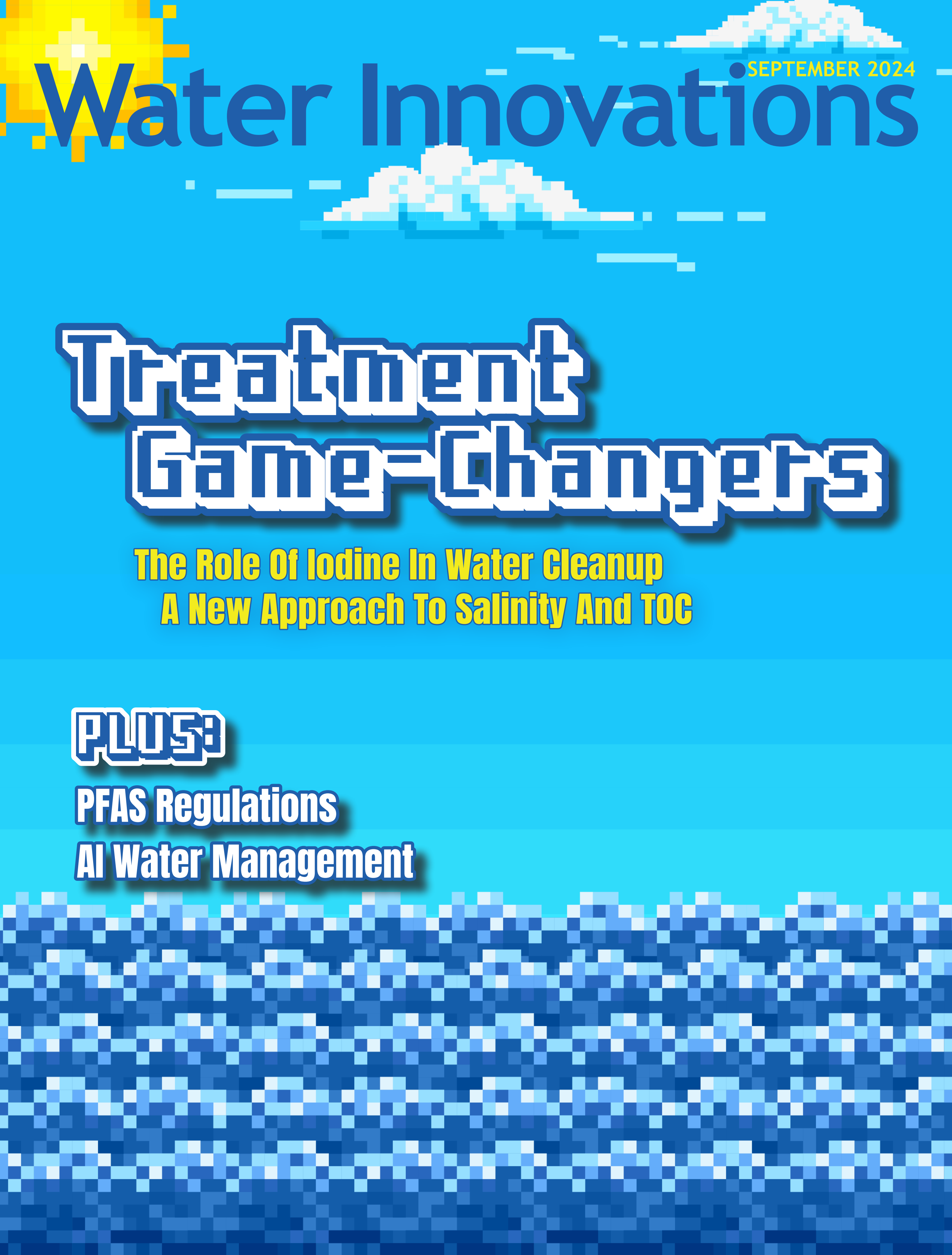

Water Innovations

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FROM THE EDITOR

By Kevin Westerling
Chief Editor, editor@wateronline.com

New Approaches To "Old" Industry Issues

A look at the latest thinking on some longstanding but still very relevant concerns — replacing water pipelines and workers.

Ever thought times are tough… then they get even worse, and you yearn for the regular ol' tough times?

I've been covering the water industry long enough to remember when our two biggest challenges were merely products of time — aging pipelines and an aging workforce. Since then, we've had the Flint water crisis that uncovered long-standing, underlying lead contamination; per- and polyfluoroalkyl substances (PFAS) discovery, starting with "hot spots" before expanding virtually everywhere; and the steady drumbeat of changing climate patterns that have worsened storms and droughts, with direct effect on water and wastewater operations.

Then came the (necessary) regulatory response, particularly Lead and Copper Rule Revisions (to be followed by Lead and Copper Rule Improvements) and National Primary Drinking Water Regulation of PFAS, demanding prompt industry attention. With regard to climate impacts and resiliency, municipalities have the pressure of dealing with current problems — scarcity, flooding, wildfires — while preparing for the next emergency.

With these challenging, pressing, and expensive requirements taking center stage, water and wastewater professionals might miss the days of mostly worrying about replacing pipes and people. However, these issues still exist, and they are no less important now than they were then — just overshadowed. Let's harken back to somewhat simpler times, while also looking forward, by providing some new thinking and solutions around these problems of "old" (with a tip of the cap for their years of great service).

The aging infrastructure and workforce issues coalesce in terms of advancements for pipeline renewal, as staff shortages demand more efficient processes. Rather than reliance on the woefully inefficient "chase and replace" approach, advanced pipeline inspection and assessment technologies have gained in popularity. These include:

- **CCTV and 3D laser scanning**, providing high-definition video and precise measurements inside pipelines, enabling detailed assessment of conditions.
- **Acoustic leak detection**, using sound waves to identify leaks in pressurized pipelines, allowing for early detection and repairs.
- **SmartBall® technology**, utilizing a free-floating device equipped with sensors that travel through pipelines to detect leaks and other anomalies.
- **GIS and asset management systems**, integrating pipeline data with GIS to map and manage pipeline networks efficiently.
- **Predictive analytics**, using historical data and machine learning models to predict the likelihood of pipeline failure and prioritize maintenance efforts accordingly.

Replacing the retiring water workforce with the next generation is a less tech-oriented endeavor, but technology is still very much part of the story. Incoming operators and engineers are digital natives, meaning they grew up in the age of smartphones. They "speak" tech, and thus are comfortable with and therefore encourage the implementation of more digital technologies as they become the new workforce.

The real challenge is locating labor prospects and energizing them for a career in water. Here are some recent and effective initiatives:

- **School partnerships:** Collaborating with high schools, vocational schools, and colleges to introduce students to careers in the industry. This includes offering curriculum support, guest lectures, and field trips to water treatment facilities.
- **STEM initiatives:** Promoting science, technology, engineering, and mathematics (STEM) programs to highlight the technical aspects of water industry careers. This helps attract students with an interest in these fields.
- **Water career fairs:** Hosting or participating in job fairs focused on water and environmental careers, providing students and job seekers with information about opportunities in the industry.

So, while you worry and work to surmount the water and wastewater concerns that seem to mount by the day, consider the techniques and tactics above to help you stay on top of those old issues that never went away. And then page through this latest edition of *Water Innovations* for more technology and strategy guidance on a variety of other industry topics. ■

Kevin Westerling

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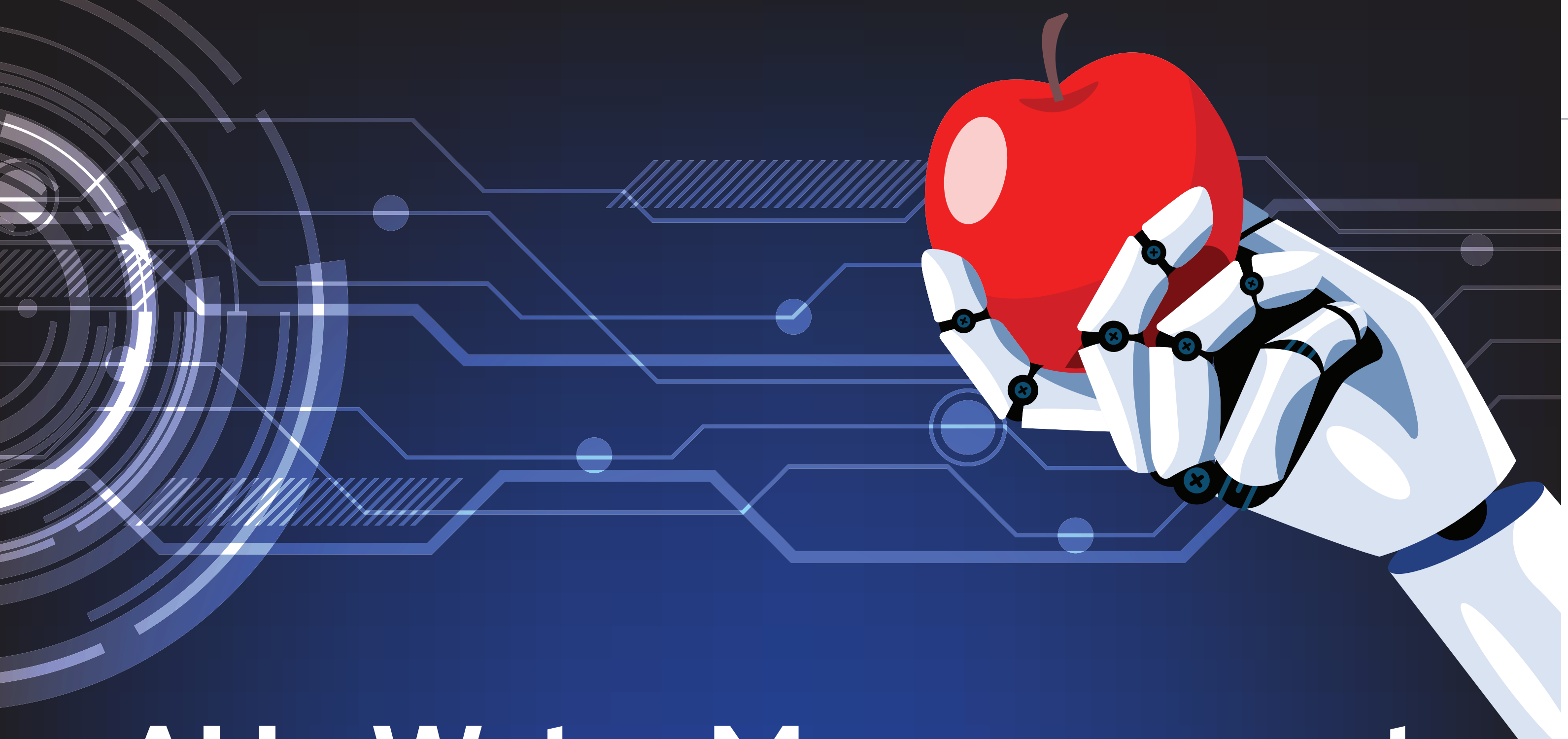

AI In Water Management: Plucking The Low-Hanging Fruit

Tips for bringing the promise of digitalization and AI within reach of water utilities.

