MAY 2021

Water Innovations

SAFE STRONG SECURE

HOW TO PREPARE FOR CYBERATTACKS AND NATURAL DISASTERS

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By Kevin Westerling
Chief Editor, editor@wateronline.com

How To Address Your (Water) Sensitivity

As I monitor the daily flow (pardon the pun) of water-industry news, product launches, and initiatives for special coverage on *Water Online* and in *Water Innovations*, a basic investigative question is "Who is this intended for?" When the opportunity arose to inverview Gemma Dunn, the integrated water management service line coordinator with GHD North America, about GHD's new Water Sensitive Cities Index, I soon came to a new question:

What city isn't water sensitive?

If water scarcity isn't an issue, due to drought, population growth, and overdrawing or contamination of source water, then flooding and sewer overflow — the result of old infrastructure and increasingly frequent extreme weather events — are likely concerns. In the U.S., at least, you would be in the minority if you are not experiencing one or the other, and sometimes both (see Texas). Elsewhere, cities and communities of all types are dealing with the degradation of once-reliable resources — the result of saltwater intrusion or Per- and polyfluoroalkyl substances (PFAS) contamination in groundwater, for instance — as yet another threat. And considering the importance of water for both individual and community survival, every city should be water sensitive in terms of prioritizing this precious resource and safeguarding future supply, even if these stressors aren't impacting current operations. When Benjamin Franklin stated, "When the well's dry, we know the worth of water," it was actually a lesson on preparedness — a plea to address a potential crisis *before* it happens.

These days, Gemma Dunn is spearheading efforts to make sure the well never runs dry. With 20 years' experience in water management at GHD, a PhD with the Cooperative Research Centre for Water Sensitive Cities in Melbourne, Australia, and a decade-long focus on integrated water management and One Water approaches, she is well equipped to do so.

A frequent advisor to government agencies, NGOs, and corporations, Gemma is known for her extensive work on the development and use of indicators and assessment frameworks, including the recently launched Water Sensitive Cities Index. She shares her insight on the index, as well as the underlying issues it addresses, in the Q&A below.

What is the Water Sensitive Cities Index, how was it formed, and what is it meant to achieve?

The index is a benchmarking and diagnostic tool scientifically developed to assess the various aspects of One Water or integrated water management (IWM) services. These services include stormwater, flood management, groundwater, wastewater, water supply, and concepts such as governance and community values.

Developed over two years by the Australian Cooperative Research Centre for Water Sensitive Cities (CRCWSC), the Water Sensitive Cities Index has undergone significant industry testing to ensure it is relevant, robust, functional, and reliable. To date, it has been applied in more than 50 communities and is designed to benchmark communities against a range of indicators characterizing One Water goals: Ensure good water-sensitive or One Water governance, increase community capital, achieve equity of essential services, improve productivity and resource efficiency, improve ecological health, provide quality urban design, and promote adaptive infrastructure.

There are multiple characteristics and benefits of using the index to move toward your One Water goals:

- *Robust and independent* — scientifically developed by an independent organization based on an analysis of over 50 indexes/indicators;
- *Generates alignment* — gets people on the same page in understanding what the characteristics of One Water are and what aspiration we are working toward;
- *Cost-effective* — prioritizes areas for deeper investigation or investment — without having to spend hundreds of thousands on additional studies — and leverages the shared knowledge of a range of organizations;
- *Relevant* — developed specifically to meet the needs of industry and has been applied in more than 50 communities around the world.

How did you determine the need for the index in the U.S. in terms of vulnerability, preparedness, and worsening environmental conditions?

Like many countries around the world, the U.S. is vulnerable to the impacts of climate change and worsening environmental conditions. In recent years, we have witnessed an increase in the occurrence and severity of floods, droughts, wildfires, winter storms, and heat waves. Many communities across North America are declaring climate emergencies and discussing a myriad of complex issues, such as equity.

Failure to evaluate vulnerability, and make adequate preparation, can result in an increased risk of loss of life, property damage, environmental damage, and significant financial loss. Community preparedness (preparation and planning) can increase our ability to respond efficiently and effectively and to increase resilience. The index helps frame this discussion with indicators such as equitable access to flood protection and robust infrastructure.

There is a growing interest in One Water approaches — initiatives from the US Water Alliance, for example — to respond to the myriad of challenges facing the sector, and the index is really at the vanguard of this movement. The index facilitates the conversations and generates alignment. It helps get people onto the same page in understanding what the characteristics are and what aspiration we are working toward.

How can this information be integrated into smart-water and smart-city platforms as the industry undergoes digitalization?

Within the index, there are indicators to examine digital intelligence systems and optimization of water system network performance using a smart-city approach. Also, the index platform is web-based and enables the visualization of results for policy makers, service providers, and the community.

A smart-city approach is important but does not guarantee system resilience by itself. Digital solutions are just one element within a broader context. The index helps identify where to focus the implementation of digital solutions to track and gain an improved understanding of regional challenges.

What are the costs of ignoring environmental trends and warning signs, or staying status quo?

There is a misunderstanding that the status quo (or inaction) does not cost anything. Populations are growing, our infrastructure is aging, there are maintenance backlogs and rising systems costs, and communities worldwide have degraded watersheds. The American Society of Civil Engineers (ASCE) recently estimated every household in the U.S. pays a hidden tax of $3,300 a year due to poor infrastructure. Climate change exacerbates these already difficult challenges.

We often talk about climate change in terms of greenhouse gas emissions, but we experience climate change primarily through water (from too much to not enough). The majority of natural disasters (over 90 percent) are water-related, with significant impacts on people and the economy.

We must take action.

Change is hard. Existing structures and processes tend to often reinforce the status quo. Decision-makers need support in guiding and motivating change. The index is a tool to enable decision-makers to use the information to drive change.

How can utilities that are struggling financially make the necessary resiliency improvements?

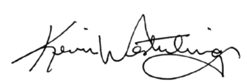
According to the Insurance Bureau of Canada, "Studies have shown that investments in resilient infrastructure have a return on investment of $6 in future averted losses for every $1 spent proactively. ..."

Decision-makers urgently need robust tools to help them prioritize action, maximize investments, and enable more effective collaboration within organizations and across institutions to make the best use of limited financial resources. The index can provide a forum or initiate collaborations with the broader sector or industry to form the first step in identifying better solutions (such as multibenefit projects) and/or funding mechanisms that address funding constraints.

How can the engineering community continue to promote resiliency and influence action?

Primarily, there must be recognition that climate change is occurring; our communities face significant costs and decisions. The scientific and engineering community has a duty to lead this conversation and work together more effectively to advocate for change.

At GHD, we recognize how challenging it is for communities to take swift action in light of these complex challenges and future uncertainty. Water literacy is an indicator in the index. I would argue that we (the engineering and scientific community) have not done enough to highlight the true value of water and how this links to the level of service. We need to get better at communicating the linkages between the desired level of service with the true cost of providing water services and the cost of changing climate and resiliency. The index is the first step in navigating this discussion. ■



Water Innovations

101 Gibraltar Road, Suite 100
Horsham, PA 19044
PH: (215) 675-1800
FX: (814) 899-5587
Email: info@wateronline.com
Website: www.wateronline.com

Eprints and NXTprints
The YGS Group (800) 290-5460
VertMarketsReprints@theYGSgroup.com
www.theYGSgroup.com

SECURING A CLEAN AND SAFE WATER SUPPLY

Cyberattacks targeting U.S. water utilities are no longer hypothetical scenarios, so it is past time to increase public protection by hardening cyber infrastructure.

By Jeremy Rasmussen

This past February, a supervisor working remotely at the city of Oldsmar's water supply plant in Tampa Bay, FL, noticed something unusual on his computer screen. Someone outside of the plant took control of the mouse and moved it across the screen to change the concentration of sodium hydroxide, or lye. All of this was happening right in front of his eyes.

