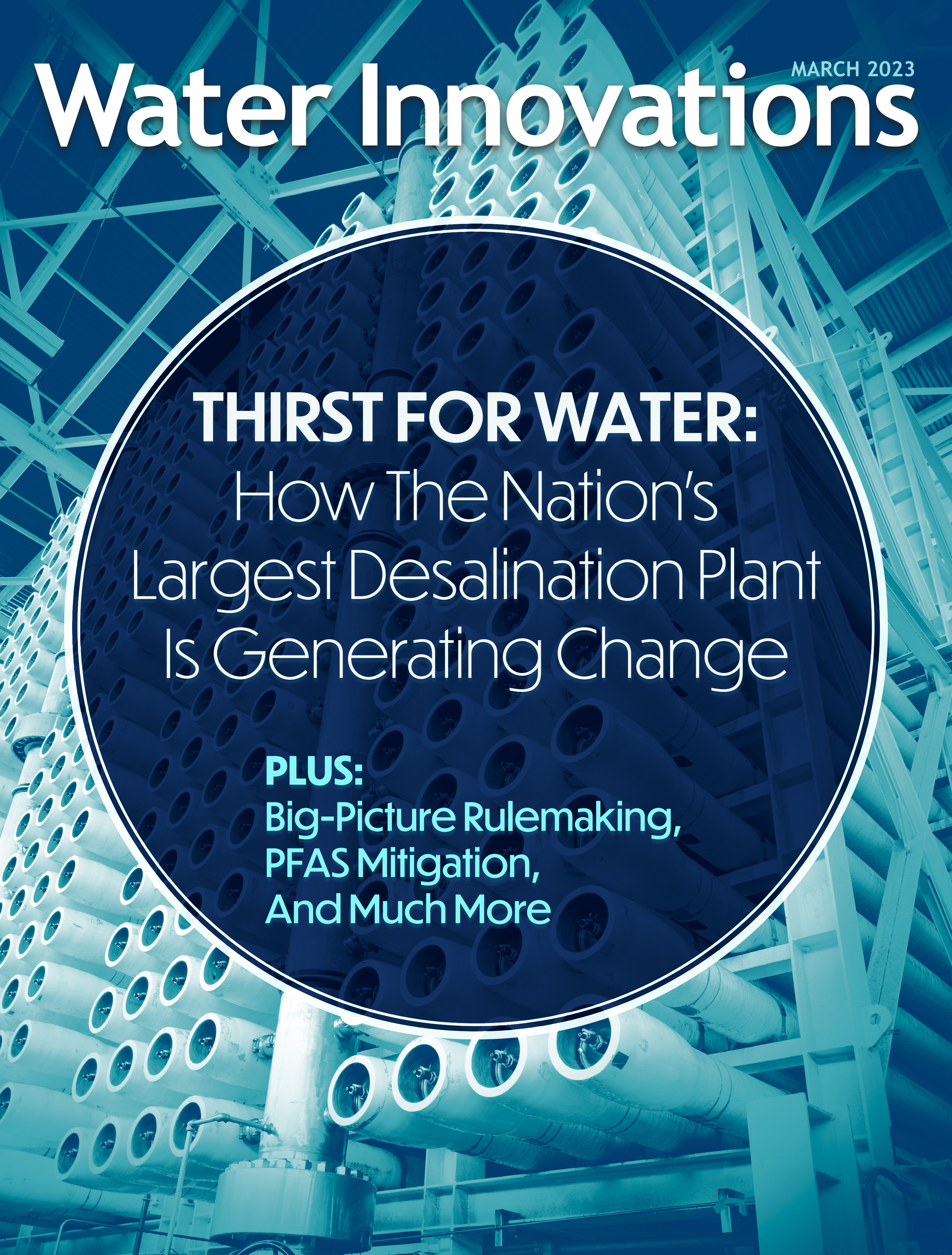
MARCH 2023

Water Innovations



THIRST FOR WATER: How The Nation's Largest Desalination Plant Is Generating Change

PLUS:
Big-Picture Rulemaking,
PFAS Mitigation,
And Much More

TABLE OF CONTENTS

MARCH 2023

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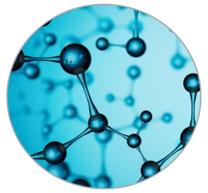
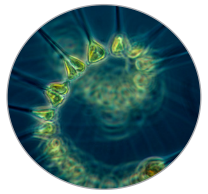
Editor's Insight

Articles





Advertiser Index

FROM THE EDITOR

By Kevin Westerling
Chief Editor, editor@wateronline.com

A Big-Picture Approach To Water Regulations

A Q&A with human health toxicologist and environmental risk assessor Janet Anderson, Ph.D., DABT

I went into my interview with Janet Anderson, Ph.D., a principal at GSI Environmental Inc. who also recently joined the Water and Health Advisory Council, with plans to discuss drinking water regulations from the standpoint of cold, hard numbers — maximum contaminant levels for dangerous and emerging contaminants such as per- and polyfluoroalkyl substances (PFAS). That's what a toxicologist would want to talk about, no?

To that extent, Anderson is certainly equipped, and the topic is explored. But she is also an expert on risk assessment and risk management, which informs her input on rulemaking as much as the toxicology part of her job. Understanding and reducing contaminant exposure is a vital safety measure, of course, but how many other factors within the scope of water management affect the human health condition?

During our conversation, I was enlightened — as I hope you will be — by Anderson's risk-based regulatory philosophy, which looks at water issues holistically to arrive at solutions that provide the greatest overall health benefit. Should this approach be embraced on the federal level and utilized locally in the manner Anderson describes, it would be a win for public health — and for common sense.

The following has been edited for clarity and conciseness.

What role do you serve for the Water & Health Advisory Council and GSI Environmental?

My job is to translate science and help all stakeholders understand how regulatory and public health agencies are looking at the science to inform decisions, and what that means in terms of human health risk. I study risk — of exposure and potential adverse effects — and the combination of those two gives us an understanding of what might be a risk to human health.

What other factors are regulatory and public health agencies considering when determining regulations?

Safe Drinking Water Act requirements for deriving a final MCL, or maximum contaminant level, take into account how we're going to treat contaminants and the cost implications for that treatment. Those aren't my areas of expertise, but that's why it's important to bring together different disciplines. It's all related, and the general public is faced with a multitude of risks. It's not just water contamination; it may be having access to water in the first place.

As a toxicologist, I think about cumulative or multiple potentials for concern. As a nation, we haven't adequately addressed some of those fundamental and basic issues — access to clean water and infrastructure challenges. I think those issues need to be brought to the discussion of any new regulation, for sure.

How are those different considerations weighed or prioritized?

The prioritization of what is most impactful to a given community must be decided at the state and, even more so, at the local level. That's why we have differing MCLs, because: 1.) we have differing interpretations of the science; and 2.) we have various tools for the states to use — different resources at their fingertips to make these decisions, and therefore different policies and programs written into state statutes. They also have different priorities beyond MCLs. Some look at their communities and prioritize fixing infrastructure, while others are going to prioritize measures for managing water resources.

Unfortunately, resources, time, and — most importantly — finances are not infinite. And so a cost-benefit analysis discussion is key, and that happens at the local level. The more we can implement federal policies that allow flexibility and allow for regulations that provide the greatest good for the greatest number of people, the closer we get to the ultimate goal.

What do you mean by regulatory "flexibility?"

It comes back to a cost-benefit analysis at the local level. For example, the American Water Works Association (citing Black & Veatch[1]) estimated upwards of $50 billion to comply with potential perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) regulations. What if, for half of that, we could have the same level of public health protection, but the other half could be spent on infrastructure, on addressing lead, on addressing arsenic, or addressing access to water? It's not an "either/or," it's an "and." How can we come up with regulations that are an "and" — that allow everyone to have the most meaningful reduction in public health risk?

