have to start looking at what it costs, what are the benefits, who are we impacting," Kury explained. "If you tell people they don't have to pay their bill this month if they don't feel like it, then you aren't distinguishing between people who can't and people who just don't want to. And we need to get better at distinguishing between those two groups."

Separating the unwilling and the unable is no easy task. Even defining the terms is difficult, as Atkins explained.

"Many people will not pay their utility bill to be able to pay their rent," she said. "And people will go without food or medicine to keep their lights on or the water running. There is a ripple effect that happens. These kinds of choices keep you up at night."

***Will Fowler** is the Associate Editor of* Water Environment & Technology. *He can be reached at wfowler@wef.org.*

U.S. EPA Tightens Lead and Copper Rule

Regulatory action incorporates science-based testing protocols and better risk communication

By Jeff Gunderson

In December 2020, the U.S. Environmental Protection Agency (EPA) finalized an update to the Lead and Copper Rule (LCR). This is the first major update to the regulations concerning lead in drinking water in 30 years.

The new rule accelerates actions that reduce lead in drinking water to better protect children from lead exposure, EPA says. "For the first time in nearly 30 years, this action incorporates best practices and strengthens every aspect of the rule, including closing loopholes, accelerating the real world pace of lead service line replacement, and ensuring that lead pipes will be replaced in their entirety," said then EPA Administrator Andrew Wheeler.

The new LCR promises to reduce lead by more effectively managing corrosion control treatment. With the application of better science, the rule also mandates that water systems follow improved tap sampling procedures to better locate elevated levels of lead in drinking water.

In a press release, EPA highlighted the following improvements under the new rule:

- Using science-based testing to better locate elevated levels of lead in drinking water;
- Establishing a trigger level to jumpstart mitigation earlier and in more communities;
- Driving more and complete lead service line (LSL) replacements;
- For the first time, requiring testing in elementary schools and childcare facilities; and
- Requiring water systems to identify and make public the locations of LSLs;

Speedier Reporting Required

The new rule requires that utilities inform customers more quickly when testing finds high lead concentrations in water.

Under the previous rule, water systems were required to provide consumers with their tap sample results within 30 days. The new rule mandates that utilities alert consumers whose individual tap samples exceed the lead action level of 15 parts per billion (ppb) as soon as practicable but no later than 3 calendar days after the water system learns of the tap monitoring results. This speed is intended to enable steps to reduce lead exposure to be taken immediately.

A focus on improving transparency to increase community awareness

In the event of a systemwide action level exceedance, water systems are required to notify all customers within 24 hours and provide educational materials within 60 days. The previous 30-day notification rule is maintained for tap samples that are less than or equal to 15 ppb.

More Transparency

The rule update also incorporates a focus on improving transparency to increase community awareness and accelerate the replacement of LSLs. Water systems also must complete and maintain an LSL inventory. If the system serves more than 50,000 people, the inventory must be posted on a publicly accessible website.

To reduce elevated levels of lead in certain locations, the final rule also requires water systems to engage in a "find-and-fix" process to identify the causes of these elevated levels and take potential actions to reduce lead levels.

More information and supporting materials describing the final revisions to the LCR can be found on EPA's website at bit.ly/EPA-LCR.

Jeff Gunderson is a freelance writer and founder of Waterstone Writing Inc. (Portland, Oregon). He can be reached at jeff@waterstonewriting.com.

A 40-Year Plan to Improve the Great Lakes

A new regional approach to wastewater services is designed to seek lower costs for the region overall rather than individual systems.

More than 100 Great Lakes water resource recovery facilities, regulators, watershed advocates, and other stakeholders have cooperated to adopt a regional master plan for wastewater management. The plan will help guide services serving 2.8 million people in 79 different southeast Michigan communities, amounting to more than 24,000 km (15,000 mi) of pipes.

The plan, developed and managed by the Great Lakes Water Authority (GLWA; Detroit), aims to serve the region for the next 40 years. The plan is designed to give the region a "roadmap for the future" that improves water quality and manages affordability, according to a GLWA news release in December 2020.

"The Wastewater Master Plan is a true demonstration of the spirit of regional collaboration on which GLWA was established," said Sue F. McCormick, GLW CEO, in the release. "Pipes don't know where one community ends and another begins. This new plan is specifically designed to optimize the wastewater system based on need at the lowest cost for the region, as opposed to an individual system approach. It offers us tremendous opportunity to leverage the infrastructure the region has invested in to-date and identify future investments and improvements that will continue to advance water quality in the region for decades to come."

The plan will be implemented in three phases: Optimization; Adaptation and Expansion; and Sustaining. Some Optimization phase initiatives have begun. They include:

- launching a Regional Operating Plan for using data technology to optimize flow based on precipitation and overflow;
- expanding connectors to the Detroit River Interceptor at a cost of $15 million to redirect 605 million L (160 million gal) of wastewater to water resource recovery facilities;
- developing a Regional Water Quality Monitoring Program to collect real-time data on the Detroit, Clinton, and Rouge rivers as well as Lake St. Clair, which will be used to decide what areas need system upgrades or maintenance; and
- partnering with the Michigan Department of Transportation and Detroit Water and Sewerage Department to improve freeway drainage or treat flow prior to direction to the Detroit River.

Ancient Mayan Water Filtration Method Rediscovered

A team of archaeologists has discovered that the ancient Mayans living in the city of Tikal (in present-day Guatemala) more than 2,000 years ago used a water treatment process based on zeolites, a family of minerals used extensively in modern water treatment.

Kenneth Tankersley, curator of the University of Cincinnati's Court Archaeological Research Facility and lead author of a recent study about the discovery, said that the Mayans likely learned about zeolites' water-purifying properties by chance.

He said, "30 km (18 mi) outside the city there is a volcanic formation with amber-colored zeolite, and water flows out of it. They probably figured out that if the water there was good, maybe they could take some of that material and put it in their own water system. I think it's as simple as that."

In terms of mineral-based water purification, the finding suggests the Maya were more than a millennium ahead of European civilizations, and it challenges the notion that people indigenous to the Americas were technologically primitive.

"The truth of the matter is that ancient indigenous people didn't value the technologies of Old-World civilizations," said Tankersley. "What they were good at was taking care of this planet's most precious resource: water."

The zeolites used in Tikal were effective at removing both bacteria as well as inorganic contaminants, such as the mercury sulfide, that the Mayans used for painting and dyes. The research team noticed that those contaminants were not in the drinking water reservoirs that supplied Tikal.

"Some of our most powerful water filters on the planet today use zeolites," Tankersley said. "Because of their structure they have micropores that allow them to both adsorb and absorb toxins from the environment. That means it can attract and hold bacteria and toxins like mercury sulfide."

Tankersley said that the water is "cleaner than what comes out of my tap," and that he hopes conclusions from the study can find applications in the modern world. Much like the original Mayan discovery of zeolites' water-purifying properties, Tankersley and his team made their rediscovery serendipitously.

"We talk about the scientific method and creating theories and explanations, but in all scientific disciplines serendipity plays a huge role," he said. "Many of the world's greatest discoveries have been serendipitous. In a way we were very lucky, so I hope that we can use this discovery to help our modern society."

The Mayan ruins of Tikal still stand in the rainforest of Guatemala. Scientists recently discovered the civilization used a mineral filtration system. Wikimedia Commons

Water Found on Sunny Side of Moon

The U.S. National Aeronautics and Space Administration (NASA) has confirmed the presence of water on the sunlit surface of the moon. Water was previously thought to exist only on the cold, shadowed areas of the moon. This new discovery suggests that much more of the lunar surface may contain water, according to a NASA release.

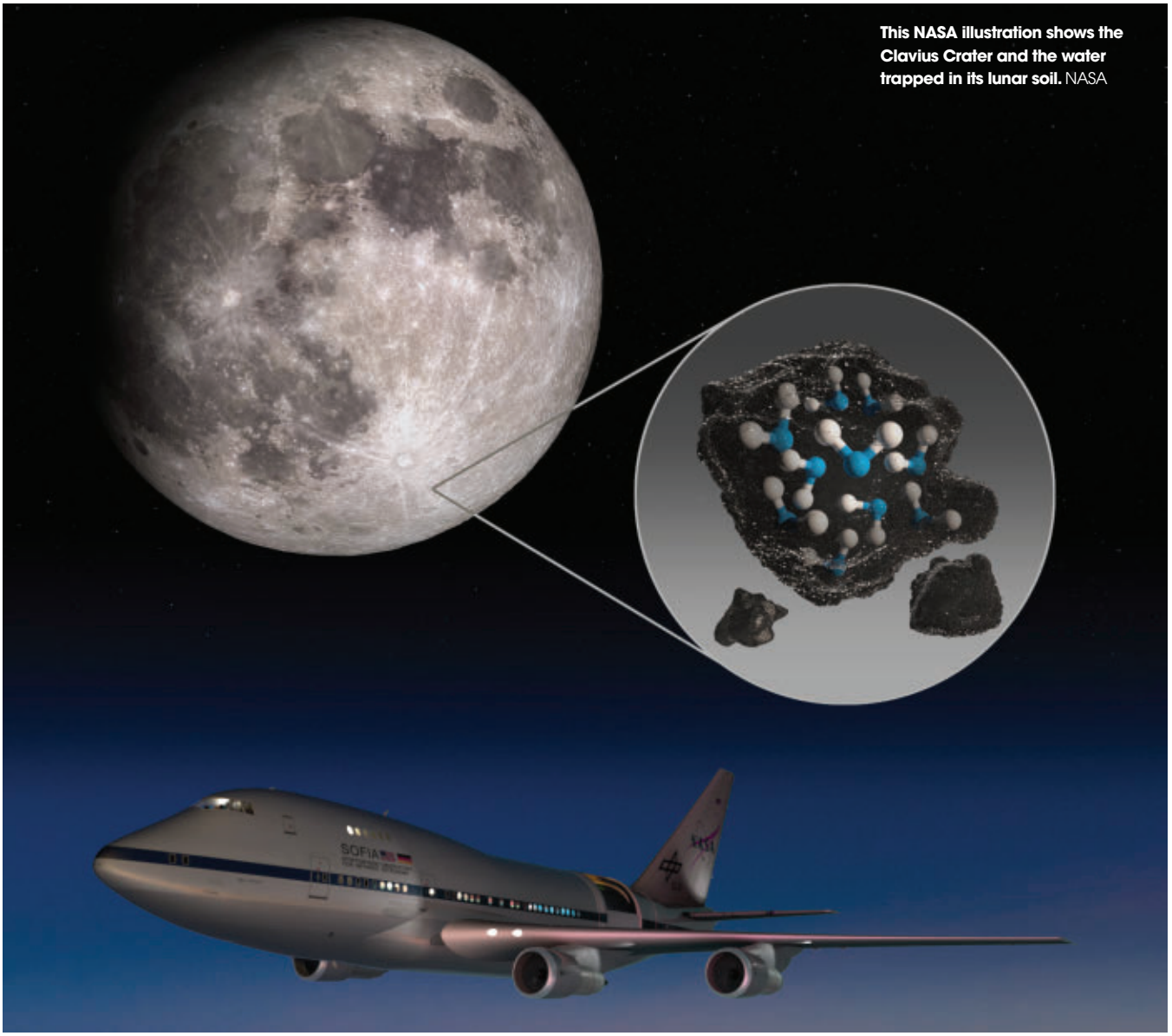
The water was discovered in Clavius Crater, one of the moon's oldest and largest craters, measuring 231 km in diameter — about the length of the U.S. state of Vermont. Previous surveys of the crater had detected hydrogen, but they were unable to distinguish between water and hydroxyl, which is chemically similar. New technological innovations — such as an aerial telescope carried by plane — have enabled more precise measurements of lunar water.