Used correctly, lye helps control the acidity of water. When the concentration is altered to higher levels (in this case it was increased from 100 parts per million to 11,100 parts per million), the result can be extremely harmful. Lye can cause severe corrosive burns to the throat, esophagus, and stomach, with permanent damage if swallowed.

The potential Oldsmar water plant crisis was ultimately avoided thanks to the actions of the supervisor mentioned above. But the incident once again spurred concerns around cyber vulnerability at water utilities and the type of impact a breach could have on local residents.

The risks are such that in the Oldsmar breach, the FBI and the Cybersecurity & Infrastructure Security Agency (or CISA, the U.S. government's cybersecurity organization) got involved. In this case, CISA found the breach was likely the result of factors that could have easily been avoided:[1]

1. Desktop-sharing software called TeamViewer, used by IT staff for remote access to deliver periodic support, may have been compromised and used to gain unauthorized access to the system.
2. Employees were sharing a single poor password for all computers using the remote access system.
3. Vital security updates for the Windows 7 operating system had not been performed.

Moving From Reactive To Proactive

Since then, Microsoft Exchange and Office 365 systems have also been breached worldwide. Ominously, authorities have concluded that many U.S. state and local governments were specifically targeted, among other sectors.

One thing is crystal clear: Municipal water districts and related utilities need to harden systems and processes as fast as possible. What's more, these cannot be "one-off" initiatives. There are 153,000 public drinking water systems in the country, and more than 80 percent of the U.S. population receives their potable water from these drinking water systems.[2] Taking these figures into account, it's clear that water systems must move now from being reactive to proactively deploying best practices in cybersecurity.

These practices must focus on immediate cyber-hardening programs, such as vulnerability assessments, penetration testing, crisis response, and remediation planning, as well as include ongoing monitoring and oversight. In most cases, that means employing a managed security service with the depth of experience, security systems, monitoring procedures, and expertise to stop cyber intruders at the door more efficiently and effectively than can be done in-house. Every facility must commit to these improvements, from those in larger U.S. cities to smaller facilities such as Oldsmar, serving its community of 15,000 people.

Separating IT And OT

Another cybersecurity best practice for entities like municipal water organizations or utilities begins with separating two key elements, operational technology (OT) and information technology (IT). As water treatment facilities become increasingly more digitized and complex — by adding more internet-connected devices that control various parts of the processes, for example — OT becomes more susceptible to cyberattacks. Some teams simply haven't extended security protocols into the OT realm. For now, the best course of action is to separate the OT networks from IT.

Securing Remote Access

Facilities next must assess the use of remote-access solutions. Not surprisingly, remote-access solutions have become increasingly widespread as a result of COVID-19. While they offer tremendous benefits, such as enabling employees to execute critical job functions and get support from outside the office, they also dramatically increase susceptibility to attacks. According to a recent research report entitled *Cybersecurity in the Remote Work Era: A Global Risk Report*, 42 percent of organizations report they simply do not know how to defend against cyberattacks aimed at remote workers.[3]

The same study also found that 31 percent of respondents are not requiring their remote workers to use authentication methods, and only 35 percent require multifactor authentication. Access to system control must be protected by advanced-identification protocols, including the following:

- Ensure that all employees are using strong passwords that include upper and lowercase letters, numbers, special symbols, and more.
- Use multifactor authentication where users must present two or more pieces of evidence to access a program.
- Embrace whitelisting, where only identified entities are allowed access to the facilities network.

Managed Cybersecurity Services

In addition to tightening the protocols of your team, the value of identifying a third-party cybersecurity partner at this critical time cannot be overstated. Cybersecurity companies combine 24/7 threat monitoring with the ability to identify and react to breaches as they happen, which ultimately minimizes impact or damage, or avoids it altogether.

In the case of Oldsmar, the good news is that a potentially deadly crisis was averted. The bad news is that other dangers loom large. U.S. Sen. Mark R. Warner, D-VA, chairman of the Senate Select Committee on Intelligence, put it nicely when he said, "This incident has implications beyond the 15,000-person town of Oldsmar."[4] More needs to be done, and this includes a new and expansive set of best practices that all adhere to across all facilities. This is how we prevent another incident and ensure the integrity of our drinking water.

Whether it's a public water system, a major bank, or a small business, every organization needs to take proactive measures against cyber threats. ■

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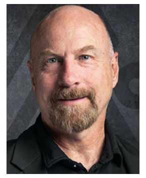
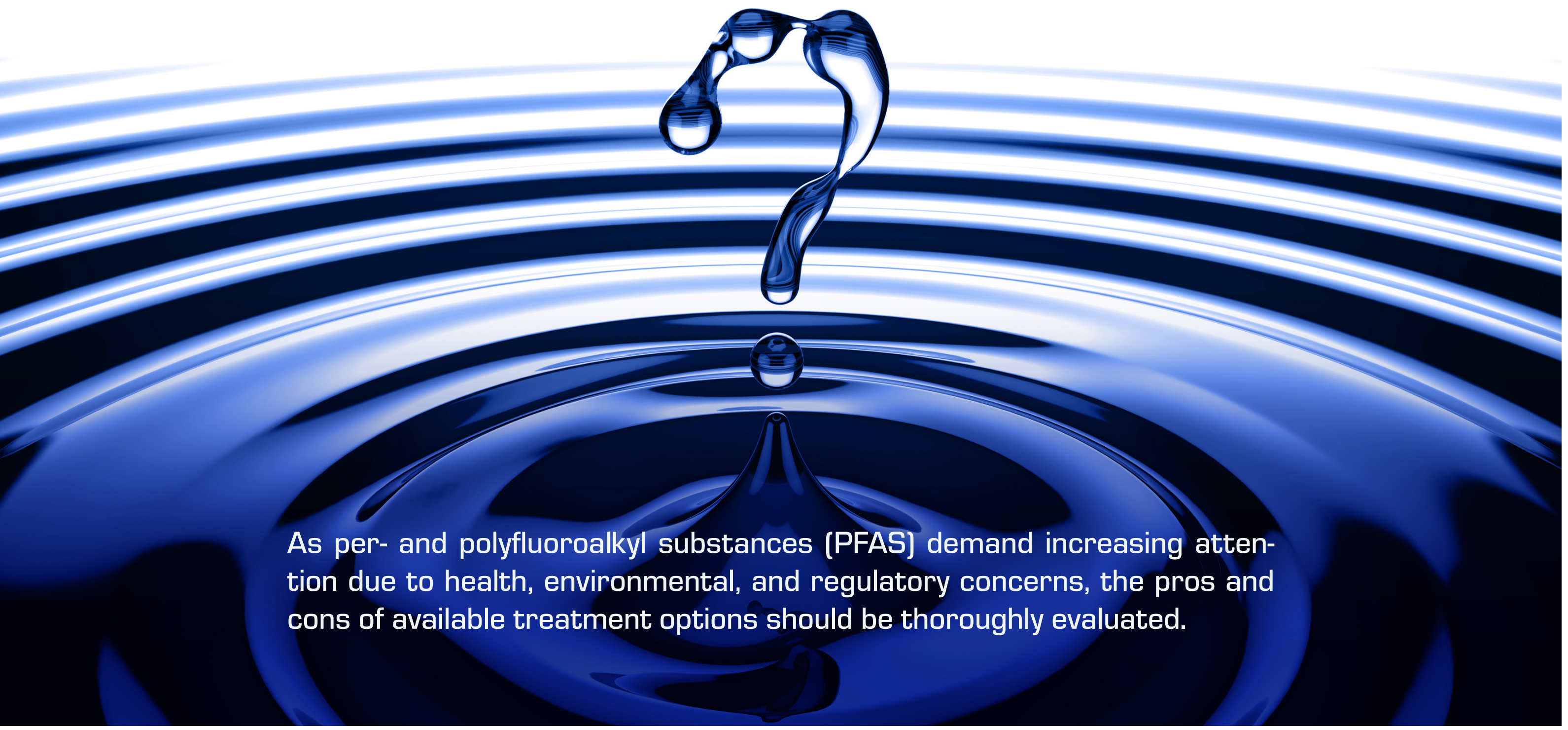


Jeremy Rasmussen is chief technology officer and chief information security officer (CISO) at Abacode, a next-generation managed cybersecurity and compliance provider (MCCP) that works with municipal water plants and utilities across the U.S. Leveraging a unified platform, Abacode helps businesses of all sizes implement a holistic, framework-based cybersecurity program with a unique service model that enables customers to transform cybersecurity challenges into a competitive advantage.