By Joe Halliday

The water sector stands on the brink of a technological revolution. Society at large has already embraced automation of manufacturing, self-driving cars are on the streets, and both healthcare professionals and commercial airline pilots are significantly guided by intelligent, digital technology to make better, faster, and safer decisions. Water and wastewater management is poised for a future where intelligent systems optimize operations beyond what we as humans can do alone. This transformation is partly driven by a new generation of variable speed drives that are no longer just simple motor shaft turners controlling the speed of a pump or mixer, but valuable sensors and AI-powered processors.

The Digitalization Dilemma: Overcoming The Barriers To Entry

Despite the promise of digitalization, water utilities face significant challenges. The water industry is characterized by a wide spectrum of digital maturity. Some utilities operate with minimal digital infrastructure, while others boast sophisticated, sensor-driven systems. Irrespective of the current maturity level, most utilities realize that the future is smarter and more digital. Budget constraints often limit investments in new technologies, and the initial costs of sensors and systems can seem prohibitive. There is a clear need to be able to do more with less, instead of adding costs and complexity. Moreover, the critical nature of water infrastructure demands robust cybersecurity measures, adding another layer of complexity and cost.

The AI Revolution: Drives As The Unsung Heroes Of Digitalization

A new breed of smart drives is emerging as a game-changer in this landscape. Conventional drive wisdom will tell you that, by the law of affinity in physics, you can save 40% of the energy used on variable-load applications by equipping direct on-line (DOL) motors with variable speed drives. Smart drives go beyond simply controlling motor speed to save energy on variable loads; they act as advanced sensors, continuously monitoring parameters like current, temperature, and vibration. More importantly, they possess built-in AI and machine learning (ML) capabilities, allowing them to analyze and correlate data in real time, detect patterns, identify anomalies, and predict potential issues before they escalate into costly downtime. Water and wastewater systems are immensely complex, and many of the challenges operators face are not visible to the human eye or comprehensible to us.

Like surgeons and pilots, operators and managers could benefit immensely from digital, data-driven decision support.

> **Imagine a drive that can detect a slight increase in motor vibration, indicative of bearing wear, weeks before a potential failure.**

Unlocking Efficiencies With AI-Powered Drives

The new generation of smart drives offers a plug-and-play approach to AI, delivering immediate benefits across the water sector:

- Predictive maintenance: Imagine a drive that can detect a slight increase in motor vibration, indicative of bearing wear, weeks before a potential failure. This early warning allows for proactive maintenance, minimizing downtime, reducing costs, and preventing environmental incidents.
- Operational optimization: AI-powered drives can analyze operational data to uncover hidden inefficiencies. For example, by analyzing pump performance curves, the drive can identify optimal operating points and detect anomalies before they are visible to the human eye, reducing energy consumption and extending equipment lifespans.
- Real-time control: These smart drives can dynamically control motors in real time based on changing conditions and operating patterns. In a wastewater treatment plant or collection system pump station, this could mean automatically detecting clogging pumps and running a de-ragging function to avoid expensive maintenance and increase pump and system efficiency in real time.

Cybersecurity In The Age Of Smart Drives

As water systems become increasingly interconnected, cybersecurity is paramount. Intelligent drive manufacturers are acutely aware of these risks and incorporate robust security features into their products. These include secure communication protocols, data encryption, and tamper-proof designs. By choosing drives with built-in security features, utilities can strengthen their overall cybersecurity posture. Some smart drives offer built-in edge computing, allowing utilities to harvest the power of advanced machine learning and data processing without relying on external computing power and cloud systems.

Collaboration: Driving Innovation In The Water Sector

The transition to a smarter water future requires collaboration. Drive manufacturers are partnering with utilities to develop tailored solutions and provide ongoing support. Knowledge-sharing platforms and industry forums are crucial for disseminating best practices and fostering innovation. The smart drives are ready off the shelf today, but further work in real-life systems and settings is required to fully capture their potential. As examples, advanced pattern recognition of pressure transients, as well as early and reliable cavitation detection and control in water and wastewater systems, require more demonstration and learning in real-life systems outside manufacturers' labs.

In a nutshell, the technology has matured but applications need further work and will have to rely on a collaborative approach to innovation.

> **Smart drives are not just a technological advancement; they are the building blocks of a self-driving, human-in-the-loop AI future in water.**

Embracing An Intelligent Water Future

The water sector is on the cusp of a paradigm shift. Smart drives are not just a technological advancement; they are the building blocks of a self-driving, human-in-the-loop AI future in water. By leveraging drives as sensors and intelligent controllers, instead of mere motor shaft turners, water utilities can overcome initial digitalization hurdles and reap immediate benefits. Effects not only include drastic reduction of breakdowns, improved operational efficiency, and improved cybersecurity but also pave the way for more ambitious digital transformation initiatives in the future. The key is to start small, focus on achievable goals, and leverage the low-hanging fruits of AI to cultivate a smarter, more sustainable water future. ■

About The Author

Joe Halliday is the director of sales, U.S. water market for Danfoss Drives. He joined the Danfoss water team in October 2010. Prior to that Joe was the sales director for Sierra Instruments, a thermal mass flow meter company in Monterey, CA. Joe has been working in the industrial automation industry for more than 25 years. He is a graduate of the University of Rochester and spent nine years as a naval aviator flying helicopters for the U.S. Navy in the Mediterranean and Persian Gulf, where he became a veteran of Desert Storm.

9 Things

To Know About The EPA's Regulations For **PFAS** In Drinking Water

By Naomi Senehi and Sudhakar Viswanathan

In April 2024, the U.S. EPA introduced new regulations[1] establishing maximum contaminant levels (MCLs) for six specific per- and polyfluoroalkyl substances (PFAS) in drinking water, highlighting the urgency to address their presence due to environmental and health risks. The regulations mandate MCLs for individual PFAS and utilize a hazard index for mixtures to ensure safe levels are maintained. Additionally, the EPA proposed the best available technologies for PFAS treatment and disposal methods for residuals, emphasizing the need for effective and sustainable water treatment solutions. The recent EPA regulations on PFAS in drinking water show the importance of addressing contamination, the need for substantial investment in infrastructure, and the importance of environmental justice and innovation, making these issues critical for the upcoming November elections.

Here are nine important things to know about the EPA's PFAS regulations:

1. The EPA has determined MCLs and a hazard index (HI, for mixtures) for six PFAS in finished drinking water.

PFAS are a class of nearly 15,000 chemicals that have gained significant attention since their incidental production in the 1930s and subsequent manufacture and commercialization starting in the 1950s. Since the 1990s, the EPA has examined the impacts of PFAS and has now established enforceable individual MCLs for five PFAS (PFOS, PFOA, PFNA, PFHxS, and HFPO-DA) in finished drinking water. In addition, a sixth PFAS, PFBS, is also considered under an HI when it is present with PFNA, PFHxS, and/or HFPO-DA in excess of their limits.

These six PFAS were regulated based on their occurrence in drinking water and their corresponding health effects at low concentration levels. Occurrence data was mainly informed by results from the Unregulated Contaminant Monitoring Rule (UCMR 3) program, which required public water systems (PWSs) to monitor for these six PFAS in finished drinking water from 2013-2015.

2. The EPA mandated individual MCLs for five of these PFAS, which ranged from 4 to 10 parts per trillion (ppt).

The MCLs for the five individually regulated PFAS are 4 ppt for PFOS, 4 ppt for PFOA, 10 ppt for PFNA, 10 ppt for PFHxS, and 10 ppt for HFPO-DA. From the EPA's occurrence analysis, median levels of these five PFAS at non-targeted sites (i.e., no suspected major PFAS contamination) ranged from 0.35 ppt (below limit) to 29.6 ppt (above limit), with maximum levels as high as 856 ppt. Compared to their health risk limits (HRLs) of 10 ppt, it is evident that levels of PFAS in finished drinking water must be addressed to protect public health. There is no individual limit for PFBS.

3. A calculated HI > 1 for any combination of PFHxS, PFNA, HFPO-DA, or PFBS indicates the need for action.

In certain instances, individual PFAS levels may be below their individual MCL, but the total PFAS concentration in finished drinking water may exceed maximum levels of safe exposure. In this case, an HI is calculated to ascertain the need for action and applies to any mixture of two or more of PFBS, PFNA, PFHxS, and/or HFPO-DA. Note that PFBS is regulated within the HI but not individually, as more data is needed to assess its occurrence.

4. The EPA's proposed best available technologies for the treatment of PFAS in drinking water include the use of GAC, AIX, NF, and RO, which concentrate (vs. destroy) PFAS.

The EPA assesses the best available technologies (BATs) for drinking water treatment based on seven criteria. To qualify as a BAT, the technology must: (1) have a high removal efficiency, (2) have been demonstrated at full-scale, (3) be geographically applicable, (4) be economically feasible for large water systems, (5) have a reasonable service life, (6) be compatible with existing water treatment processes, and (7) be able to treat water to compliant levels. The EPA proposed granular activated carbon (GAC), anion exchange (AIX), nanofiltration (NF), and reverse osmosis (RO) as BATs for medium to large PWSs. Only GAC and AIX were suggested as BATs for small water systems (serving less than 3,300 people). GAC, AIX, NF, and RO are all designed to concentrate PFAS onto a particular media. Once spent, these residuals require regeneration and eventual disposal. Additionally, reject streams are generated, requiring further treatment or disposal.