What forces deliver or create the water, however, remain unknown.

"Micrometeorites raining down on the lunar surface, carrying small amounts of water, could deposit the water on the lunar surface upon impact," wrote Felicia Chou, Public Affairs Officer at NASA headquarters, in an article published on phys.org. "Another possibility is there could be a two-step process whereby the Sun's solar wind delivers hydrogen to the lunar surface and causes a chemical reaction with oxygen-bearing minerals in the soil to create hydroxyl. Meanwhile, radiation from the bombardment of micrometeorites could be transforming that hydroxyl into water."

Data from the Clavius Crater reveals water concentrations of up to 400 ppm. The amount is negligible — the Sahara Desert has about 100 times the water of lunar soil — but the fact that water is there at all raises new questions about how water forms and how it has persisted on the lunar surface without air.

"This discovery challenges our understanding of the lunar surface and raises intriguing questions about resources relevant for deep space exploration," said Paul Hertz, director of the Astrophysics Division in the Science Mission Directorate at NASA Headquarters, in a release.

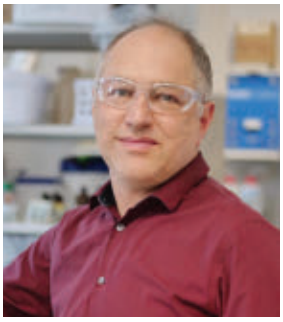


This NASA illustration shows the Clavius Crater and the water trapped in its lunar soil. NASA

Ultraviolet Expert Karl Linden Wins 2020 Clarke Prize

During the last few decades, using ultraviolet (UV) light for wastewater disinfection and oxidation has become common, trusted practice. The rise and spread of UV technology results from the efforts of such sector-leading experts as Dr. Karl Linden.

In November 2020, the National Water Research Institute (NWRI; Fountain Valley, California) awarded its annual Clarke Prize for Excellence in Water Research to Linden, a civil engineering professor at the University of Colorado, Boulder. Clarke Prize nomination materials describe Linden as the world's most published researcher in the fields of UV light-emitting diode (LED) systems as well as UV disinfection and oxidation for decentralized water resource recovery facilities (WRRFs).



Karl Linden

"This is a huge honor," Linden said. "The Clarke Prize is known as the highest honor for water treatment innovators in North America, and to be counted among this prestigious group is an honor for me and my students and colleagues who have worked together with me over the years."

In his various roles, Linden and his colleagues have made revolutionary breakthroughs that have helped shape the way WRRFs use and understand UV today.

Linden also received the Water Environment Federation (WEF; Alexandria, Virginia) 2013 Pioneer Award in Disinfection and Public Health. He has also contributed to WEF technical resources on disinfection.

Linden describes that the technologies that enable UV treatment are becoming more sophisicated and accepted. Confidence in UV performance has risen in recent years, in part because of the thorough, scientifically sound validation protocols he and his collaborators helped develop.

"When I published my first UV paper in 1993 as a graduate student, there were only a dozen or so citations that year for publications with the topic key words of 'UV and Water Treatment and Disinfection'," Linden recalled. "In 2020 alone, there [were] over 14,000 citations with these same key words."

Today, about half of newly installed WRRF disinfection systems rely on UV, Linden said. Linden's current work focuses on improvements to distributed treatment using LED-based UV and multi-wavelength systems.

"I see a bright future for UV processes in distributed wastewater treatment and reuse systems and supporting the transition to autonomous and remote operation," Linden said.

DOUBLE VISION

Digital twins facilitate cost-effective CSO monitoring and reporting

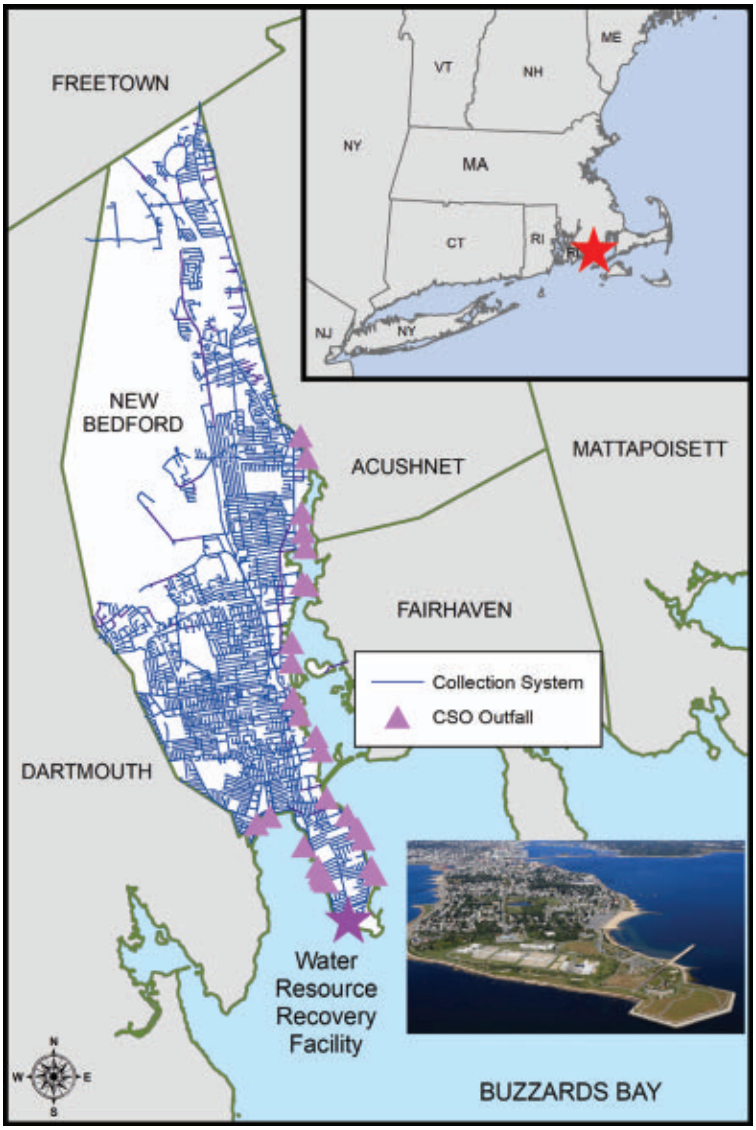
Scott Craig, Karilyn Heisen, Amy Corriveau, Shawn T. Syde, and Justin A. Chicca

The City of New Bedford in Bristol County, Massachusetts, is on Buzzards Bay. Nicknamed "The Whaling City" during the 19th century, the city was the most important whaling port in the U.S. The city's age and development history has resulted in a large and complex combined sewer system. Smart water approaches are proving valuable for managing the system's operations, performance, and regulatory requirements.

Like combined sewer communities across the country, New Bedford is required to monitor and report combined sewer overflow (CSO) activity through its National Pollution Discharge and Elimination System (NPDES) permit. In addition to reporting under the permit, the city must also report CSOs under an Administrative Order (AO) on Consent. The U.S. Environmental Protection Agency (EPA) typically prefers monitoring at CSO outfalls with permanent flowmeters to identify the frequency and magnitude of CSOs. This approach is generally consistent with proposed "right to know" legislation. These monitoring and reporting requirements pose significant burdens to CSO communities. Monitoring costs, meter accuracy, meter accessibility, system complexities, and other technical issues can limit a community's ability to successfully monitor CSOs.

New Bedford 's collection system has unique characteristics and a configuration that complicates CSO monitoring. Installation of permanent meters in the city's 27 outfalls is not an option due to stormwater discharges that share a common outfall downstream of CSO regulators, tidal influences, and accessibility issues. While permanent flowmeters are often considered to provide the best means of reporting overflow magnitude, they are not always the best solution, since meters often have errors associated with them, especially when they are not installed or maintained properly. Additional challenges include meter calibration in normally dry locations, difficulty in measuring sudden and intermittent large flows, and isolating CSOs from separate stormwater discharge to the outfall pipe.

Figure 1. City of New Bedford Collection System



CDM Smith

CSO Control Plan

In New Bedford, the cost of implementing permanent monitoring would be significant due to system characteristics requiring monitoring of most of the 72 CSO regulators. An overview of New Bedford's collection system in shown in Figure 1 (above). Through development of a Long Term CSO Control and Integrated Capital Improvements Plan, completed in accordance with EPA's Integrated Planning framework, the city determined that investment in permanent monitoring at all CSOs would divert critical resources away from implementation of system improvements to address the city's Clean Water Act obligations. Although the Integrated Plan did not prioritize investment in a permanent CSO monitoring system, the city's Department of Public Infrastructure (DPI) Wastewater Division determined that it would be in the city's best interest to assess the possibility of implementing remote monitoring of targeted CSOs to streamline collection system operations. Historically, the city used a simple block testing program to assess CSO activity. Although relatively effective, the block testing program is labor intensive and prone to both human error and spurious data. In addition, block testing does not measure CSO volume as required by the NPDES permit and AO.

Given these needs, the city worked with a consulting firm to develop an approach for a pilot program to evaluate a remote CSO monitoring program. The pilot gauged the accuracy of various meter types and the feasibility of implementing cost-effective long-term monitoring. The city had an initial goal of eliminating the block testing program to reduce labor needs and capture real-time data that could be used to improve the city's existing EPA Stormwater Management Model (SWMM). After further consideration and review of available technologies, the city determined that remote monitoring could provide added flexibility for monitoring system performance. Remote monitoring could help minimize wet weather flooding, surveil areas prone to sediment accumulation, and — through the power of a digital twin — leverage the investment in the SWMM model to build real-time understanding of system issues. A digital twin replicates sewer system performance using a continuous simulation model.

Pilot Monitoring Program

Between 2018 and 2020, DPI implemented a pilot monitoring program at five locations. The pilot assessed the viability of implementing different types of meters (such as, level sensor and/or depth and velocity) and installation approaches for different regulator configurations. Metering data was compared to block testing data and to SWMM results using the digital twin platform that enabled analysis among the datasets and model results. Monitoring methods included a range of low-tech and real-time monitoring approaches paired with the digital twin. Each method differed in cost, ease of implementation, data accuracy, and other considerations.

Block testing has been employed by the city for more than 20 years as a reliable approach for checking overflows. This simple but labor-intensive method relies on a wooden block placed on the overflow weir wall, as shown in the images on p. 33. After storms or during extended dry weather periods, a crew visits each CSO regulator and notes whether the block is dislodged. Not all regulator configurations can be monitored using block testing, as it requires a suitable weir wall for placement of the block and easy access to the regulator.