Addressing PFAS In Our Water Supply: Treatment vs. Destruction



As per- and polyfluoroalkyl substances (PFAS) demand increasing attention due to health, environmental, and regulatory concerns, the pros and cons of available treatment options should be thoroughly evaluated.

By Amy Dindal

Per- and polyfluoroalkyl substances (PFAS) are man-made chemicals that have been widely used for decades in various applications — from cookware and packaging to stain repellants and firefighting foam. As required by their applications, the chemicals are extremely durable and have been observed in the environment, exposing humans and animals around the globe, and earning the somewhat ominous nickname of "forever chemicals."

Widespread use of PFAS chemicals over a long period of time has resulted in varying levels of impact to most environmental media worldwide, including sources of drinking water. As noted by the Interstate Technology and Regulatory Council's Fact Sheet on the Occurrence of PFAS: "The concentrations of these human-caused ambient or 'background' PFAS concentrations may vary widely, based on proximity to industrial areas, patterns of air and water dispersion, and many other factors."[1]

The Safe Drinking Water Act (SDWA) requires the U.S. EPA to evaluate unregulated contaminants for occurrence in our public drinking water systems every five years. As part of the EPA's mission in protecting public health, occurrence data are collected through the Unregulated Contaminant Monitoring Rule (UCMR) to support the agency's determination of whether to regulate new contaminants. The impact of PFAS to our drinking water supply has been under evaluation since the EPA began monitoring for six PFAS under the Third UCMR in 2013.[2] Under the Fifth UCMR, the EPA intends to extend the list to monitor 29 PFAS in public drinking water systems, starting in 2023.[3]

In May 2016, the EPA announced a lifetime health advisory for PFOA and PFOS in drinking water, which was not an enforceable standard, but has been implemented as such in several states in the absence of a federal maximum contaminant level (MCL). In February 2021, the EPA announced proposed regulatory determinations for PFAS in drinking water, so an MCL for PFOA and PFOS could be in place by the end of the year.[4] With growing public awareness and expected national standards, municipal water utilities will want to be prepared to address the MCL. Current treatment options are limited and expensive, but technologies that could lessen the cost and burden of PFAS treatment and removal for the water industry are emerging.

Options For Treating PFAS In Drinking Water

The EPA has identified several ways to remove PFAS from drinking water. These technologies can be used at water treatment facilities, hospital water systems, individual buildings, or even in homes. According to the EPA, each has financial and logistical considerations that need to be evaluated on a case-by-case scenario.[5]

Filtering water through tanks containing granular-activated carbon (GAC) is the most commonly used approach. Once PFAS are observed at the outlet of the GAC tanks, the GAC is considered spent and must be removed.[6] This approach has the scale and capacity to effectively extract PFAS from drinking water, and there are GAC systems at water treatment facilities across the U.S. The drawback is that spent GAC must be heated to 1,300°F in an oxygen-free environment to be reactivated, which can be a costly and cumbersome process.[7]

Drinking water can also be treated with powdered activated carbon (PAC). While it is less effective at removing PFAS than GAC, and more expensive, it is useful in scenarios that require rapid removal of PFAS because the PAC can be added directly into the rapid mix tanks of a water treatment plant.[8] Like GAC, the issue of what to do with the sludge that contains adsorbed PFAS remains.[9]

Ion-exchange resins are another option. Treatment with ion-exchange resins is typically more expensive than GAC, but it is possible to remove a high percentage of the PFAS for a window of time dictated by various factors, including the type of resin used, water quality, and which PFAS need to be removed.[10] These ion-exchange resins are either single-use or require regeneration with solvents, which yields a concentrated waste stream that needs further treatment.

Nanofiltration and reverse osmosis filter water through membranes that are typically more than 90 percent effective at removing a wide range of PFAS. Approximately 80 percent of the water coming into the membrane passes through to the treated water, leaving roughly 20 percent as a high-strength concentrated waste.[11] Both technologies can be costly and energy intensive.

Promising Destruction Technology Is Here

With all of the above treatment technologies, PFAS contamination is transferred from one media to another. An ideal solution would be one capable of destroying PFAS and preventing them from transferring elsewhere to avoid creating harmful byproducts. Fortunately, a technology that can destroy PFAS from environmental aqueous media and the concentrated waste streams generated from other treatment applications does exist — supercritical water oxidation (SCWO).[12]

SCWO powers an exciting new onsite destruction solution that is currently being scaled for treatment of waste materials. Unlike treatment technologies that transfer PFAS from water to another media, supercritical water oxidation can effectively destroy PFAS in contaminated water to non-detect levels in seconds, leaving only inert salts, carbon dioxide, and PFAS-free water behind. An added benefit of reducing PFAS to the lowest levels of detection is that it mitigates concerns about meeting unknown future regulatory limits.[13] Once tested to confirm regulatory compliance, the treated water can be used or discharged back into the environment.[14]

Currently, SCWO is available for treating onsite finite volumes of contaminated water. However, it has the potential to be paired with other drinking water treatment techniques. Reverse osmosis can be used on the front end to reduce water volume, after which the resulting highly concentrated PFAS stream can be destroyed using SCWO. Similarly, SCWO can be used for onsite treatment of GAC and ion-exchange resin regenerant, enabling recycled GAC and ion-exchange resins to be used for multiple treatment cycles. This would also reduce operation and maintenance costs and lengthen the life of the GAC system.[15]

The addition of destruction technologies such as SCWO provides the most promising solution for PFAS removal in aqueous media. The technology also enables continued use of existing treatment systems, which could potentially save water utilities a lot of money. There is still more to learn about coupling PFAS treatment and destruction technologies, but the rigorous research that is underway is providing the solutions we need to address this challenge. ■

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About The Author

Amy Dindal is currently leading Battelle's PFAS program and is responsible for setting technical direction and oversight of a multidisciplinary team of more than 50 staff that includes scientists, engineers, chemists, biologists, toxicologists, and modelers. In this role, Dindal has applied her technical understanding of chemical processes and analytical chemistry to support development of innovative approaches and technologies to characterize, model, and remediate PFAS compounds in water and soil. Under Dindal's technical leadership, the team has filed 10 provisional patents, three nonprovisional patents, and five trademarks in less than 2 years. Amy holds a B.S. in chemistry from Penn State University and has been a certified Project Management Professional (PMP) since 2006.

MANAGING WATER IN THE FACE OF NATURAL DISASTERS

With resiliency, water scarcity, and cost efficiency top of mind for water utilities, smart water operations come to the fore as an all-of-the-above solution.

By Jeff McCracken

Data show extreme weather events are increasing.[1] This is challenging utility providers who are managing critical infrastructure around the globe. The year 2020 was truly devastating for wildfires. From California to Australia, the world got a firsthand glimpse into how warmer, drier conditions are causing harsher droughts — resulting in longer fire seasons and greater water scarcity.

Extreme weather makes managing water an even more onerous task, as droughts causing dry and hot weather in the West increase fire danger and limit available resources, and populations continue to grow. Conversely, storm-ravaged parts of the country are dealing with excessive water that threatens to push wastewater systems to their breaking point while also potentially contaminating freshwater systems.

Today's water utilities can best prepare for either scenario by taking a more active and forward-thinking approach to managing resources.