So, what does "meaningful" mean? Would meaningful be the same for a city in the East versus a city in the West? That's where we need to carefully have discussions — about what provides the greatest good and about federal regulations that have extremely onerous or costly compliance requirements. What is the real benefit of a federal regulation for the entire country versus one that allows local decision-making?

Could this local approach be applied to PFAS as well?

For PFOA and PFAS, the reality is that we have seen a dramatic decline in general U.S. population exposure levels to those two chemicals, and that's without a federal MCL. There are other tools in the toolbox that can be used.

We have great data from the CDC through a program that's called NHANES — the National Health and Nutrition Examination Survey. It collects nationwide serum data for a whole host of chemicals, along with nutritional, dietary, and medical survey information. And what we've seen, since 1999, is more than an 85% reduction in PFOS and a 70% reduction in PFOA in the general population serum.[2]

To what do you attribute the drop in PFAS serum concentrations?

We're just not being exposed to those chemicals through the same pathways anymore. We have cleanup actions, as well as response actions driven by litigation, throughout the U.S. And by phasing out manufacturing through the Toxic Substances Control Act (TSCA) — the EPA just announced, in January 2023, a proposed Significant New Use Rule for what it calls inactive perfluorinated compounds[3] — we're seeing dramatic exposure reduction, without an egregiously expensive MCL.

But a PFAS MCL is coming, set to be finalized by the end of 2023, so where do you see it landing?

I don't have a crystal ball for the EPA's regulations, but the final MCL will consider what can be done from a measuring perspective, a treatability perspective, and a cost perspective.

I do think it's important to note that other agencies have looked at the same information and have come up with different interpretations of what is a reasonable limit. The World Health Organization (WHO), for example, released proposed guidance values for PFOA and PFOS, and they basically said the data are too uncertain to come up with numbers. They are proposing to set a "prudent level" — that was their term — based on the ability to detect, the ability to treat, and cost. They kind of took the health discussion off the table, which is really interesting for the WHO. It will be interesting to see where they land.

To sum up, what are the tenets for the risk-based approach to water regulations and policy that you advocate?

I think what's important is that we understand that there are multiple risks facing our drinking water today — that nothing is as black and white as we would like for making decisions. We need to be prioritizing the multitude of risks, with consideration for the available funding and resources, and ask the hard questions:

Where does it make the most sense to spend our resources from a public health perspective?

Where are we going to most have the largest meaningful reduction in public health risk? ■

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THIRST FOR WATER: How The Nation's Largest Desalination Plant Is Generating Change

Nearly a decade on, the Carlsbad Desalination Plant is a model of success not only for seawater reverse osmosis but also for visionary problem-solving.

By Vic Bianes and Jeremy Crutchfield

When the nation's largest desalination plant opened in Carlsbad, California, in 2015, people across the country were watching to see how it increased water supplies as groundwater dwindled, reservoirs dried up, and drought ravaged the Golden State.

Nearly 10 years later, the plant has demonstrated how seawater desalination can play a pivotal role in achieving water security.

Dependent on the Colorado River and State Water Project, California found itself watching water supplies reach dangerously low levels, forcing water agencies statewide to look beyond the usual solutions and tap into new opportunities.

With a near-endless supply of water from the Pacific Ocean, the Claude "Bud" Lewis Carlsbad Desalination Plant processes up to 100 million gallons of water per day. The water is filtered through gravel, sand, and other compounds to reduce particulates before it goes through reverse osmosis (RO) filtration. Approximately half of the saltwater taken into the plant is converted into potable water — enough to supply about 400,000 people daily — while the remaining water is discharged as brine.

The plant's success has fostered larger discussions about water supply and water management in the era of climate change.

> **Water supply will continue to be complex and contentious, especially across the western U.S., as drought, climate change, and diminishing groundwater supplies upend historical norms.**

Private-Public Partnerships

Water supply is not an issue that affects just municipalities or public works agencies; its reach is far and broad, impacting residents, businesses, agriculture, and manufacturing operations. In San Diego County, regional water officials knew they couldn't go it alone. Businesses and residents were critical to ensuring the desalination plant would move from concept to commercialization.

Together with Poseidon Water and the Water Authority, a blue-ribbon panel of public agencies, residents, and stakeholders was engaged to educate and gain support for the project, which ultimately led to successfully obtaining required permits. While development costs and associated risks were shouldered by private enterprise — in this case, Poseidon and its investors — the Water Authority and its member agencies walked side-by-side every step of the way. With a thoughtfully developed plan, operational strategy, and design, the project became a gold standard among seawater desalination plants around the world.

Economics At Play

In an era when "do-more-with-less" has become a way of life, building and operating seawater desalination plants can be overwhelming. Although technical and scientific advancements have made desalination plants more efficient, they are still expensive to build and operate. That means water generated also costs more than water from other sources, including groundwater and the Colorado River. However, the costs of seawater desalination are comparable to costs of other next-generation sources such as potable reuse — and those are the only new water resources available in many areas.

Given the scarcity of new supplies, the price of desalination is reasonable. Bringing the new water supply into homes through the Carlsbad plant increased the average monthly water bill in the San Diego region by just $5 per household — or about the cost of a cup of coffee.

Measuring Environmental Impact

California has some of the strictest environmental regulations in the nation. With requirements on design and operation, the Carlsbad plant continually monitors water coming into the system, as well as the brine discharge.

Studies, along with continual monitoring, have demonstrated seawater desalination can be performed in an environmentally sensitive way without causing harm to the aquatic ecosystem.

Trailblazing

The Carlsbad Desalination Plant has also been a beacon for several other projects that are at various stages of development in California.

Last November, state officials approved a desalination plant along the state's central coast. There is relief in sight as the California Coastal Commission voted to approve a permit for the California American Water Co. to draw water from the coast of Marina, CA, to supply a private plant in Monterey County. Under the plan, the new water desalination plant would boost future water supplies in drought-stricken Monterey County.

But perhaps the most surprising desalination project comes from the Sonoran Desert. As part of an ambitious plan, Arizona officials recently voted to evaluate the prospects of creating a desalination plant on the Gulf of California. The goal would be to pipe water from the Sea of Cortez near Puerto Peñasco, Mexico, to Arizona, while allowing Mexico to use water generated by the plant in exchange for a share of the country's water sourced from the Colorado River.

Critical Conversations

Water supply will continue to be complex and contentious, especially across the western U.S., as drought, climate change, and diminishing groundwater supplies upend historical norms.

But given improvements in technology — as well as the growing need to diversify water supply options — desalination is becoming an increasingly important source of fresh water. Innovation is driving costs down to the point where desalination is an economically viable solution for alternative water supplies.

Similarly, legislative initiatives are receiving greater attention for their focus on alleviating pressure and finding practical solutions for water supply reliability. Public utilities, including the American Public Works Association, are driving forward the principle of responsible water use beyond conserving and recycling to innovating and responsibly pushing the envelope when it comes to ensuring this valuable commodity is available for generations to come. ■

About The Authors

Vic Bianes is an American Public Works Association national board technical director for fleet and facilities and grounds. He is a registered engineer and currently works for Kleinfelder Engineering as a major client manager. In 2018, he served as a board director for the County Water Authority and, in 2005, as the engineering design section manager for the County Water Authority.

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Learn more about the American Public Works Association's water priorities at apwa.net.