The City of New Bedford, Massachusetts, compared data on combined sewer overflow activity that was gathered through level sensor testing (left and right) and block testing (seen in the blue block at right) to area-velocity meters. ADS Environmental Services

Level sensors provide more valuable data on overflow activity compared with block testing because they continuously record water depths that can be compared with weir elevations to determine overflow occurrence, duration, and severity. The level sensors used by the city provide continuous system monitoring using a narrow-beam ultrasonic sensor. The city deployed both extension rod and wall mount installations. These simple mounting approaches allow for easy removal, resetting, or relocating of the sensors as needed. Data are transmitted wirelessly to the supervisory control and data acquisition (SCADA) system.

Overflow estimates at each regulator are calculated based on reported depths and site-specific weir equations. The equations used to calculate overflow volume depend on the regulator type and structure configuration. Equations were selected based on the historical use of similar approaches in other communities where long-term monitoring data has been used to define the most appropriate equation based on regulator configuration.

The level sensors used in the pilot program were selected because they can be installed easily and without the need for a confined space entry, and they can be easily relocated. This flexibility was an important factor for the city when selecting a meter type. Level sensors provide accurate information on timing and duration of overflow events, as well as enable real-time alarms.

For the pilot study, overflow estimates from the level sensors were compared to flows measured with area-velocity meters. Area-velocity meters measure depth and velocity in the overflow pipe. Installation requires a confined space entry and direct access to the pipe being metered, as shown in the image on p. 34. Calibration of area-velocity meters is challenging in outfall pipes that are normally dry. Tailwater or tidal conditions and connecting storm drain flows discharging directly on sensors also can affect flow monitoring in outfall pipes. Accurate flow measurement requires correct depth, velocity, and cross-sectional area data. Consequently, system operation and maintenance, debris, surcharging, and flow surge may drastically affect the accuracy of velocity, depth, and channel section data used to calculate flows.

Digital Solutions

The metering approaches described above provided data in electronic formats. As part of the pilot program, this information was collected and compared to the city's SWMM model. To analyze the flow monitoring/level data and allow for future real-time comparison of system operations to the SWMM model, the city utilized a digital twin. The digital twin was developed in the consultant's platform. By integrating the continuous feed of data into the platform, the simulated twin was compared against observed conditions for validation of expected system performance. This approach enabled the city to answer questions about actual system performance and what should be expected according to the model compared with what actually was happening according to meter data.

The platform accessed flowmeter and level data via an integrated application programming interface and simulated system performance in SWMM

Area-velocity meter in-pipe placements are challenging because they require confined space entry and direct access to the pipe being metered. Flow Assessment Services

using these data. It also incorporated rainfall data collected by the city, using tipping bucket rainfall gauges along with public domain data relevant to the receiving waters such as tidal data from the National Oceanic and Atmospheric Administration. The cloud-based platform then analyzed the data and model results. Model simulation results and data were posted to a secure web viewer for easy access and viewing. Sample output is shown in Figure 2 (p. 35).

Pilot Monitoring Program Results

The 2020 pilot program consisted of level sensors deployed at five locations and area-velocity meters installed downstream of three overflow weirs to compare measured flow with overflow estimates based on the level sensors and the SWMM model. The overflow monitoring locations were selected to represent a variety of regulator types. Each regulator had unique hydraulic conditions that had shown higher or lower overflow frequencies as compared to block testing based on previous reporting.

The study found that the level sensors matched the general number of events recorded by the block testing and area-velocity meters in outfalls; however, in several instances overflow volumes were determined to be either over- or under-estimated by the area-velocity meters. This was caused primarily by other inflow sources, such as direct catch basin connections or tailwater conditions due to tidal influences. Metered flow results were compared to flows calculated from site-specific weir equations using data from the level sensors. The results demonstrated that it was appropriate to develop site-specific weir equations to provide calculated overflow volumes. In some locations, tailwater and downstream conditions influenced overflow volumes driving the need to recommend additional meters either upstream or downstream of regulators to validate overflow results.

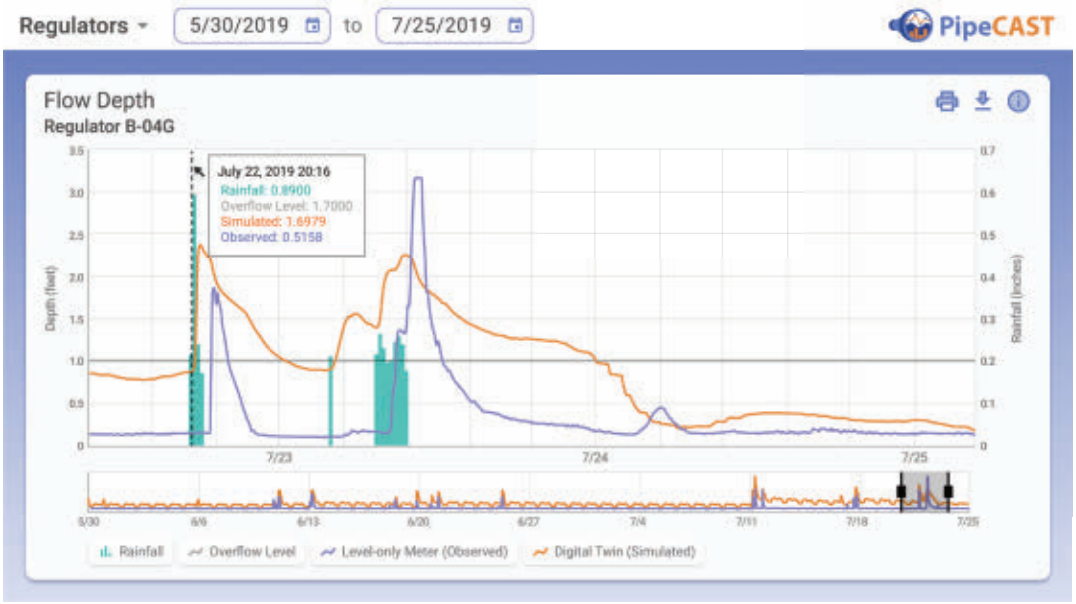
Hybrid Approach Chosen

The CSO Monitoring Pilot Program concluded that use of level sensors combined with site-specific weir equations and the calibrated SWMM model was cost-effective and offered the preferred means to estimate frequency and volume of CSO. Area-velocity meters in outfalls are not a viable long-term monitoring solution due to the complexities associated with tailwater effects, stormwater system inflows, meter calibration requirements, and installation challenges that limit flexibility for meter relocation. The results also determined that a hybrid solution, including level meters, block testing, and a digital twin, would be the most cost-effective and appropriate long-term solution for the city. The hybrid approach will allow the city to meet EPA's requirements under the NPDES permit and AO for reporting CSO volume. More importantly, it would provide the city with means to streamline system operations and advance from reactive to proactive maintenance and emergency response.

The use of a digital twin is enabling the city to selectively deploy CSO monitoring and evaluate system performance without having meters at all outfalls or regulator structures. This is possible due to the functionality of the digital twin platform, which enables the city to compare observed and expected performance and to integrate all data as it is collected. This process inherently helps the city make sense of the data, identifying anomalies in measurements or model results, so that appropriate action can be taken to check meters, improve model representation if necessary, and adapt the monitoring plan or the overall integrated plan based on the information gathered. Through implementation of the pilot program and development of the digital twin, New Bedford identified a sensible metering approach while satisfying EPA requirements. The approach provides useful data to city engineering and operational staff beyond just CSO metering.

The metering approach combined with the digital twin bridges the gap between city engineering and operational staff allowing them to work together to quickly assess system performance and issues. Coupled with the flexibility of the level sensors, DPI staff can proactively adjust metering locations

Figure 2. Sample Real-Time Digital Twin Results



The use of a digital twin allows for comparison of expected depths to real time monitoring results and recorded precipitation. CDM Smith

based on the current system information. This approach enabled the city to cost-effectively leverage both metering data and the model, both of which represent considerable investments for the city.

Looking Ahead

Given that the pilot metering program was successful in achieving the project's objectives, the city in 2020 initiated rollout of an expanded and targeted monitoring program. The monitoring program will expand the current five meters and single rain gauge to 30 level meters and two rain gauges. Metering will continue at the five locations monitored for the pilot study, and three meters will be placed downstream of regulators to monitor tailwater and tidal conditions. An additional 18 level meters will be deployed at regulators, and four meters will be deployed within the collection system to provide information on maintenance and operation.

Once implemented, the proposed monitoring program will monitor overflow events at a total of 23 out of 72 regulators at a cost of $125,000 per year, capturing key insights into discharges to receiving waters. Metering locations were selected to provide a representative assessment of effects to receiving waters, as well as to help refine system understanding where additional information may be useful to operations and engineering staff.

In parallel, the city will expand its use of the digital twin platform to take advantage of additional features available through the software to facilitate proactive, data-driven decisions on system operations, maintenance, and facilities planning. These additional features include the integration of electronic field reports with GIS and the city asset management system, the comparison of expected performance with real-time performance to assess high O&M areas, and the incorporation of SCADA systems to monitor system operations. Once fully implemented, the city will be able to access real-time SCADA output, continuously monitor depths at CSO regulators, and track CSO discharge volumes and system control gate operations.

This approach of expanding monitoring locations, while simultaneously monitoring real-time data, will help the City of New Bedford make better use of its resources while satisfying the "Right to Know' requirements and regulatory reporting. This approach has the potential to be used as a model for other utilities facing similar CSO monitoring challenges.