Managing Water Operations In The Face Of Storms

Hurricanes and tropical storms can cripple water infrastructure facilities. In the wake of Hurricane Katrina in 2005, the U.S. EPA estimated that more than 1,220 drinking water systems[2] and more than 200 wastewater treatment facilities in Louisiana, Mississippi, and Alabama had been affected. More than 10 billion gallons of raw and partially treated sewage[3] gushed into waterways and bubbled up onto streets and into homes as a result of Hurricane Sandy in 2012.

Restoring damaged facilities and ensuring water safety — from repairing equipment and cleaning sewer lines, to testing for toxic chemicals and bacteria and activating disinfection units, to restoring pressure for water distribution — are time-intensive and costly. The restoration process also involves cleaning and repairing.

Bringing intelligence to the edge, similar to what is happening in the power grid, enables utilities to manage water operations using innovative algorithms and dashboards to manage devices, software, and services holistically.

While clean, safe potable water is critical, removing millions of gallons of wastewater is vital. Modern technology can help by tying in a wastewater solution to a smart network. Bringing intelligence to the edge, similar to what is happening in the power grid, enables utilities to manage water operations using innovative algorithms and dashboards to manage devices, software, and services holistically. The added intelligence also allows utilities to deliver better services day-to-day by gaining visibility into its network to identify and prioritize leaks and manage service delivery and wastewater treatment.

For utilities, predicting the unpredictable can be a challenge. Digital twin technology is providing promise in this regard. Digital twins are software representations of assets and processes that help understand, predict, and optimize performance to achieve improved business outcomes. Digital twins consist of three components — a data model, a set of analytics or algorithms, and knowledge — and are extremely valuable when it comes to predicting the impact of a storm for sewage and stormwater management.

The first step in creating a digital twin is to simulate the water operations network in a digital replica. Next, develop a data model of normal operations. Then apply knowledge of what we know from previous storms to predict what may happen in a specific scenario.

While a digital twin can help simulate oncoming storms, like forecasting what may be happening, the real value is in the ability to predict future events, understand areas of weakness, and address these all before a storm hits. The ability to identify the aging infrastructure that may be a point of weakness and replace or repair proactively is a key value added by digital twins. This proactive insight prevents emergency repairs and makes regular repairs less costly to manage. It also allows water providers and utilities to develop protocols and scenarios ahead of time to better manage wastewater removal under the worst conditions. When multiple scenarios and potential failures are simulated digitally, artificial intelligence (AI) and machine learning (ML) technology can rapidly learn from these scenarios to provide insights into how to best manage resources when a storm hits.

The ability to identify the aging infrastructure that may be a point of weakness and replace or repair proactively is a key value added by digital twins.

Managing Water Operations In The Face Of Fires

Water scarcity from drought, hot weather, or other factors is a critical contributor to how we prepare for and manage water operations in fire-prone areas. The Australian wildfires provide a recent example of how drought and growing wildfires can threaten wildlife and humans, as well as their impact on the availability of water overall.

In areas like this, every drop of water counts, as almost one-third of water — 128 million cubic meters of water globally each year — is lost before even reaching a customer. To put this into context, this is about a quarter of the amount of water in Sydney harbor — 562 million cubic meters of water.

Why are we losing so much water? Unfortunately, most of the aquatic utility infrastructure in the U.S. is more than 60 years old, underground, and hard to inspect. Nonrevenue water loss is a big problem and costs $39 billion each year — not counting the other costs due to drought or fires. Regulatory mandates are also driving the need to decrease water loss. How can utilities better protect water resources in times of drought and in the face of the fire season?

Similar to the example above, adding more intelligence[4] to water operations systems can provide critical insights to save on water loss. Artificial intelligence and advanced data analytics are providing a better understanding of historical data to generate insights we can use today. Using historical data can help utility providers understand average water usage models and ways to reduce use. Data also allow utilities to engage with customers proactively. Benefits include the ability to flag higher-than-usual water usage earlier to identify potential leaks, as well as to understand potential inefficiencies and reach out to customers to help incentivize changes in usage.

Utility providers can also leverage data to detect leaks in the system by using sensors that can "listen" for the frequency of a water leak. Digging is costly and disruptive. Data analysis can help utility providers reduce costs by fixing leaks before they become an emergency fix (and more expensive). This also allows for the ability to disaggregate water loss. Providers can see potential nefarious water resource theft by looking at a physical loss from leaks.

Conclusion

We must take an active approach to water operations management as we face increases in extreme weather events. There are many challenges utilities face in managing this precious resource, but modern technology is giving us new ways to help predict and control the unpredictable. Adding more intelligence to our water operations network allows forward-thinking utilities to manage resources and minimize risks, while providing a more proactive path to increase operational efficiencies and improve the overall customer experience. ■

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About The Author

Jeff McCracken, director of operations management outcomes, provides global leadership for software and services solutions that incorporate Big Data technology, industry expertise, and advanced algorithms to deliver business intelligence and predictive analytics to Itron's utility customers. He oversees the discovery and validation of market opportunity and market use cases and drives go-to-market strategy ensuring strategic positioning, allowing the utility to achieve maximum value from its smart grid, smart water, or smart gas investment.

Addressing The Utility Workforce Challenge With A Pipeline Of Opportunities For Youth

With training and development as a high priority for top talent, one nonprofit partners with a utility leader to uplift the next-generation workforce.

By Luis Olivieri, Bridgette McCauley, and Shelton Anderson

The water industry, like many others, is facing an enormous workforce development issue. Some of the most skilled and longest-tenured workers are aging out and leaving a knowledge gap for the incoming workforce. And with the COVID-19 economy pushing some workers into early retirement, it's never been more timely (or important) for utilities to focus on new and innovative ways to identify and train the next-generation workforce.

Yet, for utilities specifically, this pivotal moment of workforce transformation brings great opportunity to diversify the industry's workforce. Because of new technologies and innovations, front-line utility jobs are not as labor-intensive as they used to be, so companies have the ability to recruit people from a variety of backgrounds vs. the traditional labor workers that historically filled these positions — resulting in a greater, more inclusive pool of talent. But how can the utilities industry and your company specifically get started with recruiting (and retaining) talent to meet current and future needs?

1. Identify the right partner(s) to help develop an inclusive workforce development strategy.

Maintaining a dependable workforce is crucial in today's world, and now, more than ever, inclusion and diversity must be top-of-mind. There are various programs and partnerships in each community that can help attract and recruit young talent to meet your organization's current and future needs.

Organizations and employers of all industries are having important and challenging conversations about workforce development and how they can not only identify potential talent but also ensure that talent is representative and inclusive. Helping to facilitate this requires an early introduction of various career paths and possibilities to America's youth, especially in essential and increasingly tech-driven industries like ours.

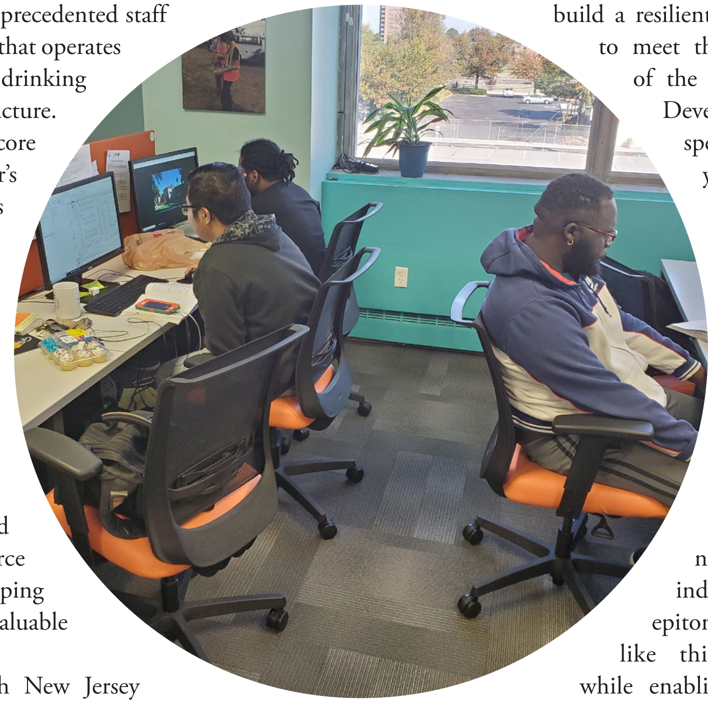
One highly successful partnership that is a model for creating opportunities, as well as a qualified pipeline of employment, is American Water, the largest and most geographically diverse U.S. publicly traded water and wastewater utility company, with Hopeworks, a social enterprise based in Camden, NJ, that uses technology, healing, and entrepreneurship to transform lives. Through this partnership, Hopeworks and American Water are able to provide real work experience to youth with state-of-the-art geographic information system (GIS) and global positioning satellite (GPS) technology and, in turn, provide a qualified pool of diverse applicants for in-demand jobs.