5. The EPA's proposed disposal methods for spent residuals and reject streams are reactivation (of GAC), incineration (of AIX), and treatment and discharge (of RO or NF reject streams).

The EPA provided guidance on managing the solid residuals (spent GAC, spent resin, or spent membranes) and reject streams (from NF or RO) from their proposed BATs. For solid residuals, EPA suggested reactivation of spent GAC and incineration of spent AIX resin. Guidance was not provided for disposal of spent GAC after the number of reactivation cycles is surpassed. Notably, while acceptable, these management methods have not been shown to mineralize PFAS fully, and improved test methods for quantifying PFAS emissions from processes such as incineration are still in development. No guidance was provided for the disposal of solid wastes from RO or NF (i.e., spent membranes). The suggested management for the reject streams was general: Reject streams should be treated and discharged to surface water or the sewerage system in compliance with NPDES permits. In some cases, groundwater injection is recommended.

6. The EPA does not expect the designation of PFOA and PFOS as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to jeopardize these disposal methods.

According to some public comments, these management methods are simply "media shifting" rather than the terminal elimination of PFAS, as these methods have poor destruction efficiency. In combination with the recent designation of PFOA and PFOS as CERCLA hazardous substances, disposal of these residuals and retentates must be carefully evaluated. The EPA's response to these concerns is that PWSs will likely not generate enough PFAS-laden waste to require reporting under CERCLA. These systems would have to report if ≥ one pound of PFAS is released in a 24-hour period. Municipal water, wastewater, and landfills are not expected to be heavily impacted by this CERCLA designation, which instead affects agencies such as industrial dischargers.

7. Treatment options are not limited to the EPA's proposed BATs, leaving the gate open for technologies such as supercritical water oxidation.

While the EPA proposed BATs for medium to large PWSs (GAC, AIX, NF, or RO) and small PWSs (GAC, AIX), PWSs are not required to use the suggested BATs. Alternatively, PWSs can elect treatment processes that evade or minimize the generation of difficult-to-handle solid and liquid wastes. For example, a PWS could combine a concentration process such as foam fractionation or precipitation (with a commercial polymer) with destruction technologies such as supercritical water oxidation (SCWO). This ability can also help PWSs make informed investments in technologies that would be suitable not only for treating PFAS, but other currently or soon-to-be regulated contaminants.

8. SCWO technology has a demonstrated ability to destroy treatment residuals (spent GAC, spent AIX, and spent membranes) contaminated with PFAS.

When water is heated and pressurized above 374° C and 221 bar, organic wastes, such as PFAS, break down into their elemental components (e.g., C, F, etc.). 374Water's AirSCWO system is unique because this process is further aided by the introduction of ambient air (containing oxygen) into the waste stream to initiate oxidation reactions that destroy the organics (i.e., PFAS) within seconds. Notably, the system has the unique capability to destroy a wide range of organic compounds, including pharmaceuticals, microplastics, and over 40 different types of PFAS and their precursors.

AirSCWO can destroy up to 99.99% of total PFAS (∑40 PFAS) from (1) spent GAC (after processing PFAS-laden groundwater), (2) spent AIX (after processing PFAS-laden groundwater), and (3) spent AIX (after processing wastewater). Full destruction results can be found in the peer-reviewed study in the *Journal of Hazardous Materials*.[2]

9. Additional upcoming changes to look out for include the potential additional listing of nine PFAS as hazardous constituents under the Resource Conservation and Recovery Act (RCRA).

In addition to regulating PFAS in drinking water and designating certain PFAS as hazardous substances under CERCLA, the EPA is proposing to regulate nine additional PFAS under RCRA due to their negative health effects to humans and other life forms. These PFAS include PFOA, PFOS, PFBS, HFPO–DA, PFNA, PFHxS, PFDA, PFHxA, and PFBA. Future management of solid drinking water treatment residuals contaminated with PFAS may be altered depending on what the RCRA definition entails. PWSs may need to keep this in mind to avoid the accumulation of PFAS-laden wastes on site prior to any new RCRA requirements. ■

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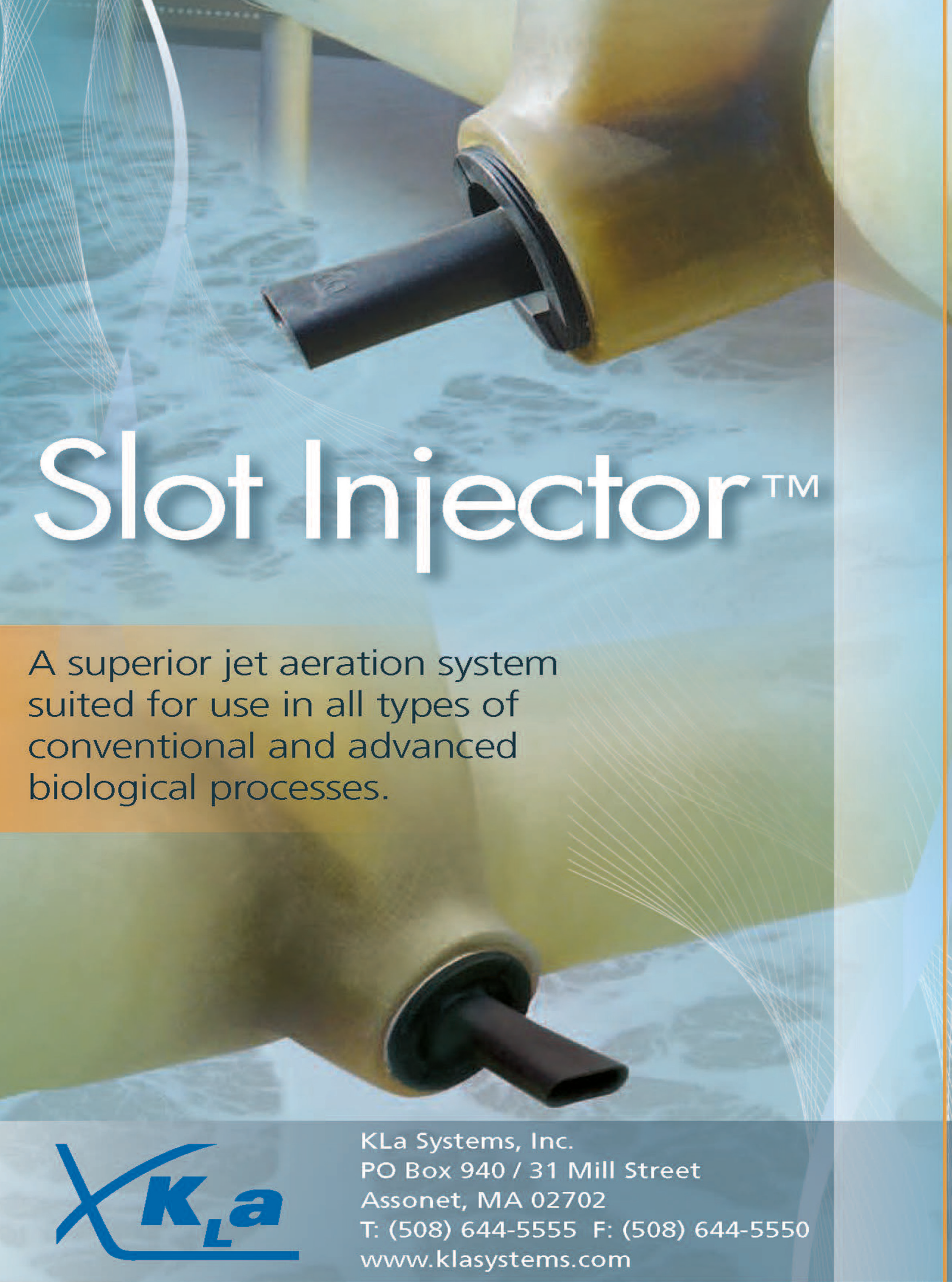
About The Authors

Naomi Lynn Senehi, the municipal technical solutions lead and global access manager at 374Water, holds a bachelor's and master's in environmental engineering. With five years of R&D experience, she specializes in applying SCWO technology to diverse waste streams.

Sudhakar (Sunny) Viswanathan is vice president at 374Water. He has a bachelor's and a master's degree in environmental engineering from Syracuse University. He has nearly 25 years of industry experience, including leadership positions at Suez and Veolia, and has authored over 35 technical papers. He currently spearheads the commercialization and business development of SCWO technology.



A GAME-CHANGING Approach To Salinity And Total Organic Carbon Treatment

With applications for drinking water, wastewater, and reuse, XBAT — ion exchange-based advanced treatment — could have revolutionary, far-reaching impacts for utilities.

By Rosa Yu, Melanie Pickett, Eva Steinle-Darling, and Vincent Hart

Water and wastewater professionals face a persistent challenge in managing salinity, a critical aspect of water quality that is often characterized through the measurement of total dissolved solids (TDS). Salinity is due to a complex mix of dissolved anions and cations, including chloride (Cl-), sulfate (SO42-), bicarbonate (HCO3-, or alkalinity), sodium (Na+), potassium (K+), calcium (Ca2+), and magnesium (Mg2+). In addition, dissolved organic matter (DOM), or total organic carbon (TOC), is an important constituent that must be managed in many water treatment applications to prevent the formation of disinfection byproducts or reduced oxygen demand in receiving waters.

Conventional water treatment methods don't address salinity because most physicochemical and biological treatment processes don't remove inert ions such as chloride, sulfate, and sodium. In fact, some chemical treatment processes (e.g., coagulation) add anions to the treated water. Combined with the copious use of salts in household, commercial, and industrial enterprises, this can elevate salinity in the community-wide water cycle.

Salinity removal is currently achieved through the use of reverse osmosis (RO), a highly effective, pressure-driven membrane process that removes almost all dissolved solutes, including salts. However, RO is not without challenges due to its concentrate waste stream that must be handled. This waste stream poses an issue, particularly for inland communities where ocean discharge is inaccessible or when deep well injection is not permitted, as well as for any communities where 8–15% water loss in the form of a brine waste stream is unacceptable.