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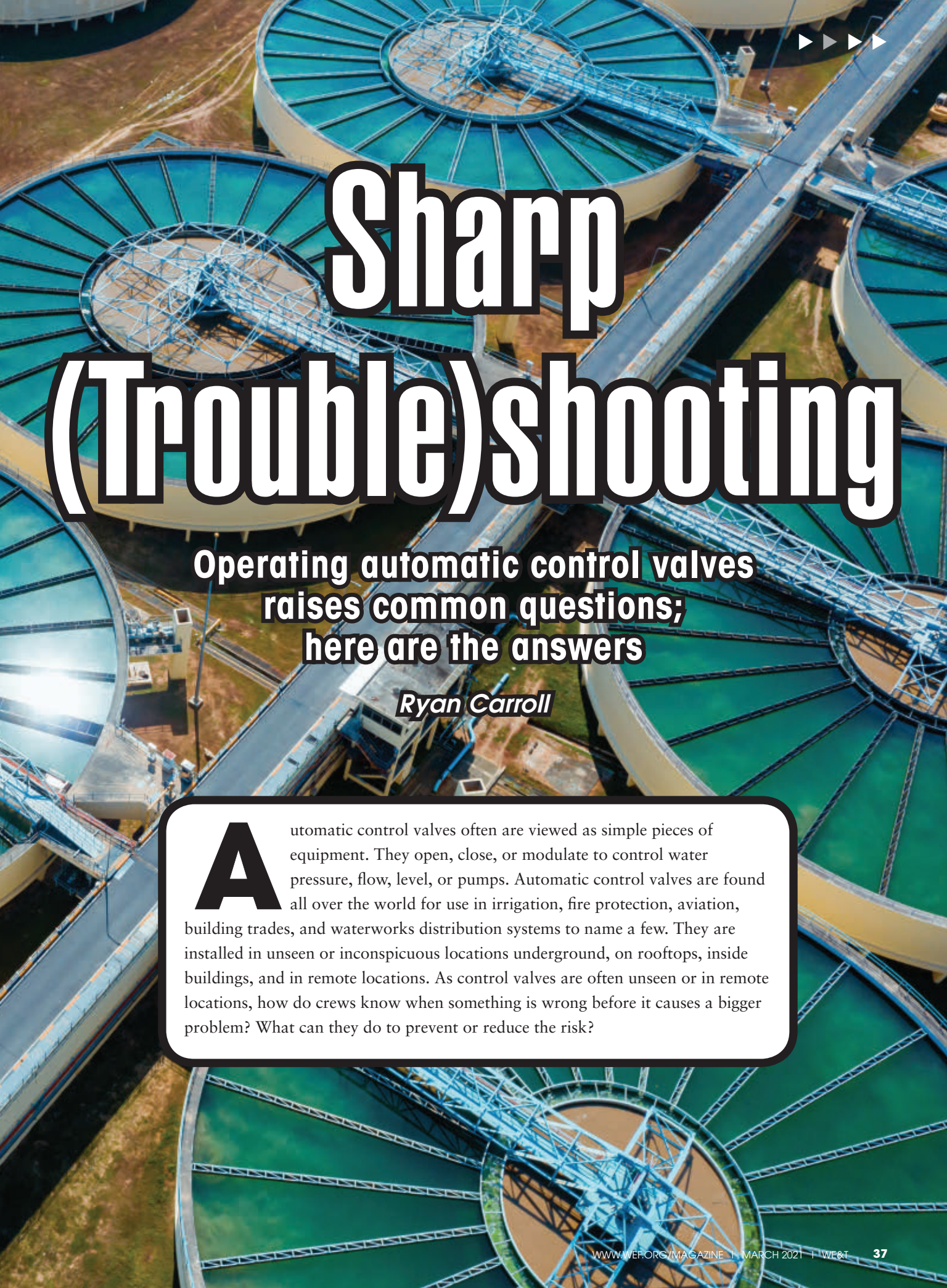
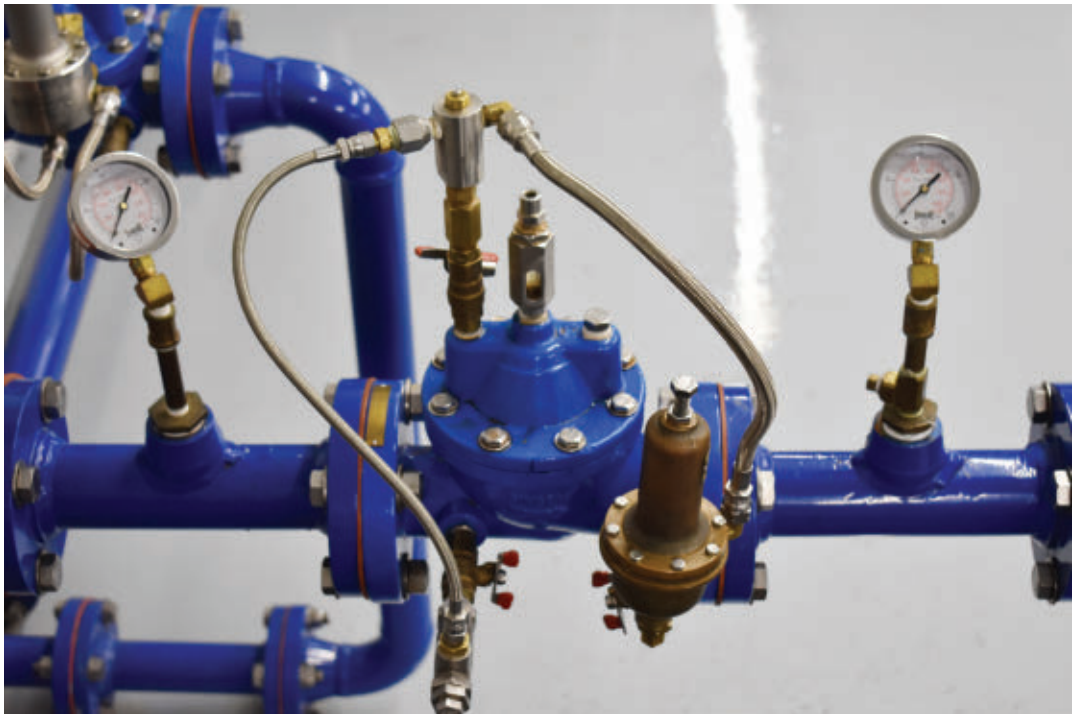


Sharp (Trouble)shooting

Operating automatic control valves raises common questions; here are the answers

Ryan Carroll

Automatic control valves often are viewed as simple pieces of equipment. They open, close, or modulate to control water pressure, flow, level, or pumps. Automatic control valves are found all over the world for use in irrigation, fire protection, aviation, building trades, and waterworks distribution systems to name a few. They are installed in unseen or inconspicuous locations underground, on rooftops, inside buildings, and in remote locations. As control valves are often unseen or in remote locations, how do crews know when something is wrong before it causes a bigger problem? What can they do to prevent or reduce the risk?



This 2-in. Singer pressure-reducing valve sets a maximum downstream pressure regardless of fluctuations in demand or inlet pressure. Mueller Water Products

The capabilities of the control valve hold the answers. Many control valves are located in areas where access to power is unavailable. In these locations, hydraulic pilots sense flow, pressure, or level to control valves. The operators responsible for these valves should look to create and/or use a preventive maintenance and valve exercising program. This would ensure the correct valve operation. The valves also would perform as required when hydraulically called into service. If there is access to power, then electronically actuated controls using solenoids, motor operators, and panels will help integrate the control valve to a supervisory control and data acquisition (SCADA) system and enhance the monitoring and control of the system or zone it controls.

When choosing a control valve for a specific application, consider conditions that will exist where control valves do not perform well and should be avoided when possible. Control valves need at least 10 psi of differential pressure to work effectively in most cases. If you do not have this amount of differential in the application, it is recommended to partner with a control valve manufacturer to help provide a solution. Issues like cavitation will occur whenever there is a pressure drop of greater than 65% through the valve. This condition is unavoidable at times and can be mitigated by using orifice plates or anti-cavitation trim to provide additional pressure drop areas before the water flows downstream of the valve. Anti-cavitation trim should be an engineered product created for the application to ensure the destructive nature of cavitation is controlled.

There are many operational issues one faces when dealing with a control valve. Here are some of the common questions I hear and the answers I have found.

Question: What are the locations and functions of each control valve in the system?

If you are responsible for a system with multiple automatic control valves, I recommend creating a spreadsheet or database to enter the important data about the valve. Enter the manufacturer, model, serial number, and any other pertinent information available. Take a picture of the valve when it is installed when possible. Then, use a map to show the location of the valve with a corresponding number that can be cross-referenced with the spreadsheet or database. Make a reference sheet of customer service numbers for manufacturers responsible for items within your system and who is responsible for service and supply for those valves. The database can be used to keep track of valve servicing and additional parts that may be added to the valve and changes made to its operating conditions.

Question: What are the most important maintenance tasks for valve operators to perform and how can we streamline tasks?

As mentioned earlier, there are many valves that perform control tasks for different applications in different areas. For example, valve 1 may perform the same tasks as valve 2, but valve 1 operates in a distant area with more particulates, increased pressures, and a higher possibility for tuberculation (the formation of small mounds of corrosion products on the inside of iron pipes). As these are identified, valve 1 is at a much higher risk for problems that can lead to reduced performance. If maintenance is not performed at an appropriate rate — i.e., most likely quarterly — it may lead to a failure due to a blocked strainer. If electrical options are present, utilizing local panels or integration to SCADA controls can alert an operator to a possible failure in some applications. Many manufacturers have products that can help with reactionary maintenance options, but a good preventive maintenance program will reduce the failures a system may experience.

Question: Are quick reference manuals or troubleshooting guides readily available for every operator or maintenance tech?

When troubleshooting a control valve, it is always recommended to have the schematic of the valve as well as the instruction and operation manual (IOM) on site. Many manufacturers of automatic control valves provide a full submittal document about every item utilized to make the control valve function as it is provided from the factory. In addition, an IOM is provided with a schematic, valve startup instructions, and troubleshooting FAQs. If this manual is lost or unavailable, many manufacturers maintain a library of IOMs on their website or with their customer service team. If the troubleshooting issue is not addressed either in the IOM or the submittal documents, contact the manufacturer for assistance.

Question: Does the operator know how to manually override the control valve to close, open, or lock the valve and its current hydraulic position?

Using isolation ball valves at the ports of the pilot system will enable an operator to close the upstream ball valve to lock the main valve in an open position, close the downstream ball valve to lock the main valve in a closed position, and close the top cover/bonnet ball valve to lock the diaphragm in its current position. These isolation ball valves enable the operator to lock the valve in certain positions to perform safe maintenance of the main valve and the pilot system without removing the valve from the line. For operators who do not know how to perform these tasks, many manufacturers hold training courses on automatic control valves.

Question: Are any regular tests of the hydraulic system required?

A valve can be tested at any time and often simply by utilizing the above-mentioned pilot system isolation ball valves and or by a gate valve exercising program. The use of these isolation valves ensures both the spring settings of the pilot controls and the function of the mainline valves as well.

As control valves are often unseen or in remote locations, how do crews know when something is wrong before it causes a bigger problem?

Question: If SCADA is in use by the utility, can information be transmitted back from existing control valve locations?

Yes, a control valve is an asset to be used for information, as well as control. Every valve manufacturer has a multitude of transmitters, in addition to controls, and whether it is converting a standard hydraulic valve into a metering control valve or passive metering measurement. If one has the right amount of differential pressure, a diaphragm-actuated automatic control valve can control or measure almost anything a district would want or need.

Ryan Carroll *is the Training Manager at Mueller Water Products (Atlanta).*

Operational Edge

Total Insight enables digital transformation for sustainable, continuous business improvement

Nicholas Meyer and Kevin Finnan

Yokogawa

As companies in the process industries pursue their digital transformation journeys, the collective role of process analyzers and field instruments such as pressure transmitters, flowmeters, and the common pH and conductivity analyzers can vary widely. Thousands of them could be deployed in a manufacturing facility. Although they have not moved physically, these instruments have found themselves in a situation now described as "the Edge."

Where do they fit into the digital transformation strategy? While digital transformation plans often overlook measurement instruments or simply look at them as a number, certain types of instruments actually could be digital transformation enablers.

Operations Rely on Data

The transformation program team might be quick to list an analog device such as a pressure transmitter that outputs a 4–20 mA signal as a "non-digital" entity that calls for replacement. However, in a facility in which thousands of them operate, that will not happen very quickly. Although the analog instruments support very little in terms of the needs of a digitally transformed enterprise, they can be enhanced with wireless communications and effective analytics at the Edge or in the Cloud. Those enable the facility to realize reasonable value from the limited information that can be derived from analog instrumentation.

Ultimately, however, facilities will demand a comprehensive digital infrastructure that extends to

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the Edge. Otherwise, they cannot fully realize all the benefits digital transformation offers.

Facilities rely heavily on devices at the Edge. Actuators, analyzers, flowmeters, sensors, transmitters, and valves are where the physical world first meets the digital world. Sensing devices form the foundation of an operating technology platform and, collectively, indicate a facility's vital signs. Sensor data informs and drives the performance of operations. Analytical models, artificial intelligence, digital twins, machine learning, and many other technologies count on it. A successful digital journey rests on the quality and fidelity of measured data.