2. Introduce young professionals to pathways in the utility industry.

Utility jobs offer a career path toward a sustainable future, with fewer educational barriers than other fields. Unlike some public-sector jobs, a rewarding, lifelong position in the water and wastewater industry does not requre a college degree. Companies need to ensure that there are meaningful and different pathways for young people that will lead to high-quality jobs and a supply of workers who have mastered the skills necessary to succeed.

American Water provides its customers with safe and reliable water and wastewater services. Its employees help make that happen. However, one of the major challenges facing the nation is the critical and unprecedented staff shortage in the water workforce that operates and maintains our essential drinking water and wastewater infrastructure. Workforce development is a core component of American Water's strategy, and it regularly looks to identify opportunities to partner with nonprofits in the communities it serves, which is why New Jersey American Water partnered with Hopeworks. New Jersey American Water saw real potential in partnering with the organization, creating new possibilities to expand and enhance its current workforce development strategy while helping Camden-based youth develop valuable job skills.

The partnership began with New Jersey American Water engaging one or two Hopeworks youths as in-house interns, where they had exposure to GIS mapping and GPS, as well as day-to-day tasks. New Jersey American Water needed additional support on asset records, specifically legacy assets, in its Camden service area. The legacy asset component volume was so immense that Hopeworks was able to provide additional support to get the legacy information accurately updated in the systems. In addition, the interns were able to help support other needs such as main-break mapping, which impacts all aspects of the business, and getting that information accurately updated.



3. Identify opportunities to cultivating long-term talent.

Investing in youth and identifying opportunities to develop their workforce skills with the potential for advancement will build a resilient and adaptable workforce ready to meet the challenges and opportunities of the water and wastewater industry. Developing the next generation of specialists requires engagement with youth to promote awareness of promising career opportunities in the industry. Partnering with an organization can help enlarge the pool of potential applicants for water industry careers that need to be filled now and in the coming years.

Hopeworks and American Water continue to provide youth the opportunity to develop and understand the skills needed for a career in the water industry. One young woman's story epitomizes the value that partnerships like this bring to the community while enabling the company to fulfill its mission of providing safe and reliable water and wastewater services.

When the partnership began, Ashley Pena served as an intern with the tap imaging project, and since then, Hopeworks and New Jersey American Water have had the pleasure of witnessing and contributing to her professional growth. She first came to Hopeworks and began to nurture her skills in tech, then advanced into an internship with Hopeworks' GIS department. During her

Developing the next generation of specialists requires engagement with youth to promote awareness of promising career opportunities in the industry.

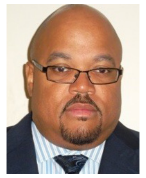
internship, New Jersey American Water saw real potential in her and made an opening for her to work full-time in the Camden office. She is a prime example of why the partnership works. When there are opportunities to expand, training youth to be the best they can be inspires more young people to get involved.

The opportunity is now. American Water and Hopeworks expanded their partnership to include another state subsidiary, Tennessee American Water. This partnership continues to provide real-world work experience in one of the most in-demand, growing fields, while also benefiting customers. The partnership has resulted in several Hopeworks youth securing positions with New Jersey American Water after their internships, as well as creating a steady pipeline of jobs for Hopeworks graduates in the GIS field. As utility companies continue to develop their workforce development strategies, organizations like Hopeworks are ready to help with solutions and provide their expertise because they acknowledge that this is a game everyone can win and that there is so much need for workforce development with plenty of opportunity to do things differently. ■

About The Authors

Luis Olivieri is the GIS Director at Hopeworks. For 16 years, he has worked as a professor in the areas of GIS, remote sensing, and GPS at various universities and colleges, including the University of Puerto Rico at Mayaguez, where he received his B.S. and M.S., and Rowan University. Luis worked as a researcher for the Puerto Rico Water Resources and Environment Research Institute and has worked as a consultant for the private sector as well as state and federal agencies.

Bridgette McCauley is a GIS Project Manager at New Jersey American Water. She has worked directly with the Hopeworks organization since July 2019. Bridgette graduated with a B.S. in Environmental Science from the State University of New York at Oneonta and worked for a series of non-profits before moving into the water/wastewater sector. She has been with New Jersey American Water since July 2015.



Shelton Anderson is the GIS Manager at New Jersey American Water. Shelton has been with American Water for six years and during this time has held various GIS roles in New Jersey, Virginia, and Maryland. Prior to American Water, he worked for three years in GIS at Hamilton Township MUA in Atlantic County, NJ.

Shall We Compromise The Health Effect Of Disinfection Byproducts To Control Waterborne Diseases?

Disinfection has come a long way — enough so to consider alternative options that can help water suppliers avoid harmful byproducts.

By Emma Flanagan

While chlorine-based disinfectants are the most commonly used, not a single one is always effective against all pathogens, biofilms, and oxidizable compounds. All oxidizing disinfectants generate disinfection byproducts (DBPs), which pose potential health risks of their own. Currently, most drinking water regulations aggressively address DBP problems in public water distribution systems, with the most concern placed on trihalomethanes (THMs), haloacetic acids (HAAs), bromate, and chlorite. The World Health Organization, via *WHO Guidelines for Drinking Water Quality*, recommends that water disinfection should never be compromised by attempting to control DBPs. The risks of human illness and death from pathogens in drinking water are much greater than those from exposure to disinfectants and disinfection byproducts. Nevertheless, if DBP levels exceed regulatory limits, strategies should focus on eliminating organic impurities that foster their formation without compromising disinfection.

The Chlorine Dilemma Continues

Long gone are the times when good taste and smell were the guarantees of safe drinking water. In 1854, the British scientist John Snow discovered that cholera was spread through contaminated water. He applied chlorine to purify the water, which paved the way for the future of water treatment … happily ever after until 1971, when the American scientist Thomas A. Bellar discovered that chlorination in a drinking water treatment plant with a source from the Ohio River was creating disinfection byproducts in the form of chloroform. When in 1972 the Clean Water Act was introduced in the U.S., the discovery of more DBPs followed soon after.

When it comes down to water disinfection, there has been an interesting trend over the past several decades. More and more water treatment facilities are switching from chlorination to other means of disinfection. Based on efficiency, UV, ozone, and chlorine dioxide are the most efficient overall as broad disinfectants. Each has unique advantages and disadvantages in cost, efficacy-stability, ease of application, and the nature of DBPs. Interestingly, all current chemical disinfection methods are associated with byproducts, but chlorinated DBPs are the most well studied.

