JOURNAL

OF THE NEW ENGLAND WATER ENVIRONMENT ASSOCIATION

VOLUME 57 NUMBER 4 / ISSN 1077-3002 WINTER 2023

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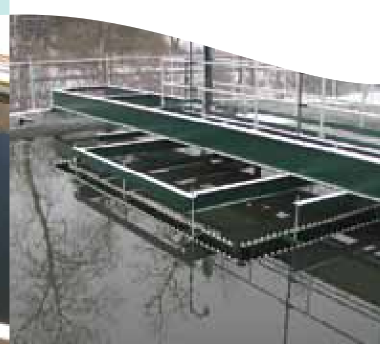

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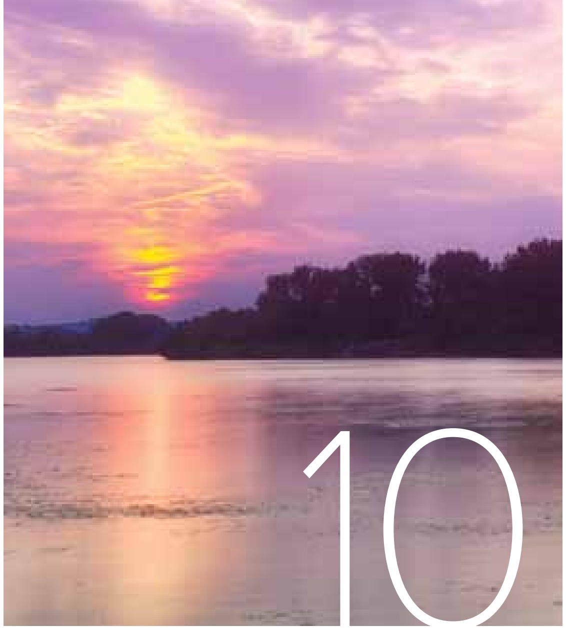

JOURNAL OF THE NEW ENGLAND WATER ENVIRONMENT ASSOCIATION

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The concepts, ideas, procedures and opinions contained in the articles in this publication are those expressed by the various authors who submit the material for publication. The New England Water Environment Association, its executive committee, the editors, the executive director, and administrative staff hereby assume no responsibility for any errors or omissions in the articles as presented in this publication, nor are the concepts, ideas, procedures and opinions in these articles necessarily recommended or endorsed as valid by NEWEA, its executive committee, the editors, the executive director or staff. References to specific products or services do not constitute endorsement of those offerings by NEWEA. The Journal's committee reserves the right to make any editorial changes deemed necessary for publication of submitted papers.

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NEWEA
WORKING FOR WATER QUALITY

OUR ASSOCIATION WAS ORGANIZED NINETY-FOUR YEARS AGO in Hartford, Connecticut, on April 23, 1929, with the objectives of advancing the knowledge of design, construction, operation and management of waste treatment works and other water pollution control activities, and encouraging a friendly exchange of information and experience. From 40 charter members, the membership has steadily grown to more than 2,000 today. Membership is divided into the following classes:

Professional Member—shall be any individual involved or interested in water quality including any manager or other officer of a private waste treatment works; any person engaged in the design, construction, financing, operation or supervision of pollution control facilities, or in the sale or manufacture of waste treatment equipment.

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NEWEA
WORKING FOR WATER QUALITY

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President's Message

Time flies swiftly when having fun and learning so much, friends, and just like that this is my last *Journal* article as your NEWEA president. What have I learned? NEWEA has 44 committees—that is easy, it is on the website. However, the work of these committees is not always easy. No one person could attend all the committee meetings, but I have been to many, and what I have seen, repeatedly, are diverse groups of people who are the measure of excellence in their fields, worldwide, donating their precious time. For example, in this issue of the *Journal* most of the articles focus on the challenges of bringing forth innovative solutions.

Committees are the very heart of our work: NEWEA is not a "top-down" organization; it has always been the opposite. Collaborative leadership is the modern business standard, and in that regard NEWEA was and is "ahead of the times." Committees by nature embody collaboration. In the many institutions that Benjamin Franklin started in Philadelphia, whether a school, a hospital, or a library, the inscriptions over the doors read, "The good we can do together exceeds what we can do individually."

One Water has been my theme, as stated in my numerous speeches and *Journal* articles. One Water equals Communication. One Water equals Collaboration for Efficiencies.

What does that efficiency encompass? I do not have an answer, nor can anyone, because efficiency is always evolving and always wins in the end; it is organic and will continue long after my time in office. Did you know that Canada, Europe, and South America all embrace one water cooperation as does Vermont? I do not advocate for major changes in the industry in this country, just steps forward toward more collaboration among all who care about the future, as the collaborators are few and the tasks many. My hope is that everyone working and advocating in the water sector fosters communication and collaboration so we can exploit our commonalities, increase efficiencies, and bridge differences with cooperative communication. We are the custodians of one water, and we all care passionately for public health, the environment, and the future.

The future can look gloomy with the myriad issues facing the water sector in the Northeast. The list of challenges is endless: aging infrastructure, lagging workforce development, shaky cyber and climate resiliency, limited capacities across all sectors, etc. Here in Vermont, after the summer storms and major flooding, we could see everyone pulling together in response. How was this collaboration made possible locally? Through communication and information, much of it advanced at the Green Mountain Water Association (GMWEA) annual and spring conferences. Vendors, electricians, integrators, engineers, regulators, Vermont Rural Water Association, and others all assisting the operators and all working endless hours collaboratively as they helped operations to get back up. Help came from all across New England because failure is just not an option in the water sector. How was this collaboration possible regionally? Communication and information, much of it advanced at the NEWEA annual and spring conferences. The story is the same across NEWEA as there have been and will be disasters, and we always respond with excellence. We are among the nation's necessary first responders, as society degrades rapidly without properly operating drinking and clean water systems.

There is also much optimism, many new and evolving technologies and techniques, as you can be sure to see in this issue. There is much interagency and inter-association cooperation already, and it is increasing across New England. NEWEA and New England Water Works Association (NEWWA) have agreed to joint meetings in Washington, D.C., during Water Week 2024, and several joint conferences have taken place during my presidency, such as the recent NEWEA–NEWWA joint IT conference. As a previous chair of the NEWEA Government Affairs Committee I have seen increasing relationships evolve collaboratively. Work for Water–New England, the emerging workforce development model developed by 13 New England water organizations, continues to advance rapidly.

As they are already overworked and continue to take on so much more work, including their Work for Water role, NEWEA staff deserve a real shout out. Did you know they are now also assisting with administrative duties for three state water environment associations?

Why did I choose One Water? The challenge is hard and fraught with pitfalls and failures for so many reasons (money, diverging interests, headstrong personalities, etc.), but it is also an easy choice, because much of it is just evolving naturally. NEWEA has such possibilities. I view our NEWEA committees as a source of information for everyone across New England. If anyone has a question on energy, innovation, etc., then among the 44 NEWEA committees, an answer can be found. I am optimistic but also realistic; while many problems are daunting even with everyone working together, they would be insurmountable alone. I am honored to be the president of NEWEA, and continually impressed with the people I represent. I have learned much but also had great fun with so many outstanding people. I have attended state events and conferences and have seen nothing but celebration of excellence and promotion of state-of-the-art technologies and approaches. At WEFTEC in Chicago this year, I learned many new things, as I always have, that help me as the water quality superintendent for the City of South Burlington, Vermont. My employer realizes the time and money spent allowing me to attend these conferences is paid back tenfold. I have met water sector people from across the United States and made new friendships, as well as enjoyed experiences with old friends. The comradery at the Operations Challenge event clearly illustrates the power of One Water.

If anyone has a question on energy, innovation, etc., then among the 44 NEWEA committees, an answer can be found

There is always much to learn, and WEFTEC afforded even more surprising "one water" experiences. While in Chicago, I made a two-hour excursion to the Museum of Science and Industry, where I was intrigued by a tour inside a German U-boat submarine captured in the waters off coastal Africa toward the end of World War II. And on my way to the airport, I took a one-hour architectural boat ride on an improving Chicago River, now in the final stages of a decades-long CSO management project. One Water—an international goal for all of us in the water quality industries.

Thank you for affording me the opportunity to serve as your NEWEA president. It has been a busy year, highlighted by the many things I have learned from all of you. NEWEA is overflowing with amazing experiences and excellent, dedicated people. It has been an unforgettable privilege to represent you all.

From the Editor

When prompted to think about innovative solutions, we in the water environment industry (or at least I'll speak for myself) typically call to mind an innovative process configuration to achieve ever-decreasing nutrient limits or a new best management practice to manage stormwater flow. But there is so much more to it. Not only do innovative solutions encompass new technologies and products, but also new ideas and methods. These solutions, the ones that turn our heads upside down, can be scary. (Believe me—I understand. I still haven't toggled on the new Outlook yet!). They can, however, also be game changing, with the potential to reduce costs to treat and deliver water, improve equitable access to safe water and sanitation, improve the quality of our waterbodies, and so much more. For this Letter, I took a deep dive on the internet to find out-of-the-box innovative solutions to share with you all.

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One of my favorite stories of innovation is that of Vessel—the first leak-detecting dog in the United States.[1] Trying to find leaks can be a costly struggle for utilities, especially when they don't surface. Vessel, who joined Central Arkansas Water in 2019, can sniff out underground chlorine leaks. Without any digging, she can differentiate with near-perfect accuracy treated drinking water from rainwater and groundwater, and empower her human counterparts to dig and repair the leak on the spot. Vessel has repeatedly saved the day (via gallons and gallons of treated drinking water) for Central Arkansas. This led me down a path of detection dogs. (I warned you this was a deep dive.) Did you know that the Museum of Fine Arts, Boston, has a pup that helps protect and preserve its collection by sniffing out bugs and pests? Or that four pups are being trained to help U.S. customs workers detect stolen and smuggled ancient artifacts?[2] Maybe I should try and train my dog to sniff out my lost keys…

Vessel—the first leak-detecting dog in the United States

Another exciting discovery on my internet deep dive was the EPA's recent announcement of $2 billion in funding for projects that enable environmental and climate justice. The innovative funding opportunity, announced through the Community Change Grants Program, is a ground-breaking investment in community-driven environmental justice; I feel energized knowing that folks in our industry will be working collaboratively with community partners to enable healthy, resilient communities for our future generations. Applications will be accepted through November 1, 2024.

But of course, my favorite Innovative solutions are those highlighted in our four feature articles, happening right here in New England. Our first feature, by Ryan Flood, highlights the importance of artificial intelligence and machine learning for our industry, especially as many of us approach retirement age. Ryan astutely notes that leveraging higher-tech monitoring is one solution to help offset gaps in industry experience. The next feature, by Kamruzzaman Khan, Appala Raju Badireddy, and Chelsea Mandigo, describes an innovative technology that removes phosphorus from wastewater and captures it as struvite. They are building a mobile testing lab; perhaps it can visit your utility next? The following feature, by Terry Goss, critically reviews innovative biosolids process technologies. These new technologies offer promise of alternative ways to reduce sludge mass and volume, produce more marketable products, and recover energy along the way (and some even show promise for destroying PFAS). The final feature, by Alexie Rudman, Kate Mulvaney, and Nathaniel Merrill, presents promising behavior change strategies to encourage the adoption of innovative/alternative (I/A) septic systems. Considering the voluntary nature of the adoption of I/A septic systems, their recommendations (to harness the influence of peers, properly frame messages, provide financial incentives, and make the behavior change convenient) are invaluable.

As always, I hope you enjoy this edition of the *Journal*! Happy New Year, and I look forward to connecting with you all at the Annual Conference.

1. A Sensitive Nose Becomes a Key Technology for Sniffing Out Water Leaks. https://www.tpomag.com/editorial/2021/11/a-sensitive-nose-becomes-a-key-technology-for-sniffing-out-water-leaks. Accessed 11/25/2023.
2. Art Hound: Meet the Adorable Puppy That's Helping the MFA Boston Protect and Preserve Its Collection. https://news.artnet.com/art-world/mfa-boston-hires-puppy-1195931. Accessed 11/25/2023.
3. Biden-Harris Administration Announces $2 Billion to Fund Environmental and Climate Justice Community Change Grants as Part of Investing in America Agenda. https://www.epa.gov/newsreleases/biden-harris-administration-announces-2-billion-fund-environmental-and-climate-justice. Accessed 11/25/2023.

Industry News

Mystic River

Six Massachusetts communities selected to improve stormwater management and advance environmental justice

EPA has identified Milford, Somerville, Stoughton, Amherst, Chicopee, and South Hadley, Massachusetts, to work with the agency on stormwater management through two collaborative problem-solving projects over the coming year. The municipalities will receive in-kind technical assistance from EPA to advance environmental justice for disadvantaged communities within the Charles River, Mystic River, Neponset River, and Pioneer Valley (Connecticut River) watersheds.

"Communities, especially overburdened ones, should not worry that when a storm hits, flooding could fill their basements. They also should know that storm runoff won't dump nutrients in their lakes, ponds, and rivers and cause unhealthy algal blooms. Every person should have the opportunity to safely play in the rivers and seas that surround us," said EPA Regional Administrator David W. Cash. "For environmentally overburdened and under-resourced communities, it is especially important to address stormwater runoff challenges to improve water quality."

An EPA project team will work with staff from the selected communities in the Boston area (Milford, Somerville, and Stoughton), their watershed associations, the University of New Hampshire Stormwater Center, and Eastern Research Group. Another project team will focus on the Pioneer Valley and work with staff from Amherst, Chicopee, and South Hadley, the Pioneer Valley Planning Commission, the Horsely Whitten Group, and the University of New Hampshire Stormwater Center. For both projects, the teams will meet to discuss challenges and solutions for effective nutrient management through retrofits for targeted stormwater management in communities with environmental justice concerns.

The effort will focus on low-cost green infrastructure options that align local needs with the municipalities' maintenance capabilities and provide additional benefits to communities with environmental justice concerns. The municipalities expressed interest in the following topics:

Note: All EPA industry news provided by EPA Press Office

- **Milford** is interested in upgrading municipal stormwater controls to treat stormwater effectively and in learning about small-scale, cost-effective stormwater management solutions appropriate for municipal and private properties in densely populated areas closest to the Charles River.
- **Somerville** is interested in maximizing opportunities for stormwater practices focused on infiltration techniques that are effective in highly urbanized areas and better understanding how to maintain these practices. The city is also interested in learning about asset management tracking of public and private stormwater control measures.
- **Stoughton** is interested in learning about maintenance schedule tracking tools for public and private stormwater controls and streamlined approaches to maintain a successful stormwater control program.
- **Amherst** is interested in learning about developing more reliable funding mechanisms to increase the number of nature-based solutions and green infrastructure implementations to reduce flooding and improve water quality.
- **Chicopee** is interested in balancing the importance of managing stormwater flooding and modernizing its stormwater treatment strategy to address more frequent and intense storms with a reliable funding stream through its stormwater utility.
- **South Hadley** is interested in learning about various cost-effective green infrastructure options easy to install to increase resilience and improve water quality in receiving waters. The town also wants to address nitrogen pollution from stormwater.

The expected outcome is a tailored stormwater management strategy for each municipality, as well as important progress toward improving the water quality impacts of stormwater runoff. The results of this collaboration will build capacity and useable tools applicable to all municipalities and help prioritize stormwater management in communities with environmental justice concerns. More information is available at epa.gov/npdes/npdes-stormwater-program.

Rhode Island coastal communities awarded $4.6 million

Rhode Island communities will get $4.6 million in funding from EPA to help protect the area's coastal waters and watersheds. Communities throughout the state will also get added technical assistance and partnerships with local organizations working for clean water and healthy coastal ecosystems in southeastern New England.

More than $2 million of this funding is provided to the Southeast New England Program (SNEP) under two separate SNEP funding sources: President Biden's November 2021 Bipartisan Infrastructure Law (BIL), which is providing funds for projects across the country to improve climate resiliency and address infrastructure upgrades, and through annual congressional appropriations to SNEP.

The projects are funded by the new infrastructure law and given as part of the watershed grants in EPA's SNEP. EPA is also funding the U.S. Geological Survey via an interagency agreement and an award to the Narragansett Bay Estuary Program. Finally, it will provide direct technical assistance to two towns in Rhode Island.

The projects being funded by BIL Grants are as follows:

- **Glocester, $465,000**. This grant and a $100,000 match will pay for the town to develop a decentralized wastewater management entity and create financial incentives for septic wastewater upgrades in Chepachet Village. This will be paired with installation of innovative, alternative (I/A) nitrogen-reducing septic systems.
- **North Kingstown, $450,000**. This grant with a $18,221 match will allow the town to identify up to 30 inadequate septic systems in critical nitrogen-sensitive coastal areas and incentivize homeowners to upgrade to systems that reduce nitrogen.
- **Bristol County Water Authority, $600,000**. This grant and a $1,410,000 match will enable the authority to work in Warren, Rhode Island, to remove the upper and lower Kickamuit River dams. This will restore natural flow, improve the habitat, and help with fish migration. EPA's watershed grants program provided earlier funding to prepare for this removal.
- **Woonasquatucket River Watershed Council, $507,025**. This grant with a $326,080 match will enable the council to design, permit, and build, nature-based stormwater control measures along the Woonasquatucket River greenway.

EPA also announced an interagency agreement with the U.S Geological Survey, funded with $325,000 from the BIL, to develop models to improve septic systems. This agreement, the Susceptibility of Aquifers, Streams, Ponds, and Coastal Waters to Water-Quality Impairments from Septic-System Wastewater Disposal in Rhode Island, will determine septic-system density and characteristics of statewide drainage areas, rank the magnitude of nitrogen from wastewater and other sources in the drainage areas, obtain samples for water quality analysis to find the relationship between septic density and nutrient concentrations, and estimate how susceptible waterbodies statewide are to nitrogen impacts.

Watershed assistance grant awarded for sodium chloride-based watershed restoration

– New Hampshire Department of Environmental Services

The New Hampshire Department of Environmental Services (NHDES) Nonpoint Source Management and Drinking Water Source Protection programs have awarded a watershed assistance grant (WAG) to the Merrimack Village District to develop a sodium chloride-based watershed restoration plan.

In December 2022, NHDES solicited projects addressing nonpoint source (NPS) pollution through a sodium chloride (NaCl)-based watershed restoration plan in a priority water supply watershed that has a documented sodium and/or chloride impairment. Projects were ranked based on criteria including the waterbody's drinking water quality and severity of NaCl impairment(s), level of public participation and commitment to the project, relative value or significance of the water body or water resources, and quality of the proposal. The highest-ranked proposal was selected for funding.

The Merrimack Village District's (MVD) Naticook Brook Watershed/Litchfield Tributaries Watershed Management Plan was selected for a $80,000 WAG funded through the BIL State Revolving Loan Fund program.

The MVD provides potable drinking water to approximately 9,300 customers from a series of high-capacity water supply wells, three of which are within the Naticook Brook watershed (MVD-2, MVD-3, and MVD-9). The Naticook Brook watershed contains paved roads, parking lots, and other impervious surfaces that require winter maintenance—plowing, sanding, and salt application. Associated runoff and infiltration into surface and groundwater resources are causing salt contamination of streams, rivers, ponds, lakes, and wetlands within the watershed. While all three public water supply wells in the Naticook Brook watershed have experienced increasing sodium and chloride concentrations, MVD-3 has been exceptionally affected. Since 1992, the chloride concentrations in MVD-3 have increased by an order of magnitude. The impacts from salt runoff in this watershed have led to MVD-3 consistently being above the secondary maximum contaminant level (SMCL) for chloride (SMCL of 250 mg/L), causing the well to be taken offline as a public water supply.

The watershed-based plan funded through this grant will evaluate winter salt use throughout the Naticook Brook source water protection area. The evaluation will help develop a sector load allocation for salt and priority-based reduction goals for surface and groundwater paired with recommended best management practices (BMPs) to be implemented to achieve reduction goals. The watershed-based plan will recommend actions for project partners (municipal, state, private, commercial, and/or nonprofit) to meet the watershed-based plan salt reduction goals within 10 years. This will be the first watershed-based plan in New Hampshire where sodium chloride is identified as the target pollutant affecting both surface and groundwater resources.

In the past 50 years, winter salt application on New Hampshire roads, parking lots, sidewalks, and other paved surfaces has increased significantly. The most commonly used substance to de-ice these surfaces is rock salt, or NaCl. While winter salt provides New Hampshire residents with safe travel, this long-term practice pollutes surface and groundwater throughout the state. Elevated sodium levels can affect drinking water taste, and high levels of chloride are corrosive, which can lead to the leaching of metals from plumbing systems. Chloride, which is toxic to aquatic life at certain thresholds, is highly soluble and mobile in groundwater. Often there is enough dilution in spring melt water to keep chlorides below impairment levels, but when dilutions are not enough, particularly in smaller streams and in lakes and ponds during the summer, surface waters become impaired and drinking water wells must be abandoned due to contamination.

The only way to prevent chloride from reaching surface and groundwater is to reduce the amount applied to our roadways, parking lots, and sidewalks without compromising safety. The NHDES Green SnowPro Program offers snow and ice management professionals training and certification in state-of-the-art salt reduction practices that prioritize public safety while mitigating salt usage. Although there are over 500 Green SnowPro certified commercial salt applicators in New Hampshire, this only represents one sector contributing winter salt that affects freshwater resources. In concentrated development and transportation hubs, chlorides reach the environment through state, municipal, commercial, and private snow and ice management. For more information on the NHDES WAGs, visit the Watershed Assistance webpage.

SNEP watershed implementation grants

For watershed grants, EPA partners with Restore America's Estuaries, which manages the competitive grant process. This year, $1,707,728 is going to five projects to build partnerships to address the region's most pressing environmental issues, such as nutrient pollution and coastal habitat loss:

- **Rhode Island Chapter of Trout Unlimited, $129,300.** Removal of the Sweet Pond Dam to Restore Aquatic Organism Passage and Enhance Water Quality in West Greenwich
- **City of Woonsocket, $500,000.** Truman Drive Green Infrastructure Parkway Construction
- **Town of Warren, $400,000.** Jamiel's Park Shoreline Restoration Project
- **Audubon Society of Rhode Island, $197,348.** Stormwater Master Plan, Education and Outreach Planning in Roger Williams Park Zoo in Providence
- **City of Providence, $481,080.** Waterfront Access & Green Infrastructure at Public Street for the South Providence Green Justice Zone

The Rhode Island Department of Environmental Management (DEM) received $299,293, with a $45,344 match under a competitive research grant. Under the grant, DEM will complete a project to better understand when eelgrass seeds mature and how dense the seeds are. The goal is to create a model of eelgrass reproduction, especially under the stresses of climate change. Healthy eelgrass beds in coastal water hold carbon and provide habitat for aquatic life.

EPA is also providing $250,000 to the Narragansett Bay Estuary Program for the implementation of its Comprehensive Conservation and Management Plan, which helps protect coastal waters and build climate resilience.

New England states awarded $1.2 million for water quality monitoring at beaches

EPA announced a $236,000 grant to the Connecticut Department of Public Health, a $228,000 grant to the Rhode Island Department of Health, a $272,000 grant to the Maine Department of Environmental Protection, a $275,000 grant to the Massachusetts Department of Public Health, and a $214,000 grant to the New Hampshire Department of Environmental Services to protect the health of beachgoers. This funding is part of $10.6 million in grants, announced in May, to help coastal and Great Lakes communities. The funding will support water quality monitoring and public notification programs for beaches.