Better Analysis, Better Results

Sensor technology is not only changing the way process data is measured, but also the way it is analyzed. Eradicating process errors and improving asset efficiency has never been as important as it is for connected facilities of the future. Process operations generate large volumes of data. While in the past those large amounts of valuable data would be largely unused, a digitally transformed enterprise will take complete advantage of it.

Measurement instrumentation began its digital journey nearly 40 years ago. Microprocessor-based smart transmitters not only improved performance versus analog instruments, but they also were able to generate valuable data in addition to the measured variable. As smart instrumentation evolved, it added functionality that was useful to asset management and provided insight into the process.

Intelligent Instruments

Recently, a new class of intelligent instrumentation has emerged. It consists of flowmeters and transmitters that integrate seamlessly into a digitally transformed enterprise. Instrument manufacturer Yokogawa (Houston, Texas) has branded this concept as Total Insight and built it into its SENCOM 4.0 product line. These instruments possess deep knowledge of their health status for predictive asset management and of the process for use in conjunction with advanced analytics and digital twins at the Edge, in the Cloud, and on premise.

Concepts such as this create sustainable value throughout the product life cycle. They fully support the primary digital transformation focus areas including asset availability and reliability; human effectiveness; safety, sustainability, and compliance; and operational performance and productivity.

The figure on p. 43 shows the features available in intelligent instrumentation that can help answer questions on these topics.

Digital Twin

Concepts, such as Total Insight, support digital transformation strategies through digital twin technology. The instruments, themselves, incorporate asset management digital twin technology internally.

A digital twin is a virtual, digital copy of a device, system, person, or process that accurately mimics actual performance in real time. These twins are executable and configurable and enable a better future to be developed.

Digital twins work in the present, mirroring the actual person, device, system, or process in simulated mode, but with full knowledge of its historical performance and an accurate understanding of its potential in the future. In this way, the digital twin delivers the full scope of hindsight, insight, foresight, and oversight. As an advanced decision support tool, a digital twin enables improved safety, reliability, and profitability in design or operations through forecasting (what's next?), prediction (what if?), and optimization (what's best?).

Putting It Together

Digital twins replicate real-world events and actions by combining live sensor inputs from their physical counterparts with historical-performance data. Digital twin technology relies on a first-principle model, which simulates the performance of an asset; the physical process feeds input into the algorithm, which then uses that data to generate an accurate digital representation of the real-life event. The first-principle model is the same as those used in process simulators.

However, unlike a simulator, a digital twin is an accurate representation of the asset that goes beyond just in a particular operating case. This representation extends over the twin's full range of operation, all the time. Instead of a static provision of a snapshot in time, the digital twin captures the full history and future of an asset. The digital twin operates in an automated manner, making regular model runs that are built in to business workflows. It provides a centralized, single version of the truth, used by everyone, with outputs delivered directly to the business.

Digital twins operate at multiple levels and perform many functions ranging from asset management, predictive maintenance, production optimization, and value chain optimization.

Instrumentation and equipment productivity. Real-time and predictive data that digital twins collect reduce the risk of equipment breakdown by improving predictive maintenance outcomes. For example, data drift could be an early problem indication. Stakeholders can reduce operational expenditures through online monitoring and prediction of field device health.

Advanced chemistry. Pumps, flowmeters, transmitters, and chemical analyzers are highly intelligent devices that provide asset performance information and live process information to process and maintenance-purpose digital twins. The digital twins recommend ongoing performance optimizations for the process and instrument operations and add adaptability to changing duty requirements throughout the intelligent device life cycle.

Increased production and predictive maintenance. Breakdowns in any manufacturing system can result in delays along the supply chain. Digital twins make it possible to run an artificial intelligence or machine-learning model with a first principle-based process simulator to identify predictive maintenance and keep downtime to a minimum.

Facility process optimization. Operators can use digital twins to create high-fidelity models that they can use for performance monitoring, simulation, and optimization to deliver enhanced yield performance, flow assurance, energy-efficiency improvement, enhanced reliability, and operator-capability assurance.

Capabilities with Total Insight

While digital transformation plans often overlook measurement instruments, certain types of instruments could actually be digital transformation enablers. Yokogawa

Value-chain optimization. Understanding when and where products are in demand enables companies to adjust production and labor needs while exploiting market opportunities. Data analytics that operators derive from digital twin applications is invaluable when predicting market demand.

Asset life cycle. Operators can use data this digital twin captures to determine real-time performance across the entire life cycle of an asset for optimization.

Enterprise insight. Digital twins can set up a simulation based on existing key performance indicators. Given a dashboard with information that a simulator-based digital twin provides, operators can use the model in real time and run multiple hypothetical scenarios or predict the future course of a facility based on existing data.

Working in conjunction with intelligent instruments, digital twins facilitate information flows across organizational boundaries and enable faster identification and resolution of unit issues. With improved performance gap visibility, second-guessing of decisions is minimized and the organization can more quickly to realize benefits and outcomes. Ultimately, intelligent instruments enable digital transformation benefits including enhanced profitability, improved reliability, improved safety, extended asset performance, reduced asset failure, higher return on investments, and vastly improved productivity.

Digital Transformation

For process manufacturing industries, digital transformation has moved to center stage. At the highest levels in practically all organizations, it is no longer viewed as a matter of investigation and experimentation, but a strategic imperative linked to survival and innovation.

Key Takeaways

- A typical process facility will contain thousands of actuators, analyzers, flowmeters, sensors, transmitters, and valves. These instruments are where the physical world first meets the digital world.
- While digital transformation plans often overlook measurement instruments, certain types of instruments actually could be digital transformation enablers.
- Digital transformation technologies such as digital twins depend on trustworthy data from Edge devices to achieve their intended results.
- The digital twin works in the present but possesses full knowledge of an asset's historical performance and an accurate understanding of its future potential.
- Smart devices, such as Yokogawa's line of Total Insight transmitters and flowmeters along with the SENCOM 4.0 liquid analyzers platform, contribute to digital transformation during operations and throughout the life cycle of the instrument.

While digital transformation means different things to different people, its concept can become a mantra for earning relevance and establishing leadership in a digital economy. Rather than reacting to change or being disrupted by it, forward-looking leaders are investing in digital transformation to adapt, achieve operational excellence, and outperform peers.

There is no "one size fits all" approach to operational excellence. A utility's or company's approach could vary broadly depending on its sector, company size, and digital maturity. For instance, a smaller facility may view operational excellence to mean consistently producing a product at export quality, expanding facility capacity, or expanding regional and global business. On the other hand, a digitally savvy operation could be pursuing remote, unmanned, or autonomous operations.

Benefits in common to all approaches to digital transformation include the following:

Updated company vision. The company or utility vision is modernized and earns support from customers who have digitally transformed or are in the digital transformation process.

Thriving culture of innovation. This effort creates a buzz within the organization and inspires a culture and ability to innovate in product and service development.

Deeper data analysis. An improved understanding of what data exists and where it is across the organization. This translates into the ability to infer insights and deepen customer analysis to prove return on investment.

Increased customer value. A true 360-degree, seamless customer experience contributes to increased conversions and customer loyalty.

Improved customer journey. Customers naturally continue every step of their journey, improving conversions and outcomes.

Increased internal collaboration. Collaboration significantly improves between business functions to unlock greater business value and efficiency.

Empowered workforce. Leadership and employees feel empowered through greater knowledge and information.

Improved efficiency. Decision-making and processes become more efficient across departments.

Sustainable continuous improvement. In a survival-of-the-fittest environment, businesses that can continue to adapt and lead will thrive in a dynamic business climate.

For process manufacturing operations, the primary focus areas are asset availability and reliability; human effectiveness; safety, sustainability, and compliance; and operational performance and productivity.

Instruments like this ADMAG TI (Total Insight) Series AXG Magnetic Flowmeter integrate seamlessly into a digitally transformed enterprise. Such intelligent instruments possess deep knowledge of their health status for predictive asset management and of the process for use in conjunction with advanced analytics and digital twins.
Yokogawa

Asset availability and reliability goals call for no unplanned outages; flawless startups, shutdowns, and transitions; obsolescence management; and predictive maintenance. Human effectiveness goals include a skilled, motivated, and informed workforce and a rigorous adherence to operating plans.

Safety, sustainability, and compliance goals address functional safety, physical, and cybersecurity; environmental stewardship; and regulatory compliance. Operational performance and productivity measures target maximizing revenue, capital expense management, and operating cost containment. It also will provide for an agile response to market changes and a culture of profitability.

Operating at the Edge, instruments, like those with Total Insight, seamlessly mesh with digital transformation implementations in a manner that supports all of your goals and objectives.

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Tapping Partnerships for

Better Data

Strengthen the drinking water treatment barrier model through alliances

Michael M. Domach

Drinking water treatment facilities (DWTFs) are viewed and thus managed as barriers to the transmission of offensive or deleterious physical, chemical, and virulent agents to customers. A barrier's success is evaluated by post-treatment and within-system sampling for the abundance of biological surrogates, such as *E. coli,* and molecular classes, such as trihalomethanes (THMs). The results are made available regularly through publicly accessible online data portals. In the Commonwealth of Pennsylvania, for example, the Department of Environmental Protection (PA DEP) maintains the Drinking Water Reporter System.

What is measured routinely in the raw water is variable. In many places, state environmental departments perform and/or report no or few raw water measurements that are then sent to the National Water Quality Monitoring Council (NWQMC). In cases where measurements are made by state DEPs and reported nationally, the data sets are rich in some categories but lean in other aspects. For example, PA DEP reports monthly measurements on the Allegheny River ahead of the intake of the Pittsburgh Water and Sewer Authority (PWSA) DWTF. The data are limited to physical properties, such as conductivity or the concentrations of inorganics; there are no measurements of organic compounds routinely made. It should be noted, however, that surveys for organics of concern, such as per- and polyfluoroalkyl substances (PFAS), are done by a number of state DEPs — including PA DEP — in light of emerging new science.

Moving from the state DEP to the utility side, raw water measurements are often confined to a short list of metrics such as turbidity, pH, chlorite, etc. A certified operator, as opposed to an accredited laboratory, can perform such measurements under an Accreditation by Rule provision, for example. The prospects for a utility to gather more information on its raw water can be problematic. Increasing analytical capability raises the costs and managerial oversight associated with staffing and certification. Indeed, many utilities outsource the required analysis of the treated and distributed system water samples to avoid laboratory maintenance and certification costs that would have to be passed on to the rate payers.

Beyond state DEPs and utilities, there are independent organizations that provide raw water measurements to the NWQMC. One watershed-based and multistate-spanning example is the Ohio River Valley Water Sanitation Commission (ORSANCO). Over the years ORSANCO has provided data on organic compounds, such

This inclined settler at the Pittsburgh Water and Sewer Authority pilot facility can be used to test different ways to operate and optimize the coagulation–flocculation process. By combining both sentry monitoring to detect changing conditions and pilot facilities like this, utilities can move toward a proactive control stance. Courtesy Michael Domach

as phenol concentration in raw water from the Allegheny River, which is a tributary to the Ohio River as well as one source of drinking water for Pittsburgh. Another data gathering group on the Allegheny River is the U.S. Geological Survey (USGS). The River Alert Information System (RAIN) is a smaller scale way to gather data on the Allegheny River. The idea behind RAIN is to establish a network of sensors down the river's course. Should an anomalous conductivity event arise, for example, the sensors flag it and alert downstream stakeholders. The network is not fully operational at the moment because of needed financial support. RAIN does not appear as a source of data currently available at NWQMC.