Parameter	UV	Chlorine	Sodium Hypochlorite	On-demand Electro-chlorination	Ozone	Chlorine Dioxide	Chloramines
Bacteria	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good
Parasites	Excellent	Fair to Poor	Poor	Fair	Very good	Excellent	Poor
Viruses	Excellent	Good	Good	Good	Excellent	Very good	Fair
Biofilm control	None	Low	Very Low	Low	Low	Medium	Low
Organic DBPs	None	High	High	High	Low	Low	Low
Brominated DBPs	None	High	Medium	High	High	None	None
Operational Hazards	Low	High	Low	Low	Medium	Medium	Low
Operational Complexity	Low	Medium	Medium	Medium	High	High	Medium
Capital Cost	Medium	Medium	Medium	Medium	High	Medium	Medium
O&M Cost	Medium	Low	Low	Low	High	Medium	Low
Environmental Footprint	Low	High	Medium	High	High	High	Medium

The Case Of UV Radiation

When UV light-based reactors were discovered, the costs for installing and maintaining them were high. Over the years, development in the UV sector has decreased the costs significantly, and UV-radiation optimization has made this a viable method for water disinfection. After many years of research, it is recognized as one of the most effective alternative water disinfection processes available. UV radiation does not kill the micro-organisms directly, but it damages their DNA and RNA. By doing this, the micro-organism can still function; however, it cannot use its DNA/RNA to reproduce, causing the organisms to become extinct. UV disinfection is effective at inactivating most micro-organisms that are present in the water. What remains is often removed by adding oxidants.

One of the most important advantages is that it does not produce any known toxic byproducts. Another advantage of UV disinfection is that the effectiveness is relatively insensitive to temperature and pH differences. Also, UV installations require little supervision or maintenance. Its benefits include improved safety, minimum service time, low operation and maintenance costs, and no chemical taste or smell to the disinfected water. Two key disadvantages have to be taken into account when considering UV radiation disinfection. Probably the most crucial disadvantage is that UV light can be scattered and therefore be ineffective in neutralizing micro-organisms. Suspended solids, turbidity, color, or soluble organic matter can cause this. Turbidity also limits the penetration depth of the radiation in the water. To limit these problems, precautions have to be taken, such as filtering of the water and reducing turbidity. A second substantial disadvantage is the absence of any residual disinfectant in the water, which means that unless the water is transported through a micro-organism-free environment, there is a chance of recontamination. Another disadvantage of UV disinfection is the complicated process of measuring its effectiveness.

"Since disinfection is a critical barrier to waterborne disease, it should never be compromised in attempting to control disinfection byproducts" – *WHO Guidelines for Drinking Water Quality.*

The Case Of Ozone

Ozone is an excellent broad-spectrum and fast disinfectant, as well as an excellent oxidizer. It is an unstable compound that rapidly decomposes into much more stable oxygen. For the ozonation of drinking water, ozone must be produced onsite. Ozone is generated by discharging a high-voltage current in dry air or pure oxygen (much as in nature, where a distinct ozone smell can be discerned after a thunderstorm). This method yields a maximum of 3% ozone for air, while yields of 12% are achievable with pure oxygen. The ozone is then brought into contact with the water that has to be treated. It is used as a standalone in some cases. It can also be combined with hydrogen peroxide (H_2O_2), UV light, or active chlorine to perform an advanced oxidation process (AOP). This AOP produces highly reactive hydroxyl radicals (OH•). These reactive species are the most potent oxidants that can be applied to water. They are used to address contaminants with high chemical oxygen demand (COD) or non-biodegradable molecules. They also improve the overall quality of the water. Ozone can be used to complement chlorine disinfection of drinking water, and utilities can reduce the use of chlorine if there's a concern about dangerous byproduct formation.

Ozone disinfection equipment is more complicated than chlorination systems. It is very costly and has significant energy demand. To ensure proper disinfection and account for gas-solubility ratio, ozone dosage is higher than what is required in the water. About 85% of the energy input to a corona discharge system is wasted in the form of heat. This method is exceptionally energy-intensive, meaning that ozone generation is typically more expensive than the alternatives. Naturally, some very irritating and probably toxic ozone remains in the off-gas after contacting. To release the off-gas safely into the atmosphere, it must be run through an ozone destruction unit. Other disadvantages are that when ozone reacts with organic compounds, it creates a variety of byproducts. If the water contains bromide ions, ozone treatment can form brominated compounds like the bromate ion, a possible human carcinogen. Finally, ozone is unlike chlorine in that there is no residual or remaining disinfectant once the process is over; any ozone that doesn't react with contaminants breaks down completely. This makes it more difficult for plant operators to keep tabs on how well disinfection is working since there is no residual ozone in the water that they can monitor.

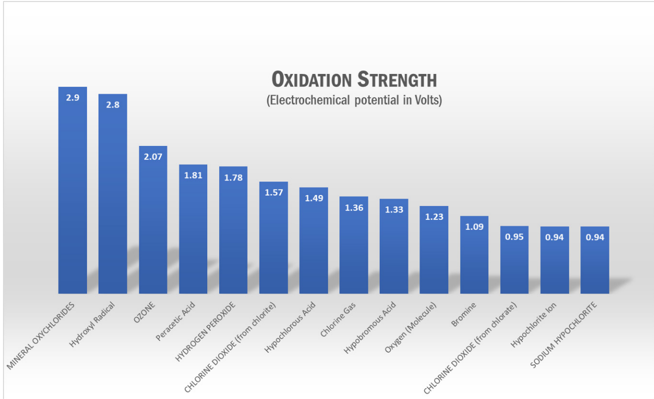
The Case Of Chlorine Dioxide

Chlorine dioxide is another break-off from chlorine that can be used to treat and purify water. More systems worldwide have been turning to chlorine dioxide to treat drinking water to improve taste, odor, and color; remove iron and manganese; and inactivate chlorine-resistant micro-organisms with a limited formation of DBPs.

Chlorine dioxide is a synthetic, green-yellowish gas discovered in England in 1814. It is a small, volatile, and strong molecule with the formula ClO_2 and a chlorine-like, irritating odor. However, it is different from chlorine Cl_2, both in its chemical structure and in its behavior. It dissociates into chlorine gas (Cl_2), oxygen gas (O_2), and heat. Diluted in water, chlorine dioxide is a free radical, and when it is photo-oxidized by sunlight, it falls apart. One of the qualities of chlorine dioxide is its high water solubility, especially in cold water. It is approximately 10 times more soluble in water than chlorine. It does not hydrolyze when it enters water; it remains a dissolved gas in solution.

In water treatment, chlorine dioxide is an effective biocide that is strong enough to attack the disulfide bonds found in the membranes of bacteria and other biological materials that play a vital role in micro-organisms, and they are not able to build resistance. It is also very good at attacking biofilms. As an oxidizer compared with other oxidizing biocides, chlorine dioxide has a significantly lower oxidation strength — this means that it reacts with fewer compounds, such as organic compounds and ammonia, which is characterized as selective oxidation.

Research indicates that pure ClO_2 used in water with organic content creates lower amounts of DBPs. It does not form THMs



but may generate small concentrations of dihalogenated HAAs. A growing body of literature shows that ClO_2 preoxidation can help reduce chlorine-related DBPs when chlorine is subsequently applied for primary or secondary disinfection. While test data can look great during lab studies, onsite generation of ClO_2 often involves the production of free chlorine, unreacted reagents, or side-reaction products; thus, the disinfectant is a mixture, and the ratios of ClO_2 to chlorine significantly affect the chlorine DBPs formed, depending on the properties of the water being treated. Even when the generation of chlorine during onsite production of ClO_2 could be negligible, the production of chlorine dioxide, its decomposition, and its reaction with natural organic matter (NOM) still lead to the formation of byproducts of its own, like chlorite and chlorate. Chlorite (ClO_2-) is a compound of health concern along with chlorate (ClO_3-), which can be harmful in high concentration but is not yet regulated.

Like ozone, chlorine dioxide must be produced onsite, implementation is expensive, and it takes more technical skills to use. Operation requires daily monitoring of chlorite and chlorine dioxide.