Enter ion exchange-based advanced treatment (XBAT), a groundbreaking alternative method to reduce salinity. XBAT consists of a combination of two mature drinking water treatment processes:

1. **Suspended ion exchange** (SIX®, developed by PWNT) for the removal of negatively charged constituents (e.g., TOC, chloride, sulfate, bromide, nitrate, phosphate, etc.). Ion exchange resin regeneration, using bicarbonate as the counter ion, is key to the success of this approach and sets the stage for the second process.
2. **Lime softening** for cation removal (i.e., calcium and magnesium) as well as excess bicarbonate removal through calcium carbonate ($CaCO_3$) precipitation.

A distinctive feature of SIX® is its high resin regeneration frequency, which regenerates the spent resin after every single pass through the reactor. This keeps the resin's ion exchange capacity only slightly utilized, allowing the resin to be regenerated by a weaker regenerant, such as bicarbonate, and at a much lower strength (3%) compared to a saturated sodium chloride solution typically used for resin regeneration. Resin regeneration using bicarbonate as the counter ion adds alkalinity to the SIX® effluent, making the treated water more suitable for lime softening and maximizes salinity reduction through calcium carbonate precipitation. Bicarbonate regeneration is the heart of XBAT, which synergizes the SIX® and lime softening processes.

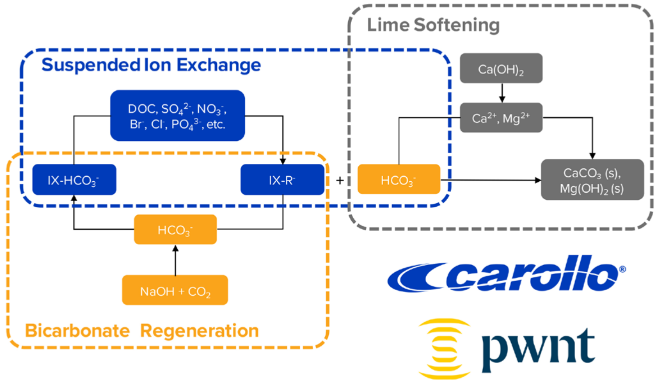


Figure 1. Schematic diagram illustrating the overall XBAT chemistry and the removal mechanism for dissolved anionic and cationic solutes.

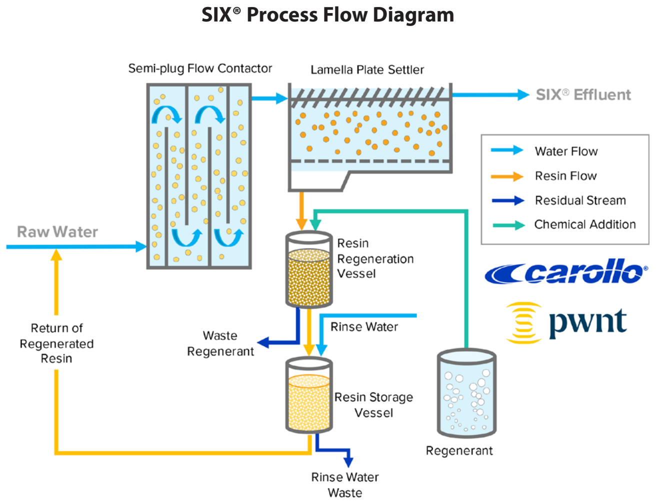


Figure 2. Unlike conventional ion exchange in a fixed-bed configuration, SIX® is a steady-state ion exchange process that keeps the resin fluidized in a reactor.

Compared to RO, SIX® produces a regeneration waste stream that is only 0.8% of the total feed water flow. With XBAT, the bicarbonate nature of the waste regenerant also makes this residual stream more treatable and manageable than a concentrated chloride-based brine waste. For instance, bicarbonate, sulfate, phosphate, fluoride, arsenic, silica, and TOC in the waste brine stream could be further removed via softening reactions with magnesium hydroxide and calcium carbonate precipitation. It could also potentially serve as a beneficial amendment for alkalinity addition in biological nutrient removal processes in wastewater treatment applications, saving the costs associated with the addition of external chemicals.

The importance of SIX®

The SIX® process is a key element of the XBAT process, and PWNT's experience and intellectual knowledge will be a critical success factor in any XBAT approach.

Bench-scale testing of XBAT with secondary and tertiary wastewater effluents has demonstrated a remarkable TOC removal rate of 50%, regardless of effluent type and initial TOC concentrations. High removal rates were also observed for sulfate (99%), nitrate (90%), bromide (94%), and chloride (74%). Subsequent lime softening resulted in 92% calcium removal, 96% magnesium removal, and an overall 50% net TDS reduction. These results are promising indicators of XBAT's potential to reduce or prevent salinity upcycling in potable reuse systems.

Carollo Engineers is currently scaling up its evaluations of XBAT with an advanced wastewater treatment pilot at Tampa, FL, and a direct potable reuse treatment feasibility evaluation at Aurora Water, CO, with a pilot to follow soon.

XBAT is poised to reshape the industry by unlocking the potential of potable reuse in inland communities, including areas in Colorado, Arizona, Utah, Texas, and beyond, where moderate salinity would otherwise pose challenges in selecting an advanced treatment approach that does not include RO. ■

Carollo's commitment to making XBAT available to the water industry

XBAT has the potential to open new treatment opportunities for hundreds of utilities. It is important that those opportunities not be limited. In collaboration with PWNT, Carollo has pursued two patents for XBAT, but will not enforce them — rather, these patents will protect its accessibility for wider use by ensuring no one attempts to impose a license on the technology. By opting against patent enforcement, Carollo commits to making XBAT available to the entire water industry without the usage restrictions typical of proprietary technologies, enabling XBAT to achieve its full potential and revolutionize the water industry.

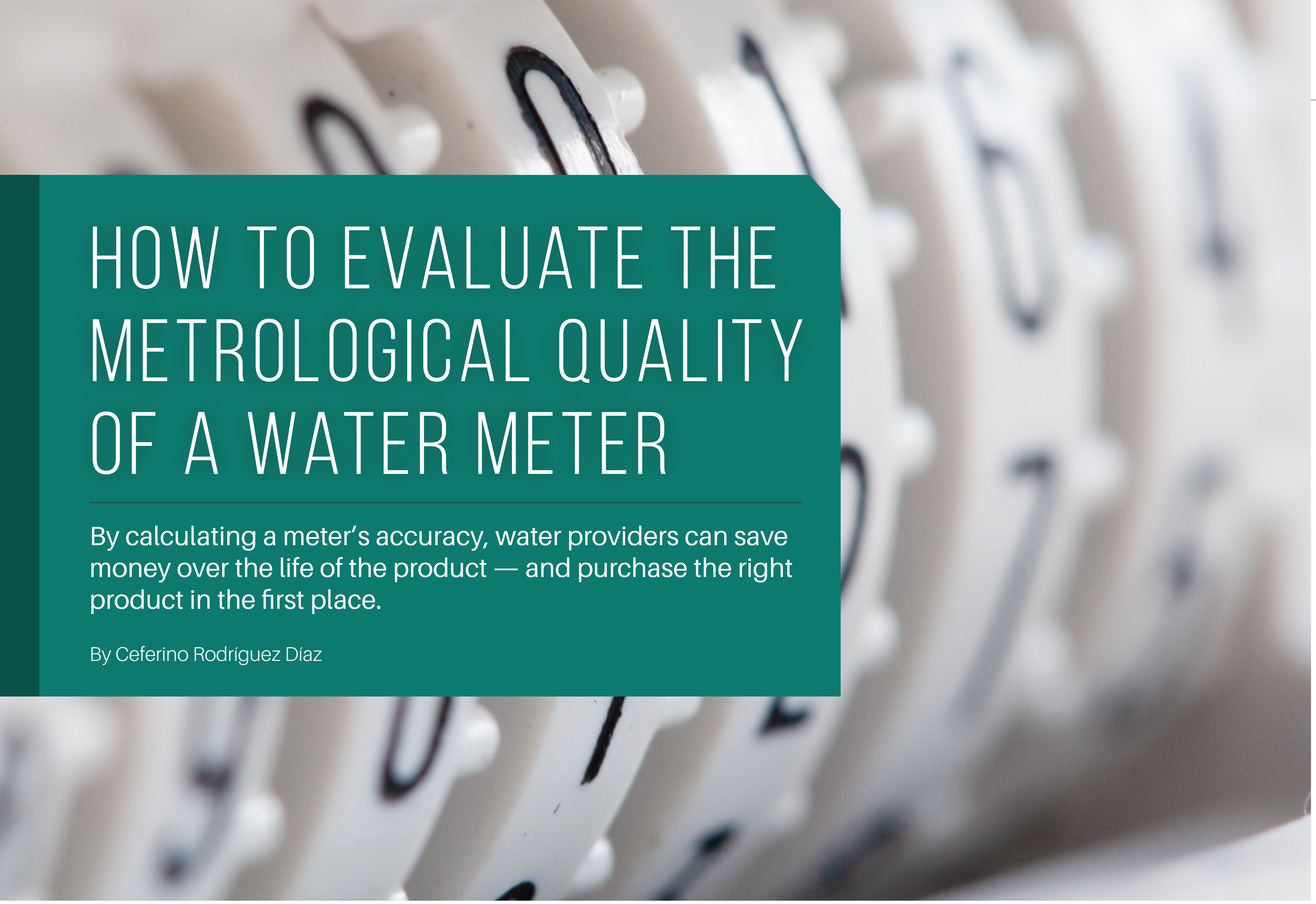
About The Authors

Rosa Yu, PhD, PE, is a lead technologist at Carollo Engineers. Rosa has over 10 years of experience in treating emerging contaminants via advanced treatment processes. Rosa works at the interface of engineering and applied research, and her primary focus is on the identification and development of innovative treatment technologies and control strategies in addressing emerging contaminants in drinking water and potable reuse.