"With so many beach closures across New England this summer, people want to know 'where can I go swimming in clean water?'" said EPA's Mr. Cash. "Today's grants will advance environmental justice in communities vulnerable to and overburdened by water quality impacts by supporting critical monitoring and notification programs. We will continue to work closely with our state, municipal and local partners to deliver information that people need to make good decisions about their health. The results of monitoring can also help us enforce environmental laws and make investments, so beach closures become a thing of the past."

These grants help fund programs to ensure that beachgoers know when our coastal waters are safe for swimming and recreation.

Under the Beaches Environmental Assessment and Coastal Health (BEACH) Act, EPA awards grants to eligible state, Tribal, and territorial applicants to help them and their local government partners monitor water quality at coastal and Great Lakes beaches. When bacteria levels are too high for safe swimming, these agencies or their local partners notify the public and post beach warnings or closings.


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Harmonization of water industry trends to drive innovation of analytics

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ABSTRACT | This article discusses the harmonization of innovation analytics and experience as we move from one generation to the next in water treatment professionals. The three trends that will help shape the future of water treatment analytics are 1) innovative technologies, 2) increasing analytics driven by regulations and the growing expectations around transparency, and 3) a gap in the technically experienced workforce. The article identifies how consumer technology trends may be used to drive analytical innovation and define challenges in the water industry, and importantly, how to capture the potential of these trends.

KEYWORDS | Data, innovation, collaboration, water industry trends, analytics, work experience

It is 4 AM on a frigid winter night in Canada, and Mitch's phone rings loudly. As he looks over, he sees that it is an alarm from the farm: the pH level is dangerously low in one of his tanks of almost fully mature fish. He must go. He quickly gets in his truck and heads off, worried he may see a dire situation when he arrives. He rushes in to go check the local controller. The value is still way too low. As he turns to go to the tank to try and fix the situation, he notices that the sensor cable is disconnected. He lifts it up and sees it has been gnawed and severed, probably by a rat. Acting swiftly, he installs a spare probe and sees that the values are perfectly in range, nothing to worry about. A false alarm. He is relieved, as he knows how bad a pH failure can be.

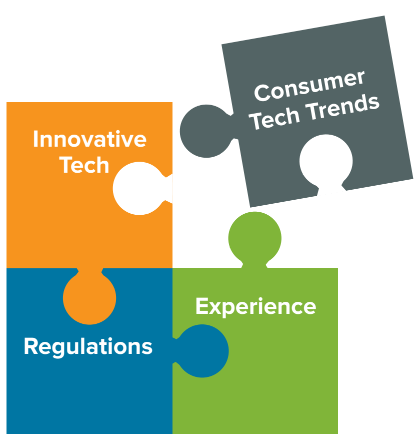

Figure 1. Harmonization for the future of our industry

His fear comes from stories from aquaculture facilities like his, like the one at an Atlantic Sapphire farm that resulted in the loss of 400 tons (360 tonnes) of salmon, a $3 million loss! He also remembers the time when someone had poured calcium hydroxide instead of feed into a tank, but the alarm went off and luckily the key staff members were all there and reacted instantaneously to "save the day." It was a near disaster averted due to the data collected and analyzed from a local controller signaling the alarm.

These stories, based on true events, demonstrate the power that automation brings to facilities like Mitch's. They also highlight the need for data-driven decisions and innovation to provide fast, reliable information. The recent tsunami of artificial intelligence (AI) tools greatly expands capabilities to do much more than simply send notifications. The cases above speak of the impact an innovative and robust automated solution can have on a company that relies on water quality, but even in these cases, there was room for innovative improvements.

The topic of this article, harmonization for the future of our industry, addresses how the paths of innovation analytics and experience will need to blend as we move from one generation to the next of water treatment professionals. Three trends will shape the future of water treatment analytics:

1. Innovative technologies
2. Increasing analytics driven by changing regulations and growing expectations around transparency
3. Bridging the gap in the technically experienced workforce

Consumer technology trends may be the key to driving analytical innovation. The harmonization of these trends could accelerate innovation in the water industry by learning from data, providing greater transparency of water quality and consumption metrics, and potentially closing the gap in expertise in the changing workforce.

INDUSTRY TRENDS BY THE NUMBERS

Let us first look at numbers influencing our market. The internet of things (IoT) and smart technology industry is big and growing. This is perfect for a workforce in which 74 percent expect more flexibility in how they work, according to a reputable report. In juxtaposition, our workforce has a gap between the experienced veterans and the emerging employees that begs planning and support to allow knowledge transfers and industry security. We also see a high growth rate of the smart water market, but the industry is still lagging on adoption. Even though 89 percent of users are "confident" in sensor data, from the same report, only around 5 percent surveyed reported having a fully integrated data management system. These users are leaving data and smart technology opportunities on the table.

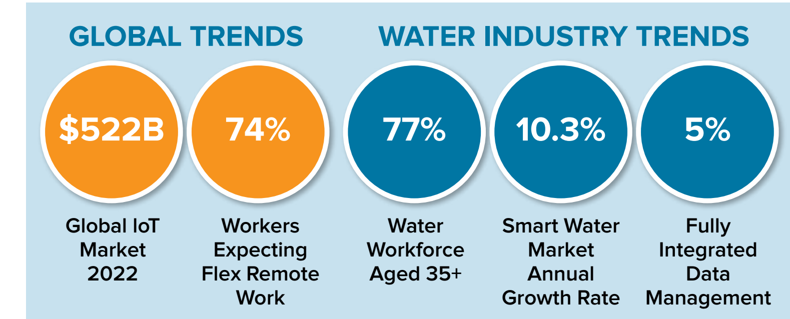

Figure 2. Global and water industry trends by the numbers

INNOVATIVE TECHNOLOGIES

Whether you are a young professional just starting your career in water or an experienced one, you are not new to the influx of innovative technology around you. Nowadays, most operations and devices in the consumer space have an app or smart logic behind them. Classes are teaching or leveraging these innovations at exceedingly earlier ages.

Those longer-tenured water industry professionals are accustomed to gradual adoption of innovation and have seen or used processes that have remained constant for 25 years or more. At every level, though, we have seen change, even if it lags other industries. That we have changed and adapted means we can continue to do so.

Think about all of the technology around you in your daily life. You could have an automatic vacuum that knows when and where to clean based on desired levels of cleanliness and user habits (e.g., not during work calls or when trying to put the kids to sleep). Most of us have a personalized dashboard on our phones or computers showing local news, market trends, the weather, traffic, the wait time at your local coffee chain, and more, all curated by AI to provide you with everything of interest. Sometimes the curated algorithm will use a predictive model that provides you content before you even know it is what you want to read. It learns from how long you look at something versus what you skip over. Wearable technology can check your heart rate and even provide metrics and trends on health and sleeping patterns. Scheduled deliveries based on your usage history are becoming more prominent as well and may even be something you use today. I know we use it at my house for diapers for my kids, as this is one thing we do not want to be without!

Some of this technology is not novel, such as timers on lights, coffee, or sprinkler systems. But even with these, technology has come a long way. Most of these are app-controlled now or are AI/machine learning (ML) driven. Each of these consumer technologies can improve our lives, from saving time, to increasing our knowledge or bettering our health, to protecting us and those around us. We embrace this technology around us, which raises the question, How can we bring this, and the benefits of this technology, into our industry?

INCREASING ANALYTICS DRIVEN BY CHANGING REGULATIONS AND GROWING EXPECTATIONS FOR TRANSPARENCY

Clearly, we need to progress in our analytics and data management if we want to keep up with changing regulations. Quality is key. We are seeing an increase in regulations and transparency of the analytics of these regulations. More and more municipalities are releasing regular reports that indicate key analytical metrics of their water quality. Industrial companies that are leveraging water in their processes are also capturing more data and sharing it with government bodies, company stakeholders, and now even the public, in their sustainability reports. We have seen the rise of Covid monitoring and other byproduct disinfection measurements and will continue to see more parameters to measure regularly. Our industry aims for the best quality water and believes that "water is a right," as the United Nations has voiced in Resolution A/RES/64/292, adopted in 2010. To keep up with these driving forces, innovation and access to the key data on the water we treat will be critical.

In the last year alone, introduced legislation has increased by over 30 percent largely due to the EPA and the driving forces of the Infrastructure Investment and Jobs Act. Emerging concerns such as lead leaching, polyfluoroalkyl substances, disinfection byproducts, water loss through leaks, Legionellosis (ASHREA 188), boil water mandates from *E. coli*, and so many more are all too present in the news and are driving more public awareness which will, in turn, drive even more regulations to improve water treatment—from drinking water to wastewater and to even industrial wastewater. Data management and innovations will be key to meeting these changes and moving the industry forward.

GROWING GAP IN TECHNICALLY EXPERIENCED WORKFORCE

In the water industry, we all know the gap in experience is a growing issue. The point is not to blame any group for a lack of adoption but rather to highlight the risk this trend poses: the loss of experiential insights and expertise. Operators who have worked in the industry for a while often have more than one story about something they learned along the way. They may know the perfect way to tune the disinfection for the different seasons or based on upcoming events, like a festival or major sporting event. They often know the first place to check when an alarm goes off. This experience, when harnessed, can drive innovation and success in the industry. Imagine what an innovative solution could provide if it had all the inputs of each experienced operator.

Those with experience have learned many of the water industry's best practices from years of research and trial and error. While many of these more tenured professionals diligently share their knowledge, much of this expertise may be anecdotal and can easily be lost in transition plans. This information is important "data" that we should not lose or forget.

When I started my career in the water industry, I was fortunate to have a primary goal of learning as much as I could from two colleagues who were retiring and had a combined tenure at the company of over 90 years. Not everyone gets this opportunity, and it is a shame, as knowledge from experience is so valuable. From the teaching of my mentors, I learned details on chlorination that were not readily available on the internet, like practical materials of construction and operating parameter considerations. Having someone talk you through topics like breakpoint chlorination, rather than independently researching it on the web, goes a long way when you are starting your career. Beyond the industry knowledge, I also learned how to operate and grow within the company, where to find the correct files, and how to navigate and troubleshoot proprietary company platforms and the company structure, past and present.

The most important learning, though, was about what worked and what did not, and *why* they were or were not successful. Knowing why a development initiative had failed before made a stark difference in navigating the process to drive success the next time. The impact AI may provide, ensuring that this knowledge is transferred to as many applicable company or association people as possible, can accelerate growth and change in a way that can enable our industry to succeed for many years to come.

In Mitch's story, his experience taught him to act fast but also how to catch the issue without panicking or overreacting. This is why we need technology to aid us. We need experiential expertise and those with it to be a part of the technological innovation process. Their insights will help accelerate progress and build success for the future. We who are young professionals grew up with smart devices. We eagerly embrace them. But the technology that we not only accept, but demand, may not be so familiar to the more experienced workforce in the water and wastewater industry. In fact, many may resist it. The result is that adapting to new digital technology in our industry lags the consumer market by years.

One cautionary tale to consider is Polaroid. Polaroid was a market leader in film. A senior engineer at Polaroid noted that the company was aware of the growing trend of digital photography and even had solutions it could have brought to market, but the potential margins were not aligned with corporate strategy. Therefore, the company focused on what they knew, and did not adapt to the industry trends. Shortly after, Polaroid filed for bankruptcy, and the one-time giant fell. By not adopting and embracing consumer trends, the company failed instead of reaping the potential success it might have had if it had embraced the change given decades of expertise in the film industry.

CHALLENGE OF PROGRESS

The road to this future looks complex, and that is one of the biggest challenges today. Many elements must be considered when developing and implementing a solution:

1. All parameters of the water sector that need measurement and communication
2. Different cloud platforms from providers like Amazon, Microsoft, Google, and others
3. Different programming languages

In a short-hand calculation there could be over 10 million approaches to a solution, increasing the complexity; but the most obvious answer to a path forward is simplicity. Smart solutions must solve the problem but be simple enough to allow adoption and usage. Smart technology for the water industry must make the processes simpler and not introduce new challenges.

A PATH FORWARD

In the path to better water quality, data is key—but how can we best use it? We can learn from the analysis of this data and build smarter and more connected systems. Knowing these trends, how can water treatment professionals leverage innovative practices to meet changing regulations? Well, supervisory control and data acquisition (SCADA) systems and water analysis will be at the forefront of this cross-section of trends. The more data we record at facilities the more we must recognize the important data and data trends to prevent issues or downtime. Thus, we need clean and effective methods to monitor everything seamlessly and understand how to act after receiving that data. This is where "smarter" SCADA systems and analytics will be critical. We should and need to see SCADA systems starting to incorporate consumer technology trends, allowing us to have better access to real-time, accurate analytics. As that occurs, clean easy-to-use data management will become increasingly necessary. As those newer to the industry come to be in charge of operations and analysis, leveraging higher-tech monitoring can offset the gap in experience. In parallel, those with experience will need to weigh in on the accuracy and requirements to develop a user-friendly interface for data analytics. To accomplish that, we will need to take the data through its journey, find a home for storage, synthesize and analyze the data, and learn how best to apply that analysis toward productive and accurate results.

Innovative solutions based on non-industry trends can drive our industry forward in many ways, but *data,* and especially *learning* from this data, hold the greatest potential to drive innovation in the water industry. The value of this data can be to increase water quality excellence, improve confidence, avoid issues, reduce operational costs, and most importantly, provide transparency! The key expertise learned will be identifying trends and uncommon multi-parameter relationships that can allow facilities and operators to drive novel predictive modeling. Ultimately, effective data management and predictive modeling in the water industry will save time and money, and potentially eliminate unnecessary water usage, changing our industry for the better.

There is a lot of data to capture, but to determine how much, we may need to put it in practical context. If a site only used one sensor, it would, on average, generate about 6 bytes per transmission (assuming no additional metadata or contextual information is included in the transmission), and assuming it communicated only every 5 seconds it would amount to *only* about 38 MB of data annually. The size of my PowerPoint presentation for this topic at the 2023 NEWEA Annual Conference was almost 35 MB, and no one thought twice about the size of the file and how to store it in the cloud.

Almost no facility has only one sensor, so when multiplying it out by more sensors and more devices, the amount adds up, but not to the point where it cannot be stored for little to no additional cost to a facility's data storage infrastructure. Again, step one is to capture that data, and while the act of setting up the infrastructure is no short task, the real effort comes in trying to learn by analyzing that data. In the above example of only one sensor, the number of data points would be over 6 million. When there are more than 20 or even 100 data sources, (sensors, pumps, controllers, etc.), that number becomes a challenging scope of work. It could take an analyst several weeks to several months to complete such an analysis, assuming a reasonable time spent each day.

Figure 3. Data's journey

There are other concerns as well. Questions swirl around, easily creating doubt and fear: What if it does not work? Is it secure? Can we afford the right solution? Do we have the bandwidth to monitor all this data? and, What if? These are valid questions and must be heard and considered, but in a way that keeps the solution to these concerns simple, as trust will be key. These questions are not only valid; they are also important. If we push innovation without answering them, the industry may miss out on fully adopting the innovation. The Blackberry phone was revolutionary, but it lacked the right connection with its audience. Eventually years later, smartphones took off, and their key to success was simplicity. If no one buys the product or uses its features, even if it is the best innovation of its kind, it is not a solution.

While this industry is not known for shying away from challenging work, luckily innovation, AI, and ML can simplify the path forward. An AI tool paired with the expertise of established water professionals can slash analysis time, and some organizations are already applying process improvements from this data. Some have even put measures in place; for instance, at the Erdao Songhua River basin in China a team assessed seven physicochemical parameters at 20 facilities to determine the best analytical models for maintaining water quality. Others have also seen success with leveraging data and implementing change, such as the City of Ventura, California, the Portland Oregon Water Bureau, and the Philadelphia Water Department.

BUILDING FROM SUCCESS

Often with change, once there is success, more success tends to follow. The water industry has seen this with the adoption of innovative and digital technology.

The City of Ventura implemented a customized water model to optimize its potable reuse and comply with discharge limitations. Prior to this integration, its team spent weeks running analyses and simulations using spreadsheets. After implementation, the team rapidly analyzed scenarios based on the changing conditions to optimize processes, reducing operational costs and improving water quality.

The Portland Oregon Water Bureau assessed customized water data using time domain transmission technology to measure soil moisture to assess water consumption needs. It reduced the water usage of participants by 34 percent, with one user seeing an almost 75 percent reduction.

Look at the technology around you that makes your daily life better and simply ask, How could that make the water industry better?

A Fortune 500 company facing health and environmental litigation implemented remote water quality monitoring, measuring seven parameters. The company leveraged a tiered alert system based on special thresholds to prevent any water quality issues, creating a proactive system. This approach allowed it to treat and manage the water without investing in additional labor to support this initiative, preventing large operating expenses.

Philadelphia Water Department implemented a surveillance and response system (SRS), which proactively addressed changes in water quality. The department improved the taste and odor of drinking water and reduced customer complaints while optimizing the use of treatment chemicals, reducing costs, and improving efficiency.

Beyond these successful data-use examples, data capture is seeing enhancements from other industries. Start-up companies have developed "robots" to move about the piping network and detect leaks. Drones are more common, so much so that the latest WEFTEC conference had a drone section. And the most prevalent blend into our industry is smartphones and associated apps.

These illustrations are just some of the ways innovation can improve the water industry; many other ways are just now emerging or likely have not even been thought of yet. The value to our industry and those that leverage the innovations from the commercial world will be great. Utilities and industrial companies can reduce operational costs by optimizing their processes; they can increase the yield of their product(s) and better protect their assets, whether that is a commodity or water itself.

WHAT CAN WE DO

We know this type of innovation is needed, we know its value, and we know that opportunities to find innovation are boundless, but how do we get there? It starts with connections and communication across the industry. For those developing innovative technologies in this industry, we must stay connected to those who will use our technology regularly. We must tap into that wealth of experiential expertise of our industry veterans, starting at the beginning by taking feedback on what to develop. From there, as the concept is being developed, we need again to connect with key members of the industry to test it, and where possible gather as diverse a group of users as possible to get a 360-style assessment. As is well known, a pilot test is most valuable in making sure we solve the given problem. Designers and developers need honest feedback on what works and what does not.

Then, as development and innovation progress, just as the industry's experts previously provided valuable insights and taught the lessons they learned over the years, the innovators must teach the industry how to exploit the novel technology and train their teams. Training must change as well; as an industry, we should define training for these new technologies as functional instruction as to how it works without having to read code, and, just as important, teaching how it will function when operators are not physically present. Even after all that, more communication and sharing of ideas, as in journals like this, are critical.

We all must be a part of this innovation journey, for only then can our industry make the progress we want and need. It was just over 100 years ago that chlorination was the big innovation. This technology in the early 1900s was considered novel and is now recognized as one of the top achievements for improving public health in the 20th century. However, though chlorination is now widely used in water, it is no longer the only method. Look how far we have come and just imagine how far we can go.

If we look at the innovations around us and effectively collaborate as an industry, we can further drive innovation. The migration of consumer trends into the water sector can solve problems in our industry. Creating an industry culture of sharing and learning from data will provide greater transparency of water quality and consumption metrics and, paired with future innovation, can close the gap in expertise in the changing workforce while still providing best-in-class water solutions.

How can you help? Look at the technology around you that makes your daily life better and simply ask, How could that make the water industry better? Concerning regulations and transparency, think about what consumers would want to know about the water and what is needed to assure them it is safe. Capture the experiential expertise around you, and if it is not there, seek it. Synergies and partnerships will be key and ultimately collaboration and communication will drive success. We are in this together and we *all* can influence change. This is the path we can all be on, and as an industry, we must continue to work with customers like Mitch to enhance our smart and innovative solutions. I, for one, am excited to see how we all drive innovation in the water industry.

ACKNOWLEDGMENTS

The AquaMetrix team (a Water Analytics brand)

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HARMONIZATION OF INNOVATION ANALYTICS

Pe¯Phlo: Innovative phosphorus removal and capture technology

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ABSTRACT | This article reviews the three stages of development of an innovative phosphorus removal and capture technology (Pe¯Phlo) by Essex Junction Wastewater Resource Recovery Facility, Essex Junction, Vermont, and University of Vermont. The Pe¯Phlo device is composed of two units critical to recover dissolved phosphorus: 1) commercial particle descaling technology (PDT) and 2) a custom-built electric filtration cell. These units can be operated individually or in tandem as per treatment requirements dictated by dissolved magnesium, ammonia, and phosphorous concentrations, and the size of colloidal phosphorus-containing crystals formed during the treatment. In addition, the electric fields generated by PDT should avoid scale build-up in distribution pipes carrying the wastewater streams. The filtration system is designed to capture colloidal struvite (un-settleable) in the concentrate and produce clarified filtered water.

KEYWORDS | Data, innovation, collaboration, water industry trends, analytics, work experience

The United States has over 15,000 water resource recovery facilities (WRRFs), many of which use industry-specific conventional biological, physical, and chemical processes to remove phosphorus. These processes generate increased amounts of sludge for further treatment and disposal. Chemical coagulation and flocculation of phosphorus are also costly to the facility and to the environment. The coagulants used to bind and remove phosphorus generate proportionally large amounts of greenhouse gas emissions during the manufacture of these chemicals.

Biological treatment processes use "mixed liquor" or naturally occurring micro-organisms that collect phosphorus and nitrogen as part of their metabolism. When the treatment process is complete, waste micro-organisms are removed as sludge and digested or forced to decompose, releasing many of those nutrients back to the process for treatment again. The constant recycling of phosphorus within conventional wastewater facilities squanders valuable treatment capacity and increases operating costs.

Pe¯Phlo breaks this vicious nutrient recycle by removing the phosphorus from the digested sludge, freeing up nitrogen and phosphorus treatment; reducing sludge production; reducing chemicals needed for nitrogen and phosphorus treatment; and improving process reliability for maintaining effluent phosphorus concentrations below regulatory limits (0.2 mg/L Total Phosphorus in the Vermont Lake Champlain basin).

The Pe¯Phlo system is composed of two units critical to recover dissolved phosphorus: 1) a commercial particle descaling technology (PDT) and 2) a custom-built electric filtration cell. These units can be operated individually or in tandem as per treatment requirements dictated by dissolved magnesium, ammonia, and phosphorous (MAP) concentrations as well as the size of colloidal phosphorus-containing particles formed during treatment. In addition, the pulsed-electric field generated by the PDT prevents scale build-up in distribution pipes carrying wastewater streams.

This study tested the feasibility of phosphorus removal and capture in the form of struvite from sidestream wastewater using a lab-scale and a pilot-scale Pe¯Phlo system, and a plan to turn the pilot-scale into a mobile trailer truck unit. This study was conducted in three phases. Phase 1 was a bench-scale Pe¯Phlo device used for testing the feasibility of phosphorus capture in the form of struvite. Phase 2 transformed the bench-scale Pe¯Phlo to pilot-scale at the Essex Junction Water Resource Recovery Facility (EJWRRF). In Phase 3 (current phase), the pilot-scale Pe¯Phlo system will be converted into a mobile trailer truck unit to be tested in various treatment applications.