BEING RESOURCEFUL WITH WASTEWATER TREATMENT TO HELP TACKLE THE GLOBAL WATER CRISIS

Trends toward efficiency and digitalization within the wastewater treatment industry promise improved operations, a healthier environment, and a more sustainable future.

By Marco Achilea

Wastewater can be a valuable but often untapped resource in helping to solve our global water shortage. When treated effectively, it can be returned safely to the water cycle for reuse, reducing the levels of untreated sewage pumped into rivers and oceans and therefore mitigating the negative impact on public health, the environment, and marine life.

Projected to grow from $300 billion in 2022 to $490 billion by 2029,[1] the wastewater market holds great potential as a key part of the solution to our water scarcity crisis. However, the UN estimates that, globally, only 52% of wastewater is currently treated.[2] This puts increased demand on freshwater and means that untreated wastewater continues to contaminate the natural environment.

With the UN predicting a global water deficit of 40% by 2040,[3] we have a collective responsibility to contribute to the UN's Sustainable Development Goal 6.3 of halving the proportion of untreated wastewater by 2030.

Balancing Wastewater Treatment With Cost And Carbon Consumption

With a growing population and industry demanding more water, it is critical now, more than ever, that we balance two conflicting imperatives: more wastewater treatment with less power. On one hand, we need to meet the growing demand for clean water by harnessing the potential of treated water for reuse in industry and agriculture. On the other hand, we need to reduce energy consumption to cut carbon emissions and costs. Treating wastewater is extremely energy-intensive, with the industry at large consuming up to 3% of the world's total energy output[4] and contributing over 1.5% to global greenhouse gas emissions.[5]

Consequently, it is expensive for operators already struggling with limited resources, rising costs, and greater demands on performance. Many plants have not been upgraded for years and depend on obsolete technology, which means they are behind in complying with new environmental and climate targets. But these obstacles are not insurmountable.

Technology is an excellent starting point to increase visibility across operations, but there is even more value to be added at the next level, namely optimization. Imagine a smart system that automatically adapts itself and responds to changing conditions. Imagine a system that uses all the power of today's data analysis tools to implement adjustments in real time.

Building on automation, the natural next step is digital. The ABB Ability Smart Solution for wastewater, for example, is a scalable and modular digital solution used for advanced process control, digital twin, process simulation, and performance optimization.

ABB has the technology to achieve the balance between supply and demand, but we need to be deliberate and proactive in taking advantage of all the solutions available to automate and optimize processes, while addressing the key issues within the evolving wastewater treatment industry.

Take, for example, energy efficiency — there is no escaping that water is heavy and requires a huge amount of energy to move, especially as treatment plants run almost 24/7. The good news is that new sophisticated processes are allowing operators to improve performance and ROI.

Operators are also under pressure to treat huge volumes of water without increasing their physical footprint, especially as treatment plants are never popular with residents, but innovative processes are available to integrate functions and reduce that footprint.

Achieving carbon neutrality is a serious challenge, but progress is being made. At a wastewater treatment plant in Schwarzenbruck, Germany, for example, ABB Ability OPTIMAX exploits onsite thermal, electric, and gas generation, saving 100% of the plant's grid energy and 300 tons of CO_2 a year.

Smart use of technology also enables wastewater treatment plants to be turned into resource factories. Energy is not the only resource that can be generated in the wastewater treatment process; it can also produce resources such as fertilizers, nutrients, and other valuable materials.

Researching The Optimum Wastewater Treatment Plant Model

Over the last year, ABB has worked with an independent economist[6] to analyze how adoption and integration of process automation and digital technologies can deliver both carbon and cost savings to enable the efficient treatment of wastewater. Through economic modeling, hypothetical scenarios based on real-world case studies complemented by further data and desk-based research for both greenfield and brownfield sites were developed to assess the impact of technologies deployed. The methodology assumed a basic level of technology adoption from 2014 in the case of greenfield (95 MLD, or 25 MGD) and from 2000 for brownfield (50 ML or 13 MGD) — in keeping with the conventional approach by utilities/municipalities.

The findings, published in ABB's *Being resourceful with wastewater treatment* report,[7] showed that by implementing advanced and integrated digital and automation technology, based on today's market, into wastewater sites, operators could achieve average carbon savings across brownfield and greenfield of 10% per annum and an annual operating cost savings of 9.5%.

In real terms, this means utilities could reduce their carbon emissions by up to 2,000 tons per annum,[8] per plant — the equivalent volume of CO_2 responsible for 30,000 tons of glacier mass lost every year.[9] With over 50,000 existing wastewater plants worldwide and a predicted industry growth rate of over 7%, the opportunity, if scaled, is upward of 100 million tons of CO_2 saved.[10]

By applying this robust package of process control and digital solutions, water companies could also reap annual operational savings of up to $1.2 million (9.5%) per plant,[11] opening new revenue streams to ensure that higher volumes of wastewater are treated and less is discarded into our rivers and seas.

The Future Of Wastewater

It is an exciting time to be working in wastewater management. And we have an opportunity — and the responsibility — to make a world of difference.

However, the energy transition is not going to happen overnight, and we need to be realistic in our ambitions. Not all the 50,000 wastewater plants currently in operation around the world are going to be replaced overnight, but we must remember that the technology we have can also transform existing brownfield sites, making a big impact on cost and carbon savings.

The future of wastewater management is not just ridding the world of polluted water, nor just saving freshwater by providing an alternative for agricultural and industrial purposes. It is about optimizing operations to the point that it generates brand-new resources and significantly cuts down on energy consumption, and therefore carbon emissions, in the process. ■

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Case Study: City of Montreal Wastewater Plant

Facts about the plant:

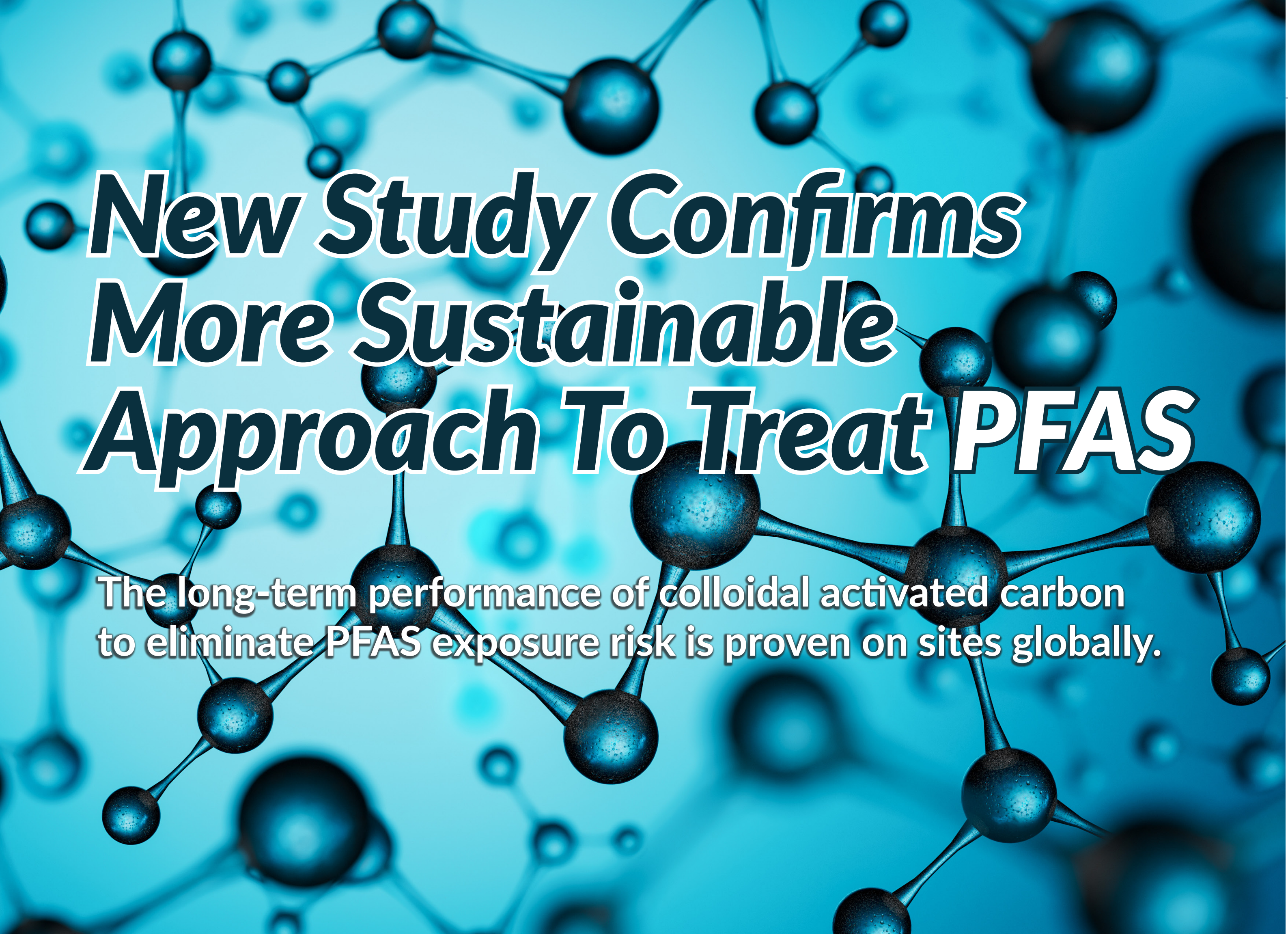
- Network is 3,500 km (2,175 miles) of sewers, 75% combined, for a population of 2 million inhabitants and daily commuters with a capacity of treating 7.6M cubic meters (2B gallons) per day, almost half of Quebec's wastewater.
- Has 18 snow drop-off points that save time and money in the snow removal process.
- Hydraulic physico-chemical treatment plant using ABB Mod300 and 800xa DCS with 3,500 controlled points, using 17 pumps and four suction wells processing wastewater arriving in two 5-meter (16.4') interceptors with a maximum capacity of 83 cubic meters (22,000 gal.) per second. This would fill an Olympic pool in 30 seconds.
- To maximize wastewater flow and limit overflow impacts, using weather predictions the plant controls 77 valves, 36 regulation sites, six basins, five collectors, and 21 pumping stations, based on a 2-hour prediction being calibrated by 53 rain gauges.

Guy Arnould, head of automation engineering, commented: "We have operational data dating back to 1995 and over 25,000 tags that can easily be viewed and analyzed. After events such as flash floods and river overflows, we review the information and then adjust our automation processes and hydraulic models. Notifications and alerts inform our operational teams, burrows, public security, and contractors of events such as high temperatures, equipment running out of normal parameters, rain, high river levels, overflows, beach closures, and more.

"To run efficiently, we need experts who review our operational dashboards and interpret and analyze our data to then propose the necessary adjustments. This is time-consuming, and the solution is more often than not after the event. To help us address this and become proactive during events to optimize our operations, we have to have quicker response times and better decision-making tools. This is where we are working with partners such as ABB to help us find tools using machine learning/AI and new equipment to limit our overflows, reduce costs, and raise efficiency. ABB is presently supporting us with their advanced applications that help optimize our chemical dosing. We also have other initiatives looking at optimizing our wastewater treatment capacity and overflow as well as preventive and predictive maintenance; but to do this, we need experts and new technologies to help us lower our carbon footprint and have better effluent quality going back into the St. Lawrence River."

About The Author

Marco Achilea is the head of water business for ABB Energy Industries. Marco has been at ABB for almost 10 years and is responsible for the development and global rollout of the Water & Infrastructure segment's business strategy.



New Study Confirms More Sustainable Approach To Treat PFAS

The long-term performance of colloidal activated carbon to eliminate PFAS exposure risk is proven on sites globally.

By Ryan Moore

Firefighting training areas at military and commercial airports are among the most significant sources of contamination of PFAS (per- and polyfluoroalkyl substances) in groundwater and drinking water globally. According to a newly published modeling study, in situ (i.e., in place) passive filtration using colloidal activated carbon represents a significantly more sustainable long-term solution to removing the PFAS exposure risk originating from these sites.

Groundwater PFAS Impacts At Airports

Based on data[1] from the Social Science Environmental Health Research Institute (SSEHRI) at Northeastern University, 437 airports, AFFF (aqueous film-forming foam) sites, or military facilities have confirmed PFAS contamination in groundwater. Many of these facilities have PFAS contaminant plumes in groundwater threatening public and private drinking water sources or surface waters.

PFAS contamination identified at firefighting training areas represents a high exposure risk for many communities. These PFAS source zones were created by spraying AFFF-containing PFAS to extinguish fires during fire training exercises, usually conducted in open fire pits or on designated areas of airport tarmacs. The mandatory periodic training exercises left high masses of toxic PFAS chemicals directly exposed to rainwater.

Rainwater causes PFAS and other contaminants (e.g., petroleum hydrocarbons from jet fuel) to leach into groundwater. Once PFAS reach groundwater, they are readily transported by it. Since the more toxic PFAS compounds such as perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) do not appreciably degrade in the environment, they can travel for miles down-gradient toward public water supply wells, domestic drinking water wells, or surface waters.

One estimate suggests that more than 200 million people[2] in the U.S. may be exposed to PFAS in their drinking water. Additionally, the forever chemicals are found in most streams and lakes with concentrations of PFAS, and PFOS specifically, in fish, triggering "Do Not Eat" warnings nationwide. Unsurprisingly, drinking water and surface water PFAS impacts are often the highest downstream of airports and other AFFF release sites.

Sustainable PFAS Groundwater Remediation

Given the scale of the PFAS problem at airports and military bases, there is substantial interest in identifying technologies and approaches that can sustainably remove the PFAS exposure risk from them. One approach continuing to gain critical acceptance and deployed worldwide uses colloidal activated carbon (or CAC) to transform the groundwater aquifer into a massive underground filter. This filter immobilizes PFAS, preventing the contaminants from reaching drinking water wells, surface water, or other downstream receptors.

Commercially known as PlumeStop, CAC is activated charcoal sourced from coconuts, milled into red blood cell size particles, and suspended in a food-safe solution to create a liquid, colloidal form of activated carbon. Ink-like in appearance, the patented novel carbon form is nonclumping, allowing it to slip through the soil or rock pores. In the process, PlumeStop "paints" the subsurface with highly reactive carbon, forming an expansive subterranean filter covering 100 acres for each pound of carbon attached to the aquifer matrix.

The below-ground CAC filter is installed as one or a series of permeable reactive barriers (PRBs) between a PFAS source and a downgradient receptor (e.g., water well or stream). Based on known measured rates of contaminant flux, these PRBs are engineered to immobilize PFAS for decades or longer.