The above illustrates that the current understanding of raw drinking water composition and dynamics relies on a patchwork of information gathering techniques. Within the spectrum, there are information gaps at one end while the other end has very few gathers making useful but limited measurements. Adding to the patchwork nature: There is a mix of privately held versus publicly available data.

While it is not broken, the barrier model can be better. The case for upgrading raw drinking water information as a means for improvement can be seen from the historical review of a 2010 water supply issue in Pittsburgh and through modern standards of optimal control drawing on the trajectories of industries that are especially sensitive to raw material variations. There are two examples of paths forward for barrier strengthening.

The Allegheny River Bromide Argument

One consequence of the patchwork of raw water analyses is if something arose in raw water that could challenge a barrier, the detection and attribution of causation could be somewhere between awkward to confounded if there was no obvious episodic source like a transportation spill. A fairly recent example of such a challenge comes from Pittsburgh.

About a decade ago, elevated bromide levels were discovered in the raw drinking water supplied by the local rivers. Press accounts attributed the detection to sampling done by PWSA and augmentation and verification by local universities.

Two concerns emerged: What was the source of the bromide, and would there be increased production of brominated compounds from the treatment system? Public debates and consultant hiring followed. Theories circulated concerning the source. They ranged from alternate industrial sources to a "normal" low water flow fluctuation that had not been well characterized because no one had really looked as hard before.

One strategy now in use in Pittsburgh is a watershed alliance.

Looking at the data publicly available at that time illustrates where the surprise came from and what the response looked like. The figure on p. 49 summarizes the bromide concentrations uploaded to NWQMC by the three major different river monitors in the Pittsburgh locale: PA DEP, ORSANCO, and USGS.

Prior to the "crisis" in 2010, the bromide concentration data available to all stakeholders was sparse. Just exactly when the increase started is hard to pin down. Whether a spike coincides with historical variation is also hard to establish. Such uncertainty can complicate determining causality and responsibility. The mix of privately held and publicly available data further complicated messaging to customers and setting public expectations.

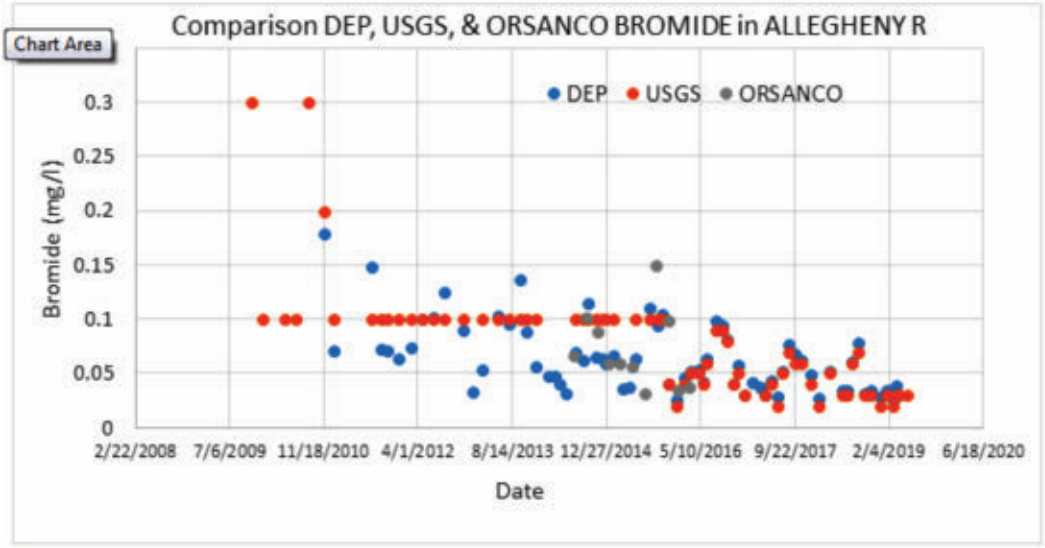
After 2010, data collection and public reporting increased. However, source-based differences in the values reported between 2010 and 2015 highlighted differences in protocols or resolution assumptions. In 2016, the data found on NWQMC from different sources began to align.

Overall, the bromide case shows the importance of having baseline data with sufficient detail gathered at an adequate frequency. To know there is (or could be) a problem, you must see a difference. Communications with water consumers are complicated as well in a fragmented data sphere.

Modern Process Control

The Pittsburgh example sets the stage for thinking now in terms of process control. Process control aims to detect anomalies and exert corrective action and use material and energy resources optimally. Optimization is enabled by sufficient data, whereas lags and/or gaps in information stymy process control.

Monitor before treatment to inform control. The traditional barrier model extensively measures the outcome. In contrast, limited front-end measurements can be the case. Moreover, in a water treatment and distribution system, the time interval for an output to travel from its origin, through treatment, then to a measurement node can be days to weeks.



Time series of measurements of bromide in Allegheny River in Pittsburgh vicinity. 11/4/13 and 1/15/14 were reported by ORSANCO as < 1 and < 2.5 mg/L; these two high thresholds values are not shown to contain chart scale. Data sourced from National Water Quality Monitoring Council

In Pittsburgh, the PA DEP performs the monthly measurements on raw water while the utility faithfully follows its required monthly schedule. Without supplemental measurements, there are time gaps between output results and input detections.

The biopharmaceutical industry is another enterprise that relies extensively on supply chains wherein altering a complex raw material matrix can have public health consequences. The industry has adopted chemometrics practices to assist. Chemometrics entails monitoring the chemical inventory of varied and often complex raw material process inputs by using a combination of statistical and typically spectroscopic techniques. For example, Raman spectroscopy can detect the signatures of a range of constituent molecular species in a complex input material. Statistics can be used in conjunction with preexisting reference data to unravel the composite signal into constituent groupings. After unraveling, predictive models can be built that relate process outputs to the composite inputs. Moreover, problematic changes in the composition of incoming raw materials can be flagged. This has been applied to flag issues in surfactant lots and other raw materials for bioprocesses. Likewise, inroads in recent academic works can be found for using chemometrics in the treatment processes that produce drinking water.

Evaluate early steps for cost effectiveness. Subproblems often arise when optimizing material and energy use. For example, organics that remain after initial treatment steps can move through the treatment process, becoming THM precursors or odor sources. To address increasing concern over PFAS, some utilities are considering upgrading to powdered activated carbon use. The carbon, of course, can contend with both PFAS and organic compounds. However, carbon dosing requires detailed knowledge of daily and seasonal loading of the more reactive THM precursors and PFAS levels. Excessive carbon dosing increases cost, treatment process intensity, and solids disposal.

Models to Consider

Measuring everything in raw water is impossible for utilities. Supply chain managers in the (bio) pharmaceutical realm also operate with constrained resources. Consider two pragmatic paths.

Watershed alliances share resources. One strategy now in use in Pittsburgh is a watershed alliance. ORSANCO has a sampling station within the PWSA DWTF that measures roughly 100 analytes on a minutes-to-hours frequency, depending on the analyte. The system is designed to alarm stakeholders of a high concentration event in the raw water. PWSA provides some support, such as space, while ORSANCO provides instrumentation, calibration, and other tasks. One lesson learned from the bromide crisis was to make weekly measurements.

While process control partially supported by mined ORSANCO-obtained data is a possibility, two pilot facilities were recently recommissioned. They are capable of parallel operations, to probe the treatment process optimization space or study an input–output response. For example, how alternate formulations used in the coagulation/flocculation process step affect turbidity *and* putative THM precursor (total organic carbon) reductions has been recently examined. The inclined settler portion of one of the pilot facilities is shown in the photo on p. 46. If compelling, then data from the pilot facilities can be used for reviews with regulators when modifications on process chemicals and/or control are proposed. Thus, in the current PWSA model, there is a sentry, pilot facility-based process data gathering capability, and some remaining data utilization capacity to mine. This

model moves toward a stronger, smarter barrier with shared and contained costs.

Academic partnerships. When watershed alliances do not exist, a partnered upgrade in analytics could be an option. Three-dimensional fluorescence spectroscopy can sensitively detect humic and fluvic acids as well as a number of other soluble organic molecules of natural and industrial origin. The measurement is rapid, so there is sentry capability for some raw water constituents. Further, chemometric methods could be applied to document seasonal and other changes in raw water composition that could supplement the "bank" of accumulated operator experience. Note, fluorescence is also sensitive enough to detect many constituents in treated water so it is conceivable to track the attenuation of compound groups as they pass through process steps. The data on raw water might even complement what streaming potential meters provide. A way to initially proceed is to partner with an academic institution where a thesis project is provided access to water samples and fingerprints are recorded along with deconvolution results.

Conclusions

The barrier model has served well for a considerable time. However, since its inception, which was heavily based on reducing waterborne pathogens, chemical science has substantially advanced. To transition to a proactive control stance and understand and optimize processes, upgrading available stakeholder information is best. Not all utilities can sustain laboratory and certification costs and effort. Alliances — within a watershed or academic institution — provide a path to upgrade data density while containing costs and managerial overhead.

ONLINE RESOURCES

Pittsburgh water quality reporting is done through the following:
Commonwealth of Pennsylvania Department of Environmental Protection Drinking Water Reporter System:
http://www.drinkingwater.state.pa.us/dwrs/HTM/SelectionCriteria.html.
National Water Quality Monitoring Council:
https://www.waterqualitydata.us/portal/#mimeType=csv

Michael M. Domach *is a Professor of Chemical Engineering at Carnegie Mellon University (Pittsburgh) and a NEWEA member.*

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What Every Operator Needs to Know About Protecting Themself from COVID-19 and Other Biological Hazards

Jeanette Klamm and Frank Manners

Note: For complete information on this topic, see the 114-page document, Protecting Wastewater Professionals from COVID-19 and Other Biologicawl Hazards. This document includes a critical review of existing water sector guidance on biohazard exposure, an assessment of whether COVID-19 prompts new guidance for biohazard safety, and recommendations for further research. See more at www.wef.org/COVID-safety.