The Case Of Advanced Oxidation

Degradation and mineralization of NOM is the best way of controlling the production of DBPs. The highest oxidation state reached by a chemical pollutant will be determined by the oxidation potential of the oxidizing agents. Advanced oxidation is a process that applies enough hydroxyl radicals to achieve significant change at the molecular level. The hydroxyl radical is a reactive oxygen species with the highest oxidation potential among all oxidizing agents used in water treatment. It is mainly non-selective and reacts by decomposition with most compounds it encounters on its path. In 2013, the International Sanitary Foundation certified NSF/ANSI 60, the first advanced oxidation reagent for the treatment of drinking water for human use. This reagent is a multimineral oxychloride liquid formula that does not need to be generated onsite, has low safety risk, and is cheaper and simpler to operate than other chlorine alternatives.

The mineral oxychloride*, $M_xO_yCL_z$, mimics the oxidation processes in nature. Although it is considered a chlorinated compound because it can produce OCl- and provide a measurable chlorine residual, its active agents are reactive oxygen species in the form of radicals and ionized oxygen with very high oxidation potential. They can complete chemical reactions extremely fast and transform all oxidizable substances into their highest oxidative state. When the mineral oxychloride reacts with water, the residual hypochlorite ion is basically on standby without the opportunity to attack micro-organisms or degrade compounds, and its oxidative potential, since it is not being spent, becomes a backup energy source for residual protection.

The mineral oxychloride is 100 percent soluble in water at all temperatures and will not break down in gas form. It has low sensitivity to pH, and its reactivity increases with the temperature of the water. Rather than being photo-oxidized by sunlight, like chlorinated compounds, it is catalyzed by the sun, and its exposure increases reactivity. The main oxidizing oxygen species that it produces are hydroxyl radicals, oxygen ions, and hydroxyl ions. It also generates large quantities of perhydroxyl and superoxide radicals.

In drinking water treatment, the mineral oxychloride has superior effectiveness to ozonation at a fraction of the cost and without external energy consumption. For this reason, it is sometimes called "liquid ozone." When comparing to ozonation, however, it is important to note how they differ in the utilization of energy and the formation of DBPs. Ozone generation requires external energy, and in water treatment the process is not very energy efficient, so more energy than what is consumed by the formation of ozone molecules must be applied. The excess energy in the water will excite bromide ions when present and produce bromate. On the other hand, the mineral oxychloride is catalyzed by the internal vibrational energy of transition minerals, which in turn activates the reactive oxygen species, a very energy efficient process whereby all the energy is created and used at the atomic level. There is no excess energy transferring to the water. The mineral oxychloride, even if applied in excess, does not react with bromide ions and does not create bromate.

There are other important conveniences of using mineral oxychloride. It has a minimum shelf life of six months in normal storage conditions, a negligible capital cost (only needs automatic liquid dosing equipment), and a smaller amount will be required to treat the same volume of water since it is a more powerful oxidant than all chlorinated products — comparable to the refractory pollutant degradation that can be obtained with catalyzed hydrogen peroxide or peroxone, without generating any byproducts and while providing robust residual protection. After all, advanced oxidation is, by definition, an oxidation process that has been taken to the next level! ■

**The mineral oxychloride solution is sold with the trademark Bio-hydrox™ by Envirocleen LLC (www.envirocleen.com).*

About The Author

Emma Flanagan is a water consulting professional specializing in applications of homogeneous catalytic generation of reactive oxygen species with transition minerals. She holds an M.S. degree in sanitary engineering from IHE Delft Institute for Water Education in the Netherlands, the largest international graduate water education facility in the world. Flanagan stays busy doing research, educating, and providing consulting services.

Why Invest Time And Resources In Reducing Non-Revenue Water?

As the incentive to minimize non-revenue water and decrease OPEX becomes ever more imperative among U.S. utilities, lessons can be learned from pioneering Danish utilities that had to do a similar maneuver 20 years ago and today have one of the lowest water-loss rates in the world.

By Frederikke Rørvang Mikkelsen

A well-run water utility runs like a typical business. Imagine if I told you that many of these businesses are losing more than one-fifth of their products every year. Chances are, you would argue that these businesses are not very well run. Nevertheless, this is the reality of many water utilities worldwide as non-revenue water (NRW) is increasingly challenging operations and expenses due to aging infrastructure, inaccurate water meters, and leaks.

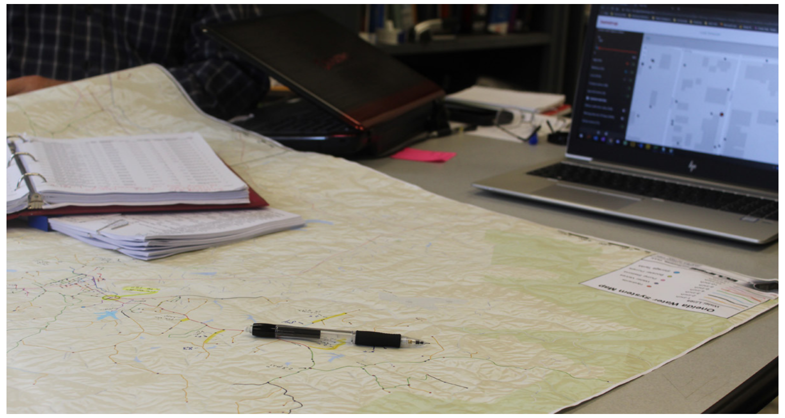
You can say that "out of sight out of mind" is readily applicable to how many utilities face NRW challenges. The issues are indeed very much out of sight, as most of the U.S.'s drinking water infrastructure, which totals 2.2 million miles of pipes, is below the surface. However, the consequences are genuine.

Studies show that between 250,000 and 300,000 water main breaks were reported in the U.S. between 2012 and 2018. This number of leaks is the equivalent of a water main breaking every 2 minutes. In general, the rate of pipe replacement is increasing, and many utilities are already working on reducing the leaks — but unfortunately, fixing the problem is easier said than done, as the solutions are often both complicated and expensive. In some cases, the cost of losing the water might seem lower than the effort it takes to solve the problem.

Also, large cities worldwide currently face a future where clean and safe water shortages will occur due to population growth and climate changes. For many of these cities, water loss accounts for a considerable amount of lost revenue. Therefore, there truly is much to gain by reducing NRW, from both an economical and sustainable perspective. "In many cases, utilities can address the issues around water scarcity within the current water resources and main water infrastructure if efforts to reduce the NRW increase," explains Michael Rosenberg Pedersen, senior technical advisor of the Danish Water Technology Alliance.

Oneida Water And Wastewater Department's Goal: Reduce Water Loss By Up To 30 Percent In One Year

The water and wastewater department of Oneida, TN, is familiar with the consequences of aging infrastructure. The utility currently loses 50 percent of its water, resulting in $180,000 loss per year. Over the past 10 years, the water loss solely related to NRW has steadily increased.



"For quite some time, Oneida has been struggling with severe water loss that primarily originates from service and main breaks and slow displacement meters aging up to 20-plus years old. In addition, leak detection efforts have been limited," says Stephen Owens, general manager at Oneida Water and Wastewater Department.

However, in 2018, Mayor Jack E. Lay hired new management that made major changes, including adding new zone meters and, in recent months, changing 3,500 displacement meters with a complete, advanced metering infrastructure (AMI) system with built-in acoustic leak detection (ALD). The system was developed by the Danish company Kamstrup, and it solves two issues — water loss and aging meters — with one solution.

The ALD system represents a new generation of meters that, in addition to exact measurements on water use and automated encrypted data transmission, also provide acoustic noise logging. This new feature monitors the noise inside the water pipe both at the consumer end and in the distribution network. This way utilities will be able to quickly pinpoint the leak in the field.

Owens explains that the utility has ramped up its efforts to reduce both the real and apparent losses. The goal is to reduce water loss by 30 percent within the following year. The challenges related to water loss, operations, and leak detection have happened quickly, and leak detection is now a big focus for the utility. It expects to have the entire water system consisting of 4,500 meters changed by June 2021.