METHODOLOGY

Sidestream Wastewater for Lab Studies

The sidestream wastewater (dewatering centrate) was obtained from the EJWRRF. 2.64 gal (10 L) of the wastewater was collected and transported to Dr. Badireddy's laboratory at University of Vermont (UVM) within one hour and stored at 39.2°F (4°C) until further testing. The wastewater sample was settled and stored at room temperature prior to the experimentation. At the time of sampling, a portion of the sample was sent to Endyne Inc. laboratory (Vermont) for the chemical composition analysis. A duplicate sample was also analyzed in Dr. Badireddy's lab at UVM. Table 1 shows the typical chemical composition of the sample employed for this investigation. The results showed the presence of magnesium (21 mg/L), ammonia (990 mg/L), and phosphorus (130 mg/L, dissolved) in the sample. These three components are collectively known as MAP and cause struvite formation under appropriate conditions. The sample had a pH of 7.54 at 72.9°F (22.7°C).

Stage I: Bench-scale Pe¯Phlo Device

Stage I consisted of feasibility studies using a bench-scale Pe¯Phlo device. The device was constructed using PDT technology and a custom electric filtration cell (patented technology, UVM).

PDT is powered by a patented technology. When installed on any type of pipe material (Figure 1), it induces a ±150 kHz, alternating current (AC) electric field. The electric induction is performed by a special transducer connected to a ring of ferrites. The unit attaches around a pipe made of any material, and no plumbing or cutting of the piping system is required (Figure 1a). It uses 120 V power and consumes less than $10 of electricity per year. The pipe and the flowing fluid act as a conducting medium which allows the electric field to propagate. The induced electric field causes the mineral ions that make up struvite to form loose aggregates or clusters. When certain conditions are created (e.g., pressure change, temperature change, and/or high-intensity shear forces) the clusters precipitate out of solution and form stable crystals of struvite that remain in suspension. The crystals are not stable enough to adhere to surfaces as hard scale and are carried away by the flow. Because hard scale no longer accumulates, the shear forces created by the flowing liquid erode and soften scale deposits over time. Note that constant liquid flow is required to remove scale deposits from a system. Figure 1b shows the bench-scale Pe¯Phlo device used in this investigation.

Custom-designed Electric Filtration Cell. A bench-scale electric filtration cell was developed at UVM. This filtration cell withstands transmembrane pressure up to 70 psi (6.9 kpa), which means microfiltration or ultrafiltration can be implemented depending on the treatment requirement. The filtration cell had two graphite electrodes with one on the feed side

Table 1. Typical characteristics of sidestream wastewater sample obtained from the Essex Junction WRRF

Parameter	Concentration	Method
BOD-5 day	99,000 mg/L	SM 5210B(11)
COD	110,000 mg/L	Hach8000/EPA410.4
Conductivity at 25°C	8,720 mg/L	EPA 120.1
Ammonia as N	990 mg/L	EPA 350.1, R.2
pH	7.54 SU at 22.7°C	SM18 4500- H B
Phosphorus, Total Dissolved	**130 mg/L**	EPA 365.1, R.2
Phosphorus, Total	150 mg/L	EPA 365.1, R.2
Solids, Total Dissolved	1,690 mg/L	SM 2540C-97
Solids, Total Suspended	220 mg/L	SM 2540D-97
Metals Digestion	Digested	EPA 3015A
Calcium, Total	48 mg/L	EPA 6010C
Iron, Total	7.1 mg/L	EPA 6010C
Magnesium, Total	21 mg/L	EPA 6010C
Potassium, Total	170 mg/L	EPA 6010C
Sodium, Total	150 mg/L	EPA 6010C

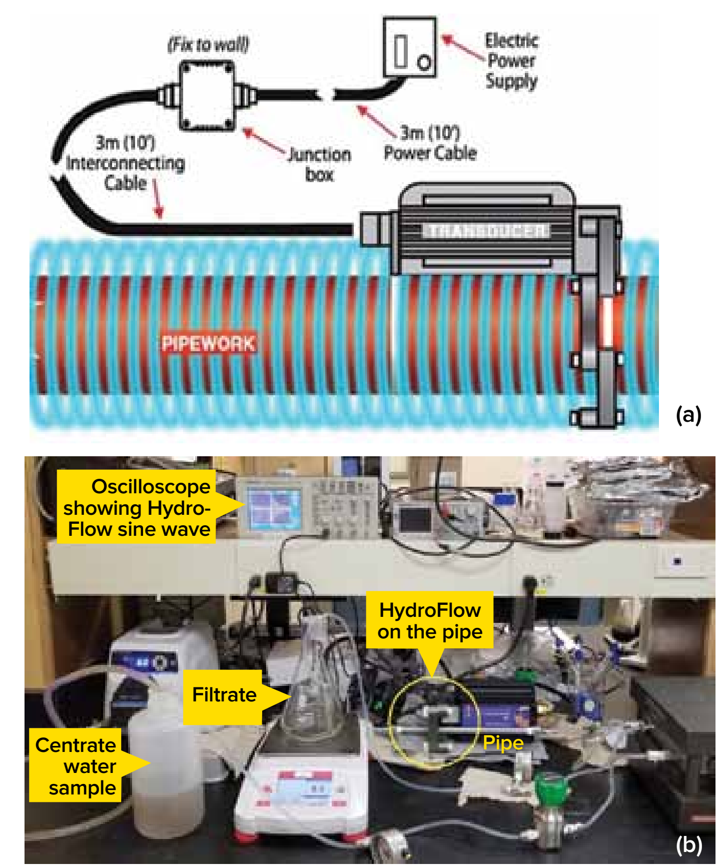
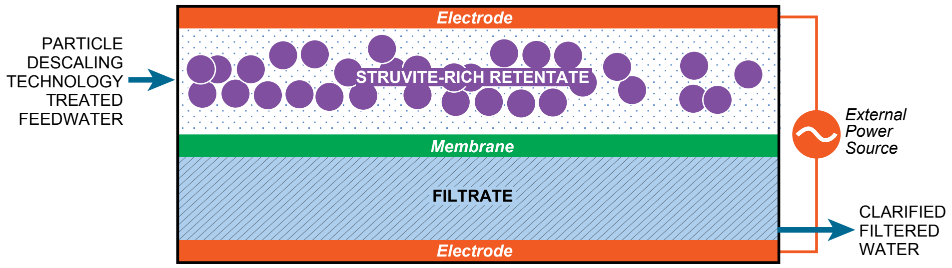


Figure 1. (a) The pipe and flowing liquid act as a conducting medium which allows the electric field generated by the PDT device to propagate in the liquid; the electric field interacts with the ions present in water to induce crystal formation. A bench-scale Pe¯Phlo device with the PDT installed on the pipe is shown in (b).



(a) Oscillating field-enhanced crossflow membrane filtration

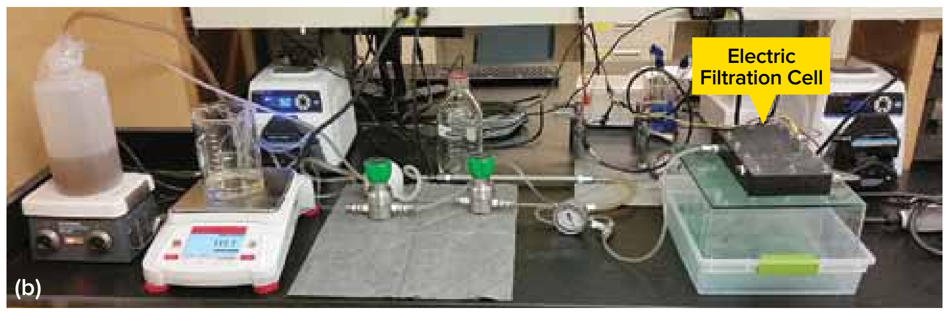


Figure 2. (a) Schematic of the working principle and (b) bench-scale setup of the custom-built electric filtration cell

(wastewater) and the other on the permeate side. A membrane is between the two electrodes separating the feed and permeate side (Figure 2a). The platinum wire leads connect the electrodes with the external power source (alternating or direct current) through the alligator clips. Each electrode was at a distance of 0.4 in. (1 cm) from the membrane surface. Figures 2a and 2b, respectively, show the schematic and actual electric filtration cell setup in this investigation. All crossflow microfiltration experiments were carried out using a 0.22 µm pore-size polysulfide membrane. This filter captures all colloidal particles greater than 220 nm.

STAGE II

Stage II tested the ability of Pe⁻Phlo system to recover dissolved phosphorus in the form of struvite from sidestream wastewater.

Laboratory Experiments

0.26 gal (1 L) of the wastewater sample was taken out from 39.2°F (4°C) storage and kept on the workbench for an hour to allow the sample to reach ambient temperature. Meanwhile, the settleable solids in the sample settled to the bottom of the bottle, and the supernatant was transferred to a clean beaker. The collected supernatant sample was used for further experimentation under the test conditions described in Table 2.

Test Condition 1—*Batch mode treatment without and with PDT for 4 hours and dead-end filtration.*

Figure 3 shows the experimental setup for the batch treatment with the PDT. A 40 mL sample in a 50 mL polypropylene vial was treated under batch conditions for 4 hours without (control) and with a ±150 kHz PDT electric field. The samples were then filtered using a 0.22 µm pore-size polycarbonate filter to recover precipitated crystals. The filters were air-dried, and the retained solids were analyzed for elemental composition using energy dispersive X-ray spectroscopy and X-ray fluorescence spectroscopy. The crystal morphologies were examined using scanning electron microscopy.

Figure 4 shows a photograph of air-dried solids on the membrane filter. The solids exposed to 4 hours of a ±150 kHz PDT electric field appeared to be dark brown, which are likely composed of a mixture of crystals and organics at a higher concentration (Figure 4b) compared to the control sample (no PDT [Figure 4a]). Figure 4a shows struvite formed without PDT. Figure 4b shows struvite formed with PDT on. The exposure time was 4 hours.

Table 2. Experimental test conditions investigated in this project

	Test Condition 1		Test Condition 2		Test Condition 3		
	Control	PDT	Control	PDT	Control	PDT + Electric field filtration OFF	PDT + Electric field filtration ON
	Batch + Dead-end Filtration	Batch + Dead-end Filtration	Batch + Dead-end Filtration	Batch + Dead-end Filtration	Batch + Crossflow Filtration	Batch + Crossflow Filtration	Batch + Crossflow Filtration
Time (h)	4	4	1, 4, 24	1, 4, 24	0–6	0–6	0–6
Centrate	✓	✓	✓	✓	✓	✓	n/a
Centrate + Mg^{2+} ions	n/a	n/a	n/a	n/a	✓	✓	✓

Figure 3. Batch experiments treating centrate with PDT

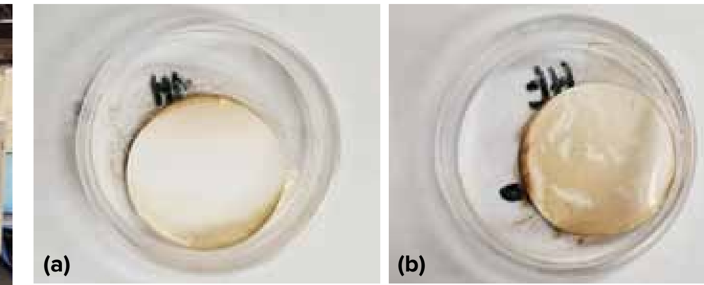


Figure 4. Solids retained on 0.22 micron filter
(a) Control centrate solids (EMF OFF)
(b) PDT (EMF ON) treated solids. Exposure time 4 hours.

A high-resolution scanning electron microscopy analysis revealed crystals that resembled struvite morphology and energy dispersive X-ray spectroscopy confirmed the presence of phosphorus and magnesium in the crystals (Figures 5a and 5b, respectively). However, the number of crystals per unit area was low, while the crystal sizes were as large as 50 µm. These 50 µm-sized crystals can be easily settled by gravity and recovered from the water sample.

The settled solids from the control sample (no PDT) as well as the settled solids from the treated sample (±150 kHz PDT) were centrifuged and filtered using a 0.22 µm filter. The solids were air-dried for X-ray fluorescence analysis. It was expected that the phosphorus-containing crystals would increase in the solids due to interactions with the PDT electric field. The elemental composition of the solids was analyzed using an X-ray fluorescence technique, and the results are summarized in Table 3.

Based on the results in Table 3, the changes in the elemental composition of the settled solids exposed to ±150 kHz PDT for 4 hours are as follows:

- Phosphorus in the settled solids increased from 9 to 13 percent
- Sulfur in the settled solids increased from 5 to 12 percent
- Calcium in the settled solids slightly increased from 11 to 12 percent
- Copper in the settled solids increased from 0.03 to 0.32 percent

The results suggest that 4-hour treatment with ±150 kHz PDT likely caused the observed increases shown in Table 3.

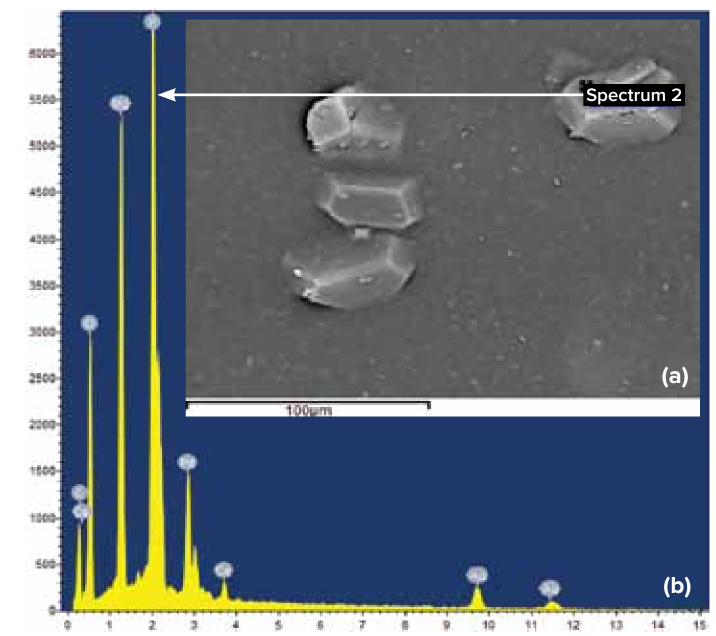


Figure 5. (a) Scanning electron microscopy image of solids on the filter. (b) Energy dispersive X-ray spectroscopy analysis of the solids. The exposure time was 4 hours.

Furthermore, analysis of filter weights with retained solids on the control and PDT treated indicated the following:

- Control sample: weight of solids retained on the membrane surface was 0.1722 g/80 mL filtered
- PDT-treated sample: weight of solids retained on the membrane surface was 0.4576 g/80 mL filtered

These results confirmed that PDT treatment likely increased the concentration of settleable solids,

Table 3. X-ray fluorescence analysis of solids

	% P	% S	% K	% Fe	% Cu	% Ca
Settled solids	8.14±0.08	3.09±0.04	13.36±0.05	3.36±0.07	0.03±0.01	12.71±0.05
Solids w/o EMP exp. (centrifuged)	9.23±0.07	5.31±0.05	17.97±0.06	0.92±0.05	0.03±0.01	11.15±0.05
Solids after EMP exp. (centrifuged)	13.13±0.07	12.16±0.05	11.84±0.04	0.71±0.03	0.32±0.01	12.34±0.04
EMF effect on solids composition	Increase	Increase	Decrease	Decrease	Increase	Slight Increase

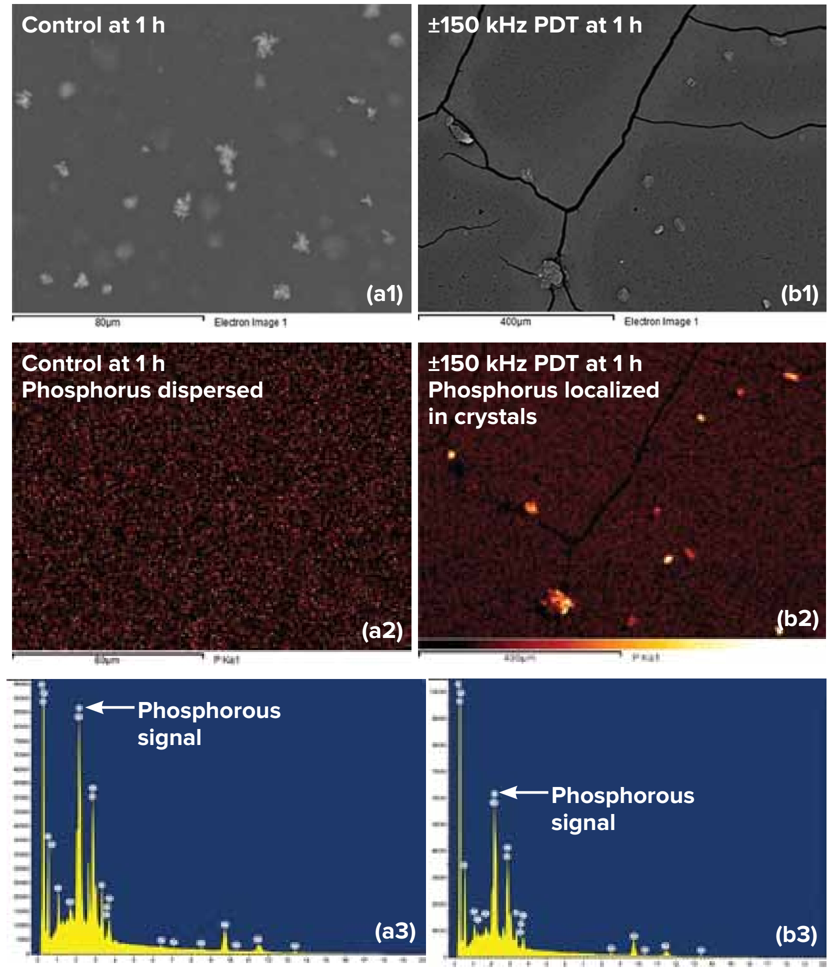


Figure 6. (a1 and b1) Scanning electron micrographs, (a2 and b2) phosphorous elemental maps, and (a3 and b3) energy dispersive X-ray spectra of control and ±150 kHz PDT treated samples. Time: 1 hour.

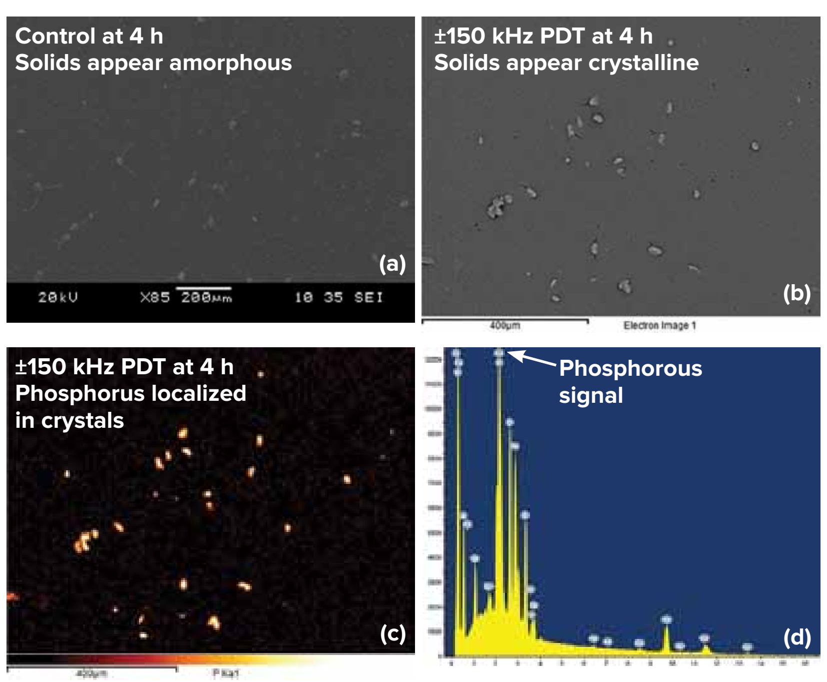


Figure 7. (a) Scanning electron micrographs of the control and (b) ±150 kHz PDT solids, (c) phosphorous elemental map of the PDT solids, and (d) energy dispersive X-ray spectrum of the PDT solids. Time: 4 hours.

and possibly a fraction of them are phosphorus-containing struvite crystals. After the PDT treatment, the total solids recovered on the filter were remarkably increased by 165 percent compared to the control samples.

Test Condition 2—*Batch mode treatment without and with PDT for 1, 4, and 24 hours.*

The effect of exposure time on the formation and growth of crystalline solids and the phosphorus-containing crystals was investigated in Test Condition 2. The samples were filtered, and the solids were analyzed using scanning electron microscopy and an energy dispersive X-ray spectrometer. Figures 6 (1 hour) and 7 (4 hours) show the results. The compositional differences between 4- and 24-hour samples were insignificant, so data corresponding to 24 hours are not shown in Figures 6 and 7.

Phosphorous-containing solids appeared amorphous and dispersed across all solids retained on the membrane surface (Figure 6: a1 and a2 [1 hour]; Figure 7a [4 hours]), as revealed by the scanning electron microscopy and energy dispersive X-ray spectrometer analysis. On the contrary, solids retained on the filter appeared crystalline, and the phosphorus was remarkably localized in the crystalline solids just after 1 hour as well as 4 hours of treatment with ±150 kHz PDT treatment (Figure 6, b1 and b2, and Figure 7b and 7c).

Test Condition 3—*Test Condition 3 included batch treatment with PDT for 6 hours followed by crossflow electric microfiltration.*

The effect of magnesium ions (Mg^{2+}) as seed species and the PDT field on struvite formation was investigated. The Mg^{2+} ions are expected to increase the struvite formation while PDT treatment decreases the nucleation time required for struvite formation. Further, the struvite exposed to the PDT electric field resulted in soft-scale formation, which can be easily removed and recovered from the surfaces. In addition, the suspensions containing colloidal struvite crystals were captured and recovered using microfiltration in the presence and absence of electric fields across the membranes.

The sidestream wastewater samples were treated for a maximum of 6 hours, to mimic the residence time at EJWRRF, and the struvite crystal formation was monitored and analyzed during that period. Two samples, obtained from two different months, were exposed to Test Condition 3. The parameters (including pH, conductivity, crystal nucleation time, and phosphorus concentration and recovery) were measured. The phosphorus concentrations in the filtrate and concentrate from crossflow electric microfiltration were also measured.

Batch and Crossflow Treatment Seeding with Mg^{2+} ions

Seeding solution—0.3525 g of magnesium chloride ($MgCl_2$) was dissolved in 100 mL of ultrapure water by stirring at 400 rpm. The stock solution concentration of Mg^{2+} ions was 900 mg/L.

Protocol—45 mL samples of sidestream wastewater in 50 mL polypropylene vials were exposed to PDT for 6 hours. Another set of samples was set aside for 6 hours but without exposure to the PDT, which served as the control. At the end of the 6-hour period, the samples were filtered using 0.22 μm polysulfide membranes using crossflow microfiltration. The water samples were spiked with Mg^{2+} ions at 100 mg/L prior to activating the PDT electric field. The control samples were also spiked with Mg^{2+} ions at 100 mg/L. The two water samples were tested under these conditions, and Table 4 shows the results.