Eva Steinle-Darling, PhD, PE, is Carollo Engineers' water reuse technical director. She has a strong background in treatability evaluation, regulatory approaches, and guidance development, particularly with respect to constituents of emerging concern in potable reuse applications, where she has supported regulatory guidance efforts for six U.S. states, the National Water Research Institute, and the World Health Organization.

Melanie Pickett, PhD, PE, is an engineer with Carollo Engineers. She received her PhD from the University of South Florida in environmental engineering, where her work focused on water purification technology development. She has been with Carollo for four years, spending most of her time working with organics removal technologies for drinking water and potable reuse.

Vincent Hart, PE, serves as executive vice president and managing director of technical practices at Carollo Engineers. With 30 years of dedicated experience in water treatment, Vincent has established himself as a leading expert in the field with a focus on innovative technologies such as pellet softening and suspended ion exchange. He has successfully led and managed multiple award-winning microfiltration projects, both as a design engineer and project manager.



HOW TO EVALUATE THE METROLOGICAL QUALITY OF A WATER METER

By calculating a meter's accuracy, water providers can save money over the life of the product — and purchase the right product in the first place.

By Ceferino Rodríguez Díaz

It is often difficult to determine the quality of any object with the naked eye. Sometimes we realize that something failed much sooner than we expected, and we feel frustrated about losing money or for not having been able to estimate its true quality prior to the purchase. The fault for this loss is not typically attributable to whoever manufactured the object; rather, it is due to the lack of criteria that allow us to anticipate what the performance of the object could have been and whether that performance is what we need.

This is what usually happens with water meters, where damage to the meters manifests itself in the premature loss of measurement accuracy. Until now, there has been no technical and objective criterion that allows us to evaluate or choose between several proposed meters that could be best in terms of their metrological performance. For this reason, we pose the problem below, and offer a solution, so those responsible for water treatment plants can use it in their evaluation of meters.

> **Until now, there has been no technical and objective criterion that allows us to evaluate or choose between several proposed meters that could be best in terms of their metrological performance.**

Problem Statement

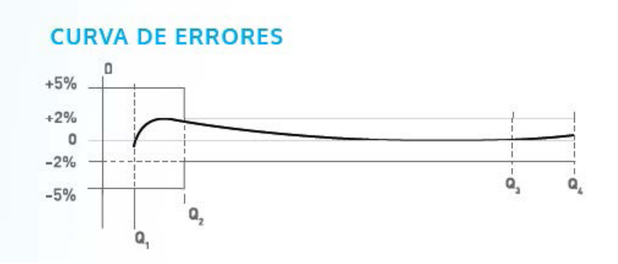
The problem has the following factors:

1. In acquisitions, we are not deciding which is the best meter among all those whose error curves are within the tunnel of admissible errors. They just have to "be in" to be considered eligible. In this case, the award is given to the cheapest meter.
2. Also, the tests carried out in the laboratory only seek to determine that the meters satisfy the total scope of the measurement field within a range of admissible errors.
3. When deciding on buying a water meter, we are not evaluating how long the permanence of the error curve of a meter is within the tunnel of admissible errors in terms of the volume of water that the meter could not register when its curve reaches the limits of the tunnel. This unmeasured water has a cost that must be evaluated.

Proposal For A Solution

As a first approach to solving the problem, the very low probability of intentional water consumption at flow rates Q_1, Q_2, and Q_4 must be considered, given that these are the extreme flows of the lower and upper measurement fields. The flow rate Q_1 is the minimum flow rate of the lower measurement field. The flow rate Q_2 is the minimum flow rate of the upper measurement field and is, at the same time, the transition flow between the lower and upper measurement fields that are distinguished by the magnitude of their allowable errors (±5% for the lower field and ±2% for the upper field). The Q_4 flow rate is the maximum flow rate of the total measurement field for which the meter can operate for a very short time, with a high probability of damage in cases of longer operating times at this flow rate.

The very low probability of intentional consumption at flow rates Q_1, Q_2, and Q_4 excludes the possible individual use of the errors obtained (even if they are average values of a batch of meters) at these flows during meter calibration. This leads us to consider that the possible solution to the problem is found in the calculation of the integral of the meter error curve — that is, in the calculation of the area under this curve.



*Curva de errores=Error Curve

The error curve generally extends from Q_1 to Q_4, covering possible errors that may occur throughout the meter's measurement field. In the event that, during the calibration of batches of meters on a test bench, the pressure of the bench is not sufficient to achieve the Q_4 flow rate, the error curve will then extend from Q_1 to the Q_3 flow rate, thus covering all the possible errors up to flow rate Q_3. It is then a matter of calculating the area under the curve from Q_1 to Q_4. If this last flow rate cannot be achieved, then the calculation of the area will be done from Q_1 to Q_3, in order to use this value as one of the inputs to estimate the metrological quality of a meter.

It had already been anticipated that the calculation of this area is not sufficient to determine the metrological status of the meter, so it will be necessary to calculate an ideal area that serves as a reference to compare the areas obtained from the different error curves against it.

An ideally accurate meter will have an error of 0% over its entire measurement range, from Q_1 to Q_4 (or from Q_1 to Q_3).

With the calculation of this ideal area, the overall error of a meter can now be calculated as follows:

$$E = \frac{\textit{Area under the meter error curve} - \textit{Ideal area}}{\textit{Ideal area}}$$

This error E represents how much the meter error curve is missing in terms of area to reach the proposed ideal area. Given the variability of the magnitude of the area under the error curve of the meter with use (entropy and wear) and knowing that the area under the error curve of a meter represents the best measurement that the meter can achieve for a given instant, then this error will characterize the metrological behavior of the meter for that same instant, so we will call it Characteristic Error E_c. The area under the error curve of the meter will be referred to hereafter as "Measured area." (NOTE: commas [,] = decimal points [.])

Therefore:

$$E_c = \frac{\textit{Measured area} - \textit{Ideal area}}{\textit{Ideal area}}$$

The Measured area then comprises the following points on the error curve of the Indication Error vs. Test Flow diagram (Q_1, $\mathcal{E}_{Q1}$), (Q_2, $\mathcal{E}_{Q2}$), (Q_3, $\mathcal{E}_{Q3}$), (Q_4, $\mathcal{E}_{Q4}$), where $\mathcal{E}_{Q1}$, $\mathcal{E}_{Q2}$, $\mathcal{E}_{Q3}$, and $\mathcal{E}_{Q4}$ represent the indication errors obtained at the test flow rates Q_1, Q_2, Q_3 and Q_4.

It is known that the Ratio R represents the relationship that exists between the flow rate Q_3 and the flow rate Q_1, like this:

$$R = \frac{Q_3}{Q_1} \qquad \textit{and that} \qquad Q_2 = 1{,}6\,Q_1$$

Therefore:

$$Q_1 = \frac{Q_3}{R} \qquad \textit{and} \qquad Q_2 = 1{,}6\frac{Q_3}{R}$$

For tests up to flow rate Q_3, the Ideal Area will be given by:

$$\textit{Ideal area} = \frac{Q_3}{R}(1 - R)$$

With the points mentioned above that correspond to the error curve and using these equivalences, we calculate the area under the curve for a meter (Measured Area A_m), which turns out to be:

$$A_m = \frac{\frac{Q_3}{R}\left[2(1 - R) - 0{,}6\mathcal{E}_{Q1} + (1 - R)\mathcal{E}_{Q2} + (1{,}6 - R)\mathcal{E}_{Q3}\right]}{2}$$

Therefore, for this case (with tests up to Q_3), the Characteristic Error is:

$$E_c = \frac{-0{,}6\mathcal{E}_{Q1} + (1 - R)\mathcal{E}_{Q2} + (1{,}6 - R)\mathcal{E}_{Q3}}{2(1 - R)}\%$$

Thus, the Characteristic Error is expressed only in terms of the errors obtained in the calibration test and in the Ratio R of the metrological class of the meter being tested. In the same way, an admissible error must be calculated. This will be determined by the area under the curve of the lines that limit the error tunnel (upper admissible limit and lower admissible limit), whose results will be related to the same Ideal Area.

The general formula for the admissible error *Ead* expressed as a function of the metrological class of the meter for testing up to flow rate Q_3 is:

$$E_{ad} = \pm \frac{2R - 0{,}2}{1 - R}\%$$

Calculating the same developments for the tests up to flow rate Q_4 results in:

$$E_c = \frac{-0{,}6\mathcal{E}_{Q1} + (1 - R)\mathcal{E}_{Q2} + (1{,}6 - 1{,}25R)\mathcal{E}_{Q3} - 0.25R\mathcal{E}_{Q4}}{2(1 - 1.25R)}\%$$

$$E_{ad} = \pm \frac{2{,}5R - 0{,}2}{1 - 1{,}25R}\%$$

The admissible error represents the operating limit of a meter, because beyond the admissible error is the zone of inadmissible errors. Therefore, the admissible error will be the limit of the useful life of a meter.

Study Cases

a) About useful life:

Suppose you want to know if the useful life of a meter (with diameter DN15 Ratio R=160 whose calibration errors are $\mathcal{E}_{Q1}=-3{,}1\%$, $\mathcal{E}_{Q2}=-2{,}8\%$, and $\mathcal{E}_{Q3}=-1{,}9\%$) has ended.

Solution:

Since errors are only reported up to flow rate Q_3, we calculate:

$$E_c = \frac{-0{,}6\mathcal{E}_{Q1} + (1 - R)\mathcal{E}_{Q2} + (1{,}6 - R)\mathcal{E}_{Q3}}{2(1 - R)}\%$$

$$E_c = \frac{-0{,}6(-3{,}1) + (1 - 160)(-2{,}8) + (1{,}6 - 160)(-1{,}9)}{2(1 - 160)}\% = \frac{748{,}02}{-318}\% = -2{,}35\%$$

$$E_c = -2{,}35\%$$

This value now is compared with the admissible error for this metrological class and tests up to Q_3:

$$E_{ad} = \pm \frac{2R - 0{,}2}{1 - R}\%$$

$$E_{ad} = \pm \frac{2(160) - 0{,}2}{1 - 160}\% = \pm 2{,}01\%$$

It is observed that the E_c > *Ead* so it can be stated that this meter exceeded the limit of its useful life.