Knowledge	Principles	Practical Considerations
Types of Hazards: Bacteria	Bacteria are microscopic and extremely common in wastewater. They can reproduce outside of hosts. They can be present in large quantities in collection systems. The most common bacterial pathogens (disease-causing organisms) found in wastewater are Salmonella and Shigella.	Bactiera are typically transmitted via the fecal–oral transmission route — that is, through ingestion of contaminated food and water or through hand-to-mouth contact.
Types of Hazards: Viruses	Viruses are ultramicroscopic agents. They cannot reproduce without a host cell and will not reproduce in wastewater. Viruses are categorized into enveloped and non-enveloped categories. Non-enveloped viruses are more persistent in wastewater, resistant to some disinfectants, and can be infectious in very low doses. Non-enveloped viruses include infectious hepatitis, meningitis, poliomyetltis, respriratory diseases, gastroenteritis, and the common cold. Enveloped viruses are more sensitive to environmental stresses and the wastewater treatment processes. Some examples include the virus that causes COVID-19, influenza, and HIV.	Wastewater personnel face a higher risk of exposure to non-enveloped viruses due to daily contact with wastewater. However, enveloped viruses generally are less of a concern to people who are in contact with wastewater.
Types of Hazards: Parasites	Parasites live on or in another organism of a different species, which is called its host. When outside of hosts, many parasites do not survive the conditions in wastewater collection systems and treatment facilities. However, oocysts, cysts, and eggs from parasites often are resistant to these adverse conditions and can be present in wastewater.	Hand-to-mouth contact is the principal cause of infection with parasites. This means it is important to use appropriate personal protective equipment (PPE) and wash your hands frequently.
Types of Hazards: Fungi	Fungi are diverse and ubiquitous in the environment. They have been found in bioaerosols associated with wastewater treatment facilities and biosolids.	People with weakened immune systems or lung diseases are at higher risk of developing health problems from fungi. Respiratory protection should be used to protect workers.
Types of Hazards: Macroorganisms	These include large organisms that may be attracted to wastewater. Macroorganisms may include rodents, worms, nematodes, and insects.	General good housekeeping and draining of any areas of standing water or ponding will prevent attraction of these types of vectors.

Knowledge	Principles	Practical Considerations
How Infections Spread	There are four basic routes that may lead to infection in the wastewater environment: ■ ingestion, ■ inhalation, ■ injection, and ■ skin contact. Ingestion can occur through wastewater splashes, contaminated food or beverages, or from pathogens on contaminated hands. Inhalation can occur through breathing in infectious agents in aerosols or bioaerosols emitted from various wastewater processes or close person-to-person contact. Injection may occur through a cut or abrasion in the skin. Direct skin contact also can lead to infection in some cases.	Wastewater workers often come in contact with untreated wastewater and solids during daily activities. Even when direct physical contact is avoided, a wastewater worker may come in contact with contaminated objects or may accidentally ingest pathogens via hand-to-mouth transmission. Cuts and abrasions may become infected from viruses and bacteria present in wastewater. Ingestion generally is the primary means of infection. Touching the face or mouth with the hand can contribute to the risk of infection. Activities such as eating, drinking, and smoking without prior hand washing should be avoided. A good practice is to not touch oneself above the neck whenever there is contact with wastewater. Where wastewater is sprayed, inhaling infectious agents increases. Therefore, appropriate PPE to prevent inhalation should be used.
Preventing Infection	Preventing infections can be accomplished through proper work procedures, wearing PPE, and immunizations.	Work procedures include the following: ■ Never eat, drink, or use tobacco products before washing hands. ■ Avoid touching face, mouth, eyes, or nose before washing hands. ■ Wash hands immediately after contact with wastewater or solids. ■ Wash hands for at least 20 seconds using an antibacterial soap. ■ If handwashing is not immediately available, use a hand sanitizer that contain at least 60% alcohol. Rub hands together to cover all surfaces of the skin. Proper PPE helps prevent exposure in many ways: ■ Gloves, boots, and uniforms/coveralls prevent contact transfer. ■ Eye and face protection with safety glasses, face shield, or goggles prevent contact by splashes. ■ Tyvek suits ot coveralls can limit whole-body contact. ■ Durable gloves designed for protection from cuts or punctures prevent abrasions, cuts, or punctures. ■ N95 respirators and surgical or dust masks prevent respiratory exposure. Wastewater treatment personnel should receive proper immunizations, following their local health agencies. The U.S. Centers for Disease Control and Prevention (CDC) enourages vaccinations for tetanus, polio, typhoid fever, Hepatitis A, and Hepatitis B.
What to do if you show symptoms of illness.	Symptoms of illness can include fever, coughing, shortness of breath, dizziness, nausea, etc. Injuries should be reported and treated promptly to prevent infection or illness.	If an employee experiences symptoms of illness, they should not enter the workplace but should remain home to avoid exposing others to potential infectious illness. Clean breaks in the skin immediately and treat with antibiotic ointment. More serious wounds that come in contact with wastewater or have been potentially exposed to infectious material should be seen by a medical professional.

Knowledge	Principles	Practical Considerations
Who is at risk?	Most studies have indicated that areas with the greatest risk for infection involve routine and direct contract with untreated wastewater or solids. This would include workers involved in sewer maintenance and untreated sludge handling. As wastewater undergoes treatment, the risk of exposure to pathogens should decline.	Collection system personnel face greater risks of infection as compared to treatment facility personnel, due to their direct high exposure to untreated wastewater. In the treatment facility, personnel involved with untreated wastewater or in enclosed areas where wastes are aerated or agitated are at increased risk for exposure. Risk for laboratory personnel is not as high as collection system personnel or outside facilities. Infectious agents are commonly found in samples and can be a biological hazard. Laboratories should be properly ventilated. Laboratory personnel must be provided with adequate training in microbiological techniques and safety.
Assessing workplace risks	Job Safety (or Hazard) Analysis (JSA/JHA) identifies each task in a job, defines the potential hazards, and outlines critical safety practices. Potential hazards can include physical, chemical, biological, electrical, and radiological sources and gas/emissions. Each task-related hazard is ranked by probability, severity, and potential consequences. Once the hazards are known and prioritized, appropriate hazard control measures can be identified.	As new hazards are identified in the work place, a JSA/JHA should be conducted to determine the controls that should be adopted to decrease risk. Hazards can emerge when changing procedures to job tasks, adding new chemicals, changing practices because of construction, dealing with emergency situations, and any other changes to operations. Any new situation can lead to a change that can trigger the use of a JSA/JHA to determine if worker protections are adequate or should be changed to address an existing or new hazard.
Risk from the virus that causes COVID-19 for wastewater workers	The occupational risk of infection to wastewater workers from the COVID-19 virus are low, and not greater than those from other pathogens typically present in wastewater. While scientists are still learning about the COVID-19 virus, experts from the World Health Organization (WHO; Geneva), the Water Environment Federation (WEF; Alexandria, Virginia), and CDC concur on this low occupational risk among others.	Generally the default PPE (as listed earlier in this article) will reduce the risks from exposure to biohazards including COVID-19 in wastewater and biosolids, treated or untreated, from collection systems to treatment and disposal. However, since each wastewater treatment system is different, each utility should conduct a JSA/JHA to determine if additional precautions are necessary.
Is a respirator needed to protect wastewater workers against the virus that cause COVID-19?	Medical or dust masks can protect workers from splashes, sprays, and particulate matter, such as dust. They also decrease the risk that sick workers will spread their illnesses. The National Institute for Occupational Safety and Health approved filtering facepiece respirators, such as an N95 or similar, provide a higher level of protection from inhalation of aerosols.	A JSA should be used to determine conditions were a respirator might be appropriate. Note: It is important to understand that respirators have strict requirements for fitting and training, and a respirator used incorrectly may not provide better protection from aerosols than medical masks. All mouth and nose protection must be cleaned and maintained in working order and replaced as needed.
Is the virus that causes COVID-19 present in wastewater, sludge, and biosolids? Is it infectious?	Studies have determined that the RNA (the genetic material) of this virus has been found in feces of sick patients. However, the infectious virus has rarely been detected and transmission via feces does not appear to be a significant route, based on both virological and epidemiological evidence.	To date, although the RNA (genetic material) has been detected in wastewater, infectious or viable virus has not been found.

Jeanette Klamm *is Assistant Director of Operations & Maintenance and* ***Frank Manners*** *is Safety Coordinator for Johnson County Wastewater in Olathe, Kansas.*

BUSINESS

Asahi/American Inc. (Lawrence, Massachusetts) has announced the addition of *Shane McDaniel* to its business development team. McDaniel joined the company in January as business development manager for actuation products. He brings a diverse set of skills and experience to the company, from instrument and controls technician work to outside sales as well as aftermarket sales and service. He will work with the company's sales and engineering teams to promote their actuation product line across various industries in the country.

Shane McDaniel

Environmental consulting firm **Material Matters Inc.** (Elizabethtown, Pennsylvania) has named *Lisa Challenger* as its new Senior Project Manager. Challenger joined the company in 2013 as an environmental scientist, and has since worked in the management of water quality nutrient credits, developing biosolids market evaluations, assessing and reporting on permitting and regulatory compliance, and facilitating site and soils evaluation.

Lisa Challenger

"Lisa's expertise in marketing, permitting, and managing biosolids and residual materials will support Material Matters' clients and scientists in developing comprehensive biosolids market evaluations, beneficial use plans, evaluating and reporting on permitting and regulatory compliance," said CEO Michelle McCall in a release.

Badger Meter Inc. (Milwaukee, Wisconsin) has acquired Analytical Technology Inc. ("ATi"), a privately held provider of water quality monitoring systems, for $44 million. Analytical Technology, which had a gross revenue of $22 million in 2020, specializes in design, manufacture, and distribution of water quality instruments based on electrochemical and optical sensors. Its technology also is used to detect toxic gases used in water treatment and various other sectors.

Scientist and engineer *Dr. Siddartha Roy* has been awarded the **International Water Association's** (IWA) Young Leadership Award for the 2020-2022 award period. Roy will begin a 2-year term as an industry ambassador for IWA and the water sector at large. He currently works as an environmental engineer and post-

doctoral research scientist at Virginia Tech (Blacksburg, Virginia), doing research on a variety of issues including the Flint, Michigan, water crisis. Roy's work on the Flint water crisis was a significant factor in President Obama's declaration of a public health emergency in the town, and he has been a long-time advocate in media for the restoration of the town's clean water supply. His recognition by IWA's Young Leadership Award Committee was unanimous.

Siddartha Roy

Severn Trent Water (Coventry, United Kingdom) has appointed **ECS Engineering Services** (Chantilly, Virginia) as its regionwide framework contractor for mechanical services. ECS will provide design, installation, testing, and maintenance services for mechanical assets at water and wastewater facilities operated by Severn Trent. ECS will specialize in delivering support for complex projects.

An ECS technician works on Severn Trent mechanics. Severn Trent Water

"We are excited to announce that we have been selected as a mechanical framework contractor by Severn Trent Water for all regions. Providing turnkey engineering services to the utilities sector, especially as water and water control, is our specialty," said Clark Williamson, Contracts Director at ECS, in a release. "We have decades of experience working with water utilities across the UK, ensuring we can offer the capabilities to support new projects or the upkeep of vital assets."

Anue Water (Alpharetta, Georgia) has announced **Kershner Environment Technologies** (Owings Mills, Maryland) as its new channel partner for the sale and distribution of Anue's eco-friendly product line in Eastern and Central Pennsylvania, as well as Central and Southern New Jersey.

"Taking on Anue Water's clean-tech product line is an important milestone in our history of providing solutions to the municipal, industrial and process water industry," said Rob Kershner, president of Kershner Environmental Technologies, in a release. "Partnering with Anue Water Technologies enables us to offer clean oxygen/ozone injection systems that pay for themselves in terms of chemical, labor and other operating cost-savings over a 2- to-3-year period."

PROJECTS

Riventa will be testing this and 89 other blowers across England. Thames Water

▶ **Thames Water (Reading, U.K.) has hired Riventa (Truro, U.K.) to test 90 aeration system blowers** across 10 of its water resource facilities for energy optimization. From Beckton, the largest facility in Europe, where 26 blowers will be tested, to the Blackbirds treatment works with just two blowers, Riventa will carry out large-scale performance testing for up to 4 months. Potential savings from 5% to 30% are forecast, depending on the age and condition of existing equipment, including valves, pipework and diffusers, as well as the actual blowers.