Key findings from Table 4 are as follows:

- Mg^{2+} ions and the PDT electric field significantly decreased the struvite nucleation time from 4 hours to 2.5 hours.
- Struvite crystals were formed more rapidly in the presence of both Mg^{2+} ions and the PDT electric field compared to Mg^{2+} ions only.
- Over 85 percent of dissolved phosphorous was recovered in the form of struvite within 2.5 hours.
- Physical examination of struvite crystals revealed that struvite formed as a soft scale (loosely held together crystal clusters) on the surfaces. This "soft-scale" nature of struvite is important because it would allow easy recovery with minimal energy from any surface, including holding tanks, distribution pipes, membrane surfaces, and others.
- Struvite nucleation time and recovery appear to be sensitive to slight changes in pH.

STAGE III

The trailer-truck Pe¯Phlo system development stage will test the system's ability to recover dissolved phosphorus in the form of struvite from various phosphorus-rich wastewaters.

EJWRRF and UVM are building the pilot-scale system to be installed on a trailer truck. Once installed, experiments will assess struvite recovery from various phosphorus-rich wastewaters. We anticipate the mobile Pe¯Phlo system will provide a cost-effective alternative treatment for all small- to mid-size WRRFs, dairy industries, and farms.

Table 4. PDT treatment and crossflow microfiltration

Sample	Visual Crystal Nucleation Time (hours)	Phosphorus Recovery Efficiency (%)	pH
March 2019			
Centrate sample	n/a	n/a	8.23
Centrate sample treated with 150 kHz PDT electric field signal	No visible crystal growth	9.53	8.19
Centrate sample treated without 150 kHz PDT electric field signal	No visible crystal growth	4.73	8.36
Mg^{2+} spiked into centrate sample and treated with 150 kHz PDT electric field signal	2.5	84.63	8.15
Mg^{2+} spiked into centrate sample and treated without 150 kHz PDT electric field signal	4	88.07	7.78
June 2019			
Centrate sample	n/a	n/a	7.41
Centrate sample treated with 150 kHz PDT electric field signal	No visible crystal growth	4.5	7.69
Centrate sample treated without 150 kHz PDT electric field signal	No visible crystal growth	10.97	7.97
Mg^{2+} spiked into centrate sample and treated with 150 kHz PDT electric field signal	5.5	78.61	7.81
Mg^{2+} spiked into centrate sample and treated without 150 kHz PDT electric field signal	6.5	76.26	7.94

CONCLUSIONS

- A combination of Mg^{2+} ions and PDT electric field was found to be most effective at capturing phosphorus in the form of struvite. The phosphorus recovery in the form of "soft-scale" (i.e., loosely held together clusters) struvite was over 85 percent at pH 8.12. The 7.0–8.5 pH is typical of dewatering centrates.
- The combination treatment was faster, with about 38 percent less time required to precipitate struvite in the form of "soft scale" compared to controls not treated with the PDT electric field. The nucleation time appears to be sensitive to slight changes in pH.
- A higher pH appears to lead to greater and rapid precipitation. Further investigation is required to determine the effects of pH, Mg^{2+} dosage (concentration and contact time), and operation conditions (batch vs. continuous).
- In the absence of Mg^{2+}, a ±150 kHz PDT electric field alone agglomerated suspended solids to a level easily captured by filters. Compared with controls

(no PDT), the percentage of solids retained by the filter increased to 165 percent in the presence of the PDT electric field.

- The findings suggest that at significantly lower nucleation time (< 2.5 h) the struvite crystal sizes may be in the range of a few microns or sub-microns that can be easily recovered by a micro-filter or ultrafilters depending on the treatment requirements.
- The X-ray diffraction analysis confirmed that struvite formed under a PDT electric field altered the crystal structure that may be responsible for the "soft-scale" nature of the precipitated struvite. This characteristic allows for easy recovery of struvite as well as easy cleaning of technical surfaces including holding tanks, distribution pipes, reactors, and membrane surfaces.

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Innovations with biosolids process technologies: Will new technologies live up to the hype?

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ABSTRACT | With ever-increasing restrictions on biosolids end uses and a growing concern with emerging contaminants, specifically perfluorinated compounds (e.g., PFAS), the timing is ripe for innovative technologies and solutions for biosolids management. Current technology developments include thermal processes such as drying, gasification, pyrolysis, hydrothermal liquefaction, and hydrothermal carbonization. These innovative and emerging thermal process technologies for sludge and biosolids are not necessarily new but have had limited success historically due to operational issues and the failure of many attempts to commercialize them. However, there are increasing interest and development activities in innovative and emerging solutions. Navigating these options with decision-makers can be overwhelming, but developing a biosolids road map can provide perspective. Several technology demonstrations and projects are in the works which, if successful, could be a significant change, leading to the question, Will the new technologies ultimately live up to the hype?

KEYWORDS | Biosolids, sludge, process technologies, innovations, regulations, contaminants of emerging concern, PFAS

Sludge and biosolids processing has been focused on traditional goals of stabilization, volume reduction, and removal of the amount of water in the final sludge and biosolids products. Most sludge and biosolids are land applied, landfilled, or incinerated.[1] With rising costs and increased pressure on landfilling and land application of biosolids and aging incineration infrastructure, many utilities are evaluating alternative and innovative processes for managing sludge and biosolids. These drivers are being further advanced due to ever-growing concerns with nutrient loading and emerging contaminants, specifically perfluorinated compounds (e.g., polyfluoroalkyl substances [PFAS]), which are increasing interest in innovative technologies. This is particularly true in the Northeast after Maine banned land application of biosolids.

Many of these innovative technologies include thermal processes such as drying, gasification, pyrolysis, supercritical water oxidation, hydrothermal liquefaction, and hydrothermal carbonization. There is renewed research and development in these technologies which may provide utilities with alternative management strategies and additional options for biosolids processing in the future. The new technologies for sludges offer promise of alternative ways to reduce mass and volume, produce more marketable products for nutrient/resource recovery, and create alternative pathways to recover energy from biosolids. Many of the technologies, however, are not yet proven at scale for sludges, so few successful full-scale operating systems exist.

These innovative and emerging thermal process technologies for sludge and biosolids are not necessarily new but have had limited success with operations historically. Many attempts in the 1990s and early 2000s to commercialize these innovative processes were not successful, with several demonstration and full-scale facilities constructed but never able to maintain long-term operation. For example, biosolids gasification was tested in Philadelphia, but the system could not work reliably. Another biosolids gasification system was also constructed in Florida and ran for a few years intermittently before being decommissioned.[2] A large hydrothermal carbonization system was constructed in California but decommissioned and dismantled a few years later after it faced issues with scale-up and could not meet contractual obligations to process sludge.[3] A supercritical water oxidation system demonstration facility was built in Florida but was decommissioned after a catastrophic failure occurred due to a reactor blowout.[4] Not all thermal processes implemented, however, were unsuccessful. A small system in Buffalo, Minnesota that has been in operation for over two decades uses dried biosolids from a belt dryer as the main energy source for the dryer in a reciprocating grate furnace.[5] These examples offer lessons learned which should be used by technology developers to avoid repeating past missteps.

Although biosolids process innovation can be slow, and there have been notable challenges, success with innovation is possible. One such success for biosolids process innovation is thermal hydrolysis. The technology was implemented for sludges in the 1990s and was still considered innovative just 10 to 15 years ago, but is now established with numerous large full-scale facilities in operation or under construction throughout North America.

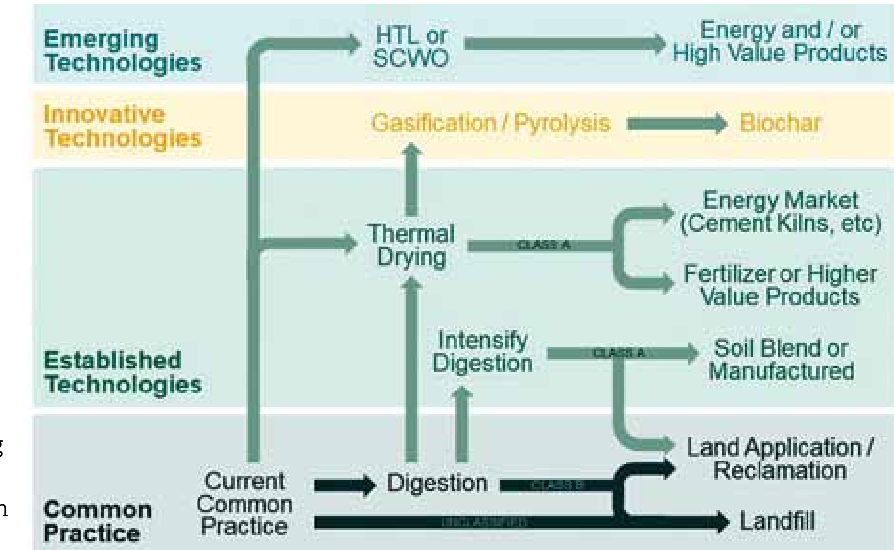

Figure 1. Biosolids innovation road map—emerging technologies: supercritical water oxidation, hypothermal liquifaction

BIOSOLIDS ROAD MAP

When planning for future uncertainty, potential regulatory changes, and market restrictions, considering all options wholistically is important. Figure 1 provides a high-level biosolids road map that can be considered for many plants that do not already have incineration. Many facilities have stabilization to allow land application or they landfill their sludge or biosolids. The road map can be one way to approach difficult challenges such as the following:

- Rising cost for beneficial use or disposal
- Restrictions to landfilling or land application
- Changing regulations and/or end market changes
- Emerging contaminants
- Possibility that landfill or land apply options go away in future

The last challenge is an extreme hypothesis, but possible in the future in the Northeast.

The biosolids road map shows how planning could include proven technologies while still planning or implementing future innovative and emerging technology solutions.

LEVERAGING ESTABLISHED TECHNOLOGIES

One path to help with managing biosolids is to leverage established technologies, particularly digestion and drying. These options can be implemented with future innovative and emerging technologies in mind, but provide immediate benefits that can alleviate challenges and buy time as innovative and emerging technology development continues. Incineration is also an established technology that can provide benefits, but would be an alternative to the innovative or emerging thermal technologies rather than a technology that could be phased in or complement an innovative or emerging one.

Anaerobic Digestion

One option is to leverage or intensify digestion, particularly anaerobic digestion. Anaerobic digestion provides mass reduction and produces renewable energy in the form of biogas. Also, advanced digestion and digestion pretreatment processes can further improve performance by increasing solids reduction, producing more biogas, and potentially generating Class A biosolids. These include options such as high solids digestion, acid-gas digestion, thermophilic digestion, temperature phase digestion, and thermal hydrolysis pretreatment (THP).

Thermal hydrolysis can be particularly interesting as it provides all the digestion benefits while also reducing needed digester volume and improving dewatering post digestion. The thermal hydrolysis process subjects dewatered sludge to high pressure of 90 to 130 psi (6 to 9 bar) and temperature of 300° to 340°F (150° to 170°C) through direct steam injection. The process breaks down the sludge into an easily digestible feed for anaerobic digestion, allowing much higher concentrations of sludge to be fed to the digester. Typically, as a digestion pretreatment, the high solids concentration feed at nearly 10 percent total solids enables digestion volume to be much lower than conventional digesters operating with feed concentrations of 5 to 6 percent total solids.

Although thermal hydrolysis is most commonly applied as a digestion pretreatment for all sludge feed to the digester, the system can also be

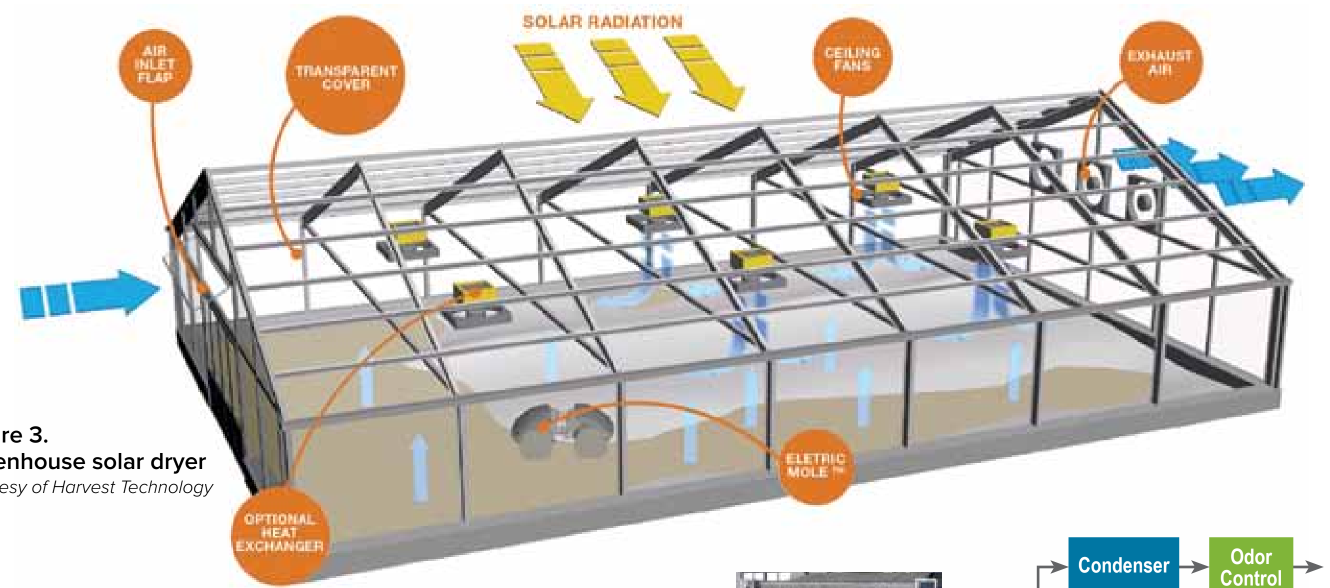

Figure 3.
Greenhouse solar dryer
Courtesy of Harvest Technology

configured in different ways. These include applying thermal hydrolysis only to the waste activated sludge (WAS) feed, applying thermal hydrolysis between two digestion steps (intermediate THP), or even adding THP post-digestion. The WAS-only and intermediate THP systems reduce steam demand and improve energy balances, but WAS-only THP does not meet Class A requirements and intermediate THP does not reduce required digestion volume compared to conventional mesophilic digestion.

The post-digestion THP application is one to consider with future planning. This configuration is the most innovative, with one facility operating in Germany demonstrating many benefits. The THP process is similar to the traditional pre-digestion THP except it is applied on digested sludge dewatered to the needed concentration for THP feed (typically 16 to 17 percent total solids). After THP, instead of feeding solids to the digester, the thermally hydrolyzed sludge is dewatered (under pressure). Data from Germany showed that nearly 40 percent total solids was achieved. The centrate from the post-THP dewatering is also high in chemical oxygen demand (COD), so with this configuration the high COD centrate is recycled back to the digester increasing both solids reduction and biogas production. Data from the German facility showed greater than 70 percent volatile solids reduction.[6] Post-digestion THP could be an option for future processing as it could reduce or eliminate the drying step.

Biosolids Dryers

Another established option is drying the biosolids. Biosolids can be dried with thermal dryers or with passive dryers such as drying beds or greenhouse dryers that use the sun's energy. There are even innovative processes that use the inherent exothermic energy from biological processes to promote drying,

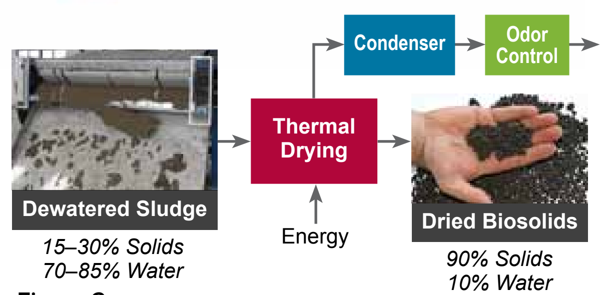

Figure 2.
Overview of typical thermal drying

known as biodryers. Biodryers are similar to in-vessel composting facilities except that they do not use an amendment as required for composting. Drying is also needed for many of the innovative processes such as gasification and pyrolysis, so drying could be part of a phased approach, with potential to add the more innovative gasification or pyrolysis once the technology has been proven and shown to be more dependable.

Biosolids thermal dryers come in several types, all of which operate with the goal of significantly decreasing water content in wastewater sludge. Drying is typically used in the last stage of solids processing and is combined with dewatering, although thermal drying can be used as a step before thermal destruction. Dryers are typically fed with dewatered sludge and dry the biosolids to greater than 90 percent total solids, but the process can also be used as a scalping dryer to raise the solid content to between 35 to 40 percent total solids before incineration. Most dryers are classified as direct or indirect. Direct dryers employ a heated air stream that contacts the solids using convective heat transfer, while indirect dryers employ a heat medium that transfers heat to sludge through another intermediate device using conductive heat transfer. Figure 2 provides a simplified overview of a drying system.

Solar dryers or greenhouse dryers (Figure 3) convert radiative solar energy into warm air for biosolids drying. Solar dryers are constructed as greenhouse-type buildings using transparent plastic panels. Dewatered biosolids are spread on the floor and periodically rotated using automatic or manual turners. The solar drying process can dry dewatered biosolids to 75 percent total solids, with drying efficiency and viability affected by the local climate. Solar dryers offer a low operating cost for drying and also include inherent storage; however, these systems require a large footprint and thus are appropriate for plants with enough land area. The potential system odors also must be considered, particularly for plants with nearby neighbors. In Germany, several systems have been coupled with thermal destruction devices that further reduce mass and volume while providing energy recovery.

Incineration

Incineration or advanced thermal oxidation is a combustion reaction that occurs in the presence of excess oxygen. Incineration is the most commonly used thermal conversion process for wastewater solids. Fluidized bed incineration and multiple hearth incineration are the most common incineration processes for wastewater solids and are established technologies. Multiple hearth incineration is considered an outdated technology and few, if any, new systems are being installed. But many systems still operate, with plans to rehabilitate some. Incineration offers a proven technology for sludge destruction that can overcome many challenges; however, the systems can be difficult to permit and can garner opposition from local residents. Incineration may also not operate at high enough temperature to provide full PFAS destruction, but research is aiming to better quantify this.

WHEN TO CONSIDER INNOVATIVE AND EMERGING TECHNOLOGIES

Given current biosolids management challenges, the time is ripe for innovative and emerging technologies that can provide alternatives. Development efforts are focused on thermal technologies including gasification, pyrolysis, supercritical water oxidation, hydrothermal liquefaction, and hydrothermal carbonization. Much excitement surrounds these processes, with numerous demonstrations and full-scale facilities in the works. Will the technologies live up to the hype? When considering development of innovative and emerging technologies, the Gartner Hype Cycle (Figure 4) offers perspective. With the number of new technologies available today, many are in the "peak of inflated expectations" phase and a few have moved into the "trough of disillusionment" when first installations or demonstrations did not meet initial expectations (often due to funding restrictions or material handling challenges associated with the heterogenous nature of sludge and

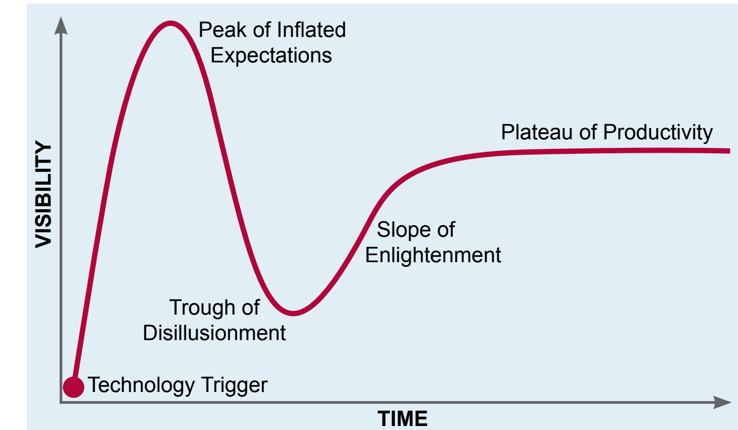

Figure 4. Gartner Hype Cycle[7]

biosolids). The hope is that a number of technologies will move past the "trough of disillusionment" and approach the "slope of enlightenment," and then reach the "plateau of productivity" phase and become proven.

Gasification and Pyrolysis

Unlike traditional sewage sludge incineration, a well-proven biosolids process technology, gasification, operates at sub-stoichiometric conditions and pyrolysis operates in the absence of oxygen. Gasification and pyrolysis also typically require a drier feedstock material than sewage sludge incineration, so an upstream drying step is normally needed. Gasification produces a fuel gas called syngas, which is composed of carbon monoxide, carbon dioxide, hydrogen, and methane and has a low heating value. Similar to gasification, pyrolysis at high temperatures generates a combustible gas called pyrolysis gas, with a low heating value, but the process can also be used to generate char and oil. Pyrolysis is the first step in both gasification and combustion reactions. Biochar produced from gasification and pyrolysis can be beneficially used in agriculture and specialty chemicals. Several companies have developed gasification and pyrolysis technologies, but the history has been mixed with several unsuccessful installations. A major challenge with biosolids as a feedstock for gasification and pyrolysis is the high ash content and low ash softening point temperature of biosolids compared to other biomass feedstocks.

A small biosolids pyrolysis system is operating in Silicon Valley in California, and a gasification system was recently commissioned in Washington state. Other gasification and pyrolysis systems are operating in Germany, Australia, and Japan. Another gasification system was operated for around two years in Pennsylvania, but the facility was decommissioned after a fire unrelated to the gasification process occurred in a storage loading bay; the system is being moved to another Pennsylvania location.

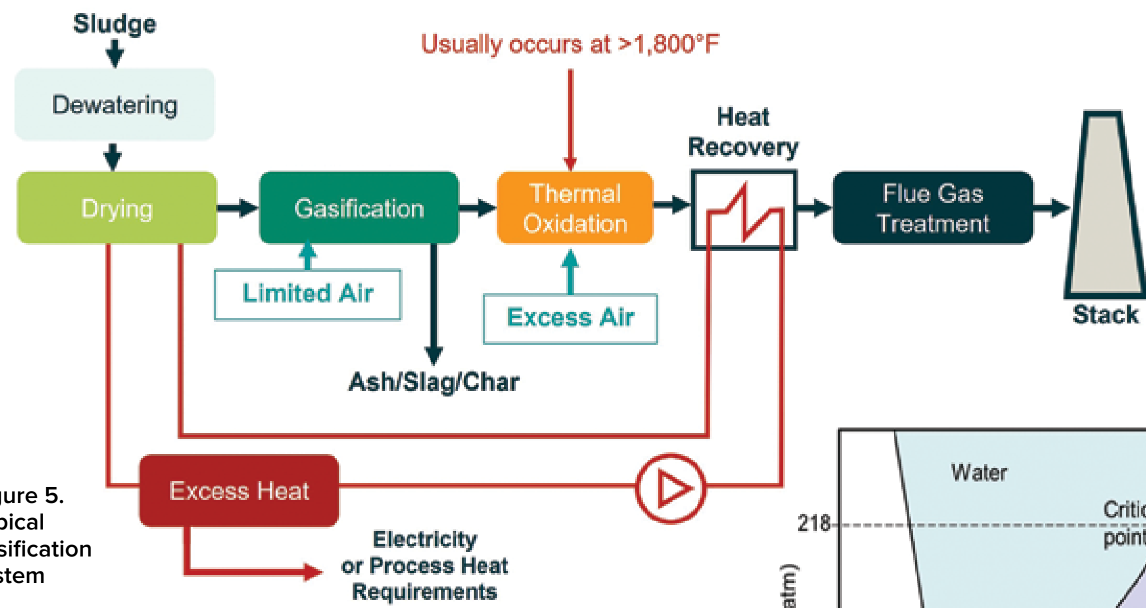

Figure 5. Typical gasification system

A few other recent systems in New York, New Jersey, and California hit roadblocks due to material handling challenges during commissioning and related financial challenges. However, several other gasification and pyrolysis facilities with potential are planned, in design, or in construction in California, Pennsylvania, and Tennessee.