---

b) Determination of metrological quality for a bid award:

A water service provider requests proposals for the supply of meters with the following characteristics: DN15 with Q_3 =2500 l/h and R≥160 in horizontal position.

The following offers were received:

Prototype N°	DN	Q_3	R	Cost US$
1	15	2500 l/h	160	25,97
2	15	2500 l/h	200	51,95
3	15	2500 l/h	315	53,24
4	15	2500 l/h	400	77,92

The prototypes were tested, and the following table of data was obtained that resulted from the initial calibration and a subsequent calibration performed after the 100-hour accelerated-wear test at flow rate Q_4.

Results Initial calibration of the prototypes								
			Reading m³		Resulting Indication Error (%)			
Prototype N°	DN	R	Initial	Final	to Q_1	to Q_2	to Q_3	to Q_4
1	15	160	0,000	0,321	-3,6	1,9	-0,5	-0,6
2	15	200	0,000	0,317	-3,1	-1,6	-0,3	-0,3
3	15	315	0,000	0,318	-2,5	-0,9	-0,4	-0,3
4	15	400	0,000	0,318	-1,9	-0,8	-0,3	-0,3
Results Calibration after accelerated wear test 100H at Q_4								
			Reading m³		Resulting Indication Error (%)			
Prototype N°	DN	R	Initial	Final	to Q_1	to Q_2	to Q_3	to Q_4
1	15	160	310,321	310,639	-3,9	0,2	-1,1	-1,0
2	15	200	310,781	311,097	-4,2	-2,3	-0,8	-0,8
3	15	315	311,250	311,267	-2,8	-1,5	-0,5	-0,5
4	15	400	311,563	311,881	-2,1	-0,9	-0,4	-0,3

The error curves of the four prototypes in the initial calibration comply metrologically because they are all within the tunnel of admissible errors. It is also observed that after the accelerated wear to which the prototypes were subjected, the error curves of three of the meters are still completely within the tunnel of admissible errors. Prototype No. 2 presents a not very significant deviation in the indication error obtained at flow rate Q_2. According to these results, the bid should be awarded to the proponent of Prototype No. 1 because it is the one with the lowest proposed cost.

Next, the application of the proposed solution is presented to verify if Prototype No. 1 is indeed the best metrological option for the award. As a first measure, the characteristic errors of the initial and post-wear test are calculated, as well as the admissible errors corresponding to the metrological classes or R Ratios involved. The formulas that apply are:

$$E_c = \frac{-0{,}6\mathcal{E}_{Q1} + (1-R)\mathcal{E}_{Q2} + (1{,}6 - 1{,}25R)\mathcal{E}_{Q3} - 0.25R\mathcal{E}_{Q4}}{2(1-1.25R)}\%$$

$$E_{ad} = \pm\frac{2{,}5R - 0{,}2}{1 - 1{,}25R}\%$$

The results are presented in the following tables:

Initial Characteristic Error

		Reading m³		Indication Error (%)				Characteristic Error %	Admissible Error %
Prototype N°	R	Initial	Final	to Q_1	to Q_2	to Q_3	to Q_4		
1	160	0,000	0,321	-3,6	1,9	-0,5	-0,6	0,4441	±2,009
2	200	0,000	0,317	-3,1	-1,6	-0,3	-0,3	-0,8229	±2,007
3	315	0,000	0,318	-2,5	-0,9	-0,4	-0,3	-0,5915	±2,005
4	400	0,000	0,318	-1,9	-0,8	-0,3	-0,3	-0,5009	±2,004

Characteristic Error Post Accelerated Wear

		Reading m³		Indication Error (%)				Characteristic Error
Prototype N°	R	Initial	Final	to Q_1	to Q_2	to Q_3	to Q_4	%
1	160	310,321	310,639	-3,9	0,2	-1,1	-1,0	-0,575
2	200	310,781	311,097	-4,2	-2,3	-0,8	-0,8	-1,403
3	315	311,250	311,567	-2,8	-1,5	-0,5	-0,5	-0,902
4	400	311,563	311,881	-2,1	-0,9	-0,4	-0,3	-0,591

The slope of the accuracy decay curve of each prototype is calculated based on the characteristic errors found and the corresponding readings by applying the formula:

$$m = \frac{E_{c\,post} - E_{c\,init}}{Reading_{fin\,post} - Reading_{fin\,init}} = \frac{-0{,}575 - 0{,}4441}{310{,}639\ m^3 - 0.321\ m^3} = -0{,}00328405/m^3$$

The results of the slopes of the prototypes are shown in the following table:

Prototype N°	Decay Slope
1	$-0{,}00328405/m^3$
2	$-0{,}00186834/m^3$
3	$-0{,}00099615/m^3$
4	$-0{,}00028899/m^3$

With this slope, the characteristic error can be projected for the same reading in each of the prototypes like this:

$$E_{c\,proy} = m(Reading) + E_{c\,init} = \frac{-0{,}00328405}{m^3}(1000\ m^3) + 0{,}4441 = -2{,}83995\%$$

The results for different readings for each prototype are shown in the following table:

Projected characteristic error (%) according to the prototype reading in m³										
Reading m³	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
Prototype 1	-2,84	-6,12	-9,41	-12,69	-15,97	-19,26	-22,54	-25,82	-29,11	-32,39
Prototype 2	-2,69	-4,56	-6,43	-8,30	-10,16	-12,03	-13,90	-15,77	-17,64	-19,51
Prototype 3	-1,59	-2,58	-3,58	-4,58	-5,57	-6,57	-7,56	-8,56	-9,56	-10,55
Prototype 4	-0,79	-1,08	-1,37	-1,66	-1,95	-2,23	-2,52	-2,81	-3,10	-3,39

The water that each prototype will have stopped measuring (lost volume) for every 1000 m³ accumulated reading is:

Volume of water not measured (m³) according to the prototype reading								
Reading m³	1000	2000	3000	4000	5000	6000	7000	8000
Prototype 1	11,976	56,786	134,430	244,908	388,220	564,366	773,345	1015,159
Prototype 2	17,570	53,824	108,761	182,381	274,685	385,672	515,343	663,697
Prototype 3	10,895	31,752	62,570	103,350	154,091	214,794	285,459	366,084
Prototype 4	6,454	15,797	28,031	43,154	61,167	82,071	105,864	132,547

If a rate of $1,17/m³ is assumed for the reference socioeconomic stratum (4), the cost of lost water will be calculated for each prototype according to the accumulated reading. The results can be seen in the following table:

Cost (US$) of water that has stopped being measured: Rate base US$1,17/m³										
Reading m3	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
Prototype 1	$ 14	$ 66	$ 157	$ 286	$ 454	$ 660	$ 904	$ 1.187	$ 1.508	$ 1.867
Prototype 2	$ 21	$ 63	$ 127	$ 213	$ 321	$ 451	$ 602	$ 776	$ 971	$ 1.188
Prototype 3	$ 13	$ 37	$ 73	$ 121	$ 180	$ 251	$ 334	$ 428	$ 534	$ 651
Prototype 4	$ 8	$ 18	$ 33	$ 50	$ 71	$ 96	$ 124	$ 155	$ 189	$ 227

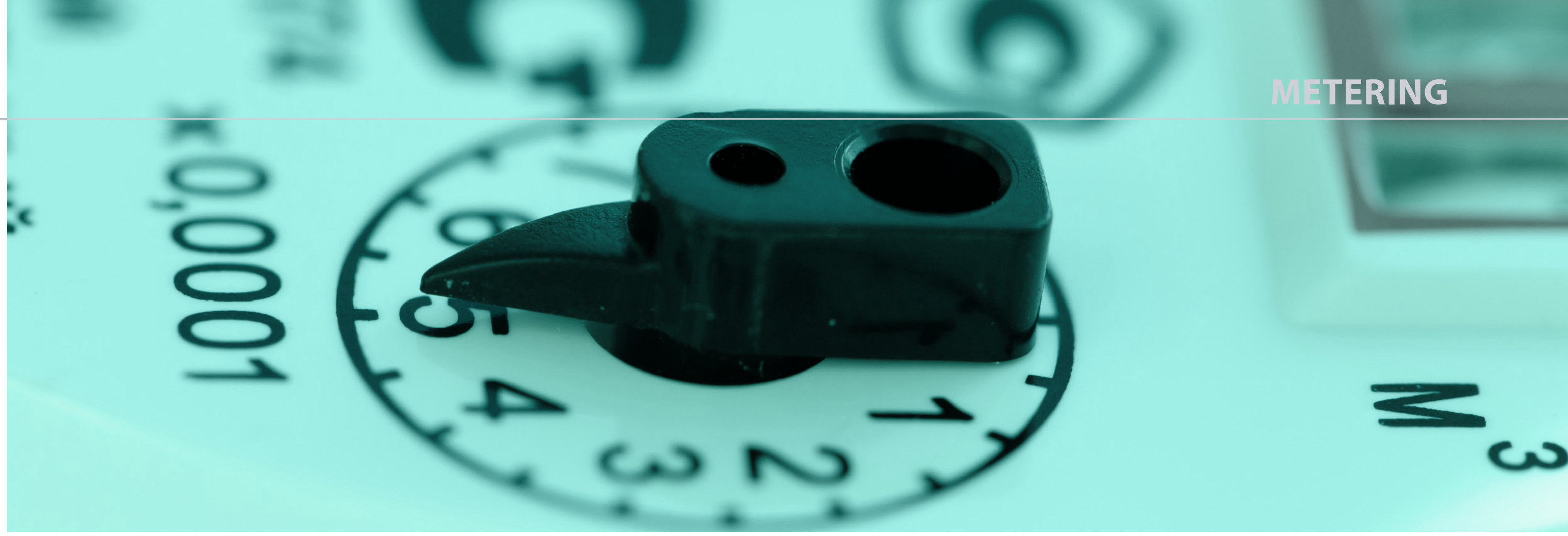
If the cost of the meter is added to this cost, the meter's combined operation cost is obtained (for simplicity, other collateral costs are not included):