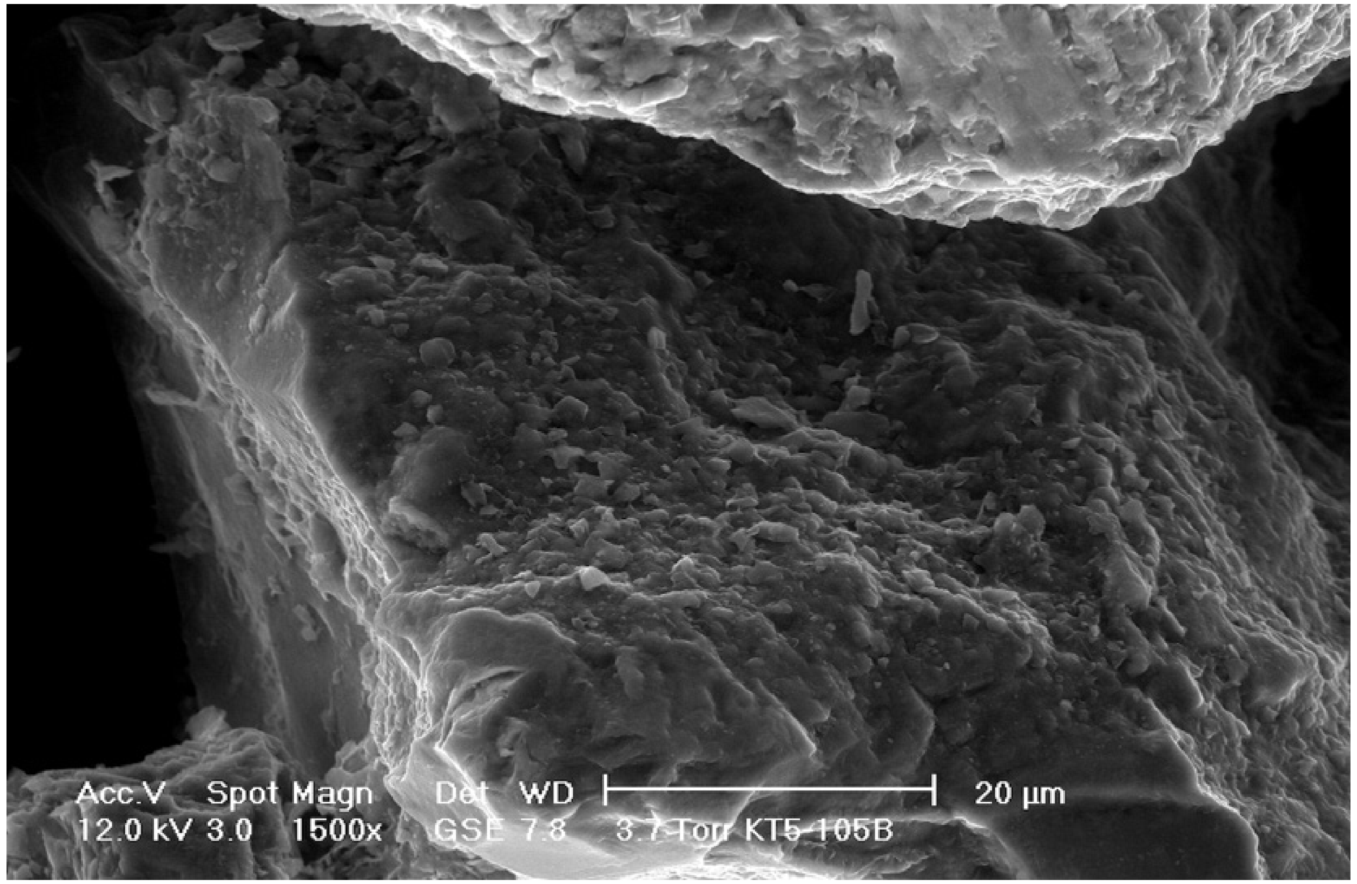
The default method historically used to mitigate PFAS involves pumping groundwater above the surface for treatment, an energy-consuming activity generating a massive carbon footprint. A single continuously operating pump-and-treat (P&T) system used to control a PFAS plume can generate millions of pounds of CO2 emissions over its lifetime and even more for hauling the PFAS-saturated wastes to a landfill, where PFAS may ultimately leach back into the environment, starting the process all over again.

More recent experimental P&T approaches seek to destroy the PFAS, subjecting the pumped water to high temperatures, pressures, or energy inputs needed to break the resilient carbon-fluorine bonds. The energy required to accomplish this destruction adds to the carbon footprint substantially. While destructive technologies such as supercritical water oxidation and electrochemical oxidation may be adequate for specific applications (e.g., treating landfill leachate), they are not sustainable for addressing large low-concentration PFAS plumes in groundwater.

In contrast, the in situ CAC treatment process is 100% powered by naturally occurring groundwater flow. This passive approach to preventing plume movement offers one of the only sustainable solutions for addressing PFAS in groundwater.

New Research Study Points To Long-Term Success Of In Situ CAC Approach

A recent study by leading groundwater modeling expert Dr. Grant Carey was published in the *Remediation Journal*. Titled Longevity of colloidal activated carbon for in situ PFAS remediation at



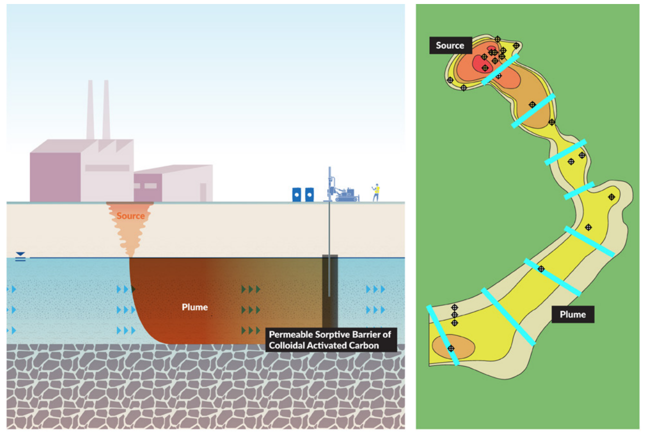
Scanning electron microscope image shows CAC coating sand grains.

The default method historically used to mitigate PFAS involves pumping groundwater above the surface for treatment, an energy-consuming activity generating a massive carbon footprint.

AFFF-contaminated airport sites,[3] the study analyzes the expected long-term performance of the patented CAC technology to effectively treat PFAS in situ based on PFAS sampling data from 96 AFFF-contaminated airport sites and performance data from 17 in situ CAC applications. Some of the key findings from the study are summarized below.

1. **CAC preferentially sorbs contaminants found at airports.** The primary PFAS detected at airports were dominated by PFOS and PFHxS (perfluorohexane sulfonic acid), compounds preferentially sorbed to CAC relative to other PFAS.
2. **Contaminant breakthrough times for in situ CAC treatments are much longer than ex situ P&T carbon use.** This is mainly due to the smaller particle size of CAC, resulting in higher mass transfer rates and below-ground application, resulting in much longer contaminant retention on the carbon particle surfaces.
3. **Seventeen (17) field sites show successful results with co-contaminants present.** Field sites where CAC was applied to treat PFAS were reviewed, showing successful results for treating both long and short-chain PFAS even in the presence of co-contaminants such as fuel hydrocarbons (used for creating flammable liquid fires). The project sites continue to perform.
4. **Modeling indicates decades of treatment longevity.** The authors developed isotherms for sorption to CAC using water collected from an actual AFFF-impacted airport site. Numerical modeling was conducted to evaluate the sensitivity of in situ CAC remediation of PFAS to site characteristics and design variables. The results further support earlier predictive modeling, conservatively suggesting decades of effective treatment at most AFFF releases, regardless of the cleanup criteria.
5. **Longevity can be extended by reducing the incoming mass flux.** Results indicate that in situ CAC treatment performance was most affected by incoming contaminant mass flux. Treatment longevities can be increased when combined with upgradient source zone treatments that prohibit further leaching and reduce the downgradient contaminant flux over time. These treatments include paving/capping a source zone to limit infiltration, mixing of materials into the upper soil layer to reduce permeability, and applying a concentrated CAC formula (commercially available as SourceStop) to the base of a source zone.