Most gasification and pyrolysis systems require a separate step to dry the dewatered sludge cake from a conventional dewatering unit (15 to 30 percent total solids) up to 70 to 90 percent total solids before gasification or pyrolysis. The dryers are normally part of the system package, and the energy recovered from gasification or pyrolysis is typically used as the main heating source for the dryer, as shown in Figure 5, although technology suppliers are offering variations. Many types of dryers can be used upstream of gasification and pyrolysis. Although most use thermal dryers (needed for large-scale systems), gasification and pyrolysis can be coupled with greenhouse or biodryers, possibly providing a more favorable energy balance for smaller facilities or facilities with land available for the low-energy, passive drying processes.

Data from various studies shows promise for PFAS and emerging contaminant destruction through gasification and pyrolysis. It shows that PFAS compounds are removed or significantly reduced in the ash or char produced from the process; however, less data is available to show whether PFAS is destroyed or potentially emitted out the stack, but research is ongoing.

Supercritical Water Oxidation

The supercritical water oxidation (SCWO) process converts thickened or dewatered residuals, at 6 to 18 percent total solid content (by weight), to inert

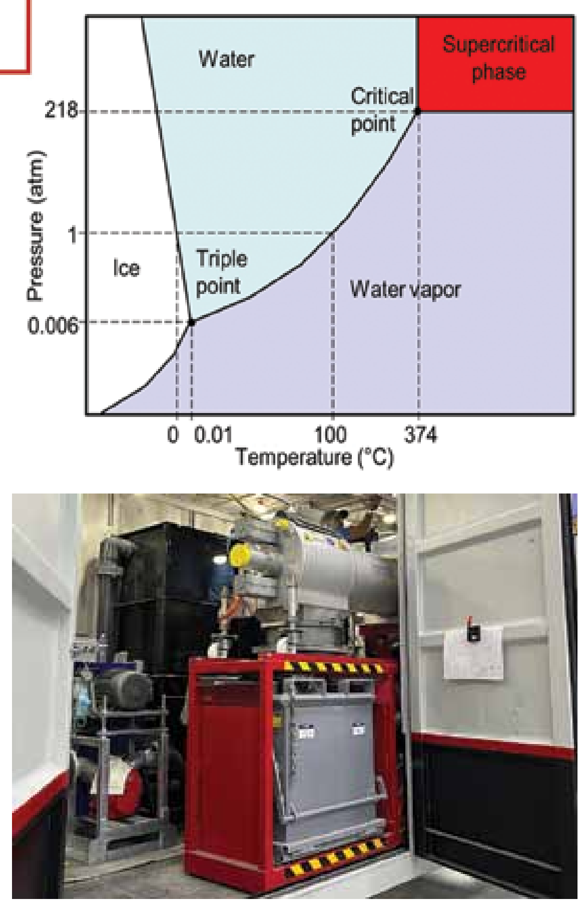

Figure 6. SCWO demonstration system planned for Orange County, California. (top) water-phase diagram
Photo courtesy of 374Water

products through a complete oxidation reaction. SCWO uses supercritical water as the medium for oxidation. Supercritical water exists at temperatures and pressures greater than the critical point of pure water (Figure 6), which is 710°F (375°C) and 3,160 psi (218 bar). Supercritical water exhibits unique properties, including its ability to completely dissolve organic contaminants and gases otherwise insoluble or sparingly soluble.

The SCWO process has potential; however, no full-scale system is operating for biosolids. A pilot system was installed in Orlando, Florida, in the mid-2000s, but this system stopped operating after a catastrophic failure occurred at the facility due to a reactor blowout.[4] A demonstration system was also installed in Ireland, but limited data was available and the status of that technology is unknown. There are, however, new technology suppliers developing systems for this application. A full-scale demonstration facility is planned in Orange County, California (Figure 6).

The high-temperature, high-pressure process has also been shown to provide PFAS and emerging contaminant destruction. Potential advantages include no drying step and the potential to produce electricity. The high-pressure process and the potential for fouling and corrosion, however, raise safety concerns. Long-term operation at the planned demonstration facility will provide valuable feedback on the viability of this process for biosolids management at a larger scale for extended operating durations.

Hydrothermal Liquefaction

The hydrothermal liquefaction (HTL) process was developed by Pacific Northwest National Laboratories, which has conducted bench-scale testing of the process on various feedstocks including wastewater sludge. The HTL process uses high-pressure 2,900 psi (200 bar) and high-temperature 660°F (350°C) to produce a biocrude product from sludge fed to the system at solids concentrations between 15 to 35 percent total solids. Although the process operates at high pressure, it does operate below the critical point of water, meaning operation is at sub-supercritical conditions. The liquid stream from the HTL process is typically treated in a catalytic hydrothermal gasification (CHG) reactor, which generates a biogas for energy recovery. Research into digestion of this liquid stream is also being planned. Figure 7 shows how the process could be implemented in a wastewater treatment plant. Nutrient recovery is also possible with the recovery of ammonia from the effluent water and recovery of phosphorus from the precipitate. Sludge metals accumulate in a precipitate byproduct. An HTL demonstration facility is being designed in Vancouver, British Columbia. Mobile HTL pilot testing has been conducted at facilities in Oregon, Florida, and Ohio.

The HTL technology offers potential advantages for maximizing resource recovery from biosolids with potential for both energy and nutrient recovery. The technology also does not require a separate drying step. The high-pressure nature of the process and fouling and corrosion potential, however, raise safety concerns. Long-term operation at the

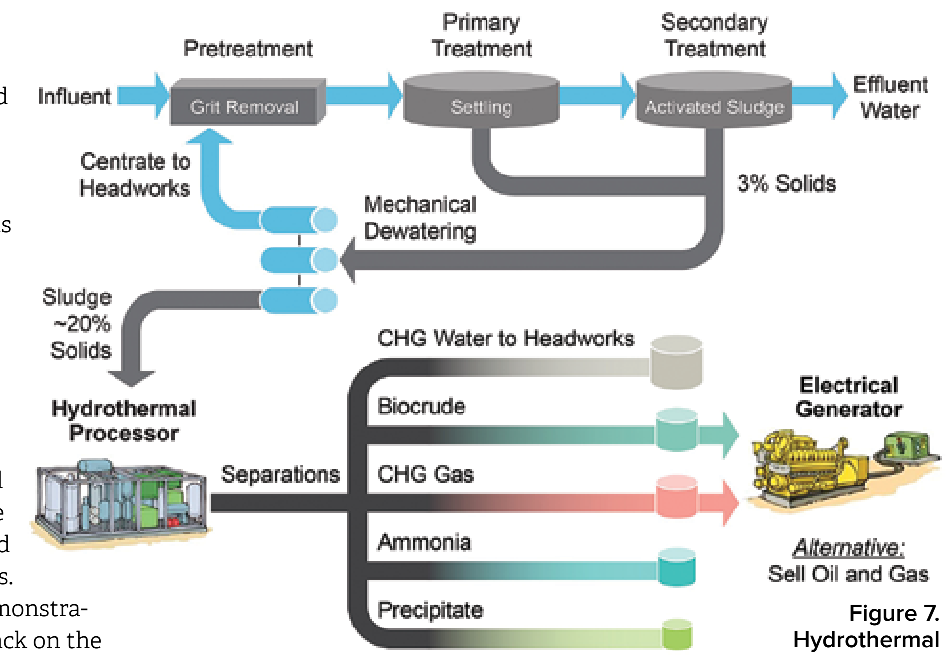

Figure 7. Hydrothermal liquefaction
Schematic courtesy of Genifuel

planned demonstration facility will provide valuable feedback on the viability of this process for biosolids management at a larger scale. This technology's high pressure and high temperature may also provide PFAS and emerging contaminant destruction, but more research is needed to validate effectiveness.

Hydrothermal Carbonization

Another hydrothermal process being developed for biosolids management is hydrothermal carbonization (HTC), which looks to convert sludge and biosolids under pressure to a hydrochar or bio-coal product. The process is similar to HTL but operates at lower temperatures of 360° to 430°F (180° to 220°C) and pressures of 290 to 360 psi (20 to 25 bar). The hydrothermal carbonization is applied to thickened or pre-dewatered sludge prior to a final dewatering device. Limited testing with a hydraulic filter press has shown potential to generate a hydrochar with a total solids concentration of 50 to 60 percent total solids. Hydrothermal carbonization is not new. A variation of the process was first tested in Georgia and implemented at a large-scale facility in Rialto, California, in the early 2000s, but the system was not successful, and was decommissioned and dismantled. A newer hydrothermal carbonization system is being commissioned in Phoenixville, Pennsylvania, and other variations are being tested and implemented in Europe. With the lower temperature and pressure of this process compared to HTLs, full PFAS destruction is not anticipated, though more research is needed to further quantify this impact.

CONCLUSIONS

With rising costs and increased pressure on landfilling and land application of biosolids, the timing is ripe for innovative process development for managing biosolids. These drivers are being further advanced based on ever-growing concerns with nutrient loading and emerging contaminants, specifically PFAS, which are increasing interest and demand for innovative solutions. Innovation and technology development can be slow and some attempts have been unsuccessful, but much development activity is occurring, leading to the question, Will the newest technologies live up to the hype?

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Motivating the adoption and diffusion of enhanced nitrogen-reducing innovative/alternative septic systems

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ABSTRACT | Innovative/alternative (I/A) septic systems, designed to remove nitrogen at its source, are being implemented through voluntary pilot studies or infrequent local mandates. Considering the voluntary nature of adoption, if I/A systems, or other household-level nutrient management strategies, are to be pursued to improve water quality, behavior change strategies to encourage their adoption are needed. Rooted in findings from an I/A septic system pilot on Cape Cod, Massachusetts, and informed by case studies on the diffusion of technologies similar to I/A systems (expensive, household-level) and the behavior change literature, we identify strategies to diffuse the adoption of I/A systems. These include harnessing peer effects, carefully framing information campaigns, providing financial incentives, and making behavior change convenient.

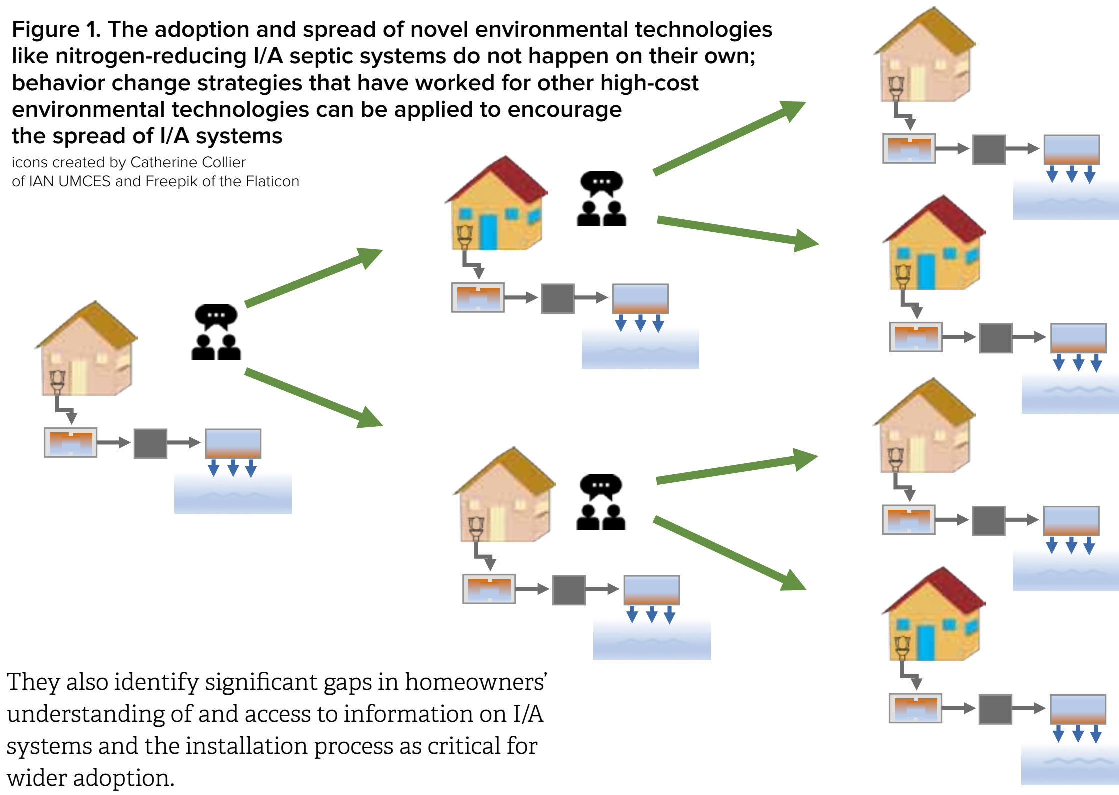
KEYWORDS | Nonpoint source, wastewater management, onsite treatment, septic systems, technology adoption, nutrient loading, behavior change

As nitrogen pollution from septic systems threatens coastal water quality, harming communities dependent on clean and healthy waters, decision-makers are increasingly considering the efficacy of alternative nitrogen-remediating technologies and best management practices (BMPs).[1] Designed to remove nitrogen from wastewater, innovative/alternative (I/A) septic systems (also known as alternative experimental [A/E] technologies) are among the technologies being studied and piloted in New York and southern New England to remediate environmental degradation to coastal embayments. Traditional septic systems, which inadequately remove nitrogen from wastewater, are among the most locally controllable contribution to this degradation.[2,3]

Despite over two decades of piloting, the public remains unfamiliar with I/A septic systems, and their wider adoption is limited. In the United States, much of the research around the technical aspects and cost-efficiency of these systems has come from Long Island and Cape Cod. Deteriorating water quality in these areas and the potential for a newer generation of I/A septic systems to achieve more significant nitrogen removal[4,5,6,7] have fueled research pilots to evaluate the viability of these systems as solutions to coastal nutrient pollution.[5,8,9] Barriers hindering the adoption of I/A systems include the costly and time-consuming permitting and approval processes; limited ability of early I/A systems to remove nitrogen, absence of regional data sharing on their efficacy, knowledge gaps and limited data on newer systems' performance and longevity, and high capital costs for installation including operation, maintenance, and monitoring.[1,6,10]

Recently, social and cognitive considerations influencing the adoption of these systems were identified through homeowner focus groups, revealing the perceived need to replace an old/failing septic system, comply with local regulations, protect local water quality, and provide financial incentives synergistically catalyzed adoption.[10] By modeling homeowners' decision-making around adoption, Rudman et al. described how adoption is influenced by the larger context within which it is occurring, perceived characteristics of I/A systems and the installation process, system aesthetics concerns, and homeowners' attitudes and beliefs.[10]

Figure 1. The adoption and spread of novel environmental technologies like nitrogen-reducing I/A septic systems do not happen on their own; behavior change strategies that have worked for other high-cost environmental technologies can be applied to encourage the spread of I/A systems
icons created by Catherine Collier of IAN UMCES and Freepik of the Flaticon



They also identify significant gaps in homeowners' understanding of and access to information on I/A systems and the installation process as critical for wider adoption.

Broader-scale implementation of high-performing I/A septic systems (Figure 1) and other BMPs is needed to curtail excess nutrient loading alongside common effective traditional technologies, such as sewer expansion.[6] But apart from localized government mandates requiring installation of I/A systems under certain conditions, their adoption is still voluntary, primarily occurring upon property transfer or septic system failure or at the town-level.[9,11,12] Given the absence of regulations mandating these systems, wider implementation in the short-term will require encouraging adoption in other ways. The adoption of a technology like I/A systems is a type of behavior change.[13] To encourage the adoption and wider diffusion of I/A systems at a household-level, we can learn from behavior change theory and the technology adoption and diffusion literature. Diffusion is the process of social communication in which new ideas and technologies are spread through a social system; it is achieved as innovations circulate by individuals making the decision to adopt over time.[14] This decision is often based on the experience of peers who have already adopted.[15] We can draw lessons from the adoption and diffusion of technologies with similar attributes to I/A systems and behavior change strategies used to encourage their diffusion. These technologies include household solar panels, electric vehicles, and agricultural BMPs, and share the following characteristics with I/A septic systems:

- Individual/household is the unit of decision-making
- High capital costs are incurred through adoption
- Perception exists of a pro-environmental technology

There are also differences between I/A systems and these technologies. For example, solar and electric vehicles can save consumers money over time, whereas I/A systems do not. Still, the literature on the adoption of these technologies is comprehensive compared to I/A septic systems. This work provides examples of how behavior change strategies from the literature and the adoption of similar technologies can be applied to encourage the diffusion of I/A septic systems or other homeowner-level technologies.

BEHAVIOR CHANGE STRATEGIES FOR INCENTIVIZING ADOPTION

There is no universal formula for changing behavior. Behavior is determined by myriad psychological and external factors that interact in complex ways and are embedded in social and institutional contexts, rendering behavior change complex and unpredictable.[16,17] While no single model adequately captures all factors influencing behavior,[17] strategies to identify and address barriers to change have arisen out of studies on behavior change and technology adoption[13,18] that can be applied to encourage the adoption of I/A septic systems. General barriers to I/A system adoption have been identified by social scientists, organizations implementing I/A system pilots, decision-makers, and practitioners[2,6,7,9,10] though local barriers (and drivers) of adoption must still be identified in communities where these systems are being pursued.

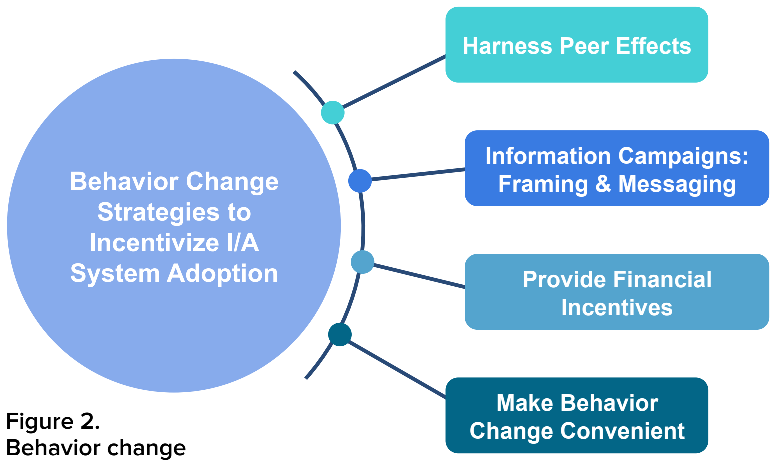


Figure 2. Behavior change strategies to incentivize the adoption of I/A septic systems

Whether a behavior change strategy is appropriate for a diffusion initiative depends on local context and barriers to adoption, available resources, and established trust. Local context and barriers can differ from one community to another and even within a community.[16,17] Familiarity with the policies, regulatory structures, physical infrastructure, resource allocation processes, biophysical and environmental characteristics, and the needs and values within a community related to wastewater is important for uncovering local barriers and drivers of adoption. Working and conducting informal interviews with community organizations and decision-makers can lead to an understanding of local context and barriers. Because behavior change is slow-moving and can be resource intensive, accounting for the capacity, time, and financial resources necessary to implement a behavior change strategy is important. Partnering with organizations can increase resource availability. Finally, trust or credibility in a messenger is crucial to behavior change: Promoting a new idea or technology can fail if the messenger is not trusted.[18,19] Partnering with organizations or individuals that a community respects, establishing fair procedures for initiatives, cultivating meaningful interactions with a target audience and expressing similar values, and responding to an audience's concerns will build trust and increase the reach of behavior change efforts.[18,20]

Below we present promising strategies to promote the adoption and diffusion of I/A systems. These include harnessing peer effects, framing and messaging, providing financial incentives and opportunities, and making adoption convenient (Figure 2). The lines between these strategies can be blurry, and they can be combined to increase the likelihood of behavior change.

Harnessing Peer Effects

Social interactions and the influence of peers play important roles in the diffusion of new ideas and technologies like the adoption of I/A septic systems.[14,21] Peer effects describe the influence that neighbors, friends, colleagues, relatives, and firms assert over an individual's attitude or behavior through interaction.[21] These occur when information and experience related to a new idea or technology are shared through direct (word of mouth) and passive interaction (observation), influencing perspectives on the reliability, desirability, or quality of a technology.[22] They are particularly relevant when potential adopters are faced with uncertainty regarding a technology, as is the case with I/A systems, and rely on their social networks as a source of perceived trustworthy information.[14,21,23]

Studies examining the role of peer effects on household solar adoption find that peer effects accelerate adoption by increasing potential adopters' trust in available information[21,23] and highlight the importance of community champions and key individuals in leveraging this trust.[21] Others find evidence that hearing about solar in a social context, especially from a familiar source, is a powerful motivator for adoption and the more solar adopters a person knows, the stronger social influence becomes.[24,25] Research on electric vehicle adoption finds that online networks and news sharing influence intentions to adopt.[26] Similarly, research on autonomous vehicle adoption finds that feedback from peers reduces uncertainty and points to the role of social influencers and social media to promote adoption.[27]

Given the novelty, uncertainty, and high up-front costs in adopting I/A septic systems, the mobilization of peer effects may be instrumental to broader adoption. Small-scale I/A system pilots in Massachusetts provide empirical evidence of the role of peer effects in encouraging adoption. In a June 2021 I/A septic system workshop, a nonprofit organization implementing a pilot described individuals encouraging their neighbors to adopt as a primary driver encouraging participation in the pilot's future phases.[6] Another nonprofit leveraged peer effects for a neighborhood-scale I/A pilot on Cape Cod by relying on several individuals with strong community ties and involvement in neighborhood associations to catalyze interest among their neighbors, relying on community champions for recruitment similar to past work described on EVs.[21] The organization then built collegiality by organizing community events like question-and-answer sessions, a field day at a camp centered around the neighborhood's water quality concerns, and tours for interested parties of I/A installations. The utility of field days and demonstration sites is documented in the literature on agricultural BMP adoption, revealing that these sites encourage adoption and provide opportunities for contact with peers and experts.[28,29] Although peer effects alone do not guarantee adoption, they

Table 1. Strategies to increase the visibility of I/A septic system adoption

Strategies to Increase the Visibility of I/A System Adoption	Description	Examples and Applications
Using communication channels to share the experiences of adopters	Share thought processes, experiences, and opinions of adopters through visual and non-visual channels including videos, blogs, podcasts, local newspapers, radio stations, and non-profit organization or town social media accounts.	The Reclaim Our Water Septic Improvement Program in Suffolk County, Long Island, embedded a video detailing homeowners' experiences on their program website: www.reclaimourwater.info/homeowners.aspx.
Using in-person gatherings to share locally specific information and experiences	Organize informal community events around an I/A system installation, like a Q&A session or system tour followed by a barbeque or picnic.	Community meetings and Q&A sessions were successful in sharing ideas, garnering interest, and communicating with neighborhood participants for the Barnstable Clean Water Coalition's Shubael Pond I/A septic pilot.
Establishing a public demonstration site	Organize visitations and trips for groups with a stake in wastewater management (homeowners, decisionmakers, contractor associations, real estate agencies). Display an exposed I/A system to accommodate those who may not be able to attend a one-off demonstration event.	The Massachusetts Alternative Septic System Test Center on Cape Cod, an independent testing and research facility for I/A systems, hosts site visits where the public can tour the test center and learn about these systems, as does the University of Rhode Island's wastewater training program
Conducting an I/A system pilot	After assessing local needs and context, implement an I/A system pilot in a community where alternative wastewater treatment is being considered.	Local governments and nonprofit organizations have implemented several I/A system pilots in southern New England.[7,8,32]
Using signage to indicate system adoption	Provide willing homeowners and businesses signage to place in a public place indicating the installation of an I/A system.	Signage has influenced pro-environmental action for low-cost/barrier behaviors such as composting.[33] Given the considerable barriers associated with I/A adoption, it is unlikely signage would incentivize adoption, but its utility would lie in publicizing these systems.

work with other factors that influence decision-making. Several ways to leverage peer effects include modeling or communicating the desired pro-environmental behavior, employing normative messaging, and encouraging learning from trusted sources.