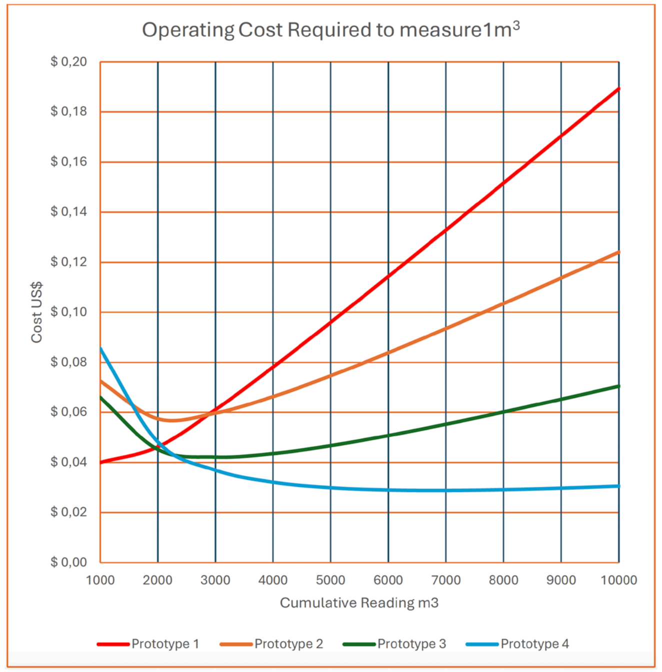
Operation Cost US$ (Only includes lost water cost + meter cost)										
Reading m³	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
Prototype 1	$ 40	$ 92	$ 183	$ 312	$ 480	$ 686	$ 930	$ 1.213	$ 1.534	$ 1.893
Prototype 2	$ 72	$ 115	$ 179	$ 265	$ 373	$ 503	$ 654	$ 828	$ 1.023	$ 1.240
Prototype 3	$ 66	$ 90	$ 126	$ 174	$ 233	$ 304	$ 387	$ 481	$ 587	$ 705
Prototype 4	$ 85	$ 96	$ 111	$ 128	$ 149	$ 174	$ 202	$ 233	$ 267	$ 305

Consequently, the operating cost to measure one cubic meter within each of the previous reading ranges is obtained by dividing the total operating cost by each of the limit values of their corresponding reading ranges. The resulting operating costs are presented in the following table:

Operating cost to measure 1 m³ (US$) based on the cumulative reading										
Reading m³	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
Prototype 1	$ 0,04	$ 0,05	$ 0,06	$ 0,08	$ 0,10	$ 0,11	$ 0,13	$ 0,15	$ 0,17	$ 0,19
Prototype 2	$ 0,07	$ 0,06	$ 0,06	$ 0,07	$ 0,07	$ 0,08	$ 0,09	$ 0,10	$ 0,11	$ 0,12
Prototype 3	$ 0,07	$ 0,05	$ 0,04	$ 0,04	$ 0,05	$ 0,05	$ 0,06	$ 0,06	$ 0,07	$ 0,07
Prototype 4	$ 0,09	$ 0,05	$ 0,04	$ 0,03	$ 0,03	$ 0,03	$ 0,03	$ 0,03	$ 0,03	$ 0,03

In the previous table, it can be seen that the lowest value for Prototype 1 is in the range of 1000 m³, presenting successive increments as the accumulated reading increases. For Prototype 2, the lowest value is in the range of 2000 m³; for Prototype 3, the lowest value is in the range of 3000 m³; Prototype 4 shows that the operating cost required to measure 1 m³ has its maximum value in the range of 1000 m³ range, which decreases successively until reaching a lowest value, which occurs in the range of 7000 m³. Note that for Prototype 4, from 4000 m³ to 10000 m³, the lowest measurement values of all the prototypes considered are presented. The corresponding curves are shown in the following figure:





Finally, we proceed to estimate the reading that each prototype will have when its characteristic error reaches the value of the admissible characteristic error. To do this, we use the following formula:

$$E_{c\,proj} = m(Final\ Reading) + E_{c\,init}$$

Where the projected characteristic error will be equal to the value of the admissible characteristic error for each metrological class.

$$E_{c\,proj} = E_{admissible}$$

$$E_{admissible} = m(Final\ Reading) + E_{c\,init}$$

$$\frac{E_{admissible} - E_{c\,init}}{m} = Final\ Reading$$

For Prototype 1:

$$Final\ Reading = \frac{-2{,}009 - 0{,}4441}{= -0{,}00328405/m^3} = 746{,}974\ m^3$$

The results are presented in the following table:

	Final Reading m³
Prototype 1	746,974
Prototype 2	633,920
Prototype 3	1418,592
Prototype 4	5199,905

It is observed that from 747 m3 of registration, Prototype 1 begins to measure water with unacceptable errors, while for Prototype 4, its useful life extends to 5200 m³. In conclusion, Prototype 1, which seemed to be the best meter to award the purchase given its low initial cost, turns out to be an unacceptable option due to its short useful life, the large water losses that affect indicators such as the loss rate per billed user and non-revenue water losses, and the money that is lost in increasing amounts. ■

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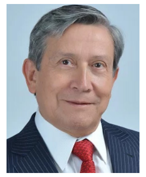
About The Author



Ceferino Rodríguez Díaz, MSc., served more than 25 years as director of the aqueduct and sewer service for Empresa de Acueducto de Bogotá. His various management positions also included director of the technification and automation unit, director of non-revenue water, director of connections and meters, and director of technical services. He holds degrees from Universidad Nacional de Colombia and Universidad Centro Panamericano de Estudios Superiores (UNICEPES).

EVALUATING THE ROLE OF **IODINE EXTRACTION** IN WATER CLEANUP INITIATIVES

How a potential contaminant itself can be utilized in treatment to remove other contaminants.

By Ellie Gabel

Water contamination poses one of the greatest threats to the world at large. As such, specialists seek sound and sustainable methods for cleaning vital water sources for safer use.

A wave of scientific and technological developments has paved the way for newer solutions, including employing iodine extraction. Although commonly used for industrial benefits, this method may deliver more pristine water for everyone.

How Can Iodine Extraction Aid Water Cleanup Initiatives?

Research has shown impressive antimicrobial and disinfectant properties[1] in iodine, making it a compelling player in water purification. When utilized in treatment facilities, it can eliminate harmful contaminants, bacteria, and viruses, ensuring a safer microbial load in drinking water.

Iodine binds to various heavy metals[2] — including lead, mercury, and aluminum — allowing specialists to filter and remove toxic compounds from water sources. Its oxidative reactivity can also degrade pharmaceuticals, synthetic pesticides, and other organic compounds in wastewater.

Contaminated soil and sediment may also undergo electrokinetic remediation — electromigration with ions and particles[3] — to remove heavy metals and harmful substances. This strategy would prevent polluted earth from leaching into water bodies.

What Are the Most Common Iodine Extraction Methods?

Mining companies must first extract iodine for water remediation purposes. Extraction methods vary depending on the source and location of reserves. Generally, miners extract iodine from natural brines, seawater, and mineral deposits in the following ways:

- **Adsorption:** Adsorbs iodine onto activated carbon and zeolites[4] from seawater and captures the compound by washing it with a solvent.
- **Chlorination:** Adds chlorine gas to the brine to oxidize ions, removing the iodine through adsorption or distillation.
- **Sulfur dioxide reduction:** Uses sulfur dioxide and other chemicals to turn iodate into iodine for easier extraction.
- **Roasting:** Extracts iodine from minerals by releasing evaporated iodine and condensing it[5] for collection.

Regardless of the method used for extraction, the process often involves isolating the iodine, refining it through crystallization or distillation, and processing it for products and other uses.

Likewise, extracting iodine from seaweed and other natural sources is a more sustainable solution. Interestingly enough, Japan — a country where nori is a staple in its cuisine — had the world's largest iodine reserves at 4.9 million metric tons[6] in 2023.

Challenges Of Iodine Extraction For Bioremediation

Iodine extraction holds promising outcomes from water cleanup initiatives. However, excessive amounts could be toxic for people and the environment.

Although iodine is naturally occurring, it also maintains industrial purposes, seeping as runoff with other chemicals and increasing the likelihood of overexposure through water and food consumption. Common sources of iodine include:

- Industries like pharmaceuticals, chemicals, and electronics.
- Fertilizers, pesticides, and fungicides containing iodine ingredients.
- Accidental spills during transportation and storage.

Too much or too little iodine could result in brain damage,[7] impaired physical and mental development, and thyroid issues, with the worst effects on children. In the natural world, iodine contamination disrupts aquatic life by posing a risk to species' health, growth, reproduction, and survival.

Because iodine bioaccumulates, humans may also become exposed when they consume seafood or animal products. For instance, one study found iodine concentrations were five to 10 times higher[8] in saltwater fish than in freshwater fish.

Considerations For The Future

Technological advancements will continue evolving water cleanup initiatives, with iodine extraction being a possibility in the future. However, industry experts and governments should consider the following:

- Maximized innovation: Research and invest in more sustainable extraction methods and technologies to minimize environmental and human health impacts.
- Targeted delivery: Concentrate on specific contaminants and microbial communities for effective treatment.
- Integrated systems: Synergize iodine extraction methods with existing treatment systems for more flexible implementation.
- Monitoring and risk assessment: Report on iodine concentrations, water quality, and remediation processes while conducting thorough environmental impact reviews.

Other considerations pertain to regulatory frameworks, stakeholder participation, and public perception. For example, laws should set clear protocols and safety guidelines for using iodine in water treatment. Exchanging knowledge, research, best practices, and technologies among companies, governments, and specialists is particularly beneficial.

Likewise, community engagement will ensure that the public knows the advantages and implications of using iodine extraction in purification and remediation methods.