The findings of this study confirm that CAC treatments offer a long-term, effective, more sustainable solution to reduce PFAS



Cross section and aerial view of CAC sorptive barriers to treat a groundwater contaminant plume

exposure risk from AFFF releases at airport sites. The CAC approach is poised to replace P&T, potentially saving billions of dollars in system installation, O&M costs, and millions of tons of greenhouse gas emissions.

Over 40 CAC in situ filtration treatments are now installed, including recent installations at airports and airfields in the Northeast, Mid-Atlantic, Midwest, and Southwest U.S. regions, Alaska, and Great Britain. Full-scale treatments meet the project objectives, with the longest-running treatment[4] having eliminated PFAS in groundwater for over six years thus far. Hundreds more projects are currently in the planning or design stages.

Additionally, several U.S. Department of Defense-funded laboratory and field research projects examining various technical aspects of the innovative CAC treatment approach are ongoing, including Strategic Environmental Research and Development Program Projects ER20-5182, ER21-1059, ER21-1130, ER21-3959, and ER21-1124. ■

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The Importance Of Water Efficiency In Enhancing Economic Development Strategies

Establishing water efficiency measures with commercial, industrial, and institutional (CII) sector partners has a lasting effect if positioned from a standpoint of cost savings, utility footprint reduction, and overall economic development benefits.

By Eric Meliton

For economic development offices and governmental stakeholders who advocate public-private partnerships, CII sector water efficiency is very important in maximizing resources (especially for companies in drought-stricken regions of the U.S. and Canada), reducing operational costs (e.g., process water, wastewater treatment, non-compliance, and regulatory sanctions), and improving corporate citizenship within a municipality, region, or as part of a broad industry landscape. Not only do CII companies benefit from improving their environmental measures by addressing freshwater uptake and downstream impact of their wastewater discharge volumes, but effective water efficiency measures also have an indirectly positive impact on social engagement with their stakeholders and their industry reputation.

For many years, economic development leaders have focused on the primary goals of economic development support — improving the local economy, encouraging sectoral industry investment, attracting business growth, and creating new jobs — and in doing so, increasing local taxation.

Progressive economic development leaders work with governmental and/or industry proponents who advocate water efficiency within the CII sector, leading to network development capacity in expertise and support that typically is the focus of technology vendors or engineering firms. By providing access to these types of support systems, economic development offices in North America have an opportunity to solve CII process water and wastewater challenges by leveraging existing conservation programs in many forward-thinking municipalities.

Companies within the CII space could then access supportive efficiency incentivization, maximize utility savings, and improve and enhance reporting key performance indicators linked to corporate sustainability, such as environmental, social, and governance (ESG), UN Sustainable Development Goals (UN SDGs), and Task Force on Climate-Related Financial Disclosures (TCFDs). These metrics are becoming important to investor relations for publicly traded companies and can influence where large national and multinational firms elect to set up manufacturing and headquarter operations in progressive cities in North America. Strategically linking to progressive governmental conservation measures that have long been in place but have not been effectively deployed in this fashion is the basis of the examples to be shared.

Economic Development Challenges Related To CII Water Efficiency Engagement

Although progressive governmental economic development programs that are matched with water efficiency programs are effective in obtaining buy-in and implementation capacity for CII companies to proceed, most companies do not have sufficient access to these types of engagement programs in North America.

Compounding the lack of access is the lack of regional, provincial, state, and even federal funding to implement innovative best practices for freshwater use, better service and technological advancements, and effective ways to treat wastewater. Even when proven in a regional context, adoption of innovative solutions is still one of the main industry barriers in the water sector. The overall resistance to change is less likely to come from CII corporations as competitiveness and economic growth factors encourage companies to adapt to the needs of the sector and learn how to remain ahead of the curve.

Engagement programs listed in the next section have helped CII companies obtain consensus buy-in at the corporate and operational levels, strengthened and/or repaired governmental relationships, and maximized the use of incentivization available to CII entities, thus mitigating the challenges and barriers to adoption typically experienced with water efficiency opportunities.

True public-private partnerships, with economic development offices providing awareness and advocacy of existing partnership engagement and stewardship programs, are something that can be effectively replicated in the CII sector.

CII Water Efficiency Engagement Programs

From a Canadian context, a cluster of Ontario-based municipalities has worked together to establish the progressive approach described above. Through the Ontario Water and Wastewater Association's Water Efficiency Committee[1] and the Municipal Water Efficiency Eco-Cluster[2] established by Partners in Project Green's Water Efficiency program,[3] sharing of CII engagement best practices and showcasing industry case studies of implementation success has been a collaborative municipal water efficiency program network dating back more than 20 years. The leading Ontario municipalities that have adopted effective water efficiency design include the Region of Peel,[4] York Region,[5] City of Toronto,[6] City of Guelph,[7] and Region of Waterloo.[8]

In the U.S., the Alliance for Water Efficiency conducts a policy tracking scorecard,[9] rating the statewide programs offered by municipalities for water efficiency and sustainability, which encompasses program capacity offered to CII sector participants. States adopting the Alliance for Water Efficiency's G480 Standard[10] provide a framework for critical design of water efficiency and conservation measures that municipalities can adopt along with ways to incorporate stewardship and engagement with residential homeowners and CII companies. States that scored high on the 2022 scorecard embedded effective best practices from the G480 standard. A historical list of progressive municipalities that have adopted the G480 standard is included for reference.[11]

From this 2022 ranking, the following were the top 10 U.S. states in policy and program offerings for efficiency and sustainability: California, Texas, Arizona, Washington, Georgia, New York, Nevada, New Hampshire, Colorado, and Minnesota. Looking at this list of states through a water use lens, many of these states have water use restrictions imposed on both residential homeowners and CII companies due to drought concerns and parallel water rights issues.

Progressive states featured in this scorecard have statewide water efficiency measures, such as the Texas Water Development Board,[12] which serves as an integrated supportive resource offered to municipal water conservation program initiatives, which aligns with the notion of CII water efficiency enhancing economic development strategies.

From the North American perspective, CII companies are not restricted to utilizing regional governmental programs but can seek out stewardship and engagement programs customized for the corporate sector. Many national and international non-profits and non-governmental organizations have established these customized programs, built by CII facing leadership to provide guidance and educational support for adoption of complex water stewardship and efficiency initiatives. The Alliance for Water Stewardship's International Water Stewardship Standard 2.0[13] has been adopted by many national and international corporations that want to improve their freshwater use, mitigate their wastewater volumes generated, and lessen their downstream impact. Similarly, The Water Council recently launched its WAVE Water Stewardship Verified program,[14] which effectively looks at water use risks, policy development, and corporate communication strategies. If strategically linked to progressive governmental efficiency programs available for CII companies to access, these national stewardship and engagement programs could further enhance the overall economic benefits a company can gain.