Modeling or communicating a desired pro-environmental behavior leverages peer effects by establishing social norms. Social norms are perceived common and accepted behaviors within a group, or what others do and approve of doing.[15,18] New social norms are established by convincing a target group that the different standard of behavior being marketed is correct. New norms must be visible, temporally relevant, and focused on a behavior's positive aspects.[15,18] Visibility increases the likelihood of adoption by stimulating the discussion of new ideas and influencing positive normative beliefs about adoption when peers observe a respected person using an innovation.[14,30,31] While I/A septic systems are underground, Table 1 provides ways to overcome the visibility hurdle that sets I/A septic systems apart from more observable technologies.

Normative messaging can also leverage peer effects by establishing social norms.[15] Highlighting rates of technology adoption, conveying cultural or societal approval, and publicizing testimonials from adopters are ways normative messaging can be applied. Studies on solar adoption found that testimonials from adopters, especially hearing from peers, increased the likelihood of adoption.[23,24,31] Individually, normative messaging could be employed at town meetings to persuade homeowners to modify their properties. Messaging that highlights an increase in the percentage of homeowners installing these systems would be most effective in regions or localities where I/A adoption is increasing rapidly. Prior to leveraging social norms, awareness of who your target audience may and may not identify with is important. Normative messaging on the behavior of an outgroup a target audience does not identify with could backfire and lead to the opposite of that behavior.[35]

Finally, fostering learning from trusted sources is a cornerstone of peer effects. Individuals rely more on the evaluations of an innovation by others like themselves than from scientific studies.[14] In a study on factors reducing uncertainty among solar adopters, 90 percent of adopters suggested talking to owners of solar panels "was or would have been useful" in reducing uncertainty.[23] Researchers studying farmers' uptake of environmentally friendly technologies and practices found adoption was more likely after hearing from other farmers or seeing these demonstrated, highlighting the utility of partnering with early adopters to serve as advocates to motivate adoption.[36] Creating environments where I/A system owners can share their experiences and connect with potential adopters in their communities to share localized, credible, and experience-based information on I/A system adoption would facilitate social learning, much like solar community organizations (SCOs) did to incentivize the uptake of residential solar panels. SCOs formed by citizens or nonprofit organizations disseminate knowledge from previous adopters on the financing, reliability, maintenance, and uncertainties around solar panel adoption. They reduce barriers to adoption by relying on trust their members have cultivated within their community, trust that may not exist with an outside government or retailer; leveraging peer effects; and providing access to credible information and advice.[21]

Information Campaigns: Framing and Messaging

Information on I/A septic systems, their benefits, and the adoption process is lacking but necessary.[10] Informational gaps exist on initial and ongoing costs; how these systems operate; system longevity; homeowners' maintenance responsibilities; installation duration; siting considerations; and how these systems will look, smell, and sound. Research has shown that most homeowners had not even heard of I/A systems prior to participating in a pilot.[10] Information campaigns led by credible communicators could address these knowledge gaps and promote system awareness. Although information campaigns alone have been unsuccessful in changing behavior,[17,18] they have potential to contribute to diffusion due to the near absence of straightforward, publicly accessible information on I/A systems and the adoption process.

Various avenues for increasing awareness of I/A systems and access to information exist. This can be done by encouraging agencies and departments in charge of permitting onsite wastewater treatment system (OWTS) upgrades and installations to brief homeowners on I/A systems. In Massachusetts, no statewide requirement for permitting institutions exists to brief homeowners on these systems. Encouraging realtors, developers, and home inspectors to introduce homeowners to I/A systems upon the purchase of a property with a failed system or the construction of a new building could also help increase awareness. Connecting with homeowner associations and hosting informational sessions and field days would allow these to be marketed in a group setting to an institution with leverage over homeowners' property-related behavior.

Framing, the way information is presented, and messaging, the information being communicated, are critical to an information campaign and require careful consideration to persuade a target audience to change its behavior.[18] Whether a message is framed positively or negatively and includes personalized information is critical to how it is received. Traditionally, attempts to spur behavior change using negative or fear-based messaging have proven less successful.[18,37] However, an issue or situation must first be perceived as threatening for individuals to perceive the need to act: This type of language can be necessary to illustrate what is at stake. Therefore, messaging around losses and threats should be coupled with messaging that empowers a target audience to act, instilling a sense of purpose and perceived control.[18] Take the following excerpt from a Cape Cod primer on I/A systems which couples negative framing with actionable solutions:

> If we don't aggressively work on the [Cape Cod's water quality] problem, we are going to pay anyway through reduced: fisheries, home values, tourism and the quality of Cape life. It will take multiple concurrent approaches to ensure quality waters for the Cape economy and for future generations. Distributed nitrogen-removing I/A septic systems will be a valuable part of that future, and they are starting to make an impact now.[9]

Making information both personalized and vivid separates it from competing information.[18] People will better relate to information tailored to their needs, values, and situations and pay more attention because the information is something they care about and will be affected by.[38] Using analogies that resonate with homeowners rather than relying on statistics and metrics will render information more vivid. For example, the amount of nitrogen a community's septic systems contribute to a surface waterbody could be described in "cars' worth" of nitrogen per year. Consider this excerpt from the aforementioned primer:

> Have you ever wondered why there is an occasional not-so-nice smell at the beach, why there are beach closures, or why eelgrass and scallops have disappeared from parts of the Cape coastline? It is primarily because of wastewater from our home toilets, and we can do something about it.[9]

Beyond framing and the use of vivid, personalized information, messaging around I/A systems should appeal to environmental values. In research, most homeowners expressed environmental values, and many discussed a concern for local water quality regardless of whether they voluntarily installed a system or were made to upgrade.[10]

Illustrating the potential benefits realized by installing an I/A system will be important, considering homeowners are largely unfamiliar with them.[10] Contrary to the potential to save money (or profit from) technologies like solar panels and EVs, I/A septic systems have no mechanism to financially benefit adopters in the absence of nitrogen crediting, enduring subsidies, or special provisions. As with solar, if consumers cannot identify the advantage of adopting an I/A system over their septic system, adoption is unlikely.[39] Promoting a societal benefit such as healthier watersheds associated with I/A system adoption could be effective, as was found in a pilot on electric vehicle adoption.[40] Table 2 highlights considerations for information campaigns and how they can be or have been applied to promote awareness and adoption of I/A systems.

Providing Financial Incentives

That most homeowners do not possess or are unwilling to invest \$20,000 to \$30,000 or more to install and maintain an I/A septic system is a reality. As with solar panels,[39] cost most prominently inhibits I/A system adoption among homeowners who have expressed the importance of financial incentives in defraying these costs.[10] Financial incentives have been key to the adoption of other high-cost technologies. They include performance-based incentives (PBIs); tax incentives such as credits, rebates, exemptions, or abatements; and loans.[24,25] PBIs, which have been used to incentivize the adoption of solar panels, could be used for I/A systems based on the amount of nitrogen attenuated over time, increasing the perceived advantage of adopting an I/A system, similar to solar buy-back programs. Financial incentives can be used to discourage the use of traditional systems through a nutrient tax on those systems, for example. Most I/A system pilots in the northeastern United States have relied on subsidies.

While financial incentives to adopt technologies with high initial costs like I/A systems are crucial to defray financial barriers, their impact on diffusion can be limited without understanding and addressing other factors influencing adoption.[24,39] The attractiveness of financial incentives can vary based on the effort required to receive the incentive, the group targeted, the incentive's timing, and requirements to take on additional debt.[16] The role of temporary incentives in encouraging diffusion is unclear. Temporary incentives or incentive reductions over time may damage an installation campaign due to a perceived lack of fairness or could encourage adoption by instilling a sense of urgency to receive an incentive. Where subsidies or tax credits are insufficient, increasing homeowners' access to financing through long-term, low- or no-interest loans and financing plans could encourage adoption by spreading costs over time. One example is Barnstable County's AquiFund loan program offering homeowners financing to upgrade

Table 2. Key considerations for information campaigns and messaging around I/A septic systems

Elements of an I/A System Information Campaign	Application
Make environmental impacts relevant	Concepts relating to environmental degradation and ecosystems tend to be abstract. Convey information about the socio-ecological impacts of a behavior into terms that are easy to visualize, perceive, and understand.[17] **Example:** Use examples of local water bodies impacted by nutrient pollution familiar to homeowners.
Use visual tools	Homeowners' familiarity of I/A septic systems is low. Visual tools such as videos, imagery, and illustrations, will be helpful in depicting what these systems are and what their installation entails. **Example:** Embed videos on a website showing the installation process at a site.
Take advantage of windows of opportunity	Timing informational campaigns around windows of opportunities can be effective. **Example:** As Cape Cod revisits its Clean Water Act 208 Plan, there has been an opportunity in which wastewater management has been a more salient topic for decision makers and the public.
Foster bi-directional communication with potential adopters	Partaking in conversations with homeowners is important to understand values and concerns that are specific to a community and to understand public perceptions and knowledge gaps. **Example:** Appointing a community liaison fostered two-way communication and helped build institutional trust in a Cape Cod pilot.[9]
Establish feedback mechanisms	Feedback provides personalized information on the use of a technology, typically with a measure of a physical characteristic like water usage or electricity consumption. It can describe an individual's performance towards reaching a goal (**Example:** reducing emissions) or provide comparisons of performance (**Example:** comparing an individual's electricity consumption to a neighbor's).[15,38] Cost is frequently used as a reference, providing individuals with feedback on costs associated with their consumption.[15,38] **Example:** Use existing reports/receipts on septic inspections/maintenance to provide feedback to homeowners on how much nitrogen they could divert from a local waterbody by installing an I/A system.

failed septic systems.[41] As a costly technology with recurring costs, I/A systems may not be appropriate for underserved communities without enduring support programs and subsidies to prevent exacerbating historic inequities and injustices.

Making Behavior Change Convenient

The cognitive effort to adopt a new technology affects decision-making. Within their busy lives individuals have limited attention and behaviors can be considered costly because of the time or effort to implement,[42] especially for complex, capital-intensive technologies like solar panels[21,23,25] or I/A systems. Limited time or non-monetary costs related to I/A system adoption include permit applications and approvals, system inspections, research, application for financial assistance, contractor identification, and displacement during system installation. As adoption must occur within homeowners' schedules where competition for time, attention, and spending are high, identifying and minimizing barriers confronted by homeowners may encourage adoption. To reduce the research burden, the Buzzards Bay Coalition, a pilot organization, worked with MASSTC to create a decision support tool for homeowners that considered rankings of I/A system characteristics including the initial cost, present worth, energy use, complexity, and aesthetics.[43] Based on these rankings, the tool suggested systems most aligned with those preferences. Establishing or appointing an organization to act as a responsible management entity (RME) to streamline the adoption process and manage monitoring and maintenance could also alleviate barriers. An RME could absorb many of the homeowner responsibilities, including hiring skilled contractors; managing the system approval; managing systems' operation, maintenance, and monitoring schedules; addressing issues; and communicating system care to homeowners clearly.[44] An RME could also provide informational and technical support to local governing authorities responsible for approving these systems, providing cognitive and capacity support to approving authorities as I/A technology and policy changes.

CONCLUSION

If I/A septic systems are to be a part of the toolkit for achieving water quality goals, they must be socially desirable. By applying lessons from the behavior change literature and learning from strategies that have worked for similar technologies, we highlight ways environmental managers and decision-makers can encourage adoption. A targeted approach that considers local context and addresses the needs and interests of user groups within communities will increase the prospects of adoption, as will building trust and partnering with local leaders and organizations to leverage relationships and credibility. Trust and credibility cannot be overlooked, as approaches to diffuse these systems will depend on how and by whom these approaches are promoted. Beyond engaging end users, implementing I/A systems on a wider scale will require changes to regulations; increased institutional capacity; investment in physical, financial, and management infrastructure to support system installers and homeowners; improved dissemination of performance and cost data; public support; and the political will to pursue a non-traditional wastewater technology.

ABOUT THE AUTHORS

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NEBRA Highlights

EPA, ECOS, and NASDA issue joint principles for PFAS in biosolids

EPA, the Environmental Council of the States (ECOS), and NASDA (National Association of State Departments of Agriculture) issued a joint statement[1] on July 24, 2023, outlining their principles for preventing and managing per- and polyfluoroalkyl substances (PFAS) in biosolids. In announcing the principles, EPA says it "is committed to working with its federal, state, and other partners to continue to prioritize protecting public health, support our nation's farmers, and work to ensure the availability of appropriate methods to manage biosolids." Signed by Radhika Fox, EPA assistant administrator for water, the document acknowledges the "presence of PFAS in biosolids is the result of the continued manufacture and use of these compounds throughout society, including by households, as well as industrial discharges of PFAS to wastewater."

The document includes guidelines for regulators and stakeholders to work collaboratively to "ensure the fate and transport of PFAS in contaminated biosolids do not result in harm to human health or the environment." The principles include the following:

1. Protect communities
2. Reduce the discharge of PFAS to prevent the contamination of biosolids
3. Aim to preserve flexibility and availability of options for the use and disposal of biosolids, while prioritizing public health protection
4. Ensure the continued safety of the food supply and support impacted farmers and ranchers
5. Educate stakeholders and communicate risk
6. Build capacity
7. Embrace transparency

EPA biosolids staff updates

Dr. David Tobias welcomed another staffer to his EPA biosolids team: Sophie Greene from the Minnesota Pollution Control Agency, where she was the PFAS coordinator. Sophie's previous work includes human health risk assessment and emerging contaminant prioritization for EPA. This will be helpful as EPA continues working on the risk assessment for PFAS in biosolids. With other team members Tess Richman and Dr. Lisa Weber, the biosolids team now includes four full-time employees to support all the ongoing biosolids regulatory work. The EPA Biosolids Program falls under the Health and Ecological Criteria Division, Office of Science & Technology in the Office of Water.

Take action today—urge Congress to protect water utilities from CERCLA and ensure polluters pay!

CERCLA liability still a concern for passive receivers

EPA has proposed to designate several PFAS compounds as "hazardous" under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA, more commonly referred to as the Superfund law) and plans to add more to the list. The agency said it would use its discretionary authority to target the sources of PFAS contamination, but that does not prevent private parties from bringing passive receivers, like water utilities, into a CERCLA cleanup action. A group including NEBRA, representing passive receivers, sent a joint letter to the Senate Environment and Public Works Committee on this issue. Congress is reviewing the issue now. NEBRA is encouraging members to reach out to their elected officials on this important issue. WEF's Water Advocate Program makes it easy at oneclickpolitics.global.ssl.fastly.net.

EPA biosolids community workshops

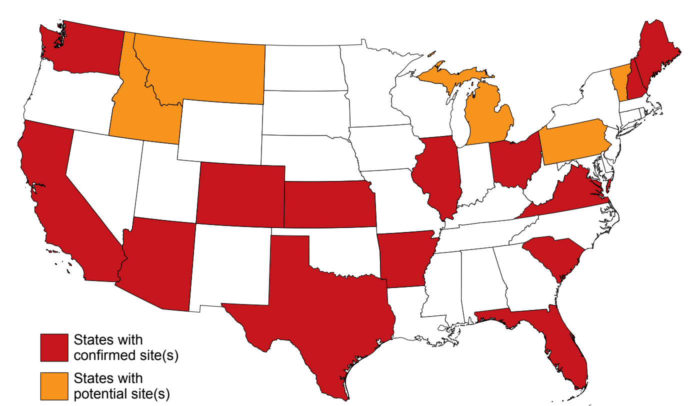
The EPA Biosolids Program at headquarters has initiated a series of interviews with regulators and the regulated community. Interviewees were selected based on recommendations from the Water Environment Federation and the National Association of Clean Water Agencies. The list of questions was extensive and broken down by biosolids end use (landfilling, incineration, and beneficial reuse). The goal is to collect and organize information and viewpoints from biosolids professionals. EPA is not seeking advice or recommendations from the group but will compile the information from the interviews. The group of 26 people to be interviewed includes familiar names from the Northeast representing organizations such as the New Hampshire Department of Environmental Services, NEIWPCC, the Vermont Department of Environmental Conservation, the Massachusetts Department of Environmental Protection, Maine Department of Environmental Protection, and the Portland (Maine) Water District.

Fourth draft method 1633 for PFAS released

In July, EPA's Office of Water, Engineering and Analysis Division, in collaboration with the Department of Defense, issued the 4th draft Method 1633, Analysis of PFAS in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS[2]. The fourth draft of Method 1633 includes wastewaters. Method 1633 is still a long way from formal promulgation through federal rulemaking where it would be approved for compliance testing. However, EPA says any major changes are unlikely and recommends the method for testing PFAS in aqueous matrices. Some National Pollutant Discharge Elimination System permits being issued in Massachusetts and other non-delegated states include the requirement. EPA anticipates the final version of Method 1633 for solid matrices and landfill leachate will be out in late 2023 or early 2024. See EPA's main page on Clean Water Act (CWA) analytical methods for PFAS for more information on this topic: CWA analytical methods for PFAS.[3]

National collaborative PFAS study update

The national study being led by Dr. Ian Pepper, director of the Water & Energy Sustainable Technology (WEST) Center at the University of Arizona, titled "Evaluation of Fate and Transport of PFAS Following Long-Term Land Application of Biosolids: A Collaborative National Study," is moving along now. For more information, including the background, objectives and methodology, see the National PFAS Research Study at nebiosolids.org. There is also an hour-long recorded presentation by Dr. Pepper about this project when it was being launched in 2022 at youtu.be/zy5A5Jg8GXk.



Land application sites for PFAS Study

Twenty-two sites have been identified to date to be part of the study, including one in New Hampshire and one in Maine. The soil sampling was started in the fall of 2022 and it is about halfway through the sites. This is not an easy project—especially when weather and other factors cause delays. Initial results show PFAS in soils at the sites to be in the low parts per billion range for most samples. Once sampling and analysis are completed, the researchers will move on to modeling. They expect to complete sampling by the end of 2023. Modeling should be done by the end of 2024.

Vermont Department of Transportation is using manufactured topsoil (containing biosolids) for improvement projects

VTrans removes temporary moratorium on biosolids-based manufactured topsoil

In 2023, NEBRA collaborated with the Green Mountain Water Environment Association (GMWEA) to share a "success story" about the approved use of manufactured topsoil (MFT) for Vermont Department of Transportation (VTrans) improvement projects. That story was about a VTrans project at the Park and Ride at Exit 12 on Interstate Route 89 in Williston. Biosolids make up only a small part of the MFT mix that also includes paper fiber, wood ash, and sand.

Shortly after publishing the success story, NEBRA learned that VTrans was concerned about PFAS and temporarily halted the use of biosolids-based MFT. This concern was generated by conversations VTrans was having with their peer agency at the Department of Environmental Conservation (DEC) about recent PFAS testing on biosolids.

The beneficial-use community rallied around this issue. After many conversations with stakeholders, and review of PFAS data and the MFT program, VTrans lifted the moratorium but did require regular testing of the MFT prior to use. Results are being compared to 2019 background concentrations for soils as established by the University of Vermont and Sanborn, Head and Associates study.[4]

The temporary moratorium in Vermont was based on concern about public perception initially. With materials meeting the screening standards, MFT is again being used on VTrans projects throughout Vermont. Increasing knowledge about product quality and sharing information with state regulatory agencies are essential for continued beneficial uses like MFT.

Update on two new committees

In April 2021, the NEBRA Board of Directors, at the urging and direction of then Vice President Lise LeBlanc, created two new committees that aligned with some of the strategic plan goals that the board started working on later that year. One committee, Residuals, is focused on non-biosolids residuals—an area NEBRA has not previously emphasized. The other committee, Carbon and Nutrient Trading, is charged with learning about carbon credits and nutrient trading programs that could benefit NEBRA members.

The Residuals Committee hopes to capitalize on the focus on reducing climate impacts of farming practices and other valorization. Its charge is to identify opportunities to expand

NEWEA/NEBRA Residuals Conference

Building on its "solid" success in 2022, 133 participants turned out for the Northeast Residuals & Biosolids Conference's return to Portsmouth, New Hampshire, for the 2023 conference on November 1 and 2. The theme was *Overcoming Challenges to Resource Recovery.* People came from as far as California, and there was a large Canadian contingent including representatives from the provinces of Nova Scotia, Quebec, and Ontario. There were 11 technical presentations, a roundtable discussion on PFAS with much audience participation, a sold-out exhibit space, and many networking opportunities. Copies of all presentations are available on the NEBRA website.

Conference attendees tour Portsmouth's Peirce Island Wastewater Treatment Plant

INSERT: Outgoing NEBRA President Deborah Mahoney passes the gavel to incoming President Lise LeBlanc of Nova Scotia

NEBRA's role in providing expert advice and information in support of programs reusing or recycling waste and by-products. The goal is to make NEBRA the go-to organization for residual opportunities across North America.

The Residuals Committee has found so far that few member organizations are focused on recycling waste residuals such as wood ash, pulp and paper, food and beverage, inorganics, and hydrosolids (or drinking water residuals). The committee has compiled residuals regulations across all the states and provinces in North America and has found that regulations related to various residuals vary from state to state and province to province. Some regulate them just like biosolids, some like solid waste, while other products—particularly organic residuals—are often included in mandatory recycling programs, especially in Canada. The committee's new webpage will include the compiled regulatory information.

The Carbon and Nutrient Trading Committee started by collecting information on Canadian and United States programs, including federal and provincial/state-level programs, for carbon and nutrient trading. It became clear that nutrient trading programs are geographically specific (Water Quality Trading and Offset Programs by State | The Environmental Trading Network[5]), and only a few exist in the Northeast region. As a result, the committee's focus (and its name) shifted to carbon trading programs and projects.