Iodine: A Natural Approach To Cleaner Water

Experts can invigorate water treatment and minimize the effects on people and the planet with a careful approach to iodine extraction. The best way forward is through stakeholder involvement and advancements in tools and technology. ■

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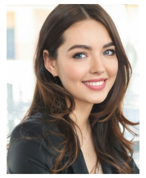

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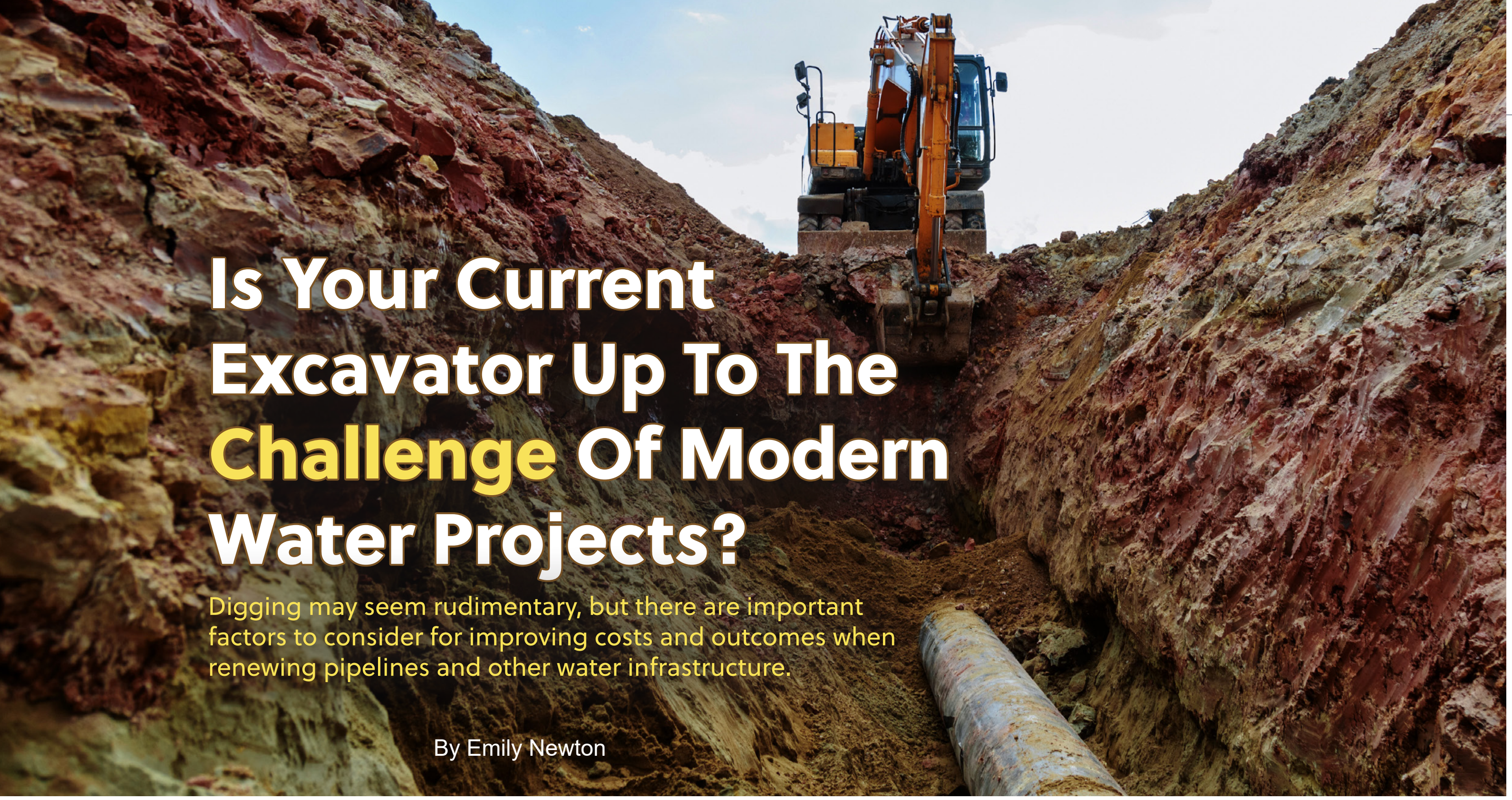

Is Your Current Excavator Up To The Challenge Of Modern Water Projects?

Digging may seem rudimentary, but there are important factors to consider for improving costs and outcomes when renewing pipelines and other water infrastructure.

By Emily Newton

The excavator is an essential piece of water utility equipment. Due to its importance, some decision-makers determine it is time to modernize their excavators to meet the demands of current or upcoming projects. Which factors should they consider when assessing whether their current models are up to the task?

Digging Depth Per Day

Project managers should start by calculating how much digging will occur during an underground utility construction project per day. That is a practical way to figure out whether a current excavator's size and capabilities will fit the job. Some experts say the daily digging depth could become a deciding factor in whether a decision-maker chooses a 50,000-ton or an 80,000-ton model.[1]

However, decision-makers should consider other factors, such as the project's water pipe depth and if the excavation work will happen in a heavily trafficked area or a more remote location. One best practice is to select an excavator that is as small as possible and can still complete the required task.

Even so, some prefer larger machines in almost all cases because they can move more dirt at a lower cost per yard than their smaller counterparts. Many individuals overseeing utility construction projects understand that time is money, and they do not want to waste hours trying to use insufficient equipment.

Another tip is to review data from past excavation projects to see how quickly the earth-moving activities occurred in those cases. How did the past depth-per-day metrics compare to upcoming projects? Such evaluations can determine if a company has suitable equipment or needs to obtain more capable options before work begins.

Age And Total Operating Hours

The total time in service is another aspect to consider when determining if it is time to update water utility equipment. In one example from India, decision-makers chose to replace all heavy machinery — including some track excavators — after using it for 15 years.[2] That strategy may work well for some organizations. Still, others will find it overly broad or not well-aligned with their financial resources.

A more practical approach is considering age and operating hours alongside other more specific parameters. For example, has it become especially difficult to source replacement parts for some older excavators in a fleet? If so, replacing those machines with newer options may make sense from a financial and time-based perspective.

Does historical data indicate a utility company's older models are significantly less energy-efficient than newer models available on the market? The money saved with upgraded equipment could quickly make the replacement costs worthwhile.

That said, older, adequately maintained equipment could last as long as newer equipment that rarely or never gets the required maintenance. Some necessary procedures are time-based, making it important to do them on the recommended schedules. For example, people should change their excavator's final drive motor oil annually or after using the equipment for 100 hours.[3]

Similarly, relying on poorly trained or careless operators could result in parts wearing down faster than expected due to aggressive behaviors or usage mistakes. Those supervising underground utility construction projects should keep records of how long equipment stays in functional condition. After noticing excavators do not last as long as expected, they should assess all contributing factors. The results will help them evaluate how much equipment age impacts performance.

Energy Source

Many excavators are diesel-powered machines, so overall water utility equipment costs will include the fuel required to run the machines. Since older models may be less efficient than newer ones, operators may determine that those using less diesel during typical workdays are more appealing than those requiring comparatively more energy.

However, electric excavators are becoming more popular and accessible, especially among decision-makers who want to make their utility construction projects as sustainable as possible. One innovative example comes from a proof-of-concept project for an eight-ton excavator.[4]

It involves a modular battery-electric system that allows users to convert diesel-powered machines into zero-emissions models.

Additionally, this technology allows people to benefit from equipment with the precise battery capacity required for individual jobs. That is because the system enables fleet managers to attach the appropriate number of modules to provide the estimated energy needed for each day's projects. This option could become more cost-effective than traditional possibilities because it prevents users from paying for unnecessary battery capacity and adding to overall project costs.

Some leaders have investigated other eco-friendly power sources, such as excavators that run on hydrogen fuel cells. Although these are less common than electric options, they are becoming more widely available.

Water project supervisors should consider calculating the average amount of diesel used across all excavators. The result will make it easier to determine the cost-effectiveness of switching to emissions-free power sources for some or all machines in the fleet. They should also research whether grants or other green energy programs could make the cost more affordable and manageable.

Reliability

Assessing a current excavator requires users to account for all recent occurrences where the equipment failed or introduced project inefficiencies. If such instances become more frequent, the worsening issue is strong evidence that the excavator is no longer reliable enough to use regularly.

Having the financial resources to cover the upfront costs of a newer model is not always a necessity. Leasing agreements typically allow people to spread the equipment expenses over periods as long as a decade.[5] Then, they can benefit from new excavators without spending so much at once.

Safety concerns could also convince those leading underground utility construction projects that current excavators have become too unreliable to continue using. Excavators and other heavy equipment are inherently dangerous. However, inadequate maintenance or faulty parts also pose dangers. Main control valve problems can make excavators unexpectedly stop moving or move too slowly. Such erratic behavior could endanger operators and others nearby.

Injuries and fatalities could bring attention to water projects for all the wrong reasons. Excavator modernization is one factor contributing to safety and reliability, but operators must also pay attention to other contributing elements, such as training and choosing an excavator capable of a particular job.

Excavator Type

A common question surrounding underground utility construction projects is whether operators should use wheeled or tracked excavators on the site. Tracked excavators have a lower center of gravity and bigger surface area than wheeled types. These characteristics make tracked models comparatively more stable and better for muddy or slanted surfaces. Wheeled excavators are road-friendly, ideal for working on paved surfaces or in cities.

Wheeled excavators also move faster and are more maneuverable than the tracked type. A potential downside is that their digging depth is less than what tracked models achieve due to the wheels that keep the machine higher off the ground.

Tracked excavators may require less maintenance in rugged conditions due to the track's durability. The track is less prone to punctures from debris often found on construction and infrastructure sites. The maintenance expenses associated with wheeled models vary due to factors such as the manufacturer's design and the wheel system's complexity.

Nondestructive excavators are also popular options for water utility equipment. These possibilities combine high-flow vacuums and high-pressure water, allowing people to accomplish excavation tasks more safely and with fewer infrastructure disruptions.[6] Features such as adjustable water pressure and remote-controlled suction booms also give operators excellent control, helping them work around existing underground utilities when needed.

Choose The Appropriate Excavator For Upcoming Water Utility Projects

Is the best excavator currently in the fleet, or is it time for an upgrade? These discussion areas will help people make confident choices, whether considering single projects or all those they expect to tackle during the upcoming months and years. ■

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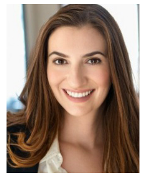

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