Conclusion

Reaching the primary goals of governmental economic development can be established through facilitated adoption of water efficiency program support or utilization of customized national and international standards. In doing so, CII companies that seek out better ways to use their water resources, reduce the downstream impact of their wastewater volumes, and mitigate their regulatory and non-compliance issues related to water use to improve the local economy, enhance regional and sectoral investment, and generate new business growth through marginal improvements, are more likely to hire and ultimately contribute to the local taxation growth. If water efficiency can be at the core of all these economic benefits, why aren't we doing more of this in North America? ■

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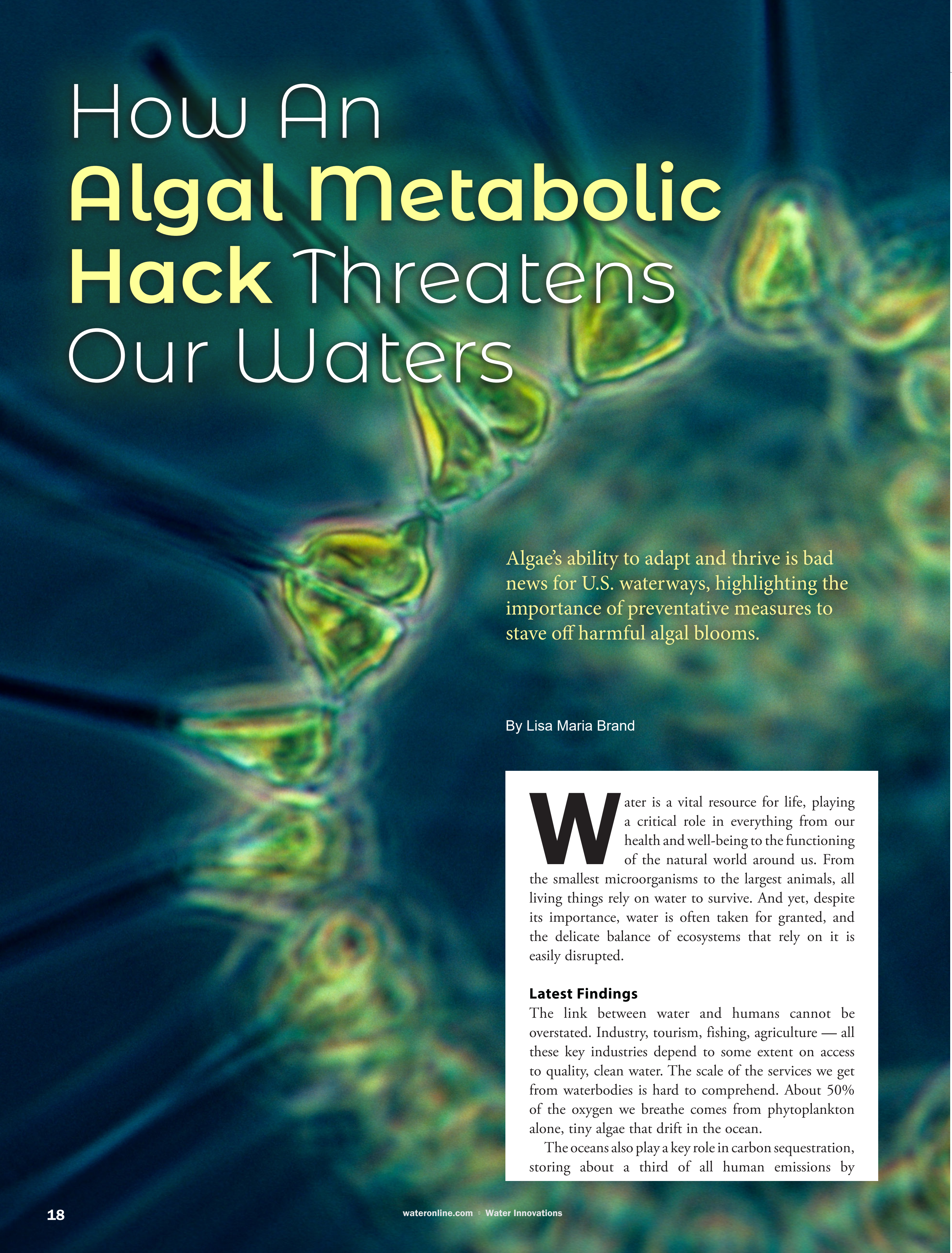
Eric Meliton is a thought leader and industry conduit with over 20 years of experience comprised of industrial manufacturing, regulatory and compliance, water and wastewater treatment technologies and governmental stakeholder engagement. He continues to analyze cleantech trends, execute corporate sustainability objectives, and maintain a trusted rapport with multinational corporations and industry trade associations, which complement an accomplished portfolio of strategic research projects and publications. Eric has served on *Water Online's* Water Intelligence Panel since 2018.



How An **Algal Metabolic Hack** Threatens Our Waters

Algae's ability to adapt and thrive is bad news for U.S. waterways, highlighting the importance of preventative measures to stave off harmful algal blooms.

By Lisa Maria Brand

Water is a vital resource for life, playing a critical role in everything from our health and well-being to the functioning of the natural world around us. From the smallest microorganisms to the largest animals, all living things rely on water to survive. And yet, despite its importance, water is often taken for granted, and the delicate balance of ecosystems that rely on it is easily disrupted.

Latest Findings

The link between water and humans cannot be overstated. Industry, tourism, fishing, agriculture — all these key industries depend to some extent on access to quality, clean water. The scale of the services we get from waterbodies is hard to comprehend. About 50% of the oxygen we breathe comes from phytoplankton alone, tiny algae that drift in the ocean.

The oceans also play a key role in carbon sequestration, storing about a third of all human emissions by

Due to the resilience and capacity to adapt shown by algae, the intensity and number of blooms worldwide have been increasing over the past few decades, and as the climate changes, these blooms are expected to increase by up to 20% over the next century.

themselves through a series of processes collectively called the biological pump. These tiny algae are the main source of food for countless oceanic species, forming the first level of many food webs and feeding the fish and seafood we all love.

Due to the importance of the ocean in biodiversity and climate regulation, which influence the habitability of our planet, interdisciplinary groups of scientists and industry professionals are working to understand how factors such as climate change and pollution will affect it. And since phytoplankton is such an important piece of the puzzle, a lot of research goes toward understanding what will happen to it. The latest Intergovernmental Panel on Climate Change (IPCC) report states an uncertainty of -20% to +20%, essentially saying that whether we get more or less of it is up to a coin toss.

The Metabolic Hack

Previous models predicted a decline in global plankton by about 8% over the next century. However, scientists have recently discovered that algae are more resilient than previously thought. In a veritable metabolic "hack," it is able to overcome nutrient shortages expected to occur due to the ocean warming through a process called nutrient uptake plasticity.

As the surface water becomes warmer, it mixes less with the underlying layers, making vital nutrients like phosphate scarcer. And while scientists feared a potential huge decline in phytoplankton production, this may not be the case. How can algae thrive without phosphate? They substitute it — with sulfur. In models that account for this mechanism, global phytoplankton production is predicted to increase by up to 5%.

At first, this seems like a good thing. If phytoplankton gives us oxygen, stores carbon, and feeds fish, this is great news, right? Well, yes and no. While everyone loves positive news and these findings give us a good reason to be cautiously optimistic, there are still problems to consider.

The first issue is that nutrients are not the only factor affecting algae. There are many more mechanisms that could potentially limit this predicted increase. A principle called Liebig's law says that growth is dictated not by total resources available, but by the scarcest resource. Think of a barrel made of multiple wood planks: the water level is limited by the shortest stave, so even if planktons overcome the lack of phosphate, they can still be harmed by increased acidification, higher temperatures, or pollution.

The Algae Catastrophe

The second issue is that having a lot of algae is not always a good thing. When a stable aquatic ecosystem is affected by a sudden nutrient influx, such as due to agricultural runoff, algae will multiply rapidly and turn into algal bloom.

Depending on the severity, a bloom can block sunlight and deplete oxygen, with disastrous consequences for the entire ecosystem, including mass fish and plant death. Some species even produce dangerous toxins, which can leave local towns and villages without a safe water source and result in fisheries being closed. Algal blooms can even clog dams and impact industrial activities such as mining and hydropower production.