The committee's goal was to help develop one residuals land application project for carbon credits in the Northeast. There were numerous challenges and barriers to accomplishing this. For example, the committee learned early on about the Natural Resources Conservation Service's (NRCS's) Soil Carbon Amendment practices, which could benefit farmers using biosolids-based soil amendments. However, in May 2022, NRCS proposed its Code 336, Conservation Practice Standard for Soil Carbon Amendment (336-CPS), which excluded biosolids-based products. The committee helped NEBRA write a comment letter [see nebiosolids.org]) in June 2022, but the response rejected the idea of developing a regional farm-based carbon credit project.

Nonetheless, the Carbon Trading Committee learned a lot and is preparing a report to allow NEBRA members to discover more about the carbon markets. Owing to guest speakers with expertise on various aspects of carbon trading, the committee heard about various concepts, including regulatory versus voluntary carbon markets, "additionality" (*The Concept of Additionality in the Voluntary Carbon Market, Explained*[6]), standards for certifying carbon credits, and program challenges. The speakers included Scott Subler, ClimeCo; Dr. Glenn Dale and Andrew Yates from Verterra, an Australian company; Serge Loubier with Englobe, who discussed using an asbestos mine reclamation project for carbon credits; Megan McCarthy with ROCarbon of Canada; and Andrew Friedenthal with CHAR Technologies on biochar credit programs. One thing learned is that Canada's current programs are more robust than those in the United States.

Read more on these topics and stay abreast of the latest biosolids/residuals news and events at nebiosolids.org/news. For upcoming events, go to the events page of NEBRA's website.

1 https://www.epa.gov/biosolids/joint-principles-preventing-and-managing-pfas-biosolids
2 https://www.epa.gov/cwa-methods/cwa-analytical-methods-and-polyfluorinated-alkyl-substances-pfas#documents
3 https://www.epa.gov/cwa-methods/cwa-analytical-methods-and-polyfluorinated-alkyl-substances-pfas#documents
4 https://anrweb.vt.gov/PubDocs/DEC/PFOA/Soil-Background/PFAS-Background-Vermont-Shallow-Soils-03-24-19.pdf
5 http://www.envtn.org/water-quality-trading/state-programs
6 https://www.forbes.com/sites/forbesnonprofitcouncil/2021/10/01/the-concept-of-additionality-in-the-voluntary-carbon-market-explained/?sh=6a523d278ecb

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North East Biosolids & Residuals Association

Innovative workforce development through the local school system

The York Sewer District, in collaboration with the York Water District of Maine, has been developing an internship program with York High School

Hiring and training new employees requires investment by the hiring entity, and in our industry, misconceptions often exist about the work we do. The York Sewer District, in collaboration with the York Water District of Maine, has been developing an internship program with York High School. The program aims to inspire the next generation of water and wastewater workers and, in turn, offset expected retirements which could lead to a severe labor shortage.

In its infancy, the workforce development program began as community education and outreach. In the fall of 2019, the York Sewer and Water districts held their first event for the York School Department. This event fell in line with the national Imagine a Day Without Water, and we created an event with hands-on demonstrations that allowed students to explore and understand the services both districts provide. The districts continued to work with the schools during the pandemic, providing educational tools and learning activities while students were at home.

After district employees attended a diversity, equity, and inclusion training at the NEWEA Spring Conference in May 2022, the idea for an internship program with the local school system was born. Immediately following the conference, the York Water and Sewer districts held their second Imagine a Day Without Water event at the Village Elementary School in York. This is where inspiration struck through conversation with the principal and curriculum director.

Over the next four months, the districts continuously met with the curriculum director and principal to establish the internship program. During this time, the curriculum director toured the facilities and saw what the program would include. After touring both the facilities, the curriculum director was more aware of what kept wastewater and water infrastructure running and the different job opportunities within the facilities. When matching up program content with the state standards, it was determined that participating students would receive a partial math credit and partial science credit for completing the program. Students would also receive authentic experience, such as safety training, exposure to new software, insight into resource protection, treatment, collection systems, and potential job opportunities.

Inaugural intern—James Jacobsohn

This intern had never considered a career in water until completing the program, but subsequently he took a full-time position with the York Water District

Through the program, students would complete one semester with the sewer district and one with the water district. At the end of the internship, students could take either the wastewater exam or water operator-in-training exam. Students who passed their exams would receive their licenses on the day of graduation from York High School.

The York Sewer and Water districts welcomed their first intern, James Jacobsohn, a senior at York High School, for the 2022–2023 school year as a pilot program. The student spent half a semester at each location with two to three hours each day (twice per week) earning science and math related credit.

This internship was eye-opening for the student, realizing the complexity of the work. This intern had never considered a career in water until completing the program, but subsequently he took a full-time position with the York Water District. The pilot program was a success, and the districts hope it will continue and help fill these essential public service positions throughout the state.

Committee Focus

Water Innovation

The Water Innovation Committee sits within the NEWEA Innovation Council and fosters connections among innovators in public, private, nonprofit, and academic organizations to bring new solutions to New England's municipal and industrial water and wastewater market. The Innovation Committee also organizes networking and knowledge-sharing events that highlight water innovation in New England, such as Pitch Nights and the Innovation Pavilion at NEWEA's Annual Conference. To learn more about the Water Innovation Committee, the *Journal* reached out to the current director of the Innovation Council and previous chair of the Innovation Committee, Michael Murphy.

Journal *What does the Innovation Committee focus on?*

Connecting innovators with the public and nonprofit domains, investors, universities, pilot opportunities, and potential partners. We do that by making introductions, brokering partnerships, and organizing events that highlight water innovation in New England.

Michael Murphy

■ *Are you looking for new members?*

Yes! NEWEA members interested in joining the Water Innovation Committee are encouraged to reach out to either the current Innovation Council Director, Michael Murphy (mmurphy.m2@pm.me), or the Innovation Committee chair, Chi Ho Sham (chihosham@gmail.com). You can also submit a committee application through the NEWEA website.

■ *Why Join the NEWEA Innovation Committee?*

We suggest that you consider joining NEWEA Innovation Committee if you are looking to become part of a larger community of professionals who are passionate about ensuring a sustainable future for our waterways and environment. Additionally, consider joining if you want to expand your network and share ideas with water professionals to bring solutions to the market faster and more effectively. If you are looking to increase your market reach, attract talent, or perhaps establish new partnerships, the NEWEA Innovation Committee can benefit you and your company.

■ *What is it about New England that sets us up to be leaders in water innovation?*

New England typically enjoys clean and ample water supplies, excellent utilities, effective local leadership, and engaged citizens. To address your question, I encourage readers to think about how strong of an entrepreneurship and investor community we have here. Building on that, New England enjoys an enviable portfolio of resources from which to create, incubate, grow, and commercialize companies. From world class universities, strong precedent of technology hubs, supportive local, state and regional governments, a diverse and highly skilled workforce, and other attributes, New England has everything needed to be a leader in this sector.

■ *What is next for innovation and the municipal water market?*

The digital transformation of municipal water and wastewater municipalities to "smart utilities" is happening and will only proliferate as grids, networks, systems, businesses, and people become more connected. Three questions to consider:

1) What are some factors that slow the digital transformation of municipalities?

There are number of headwinds in the municipal water sector that often make adoption a long and arduous journey to market traction. Smart water technologies across utilities are not sufficiently standardized. This leads to managers selecting from an array of distinct technologies that are typically in use for a long time, potentially reducing the benefits of information sharing between municipalities. That gets to the second point. Where possible and most effective, data and successful tech implementation strategy need to be more widely shared. This leads to efficiency gains. Additionally, and we all know this one, there is a generally a low tolerance for risk, which is understandable given how little incentive utilities have when taking additional risk. Wherever possible, government and industry leaders must incentivize shared risk-taking and reward successful adoption of innovative solutions. While water should be planned for and managed as One Water, a collective resource across wastewater, water, and stormwater, the reality is that fragmentation impedes alignment. If we look at the energy sector, there are only 1,600 utilities according to the U.S. Energy Information Administration (EIA). In contrast, there are approximately 16,000 wastewater utilities and 155,000 water treatment utilities. Understanding that energy and water are two distinctly different sectors with their own sets of circumstances, less fragmentation on the energy side affords greater standardization and alignment.

2) How would municipalities benefit from the digital transformation of the industry?

As the industry continues to embrace this evolution, operators and managers must work at even greater levels of effectiveness, whereby the quality and quantity of clean and safe water provided will increase. Opening data pathways and information sharing should improve utility resilience as operations would be optimized. Implementing tools across the one water paradigm would help managers collaborate more transparently. Smart Water Magazine writes that the "digital transformation can help water utilities and municipalities better understand water supply and demand patterns, identify inefficiencies and opportunities for optimization of water usage, reduce water losses, embrace water reuse and circular economy principles at every scale, and develop more effective water management strategies. These technologies can also help provide real-time monitoring of water quality, enabling rapid response to water quality issues and emergencies, and tracking when and where water is needed and which quality."

3) What factors can accelerate the digital transformation in municipalities?

An increased focus on the benefits to end users will help. For example, with increased awareness, visualized and actionable information will positively affect end-user behavior. Mentioned earlier but worth noting again, we need to develop opportunities for shared risk-taking and incentivize greater risk tolerance when demonstrating new tech. This is an open question, but how can we encourage utilities to share information more than is currently practiced? What is the long-term opportunity cost of not implementing smart water tech? I believe we must continue to build and strengthen workforce development programs built around the importance of smart water and the digital transformation of water and wastewater.

■ *What are some projects the Innovation Committee is working on?*

The primary activity for the Innovation Committee throughout the year is to help innovators connect with partners, investors, potential clients, pilot opportunities, and whomever we can. The goal is to collectively develop and accelerate technologies to municipal markets in New England, across the country, and globally.

Each year, NEWEA holds its Annual Conference & Exhibit in Boston, and the Innovation Committee, for the last six years, has organized an Innovation Pavilion typically held on day two of the summit. The Innovation Pavilion provides a forum for sharing new ideas, enables innovators and researchers to get input from people on the front lines of providing clean water, and helps them create enduring connections so they can continue building their company and developing their technology.

■ *What is your favorite part of co-chairing the NEWEA Innovation Committee?*

NEWEA has long history; however, the focus on innovation is still nascent. This provides a wonderful opportunity to help shape the sector in New England going forward.

I collaborate with a wide range of stakeholders, including government agencies, non-government organizations, research institutions, and private-sector companies. This provides opportunities to grow symbiotic networks and engage in and help broker meaningful partnerships.

…this role allows me to help innovators with cutting-edge technology improve efficiency, reduce and recover waste, decrease pollution, and help make a positive environmental impact

Most of us are passionate about environmental conservation and sustainability, and this role allows me to help innovators with cutting-edge technology improve efficiency, reduce and recover waste, decrease pollution, and help make a positive environmental impact.

In closing, there are many wonderful and efficient solutions that should find a market. We often hear that the water industry does not have a shortage of innovative tech. In contrast, the primary headwind is one of scaled adoption and implementation. A digital transformation at water utilities is slowly underway and a continuation of this path is required. In doing so, a bold vision, a thoughtful plan, and a strong ability to execute and achieve desired results is how the digital transformation will be realized.

Supporting Resources:

- https://www.xylem.com/en-us/making-waves/water-utilities-news/5-experts-on-the-impact-of-smart-water/
- https://blog.se.com/industry/water-and-waste-water/2021/06/23/how-digitization-contributes-to-global-water-sustainability-goals/?utm_source=water_world&utm_medium=banner&utm_campaign=iotf&utm_purpose=marketo
- https://smartwatermagazine.com/news/smart-water-magazine/digital-transformation-water-sector-a-game-changer
- https://www.eia.gov/todayinenergy/detail php?id=40913

New Members

September–November 2023

Anthony Avanzato
City of Westfield
Westfield, MA (UPP)

Casey Barber
Greenwich, CT (CORP)

Rhudean Bull
City of Stamford WPC
Stamford, CT (PRO)

Lyndsay Butler
Town of Newmarket
Newmarket, NH (PRO)

Daniel Cho
Onvector
Somerville, MA (PRO)

Chris Cogan
Portland Water District
Portland, ME (UPP)

Shaun Collum
Saunderstown, RI (PWO)

Damilola Daramola
Northeastern University
Boston, MA (ACAD)

Michael Dodson
CDM Smith
Manchester, NH (PRO)

Bill Garrison
Heritage Environmental Services
Sellersburg, IN (EXEC)

Ashley Harrington
NEIWPCC
Lowell, MA (PRO)

Richard Higgins
Onvector
King of Prussia, PA (PRO)

James Katz
Kennebunk Sewer District
Kennebunk, ME (UPP)

Kirsten King
NEWWA
Holliston, MA (PRO)

Carrie Lafond
Town of Fair Haven
Fair Haven, VT (PWO)

Michael Lajoie
City of Westfield
Southampton, MA (UPP)

John Marcin
Veolia
Lexington, MA (PRO)

Michael Nicholson
Ecoremedy
Pittsburgh, PA (PRO)

Matt Phillips
GWTT
Wharton, NJ (EXEC)

Joseph Prata
NBC
Providence, RI (PRO)

Vishwa Raval
Hazen and Sawyer
Wethersfield, CT (PRO)

Mohammad Rostampour
Infiltrator Water
Old Saybrook, CT (YP)

Konnor Scarponi
Brunswick Sewer District
Brunswick, ME (UPP)

Jake Shactman
Wright-Pierce
Portsmouth, NH (YP)

Caleb Shen
Thompson Pipe Group
Boston, MA (PRO)

Sarah Smith
Maine DEP
Augusta, ME (YP)

Beau Tucker II
Veolia
Boston, MA (EXEC)

Academic (ACAD)
Affiliate (AFF)
Complimentary (COMP)
Corporate (COR)
Dual (DUAL)
Executive (EXEC)
Honorary (HON)
Life (LIFE)
Public Official (POFF)
Professional (PRO)
Wastewater Treatment Plant Operators (PWO)
Retired (RET)
Student (STU)
Utility Partnership Program (UPP)
Young Professional (YP)

YP Spotlight—*Committee Chair*

In 2024, Daryl Coppola will complete his tenure as Young Professional (YP) Committee chair, and Emily Korot will be stepping into the position. (Don't worry, Daryl isn't going anywhere. He will be taking on a new role as the Outreach Council director in January!) For this edition of the *Journal*, we reached out to the outgoing and incoming chairs, to learn more about what it takes to lead the mighty YP Committee, and the role of YPs in innovation.

Journal *Daryl, leading the YP Committee is no small feat! What have been the highlights of your tenure?*

Daryl: I have loved so many moments leading and being a part of the YP Committee. I remember first stepping into the role and how nervous I was. One of the biggest parts of being chair is being the MC/host of the YP summit. I will never forget my very first summit, I got to the meeting room at 7 AM for a 9 AM start. I was so nervous; I had never spoken in front of 90 people, and I thought if I got there super early it would make it easier. Once I got through opening remarks, it was all downhill and got so much easier. I am hosting my third and final YP summit in January; it's bittersweet because this is my last one. Some memories I will treasure are all the YP summits. Somehow, we managed to top the year before and get better each year. All the great networking events we hosted. Winning the 2023 meme contest. And most importantly, all the friendships I have made working with some of the best YPs in our industry.


Daryl Coppola


Emily Korot

■ *Here's one last chance at the podium. Anything you'd like to share with the committee and the new YP chair?*

Daryl: I first want to give a huge shout out and thank you to the committee as a whole. All the volunteers and members made my job super easy. I joined the committee about four years ago, and it was the best thing I ever did. If you are unsure about joining a committee, I highly recommend it. You get what you put into it and you can put as much or as little as you want. Very thankful for this opportunity to lead such an amazing group. Also, huge shout out to Janice, Jordan, Heather, and Mary. As a new chair they all helped me so many times! And for Emily: Dive in headfirst and don't look back. As scary as it felt I regret nothing. Trust your committee and use their skills to help grow your committee. Take risks and don't be afraid to change things; always strive to do better than the last chair.

■ *Emily, we are excited for you to step up as the new YP chair. What aspirations do you have for the YP Committee for the next three years?*

Emily: I want to extend a big thank you to Daryl Coppola for his outstanding leadership and dedication to the YP Committee over the last few years. I am thrilled (and honored) to take on the chair of the YP Committee. My main goal as the incoming chair will be to support fellow young professionals and empower others to get involved in NEWEA. I think the YP Committee provides a unique opportunity for young professionals early in their careers to develop leadership skills through organizing events, leading initiatives, and taking on responsibilities that contribute to the growth and success of the industry. I would like to help maintain the strong network of passionate and engaged young professionals. And have some fun along the way!

■ *On to the Journal theme. What roles do you see young professionals, and the YP Committee, playing as our industry strives to innovate?*

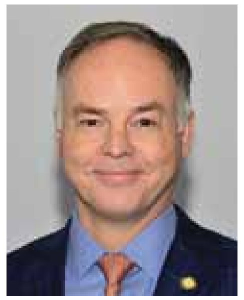
Emily: In today's rapidly evolving landscape, our industry is facing unprecedented challenges, and innovation will play a key role in our ability to address these issues. I think young professionals are well-positioned to champion the adoption of cutting-edge solutions in the water sector. Their familiarity with digital tools and data analytics, coupled with a passion for environmental sustainability, can help streamline processes, enhance efficiency, and improve overall performance. The YP Committee can serve as a platform for connecting with peers and seasoned industry professionals to foster a culture of inclusivity, creativity, and innovation. I am looking forward to the upcoming NEWEA Annual Conference with the theme of One Water, to learn more about how innovation can play a role in a holistic approach to water management.

■ *Do you have any fun facts that you would like to share with NEWEA readership?*

Daryl: I am big outdoors person, I love camping, hiking, fishing, etc. I love the work I do because it helps preserve my favorite places. When I am not camping, I am usually coaching girls' softball, another huge passion of mine.

Emily: I serve as a professional mentor to the Northeastern Chapter of Engineers Without Borders Panama project. The chapter is working with the NGO (non-governmental organization) Sustainable Harvest International and the community of La Pedregosa to address the lack of reliable drinking water. The goals of this project include the identification of an adequate water source, an improvement of the current distribution system, an increase in water storage, and the commissioning of a complete and sustainable water distribution system.

WEF Delegate Report



Peter Garvey

This is my final opportunity to share an update as a WEF delegate representing NEWEA. My term concluded at the recent WEFTEC conference in Chicago. That conference was the highlight of the last quarter, and it was great to see our other NEWEA delegates, Janine Burke-Wells and Virgil Lloyd, Delegate-at-Large (DAL) Matt Formica, and our latest delegate nominee, Emily Cole-Prescott, at the conference. We were all active representing NEWEA during the Saturday and Sunday House of Delegates (HOD) meetings and breakouts before the full conference started. The HOD welcomed a new speaker, Alexie Kindrick, as outgoing speaker Donnell Duncan summarized this year's events and his vision of the future for WEF and the HOD.

I look forward to continuing to promote advocacy for water and "Life free of Water Challenges," aligned with WEF's Strategic Plan

My activities during the quarter continued with co-leadership of the Water Advocacy workgroup. Because of that topic's importance, the HOD approved a new Water Advocacy Community starting this year, and during this first year, I will co-chair that community. I also remained involved with the HOD Nominating and Steering communities during the last quarter.

As my NEWEA delegate term wrapped up, I started a new role at WEF as DAL. In addition to the delegates sent by each member association (such as NEWEA) WEF has 12 DALs, with four new DALs cycling in each year. Any WEF member can apply to be a DAL—selecting a constituency to represent. I had applied for the role in May, proposing to represent WEF's almost 1,000 Water Advocates as my constituency, and I was selected as one of the four new DALs this year. I look forward to continuing to promote advocacy for water and "Life free of Water Challenges," aligned with WEF's Strategic Plan.

I am grateful to have represented NEWEA at WEF, and I'm confident that Jim (on behalf Ray Vermette), Janine, Virgil, and Emily will continue to fly NEWEA's flag high.

Jim Barsanti (for Ray Vermette)

I am happy to report my close friend and fellow WEF delegate Ray Vermette continues to recover from his health challenge. When we recently spoke, Ray informed me he would return to work in Dover in December to a new management position overseeing the operation of the city's wastewater treatment facility and pumping stations. Ray has requested to have me continue (and I have agreed) to serve as interim delegate for him. We all look forward to him returning with us and contributing his many talents to our NEWEA events in 2024.

Unfortunately, owing to family issues of my own including a second bout with Covid, I could not join other delegates and NEWEA colleagues at WEFTEC in Chicago. However, I have completed my term with the HOD WEF Member Association Exchange (WEFMAX) Community. Our community coordinated successful WEFMAX meetings in St. Louis, Denver, and Charlottetown, Prince Edward Island, Canada. In 2024, the Virginia Water Environment Association (WEA) will host one WEFMAX event in Old Town Alexandria in April, while in May the Utah WEA will host one in Park City and the Florida WEA will host one in St. Petersburg. More details will be shared by the host delegates in 2024 as each program agenda is developed.

I encourage all our NEWEA members to consider participating in WEFMAX events. They provide a great opportunity to network with WEF colleagues and learn about the activities and initiatives of the various member associations. I also served on the HOD of the Future workgroup. Our workgroup was challenged with aligning HOD activities with the WEF Strategic Plan, increasing delegate participation in communities and workgroups, and developing a vision for the future of the HOD. First-year results were presented to the HOD at WEFTEC, and given the magnitude of this workgroup's charge, its work will continue for another year to further address these objectives.

In addition to my duties as an interim delegate, I continue to serve on the WEF Community (formerly Committee) Leadership Council (CLC) as a community of practice director for operations and maintenance. My role in WEF is similar to our council director positions in NEWEA. I work with the WEF Laboratory Practices, Plant Operations and Maintenance, and Operations Challenge communities, and the Operators Advisory Panel. My role is to help the communities coordinate and develop activities, promote collaboration among the communities at both the WEF and member association levels, and develop future community leaders. In addition to these duties, I have been asked by the CLC chair to develop a WEF Community review process similar to the one our NEWEA Assessment and Development Committee uses to review committees. I will provide more information in my next report as this assignment evolves.

Virgil Lloyd

While attending the WEFTEC conference in early October in Chicago, I officially started my term as the newest NEWEA WEF delegate. I am thrilled and honored to represent our organization on this national level, and I am also humbled when I see the list of names from NEWEA who have preceded me over the years in this important role. My grateful thanks to NEWEA for asking me to serve in this leadership position.

Speaking of leadership, the HOD does not believe in wasting time and, to that end, encouraged and supported the incoming delegates during the run-up to WEFTEC with many virtual meetings and emails. This process helps the new delegates maximize their time and hit the ground running, and, in fact, I felt I had already developed many relationships even before this year's conference began.

I am proud to announce I have been selected as one of the eight members on the HOD's Diversity, Equity, and Inclusion (DE&I) Community. I look forward to sharing the dynamic and energetic activities of NEWEA's DE&I Committee with other delegates from around the country, as well as bringing back thoughts and ideas from other geographic and demographic perspectives.

In addition to the DE&I Community, over the coming year I will participate in several HOD workgroups, including the Workforce Development one. This workgroup focuses on a topic NEWEA has invested much time in recently. NEWEA is launching a creative regional workforce development initiative, and I look forward to sharing that, learning what other organizations are doing, and exploring their approaches to this vital topic. More to come!