▶ **Cambi (Asker, Norway) and its partners have won a contract** for a thermal hydrolysis biosolids treatment processing facility in Ukraine. The country's municipality of Lviv decided to build the facility — which is the first of its kind in Ukraine — based on Cambi's thermal hydrolysis process, followed by advanced anaerobic digestion. The total contract is worth €31.5.

Lviv has approximately 720,000 residents, and the effluent is discharged in the Poltva river, which flows into the Baltic Sea. Currently, the biosolids collected from the city is landfilled, releasing greenhouse gases and high phosphorus and nitrogen loads that pollute the Baltic Sea. The project is expected to reduce nutrient pollution, as well as greenhouse gas emissions by 128,600 tons of carbon dioxide annually.

▶ **ABB Group (Zurich, Switzerland) has begun work** on a project to help a local water authority in southwestern India's Koppal district to optimize water

use in the drought-stricken region. After the project is complete, clean treated river water will be pumped to village homes. The project includes 635 digital flowmeters and technologies to improve control at pumping stations and reservoirs. The Koppal district has a population of around a million people. Until now, it largely has relied on ancient wells and water preservation practices.

AquiSense Technologies (Erlanger, Kentucky) is working with NS Nanotech (Ann Arbor, Michigan) to develop the world's first solid-state broadband ultraviolet research device. The device will be powered on by a solid-state UV lamp, emitting wavelengths from 200 nm to 400 nm. This device could be crucial for today's research into disinfection wavelengths. "We believe our technology will revolutionize how we disinfect our world, and we're excited to get this technology into the hands of researchers to quantify the safety and effectiveness of this breakthrough," said Victor Hsia, VP of Sales and Business Development at NS Nanotech, in a news release.

Anaergia Services (Carlsbad, New Mexico) and North Sky Capital LLC (Minneapolis) have announced the start of construction of a renewable natural gas facility at the Victor Valley Wastewater Reclamation Authority (VVWRA) in San Bernardino County, California. The facility, which is the result of a public–private partnership between the three organizations, will use Anaergia's Omnivore high solids anaerobic digestion retrofit to help sludge and food waste digest into biogas. The biogas will then be conditioned and turned into pipeline quality natural gas. The public–private partnership involving VVWRA, Anaergia, and North Sky demonstrates a replicable model to meet California organic waste recycling mandates and improve wastewater infrastructure resiliency: retrofitting anaerobic digestion infrastructure to convert organic waste and sludge into pipeline quality renewable natural gas. "We are committed to protecting public health and the environment in the Victor Valley, and this partnership reflects our three core values: collaboration, dedication, and integrity," said VVWRA General Manager Darron Poulsen in a release. "This project provides operational and capacity resiliency for the future of the authority by improving our infrastructure with greater operational flexibility and increased digester redundancy and capacity needed for future growth, while benefiting the agency economically." The project will reduce more than 6,000 metric tons of methane emissions (1.5 million carbon dioxide tons equivalent) per year. The energy generated is expected to displace more than 7.6 million L (2 million gal) of diesel fuel annually. Additionally, this project is expected to create approximately 30 prevailing wage jobs through construction and related work.

EXTRA

Be the Change

Focus on small actions to make big strides for women

Aimee' Killeen

I doubt anyone can dispute that the number of women in the water sector has risen over the past several decades. There are more women operators, scientists, biologists, technicians, and engineers than ever before. All you have to do is look around you.

But then you walk into a committee meeting at WEFTEC, a technical session at a specialty conference, perhaps your Member Association board meeting (back when we had these in person), and the rooms are still overwhelmingly filled with men. The Brookings Institution's June 2018 Report titled *Renewing the Water Workforce: Improving water infrastructure and creating a pipeline to opportunity* validates that the water workforce continues to be predominantly men with women making up only 14.9% of the water workforce.

Like many of you, I read articles like the one issued by Brookings and get very impassioned and enthusiastic to go out and mentor young women, discuss the water sector at career days, talk to young students about the awesome water world out there, volunteer at Earth Day, host women's panel discussions at events, and the list goes on. While I am lucky to be able to participate in many of these extracurricular activities, eventually, reality hits. Family, work, commitments, and life start to get in way of the time I want and need to share my passion for water. And so, when I turn down career day at my alma mater for a work meeting, I get defeated, thinking really what can I, as one woman, do?

Change Agents

One evening, I was unwinding before bed, trying to purge the clutter of the workday out of my mind. I cannot even remember what I was initially scouring the web for, but I happened upon Eleanor

Roosevelt's great question speech to the United Nations in 1958, in drafting the Universal Declaration of Human Rights.

Her question to the assembly was, "Where, after all, do universal human rights begin? In small places, close to home — so close and so small that they cannot be seen on any maps of the world. Yet they are the world of individual persons, the neighbourhood they live in, the school they attend, the factory, farm or office they work in. Such are the places where every man, woman or child seeks equal justice, equal opportunities, and equal dignity without discrimination. Unless these rights have meaning there, they have little meaning anywhere."

It is, of course, at this daily level that women grapple with justice and equality; it is at work, in school, in every neighborhood, in many of the daily interactions we have. It is here, in Elanor Roosevelt's words, that I feel empowered, that I can do something that matters, I can be an agent of change for women around the world. It starts with simple everyday conversations, questions, and actions.

Each of us in our daily life, at home, at the treatment facility, at the lab, in our utility, in our office, in the field, in our neighborhood can be agents of change for women in the water sector. We must have those clear conversations, politely point out when words and actions make us uncomfortable, share those words of inspiration, support a struggling coworker, give those high fives, recognize the innovations, and amplify all women around us, young and old. These simple everyday acts can and must happen. These acts will lead to the groundswell necessary to build a more gender equitable water sector.

Building Blocks

During WEFTEC Connect in October we started a conversation. How can we as women not only be agents of change to bring more women into the water sector, but how can these same efforts and actions support the broader diversity, equity, and inclusion efforts needed in the water sector?

First and foremost, every one of us must be open-minded. We must, therefore, by definition be *receptive to arguments or ideas* and must move beyond wrong and right, embrace different. During our WEFTEC Connect conversation, I asked everyone in the virtual video meeting to point to where they saw me on the screen. Of course, the result of this exercise was that everyone I saw on my monitor was pointing in different directions. Was one person right and the rest of them wrong? Of course not, everyone had a different yet correct answer based on their differing perspective. And no one felt better than another participant for pointing a different way, more right about the way they were pointing, we all understood that it was simply our individual video screen settings. So, there is proof right there that we can all be different and all be ok with it.

Secondly, each of us has the responsibility to educate ourselves. We all have undergone some form of education

that got us to where we are today. None of us became an operator, technician, engineer, administrative professional, or scientist without some form of education. So how can we expect to move forward or make the simplest of changes to our understanding and actions without learning something we do not already know? There are so many great books, podcasts, and articles on diversity, equity, and inclusion. If you want to know how we got where we are today as a society, why is it important for women to have women only conversations, what unconscious biases maybe do I have based on where and how I was raised, why are all the Black kids sitting together in the cafeteria? There is no shortage of reputable sources to educate ourselves out there, the last of these questions being a book of the same title authored by Beverly Daniel Tatum, a really great read.

Ask participants on your next video conference call to point to you. This exercise in perception and reality help participants realize that different does not equal wrong.
Courtesy Aimee' Killeen

Share Ideas

I firmly believe that if each of us dedicates time this year to doing these two very simple things that we can begin to create the ripples that will lead to the groundswell of change. However, I want also to share some of the additional input that our WEFTEC Connect participants raised that are simple, actionable, and easily implemented at home, work, or in your association.

Bring a plus one from your office, maybe an intern, or an operator to dinners and networking events. Introduce them to your water network. Make real space for newcomers, make them feel welcomed. This can be as simple as having a greeter at the meeting room door. Know that you will feel uncomfortable. Going in with reasonable expectations can help lessen the difficulty when it happens. And most importantly, continue to create opportunities for women in the water sector to connect and collaborate.

I eagerly look forward to seeing the ripples of transformation to a more diverse, equitable, and inclusive water sector that I know so many awesome women in water work toward every day. We must further this conversation and persist in creating everyday opportunities for action and change. Let's catch up at WEFTEC 2021 to discuss our progress.

Aimee' Killeen *is the Chief Operating Officer at Providence, a multidisciplinary engineering and environmental consulting firm with offices in Louisiana and Texas. She has been a WEF member since 2008 and currently serves on its Board of Trustees.*

PRODUCTS

Heavy-Duty Connectors

Phoenix Contact (Middletown, Pennsylvania)
▶ www.phoenixcontact.com

1 The new HeavyCORE program allows customers to receive the company's most commonly used heavy-duty connector components within days of placing an order. The program prioritizes a select group of products that simplify inventory management, provide versatility during assembly and installation, and boosts productivity. The HEAVYCON line of heavy-duty rectangular connectors comprises thousands of different components that can create more than 70 million different combinations. Many common application requirements can be satisfied with a select set of those components, which make use of the HeavyCORE products. The program's products were selected based on ability to streamline the manufacturing process and to simplify the bill of materials across one or multiple products.

Custom Fabricated Structural Bearings

Hercules Engineering (Yennora, Australia)
▶ www.hercs.com.au

2 Hercules Engineering (Yennora, Australia) is introducing custom-fabricated structural bearings for extremely high-stress applications in projects requiring outstanding load-bearing performance. The bearings are designed to perform even in compact or wet spaces for processing applications, power generation, port loaders, and land or marine exploration. The company's latest Herculon series structural bearings are manufactured by integrating H-Glide fiber-reinforced composite pads sliding on 2B-finish stainless steel, resulting in an extremely low sliding coefficient of friction compared to other engineering bearing materials, even underwater. Unlike metal bearings that require continual lubrication or maintenance, or rust over time, the environmentally safe H-Glide bearing pads are dry-sliding and will not release contaminants into surrounding environments or interfere with adjacent processes.

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Coming up in the April issue

The Thick of It

Drilling down into the nuts and bolts of wastewater operations opens the doors to many topics. In April, take a fresh look at building beneficial biosolids products, choosing odor and corrosion control materials, and supporting public health in a new way with wastewater-based epidemiology.

High Heat Means More Options

Thermal drying provides utilities with more potential end users for their biosolids products. Agriculture, power generation, and consumer markets can open up when heat treatments are used.

The Right Lid for the Job

Rising trends toward capturing biogas at water resource recovery facilities demand digester covers for containment. Learn the importance of having the right type of cover. Your choice can be vital to costs and sustainability.

Building Your Wastewater-Based Epidemiology Program

Using quantitative measures of pathogens or other substances in wastewater can indicate their prevalence in communities. This concept, known as wastewater-based epidemiology, is emerging as a powerful tool for tracking public health. Find out the main elements to set up your own successful WBE campaign, including the addition of an often missing "knowledge translator" role.

Also in this issue

- **Operator Essentials.** What every operator needs to know about odor generation and vapor phase odor control.
- **Viewpoint.** Hear Albert Cho, Senior Vice President and Chief Strategy & Digital Officer for Xylem, describe how the coronavirus pandemic has accelerated the water sector's digital transformation.

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