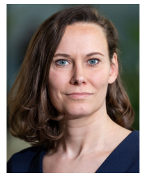
Due to the resilience and capacity to adapt shown by algae, the intensity and number of blooms worldwide have been increasing over the past few decades, and as the climate changes, these blooms are expected to increase by up to 20% over the next century.

As some species are quicker to adapt to these new conditions than others, we should expect a shift in the properties of phytoplankton, so we could be underestimating this suspected increase. This metabolic hack that allows them to survive and thrive even in low nutrient concentrations is thus a double-edged sword. Increased carbon storage comes at the cost of both the human economy and ecosystem health.

Preventing HABs

How can we prevent harmful algal blooms? The first step is to address the root causes by directly reducing pollution. Tighter environmental controls are needed to ensure that fertilizers and human and animal waste do not enter oceans or freshwater bodies. Faster and more decisive action is needed to address climate change, one of the main drivers of the increased number of blooms. Lastly, by investing in research and monitoring, algal blooms can be spotted early — and prevented. Innovative technology can now be used to stop the bloom from reaching its peak. For example, ultrasonic devices can prevent algal growth without harming the rest of the environment. We cannot expect to immediately stop all nutrient pollution and reverse climate change, so these devices are a key tool for ensuring the well-being of our waterbodies. ■

About The Author



Lisa Marie Brand is a microbiologist with a focus on water quality and algal bloom solutions. With 15 years of experience, she has deep knowledge of algal blooms and their impact on the environment. She is an experienced project manager and has led research projects on freshwater quality analysis and improvement measures.

Navigating Contaminants Of Emerging Concern

Two recent research projects — one to improve potable reuse, the other to stop the proliferation of PFAS — look to source control as the key leverage point.

By Kyle Thompson

In the U.S., over 2,000 new chemicals are introduced each year. Unfortunately, some of these chemicals have been detected in water systems and are determined to be toxic. For example, one study found over 120 pharmaceuticals in wastewater effluent and a meta-analysis counted over 70 per- and polyfluoroalkyl substances (PFAS) in wastewater effluent. The combination of detection in water and toxicity evidence leads to new guidelines and enforceable standards.

These chemicals are commonly known as contaminants of emerging concern (CECs). As new CECs are discovered, and as they attract more media attention, this increases public awareness and concern about these chemicals, especially in the realm of potable reuse.

Water utilities may need guidance on how to manage or remove chemicals with new or upcoming standards, and to know what new CECs are likely to receive scientific, public, and regulatory scrutiny.

The water industry has done significant research on the toxicity, measurement, and removal of chemicals. Carollo has long been at the forefront of this research, with projects dating back more than a decade (Figure 1). Recurring themes in this research have included: (1) chemical removal in wastewater or reuse, (2) PFAS, and (3) narrowing the numerous chemicals to key indicators or monitoring priorities. Two recent projects are highlighted in this article.

Figure 1 - Timeline of CEC research projects.

PROJECT HIGHLIGHT #1:

WRF 4960: An Enhanced Source Control Framework for Industrial Contaminants in Potable Reuse

Many CECs enter wastewater from industrial discharges and are challenging to remove, toxic, or have the potential to interfere with treatment processes. Enhancing source control programs could be more cost-effective, reliable, and environmentally just than adding further treatment barriers at reuse facilities. Much research had been done on chemical removal by the advanced processes applied for reuse. However, a comprehensive review considering reuse treatment trains as a whole was needed to assess full-scale pass-through potential. As part of Water Research Foundation (WRF) 4960, around 300 industrial chemicals were selected for review. These chemicals were reviewed for their toxicity and their removal in wastewater treatment plants, conventional drinking water treatment, and three reuse treatment trains:

- Train A: Reverse osmosis (RO) and ultraviolet (UV) advanced oxidation process (AOP) with peroxide (H2O2) addition.
- Train B: Ozonation, biofiltration, granular activated carbon (GAC), and UV disinfection.
- Train C: Ozonation, biofiltration, RO, and UV/AOP with H2O2.

Then Industrial Contaminant Screening Scores were calculated based on toxicity and whole-train removal. Chemicals that ranked highly were recommended for monitoring at planned reuse sites as the first step toward enhanced source control (Table 1).

Rank	Train A	Train B	Train C
1	NDMA	NDMA	NDMA
2	PFOA	PFOA	PFOA
3	PFOS	NMOR	PFOS
4	NMOR	PFOS	NMOR
5	1,4-Dioxane	Cobalt	Cobalt
6	Cobalt	PFBS	PFBS
7	PFBS	PFBA	Uranium
8	Uranium	Mercury	PFBA
9	PFBA	Arsenic	Mercury
10	Mercury	Chromium	Arsenic
11	Arsenic	Uranium	Chromium
12	Chromium	Cadmium	1,4-Dioxane
13	Cyanide	1,4-Dioxane	Cadmium
14	2,4,6-Trichlorophenol	Nickel	TCEP
15	1,2,4-Trichlorobenzene	TCEP	TDCPP
16	Atrazine	Selenium	Nickel
17	Cadmium	Fluoride	Atrazine
18	TCEP	Iodide	Carbon Tetrachloride
19	1,2-Dichloroethane	Copper	Selenium
20	TDCPP	Carbon Tetrachloride	Fluoride

Table 1 - Recommended chemical monitoring lists based on WRF 4960.

Benefiting A Large Reuse Project

This project was co-funded by the California Water Boards and these monitoring lists have already been implemented at Los Angeles Sanitation and Environment's Hyperion Membrane Bioreactor Pilot. This pilot is a step of the Hyperion 2035 Program, which will culminate in the largest reuse system in the world. This monitoring at Hyperion based on WRF 4960 even included the "further research recommended" version of the list, which assumed poor removal of understudied toxic chemicals.

PROJECT HIGHLIGHT #2:

WRF 5082: Investigation of Alternative Management Strategies to Prevent PFAS from Entering Drinking Water Supplies and Wastewater

PFAS are a family of chemicals notorious for their persistence, bioaccumulation, and toxicity. Two well-known PFAS are perfluorooctanoic acid (PFOA) and perfluorosulfonic acid (PFOS). Based on the third Unregulated Contaminant Monitoring Rule (UCMR3) (2013-2015), 66 water systems had PFOA and PFOS above the U.S. EPA's 2016 health advisory level (HAL) of 70 nanograms (ng)/L combined. And even more systems will have detectable PFOA or PFOS in the upcoming UCMR5 (2023-2025), which will use more precise methods. Any detectable PFOA or PFOS would be above the new EPA HALs for these compounds: 0.004 ng/L and 0.02 ng/L, respectively.

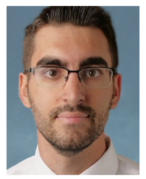
The EPA is planning to finalize an enforceable drinking water rule for PFOA and PFOS in 2023.

The effective PFAS removal technologies are expensive, which motivates more research on preventing PFAS from entering the water supply. The goal of WRF 5082 was to develop actionable strategies for utilities for effective PFAS source management. The first step was surveys about utilities' experiences in monitoring, tracking, and mitigating PFAS. The project then filled data gaps about the relative importance of different PFAS sources across wastewater, surface water, and groundwater. Investigations of two watersheds concluded that PFAS were entering primarily via wastewater treatment plants, not direct industrial discharges. A groundwater investigation found that PFAS were emanating from an airport. In four wastewater collection systems, the majority of PFAS came from residential areas, not point sources. Lessons learned while conducting these investigations are informing step-by-step guidance for tracking PFAS (Figure 2). ■

Enhancing source control programs could be more cost-effective, reliable, and environmentally just than adding further treatment barriers at reuse facilities.

Figure 2 - Step-by-step guidance for source tracking of PFAS.

About The Author



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