Rosenberg Pedersen compares the new ALD system to a Swiss Army knife, as it presents combinations not seen before — a new diagnostic tool in the water distribution system with built-in ALD.

ALD is usually an add-on the water utility runs using noise loggers installed on a small number of fire hydrants in specific areas of interest. However, this new meter integrates measurement, monitoring, and diagnostics in the entire distribution network. Furthermore, it pinpoints leaks and enables widespread sound monitoring, which allows specific inputs to the utility's asset management and pipe replacement strategy.

Adding noise loggers to the consumer end also makes it possible to monitor pipe materials usually unfit for distant noise logging (PVC and plastic pipes). The denser numbers of noise loggers also make noise data analyses more accurate and less affected by local background noises, i.e., generators and drain pumps.

The online monitoring of the distribution network also enables controlled and data-based proactive leak detection. Instead of randomly scheduling leak detection field campaigns in the distribution network, the system allows planning based on actual data — one of the benefits the utility in Oneida highly values.

"With the use of zone meters and the implementation of the new meters that offer a new approach to automated meter reading and integrated ALD from Kamstrup, we now have several tools that we can use to reduce the water loss. The system tells us where to go look for leaks, and we expect that our water loss will be 20 percent by the end of 2022," attests Owens.

Learning From The Danish Water Sector: "We Still Have A Long Way To Go"

Since the 1990s, the Danish water sector has reduced annual water loss by approximately 50 percent, and today, Danish water utilities, on average, lose as little as 7 percent of their water.

In many ways, Denmark is a small country that punches above its weight class. The water sector is no exception. Even though the utilities operate on a minor scale compared to those of the U.S., Rosenberg Pedersen does not doubt that the lessons learned in Denmark are very applicable across the Atlantic. That's because, in the '90s, Danish utilities faced some of the same challenges as the U.S. struggles with today.

Over the years, Danish utilities have worked intensely to keep the distribution network tight and reduce leaks. Efforts are driven by benchmarking performances, optimizing operations, and reducing OPEX, and the initiatives are boosted by the fact that utilities with a water loss exceeding 10 percent are required to pay a penalty fee implemented by the government in 1994.

However, operating, maintaining, and optimizing old water infrastructure and keeping it tight calls for innovative tools and solutions, so that's what the Danish utilities have been developing with vendors such as Kamstrup through the last couple of decades.

One of the keys to achieving such a low water loss has been to install water meters. In fact, installing water meters has been a requirement at all properties connected to public water utilities since 1999. This initiative has been essential in these efforts, as it has resulted in significantly more reliable data on which to base efforts to reduce water loss. Rosenberg Pedersen explains that it also allows utilities to improve planning and investments to meet future demand and prioritize long-term solutions. He continues:

"The benefits water utilities obtain by reducing NRW are, first and foremost, revenue and, secondly, an increased focus on optimizing operation and maintenance as well as a general ability to plan ahead instead of being interrupted in normal operations by numerous bursts that constantly steal the focus."

He further explains that U.S. utilities often challenge why their Danish counterparts still work on reducing leaks when the water loss rate is low. But to Rosenberg Pedersen, the reason is straightforward. He explains that as long as the second-largest city in Denmark, in theory, has one of its water purification plants producing perfectly drinkable water, only to let it go straight down the drain, it will be profitable for utilities to lower their water loss.

"Besides the obvious waste of water, it also adds to a negative equation of overinvestment in treatment facilities, as well as an excessive waste of energy, resources, and person-hours — resources better spent on optimizing operations and investment planning. Until then, we still need to do better and aim to make every drop count," he concludes. ■

Images courtesy of Kamstrup, used with permission.

About The Author

Frederikke Rørvang Mikkelsen is the PR and communications advisor of the Energy and Environment Team at The Trade Council of Denmark in North America. Based in Houston, she primarily supports the activities of the Danish public-private partnership, the Water Technology Alliance (WTA), which aims to share Danish know-how and foster collaboration. Prior to joining The Trade Council, Mikkelsen worked as a communications assistant at the Danish Society of Natural Conservation.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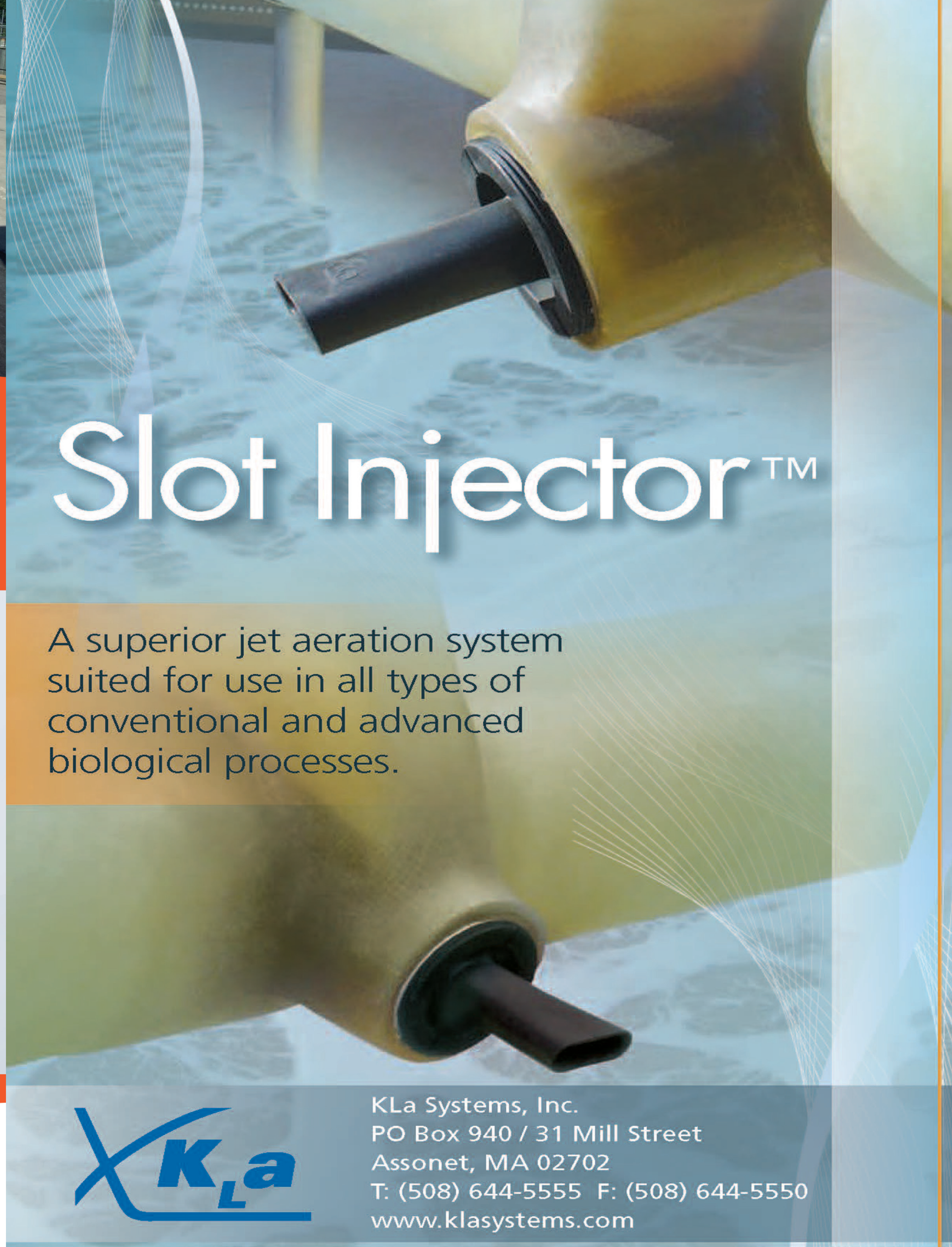
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