Janine Burke-Wells

Since my last report, I have been finishing up my assignments from last year and signing up for new assignments for 2024. In 2023, I helped with the rollout of WEF's Strategic Plan, which included compiling feedback from all the WEFMAX sessions where the new plan was discussed. The feedback from the WEFMAX sessions was consolidated and organized into a presentation at the HOD meeting on September 30.

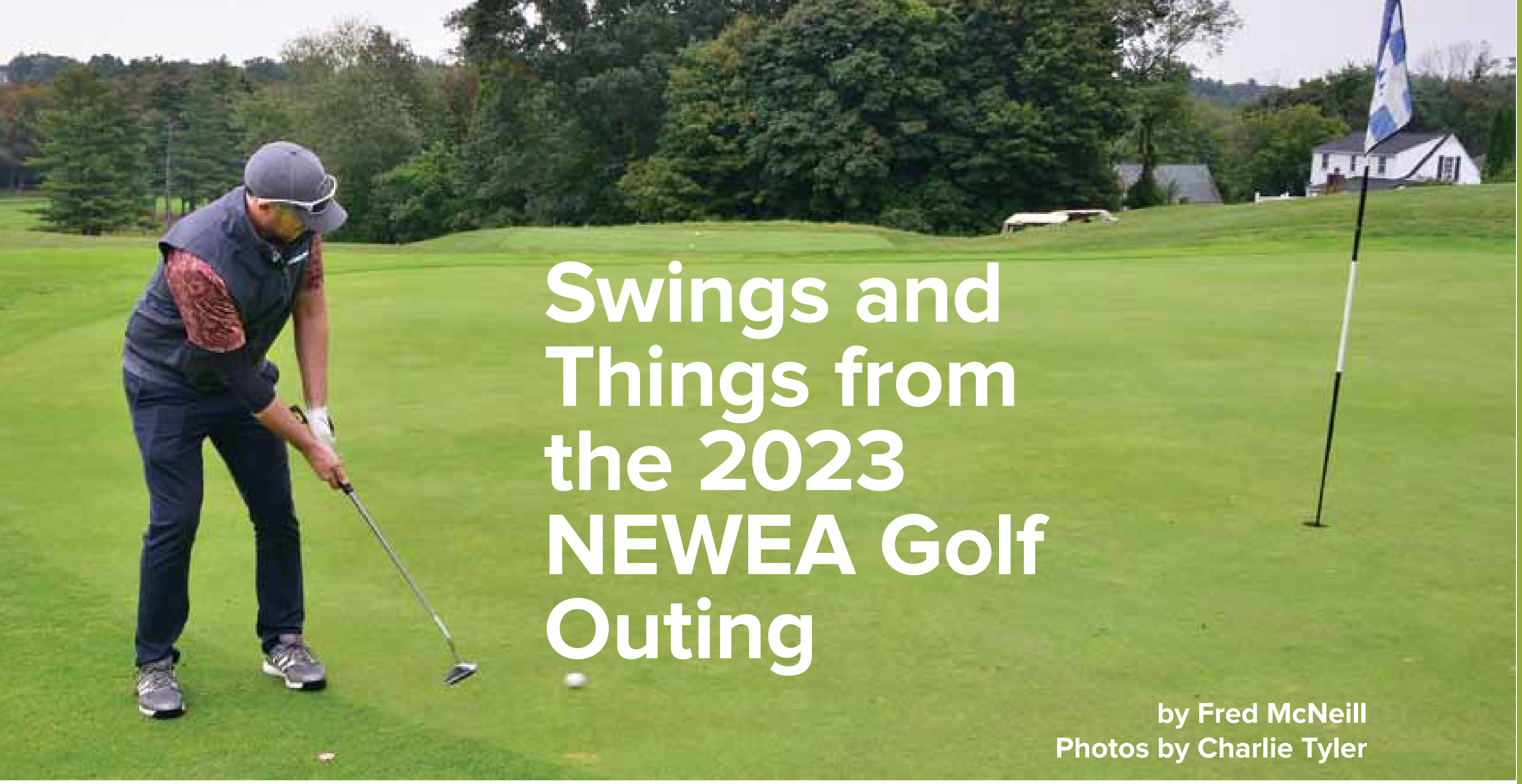
HOD Strategic Plan rollout

While I could not attend an in-person 2023 WEFMAX, I did attend the virtual one on July 20. I also attended quarterly HOD meetings and the annual HOD business meeting held virtually in September. I wholeheartedly voted for two new WEF communities in 2024 to address communications and water advocacy.

For 2024, I have signed up for several WEF HOD communities/workgroups, including the following:

- HOD Strategic Plan workgroup (separate/different from WEF's Strategic Plan)
- HOD Budget Community
- HOD Emerging Leaders Community
- HOD Water Advocacy Community (new!)

I look forward to continuing to serve in 2024 as a NEWEA delegate to WEF.



Swings and Things from the 2023 NEWEA Golf Outing

by Fred McNeill
Photos by Charlie Tyler

On a cool, gray fall day with dark clouds dancing dangerously overhead, NEWEA hosted its annual fall golf tournament at Derryfield Country Club in Manchester, New Hampshire. This is the third year Derryfield has hosted our fall golf event; the beautiful fall vistas, challenging terrain, and inviting post-game deck have made this course a fan favorite as evidenced by the event's early sellout this year.

As visitors arrived from all corners of New England, they had a chance to catch up with old friends, make new ones, and trade industry gossip. Players enjoyed a continental breakfast and early morning fortifying beverages, and then hit the putting green to hone their skills for the big golf tournament. At 9 AM, 29 teams, totaling 116 players, headed out in a shotgun start in search of those elusive birdies and even more rare eagles over 18 holes of lush fairways and lightning-fast greens.

Hoots and hollers could be heard throughout the morning as teams stiffed their approach shots and sank their putts. A tournament favorite, the putting contest was hosted by longtime industry and NEWEA leaders Meg Tabacsko and Mario Leclerc. Each team stopped by to test their skills after the 9th hole with three putts per member. It was great to see the comradery as teams tried to will the ball into the cup on a tough uphill putt. Chronicling all of the action with his trusty camera was NEWEA's legendary lensman Charlie Tyler. Charlie took team pictures and action shots, and also captured those spontaneous moments we have all come to enjoy when admiring his photojournalism. Despite a few chilly morning showers, all the golfers finished their rounds relatively dry and headed back to the clubhouse to tally the scores and enjoy a grilled steak lunch.

After lunch it was time for the awards ceremony, which started with the skill prizes that were awarded for the putting contest, closest-to-the-pin, longest drive, and straightest drive. Our friends from Carlsen Systems, led by Brian Olsen, won the putting contest. Cashing in on the closest-to-the-pin prizes were former NEWEA Treasurer Mac Richardson, Dennis Vigliotte, and Dennis Healy. Closing out the skill prizes were Tara McManus and Ian Gervais, who won the respective long-drive titles with a couple of bombs on the 420 yd (384 m) 2nd hole, and, last but not least, Kathy-Rae Emmi, who won the straightest drive on the long uphill par 5 17th hole. Helping out with the awards ceremony was past NEWEA President Ray Vermette. Ray has been battling an aggressive form of leukemia over the past year, and it was great to share time with him and see his smiling face again light up a NEWEA event.

Following the skill prize awards, it was time for the tournament tally. Coming in a respectable third place with a stellar nine-under 61 was Team Kleinfelder, led by Ian Gervais. Grabbing second place, also with a 61, was the Victaulic Couplings team, led by cool DJ Tanner. The winner of NEWEA's 2023 Fall Golf Tournament was Team Arcadis, led by New Hampshire newcomer Scott Haynes, with a ten-under 60. This was exceptional scoring on such a cool and windy fall day. Next on the golfing agenda was over $2,000 in raffle prizes courtesy of our generous sponsors. Prizes included drivers, 3-woods, wedges, bags, and plenty of other golfing goodies. Congratulations to all our winners and participants.

As it began to rain harder outside and the crowd thinned out inside, the last of the golfing gang shared one more story, one more toast, and a pledge to see each other next year. As always, we thank our sponsors whose generosity and participation are what make this such a successful and fun-filled event for NEWEA. We look forward to seeing you next year for our annual fall golf tournament on Friday, September 27, 2024, at Derryfield Country Club.

1. Stacy Thompson high-fives Fred McNeill after winning a new iron in the raffle
2. Kathy-Rae Emmi, Dennis Healy, and Evan Dalton warm up before lunch
3. The winning team: Scott Haynes, Bill Boornazian, Ron Kelton, and Sean Mitchell congratulated by Fred McNeill, center
4. Patty Rimkoski and Rich Lapointe on their way to register for the event
5. Deb Mahoney clowning with Mario Leclerc at the putting contest
6. Chris Hayward celebrates winning a new driver in the raffle

One Water: All for One and One for Water

Annual Conference & Exhibit Preview

January 21–24, 2024 • Boston Marriott Copley Place, Boston, MA

This year's event theme is One Water, a holistic, collaborative approach to water management to ensure the sustainability and long-term resilience of our water resources. The One Water movement promotes transformative solutions to solve the most pressing challenges impacting the water environment. Many elements of this year's program will address key themes related to One Water.

The program features 37 technical sessions, a Student Poster Competition showcasing the work of water quality undergraduates and graduates, the Innovation Pavilion, and two floors of exhibitors highlighting the industry's latest products and services.

The conference commences on Monday with six morning and seven afternoon technical sessions on key industry issues. The Opening Session at 11:00 AM will convene attendees to hear from NEWEA and WEF leadership and our 2024 Keynote Speaker, Dr. Jonathan Gruber, MIT Economist and Health Reform Architect. Undergraduate and Graduate students will present their research in the Student Poster Competition throughout the day. The afternoon winds down with the first of two Exhibit Hall receptions on the 3rd floor.

Tuesday offers another full day of exciting events. We celebrate and recognize operators by offering morning and afternoon Plant Operations technical sessions, as well as the lunchtime Operator's Reception. A Plenary Session will be held from 11:00 AM to 12:30 PM, featuring a 45-minute panel discussion on existing and emerging challenges impacting our water resources followed by 45 minutes of pitches from innovators developing solutions to address these issues. These water industry innovators will also showcase their technologies and foster discussions on water innovation at the Innovation Pavilion, taking place in the Arlington Room. The day concludes with an Exhibit Hall reception on the 4th floor.

The final day of the conference features exhibits and morning and afternoon technical sessions, our lunch-time awards ceremony recognizing outstanding efforts in our industry, and the passing of the gavel to the 2024 NEWEA President, Scott Goodinson of Narragansett, Rhode Island. We hope you take advantage of all the 2024 Annual Conference has to offer and use this occasion to connect with and support your water industry colleagues.

We wish to recognize the significant efforts of the Meeting Management Council and members of the Program, Registration, Exhibits, and Awards Committees who make this conference one to look forward to each year. Thanks to the members of all the technical committees who review abstracts, moderate sessions, and provide the technical and subject matter expertise we need to do our jobs better. This conference would not be possible without the tireless efforts of the NEWEA office staff: Mary Barry, Janice Moran, Jordan Gosselin, and Heather Howard. Thank you for your dedication, energy, professionalism, new ideas, and patience in planning and coordinating this great event every year!

Robert Fischer, NEWEA President
Maureen Neville, NEWEA Program Committee Chair

Conference Events

SUNDAY, JANUARY 21

YP Summit (4th Floor)........................9:00 AM – 5:00 PM
Registration (4th Floor)........................Noon – 4:00 PM

MONDAY, JANUARY 22

Registration (4th Floor)........................7:00 AM – 6:00 PM
Technical Sessions 1 – 6........................8:30 – 10:30 AM
College Student Poster Board Competition........................9:00 AM – 2:30 PM
Exhibits........................10:30 AM – 6:30 PM
Opening Session........................11:00 AM – Noon
Technical Sessions 7 – 13........................2:00 – 4:30 PM
Exhibit Hall Reception........................4:30 – 6:30 PM

TUESDAY, JANUARY 23

Registration (4th Floor)........................7:00 AM – 6:00 PM
Exhibits........................8:00 AM – 6:30 PM
Innovation Pavilion........................8:00 AM – 4:30 PM
Technical Sessions 14 – 19........................8:30 – 11:00 AM
Tuesday Keynote Presentation........................11:00 AM – 12:30 PM
Technical Sessions 20 – 25........................2:00 – 4:30 PM
Exhibit Hall Reception........................4:30 – 6:30 PM

WEDNESDAY, JANUARY 24

Registration (4th Floor)........................7:30 AM – 2:00 PM
Exhibits........................8:00 AM – 1:00 PM
Technical Sessions 26 – 31........................8:30 – 11:00 AM
Awards Luncheon Ceremony........................11:00 AM – 1:00 PM
Technical Sessions 32 – 37........................1:00 – 3:00 PM

Conference Exhibitors

as of 11/15/2023

ABBA Pump Parts and Service
ADS L.L.C.
American Water Works Association
APTIM
Aqua Solutions, Inc.
Aquametrix by Water Analytics
AquaPoint
Aquatic Informatics
Asahi/America, Inc.
Atlantic Fluid Technology Inc.
Barton & Loguidice
BAU/Hopkins- Aqualitec/ Verder
BAU/Hopkins- cleanwater1/ Saf-T-Flo
BAU/Hopkins- Macurco/ Griffco
BAU/Hopkins- Netzsch/ Prime Solutions
BioSafe Systems
BMC CORP
Boyson and Associates, Inc.
Brown and Caldwell
C.N. Wood Co., Inc.
Carl Lueders & Company
Carlsen Systems, LLC
Casella Organics
Chadwick-BaRoss
Champlin Associates
CleanWay Environmental Partners, Inc
COPPOLA SERVICES INC
Core & Main
Corrosion Products New England
Coyne Chemical Environmental Services
Crane Pumps & Systems
CSI Controls
CUES, Inc.
Denali Water Solutions
Dewberry
DN Tanks
Duke's
EJ
Engineered Concepts Inc.
Environmental Operating Solutions, Inc. (EOSI)
EST Associates
F.R. Mahony & Associates
Flow Assessment Services LLC
Flow Tech, Inc.
Fluid Conservation Systems
Ford Hall
GA Fleet - Fleet Pump&Service
GeoTree Solutions
Green Mountain Pipeline Services
Guardian Energy Management Solutions
Hach Company
Hayes Group - Hayes Pump, Inc. - Walker Wellington - Atlantic Pump & Engineering
Hazen and Sawyer
Hobas Pipe USA, Inc.
Holland Company, Inc.
Hydro-Action
Industrial Flow Solutions
J&R Sales and Service, Inc.
JWB Company- Electroscan Inc/ Nivelco USA/ Autrol America
JWB Company- McCrometer- Open Channel Flow Products and Services/ Raco Manufacturing & Engineering Co
JWB Company- Pribusin Inc/ Motor Protection Electronics/ Sewer Watch-Eastech
JWB Company- Toshiba Magnetic Flowmeters/ Halogen Systems
Kasco Marine
Kiewit
Kleinfelder
LandTech Consultants, Inc.
Lane Enterprises,Inc.
M.A. SELMON COMPANY
Maltz Sales Company
Mass Tank Inspection & Services
Mechanical Solutions, Inc.
Metro Valve & Actuation Corp.
Monarch Instrument
National Water Main Cleaning Co.
New England Environmental Equipment
Newterra
Oakson, Inc.
Omya, Inc.
Orenco Systems
Pace Analytical Services
Pennoni
Polydyne Inc.
POND Technical
Primex Controls
Pump Systems Incorporated
Rain for Rent
REA Resource Recovery Systems
Resource Management, Inc.
RI Analytical Laboratories, Inc.
Russell Resources, Inc.
Sanitary Equipment Company Inc
Savy & Sons
Scavin Equipment Company LLC
Schneider Electric
Sealing Systems, Inc.
Sherwin-Williams Protective & Marine
StormTrap
Sullivan Associates/Ritec Environmental
Synagro Northeast, LLC
Technology Sales Associates
The MAHER Corporation
Ti-SALES
Truax Corporation
United Concrete Products
USABlueBook
Utility Systems Science and Software
VEGA Americas
Veolia
Vortex
Walker Wellington, A Hayes Pump Affiliate
WaterTectonics
Wescor Associates, Inc.
Williamson Electrical Co., Inc.
Xylem Dewatering Solutions
Xylem Water Solutions

CONFERENCE REGISTRATION

View the Preliminary Program and more information about the conference at annualconference.newea.org
Register online: https://2024-annual-conference-exhibit.events.newea.org/registration/register
Best Rate Deadline: Friday, January 5, 2024

EVENT HOTEL

Boston Marriott Copley Place Hotel
110 Huntington Ave., Boston, MA 02116
617-236-5800 • SINGLE—$214 • DOUBLE—$234
Reserve online: https://book.passkey.com/event/50598846/owner/249/home

2024 Award Recipients

NEWEA Awards

Alfred E. Peloquin, CT .... Thomas Tyler
Alfred E. Peloquin, ME .... Phil Tucker
Alfred E. Peloquin, MA .... John Downey
Alfred E. Peloquin, NH .... Sharon Nall
Alfred E. Peloquin, RI .... Nathan Boiros
Alfred E. Peloquin, VT .... Bernard Fleury
Biosolids Management .... Mary Waring
Clair N. Sawyer .... Nick Tooker
Committee Service .... Kevin Garvey
Diversity, Equity, & Inclusion Leadership .... Jasmine Strout
E. Sherman Chase .... Jane LaMorte
Elizabeth A. Cutone Executive Leadership .... Steven King
Energy Management Achievement .... Concord NH WWTP
Founders .... James Barsanti
James J. Courchaine Collection Systems .... Kevin Brander
Operator, CT .... David Milano
Operator, ME .... Keefe Cyr
Operator, MA .... Eric Kerr
Operator, NH .... Sam Heffron
Operator, RI .... Kathy Perez
Operator, VT .... Matt Dow
Past President's Plaque and Pin .... Frederick J. McNeill
Paul Keough .... Sarah Robertson
Young Professional .... Casey Rosenberg
Youth Educator Award .... Jeff Kalmes

NEWEA Recognition (Stockholm Junior Water Prize)

CT .... Naomi Park (2023 International Prize Winner)
ME .... Alexander Busko
MA .... HyeonKi Lee
NH .... Abhinav Avvaru

WEF (presented at WEFTEC)

Wastewater Utility Management .... North Conway Water Precinct
Delegate .... Peter Garvey
Delegate at Large .... Matt Formica
Quarter Century Operator Award .... Erik Bailey
Quarter Century Operator Award .... Mary Waring
Quarter Century Operator Award .... Chris Robinson

WEF—MA Awards

George W. Burke, Jr. .... Cohasset WWTP
Arthur Sidney Bedell .... Matthew Formica
Laboratory Analyst Excellence .... Walter Palm
WEF Fellow .... Jennifer Kelly Lachmayr
WEF Fellow .... John Trofatter
William D. Hatfield .... Sean Greig

2024 NEWEA Executive Committee*

*Proposed 2024 NEWEA Executive Committee—pending the election vote at the annual business meeting of the membership on January 22, 2024

PRESIDENT
Scott C. Goodinson
Narragansett, RI

PRESIDENT-ELECT
Deborah S. Mahoney
Andover, MA

VICE PRESIDENT
Scott Firmin
Portland, ME

TREASURER
David VanHoven
Boston, MA

PAST PRESIDENT
Robert K. Fischer
South Burlington, VT

EXECUTIVE DIRECTOR
Mary M. Barry

DIRECTORS—COUNCIL

Collection Systems and Water Resources
Scott W. Lander
Granby, CT

Communications
Philip J. Tucker
York, ME

Innovation
Michael A. Murphy
Somerville, MA

Meeting Management
Scott R. Neesen
Londonderry, NH

Management Review
Robert K. Fischer
South Burlington, VT

Public Outreach
Daryl C. Coppola
Rockland, MA

Treatment, Systems Operation and Management
Marina Fernandes
Milton, MA

DIRECTORS—STATE

Vanessa McPherson
Middletown, CT

Paula L. Drouin
Lewiston, ME

John M. Digiacomo
Natick, MA

Michael A. Trainque
Chester, NH

Amy Anderson George
Wakefield, MA
(Rhode Island Director)

Jennie E. Auster
Burlington, VT

WEF DELEGATES

Raymond A. Vermette, Jr.
Dover, NH

Janine Burke-Wells
West Warwick, RI

Virgil J. Lloyd
Manchester, CT

Emily Cole-Prescott
Saco, ME

Upcoming Meetings & Events

NEWEA ANNUAL CONFERENCE & EXHIBIT
Boston Marriott Copley Place Hotel, Boston, MA
January 21–24, 2024

WEF/NEWEA COLLECTION SYSTEMS AND STORMWATER CONFERENCE
Hartford Civic Center, Hartford, CT
April 9–12, 2024

DC FLY-IN
Hilton Washington DC National Mall The Wharf
April 8–9, 2024

NEWEA SPRING MEETING
The Viking Hotel, Newport, RI
May 18–22, 2024

AFFILIATED STATE ASSOCIATIONS AND OTHER EVENTS

MEWEA LEGISLATIVE BREAKFAST
Augusta Civic Center, Augusta ME
January 16, 2024

CTWEA ANNUAL SKI CLASSIC,
Stratton Mountain, VT
February 2, 2024

NHWPCA LEGISLATIVE BREAKFAST
Holiday Inn, Concord, NH
March 6, 2024

NHWPCA TRADE SHOW
Sheraton Nashua, NH
April 12, 2024

MAWEA TRADE SHOW
Wachusett Mt, Princeton, MA
May 15, 2024

GMWEA SPRING MEETING,
Killington Grand Resort Hotel, Killington, VT
May 23, 2024

NEAPWA SUMMER MEETING
Sea Crest Hotel, Falmouth, MA
June 12–14, 2024

MAWEA GOLF TOURNAMENT
Heritage Country Club, Charlton, MA
June 12, 2024

RICWA ANNUAL GOLF CLASSIC
Potowomut Golf Club
East Greenwich RI
June 17, 2024

CTWEA GOLF TOURNAMENT
Skungamaug River Golf Club
Coventry, CT
June 21, 2024

Measurement unit conversions and (abbreviations) used in the *Journal*

U.S.	International System of Units (SI)	U.S.	International System of Units (SI)
Liquid volume		**Length**	
gallon (gal)	liter (L)	inches (in.)	centimeters (cm)
cubic feet (ft^3)	cubic meters (m^3)	feet (ft)	meters (m)
cubic yards (yd^3)	cubic meters (m^3)	miles (mi)	kilometers (km)
acre-feet (ac ft)	cubic meters (m^3)	**Area**	
Flow		square feet (ft^2) or yards (yd^2)	square meters (m^2)
million gallons per day (mgd)	million liters per day (ML/d)	acre (ac)	hectare (ha)
for larger flows (over 264 mgd)	cubic meters per day (m^3/d)	square miles (mi^2)	square kilometers (km^2)
gallons per minute (gpm)	liters per minute (L/min)	**Weight**	
Power		pounds (lb)	kilograms (kg)
horsepower (hp)	kilowatts (kW)	pounds per day (lb/d)	kilograms per day (kg/d)
British Thermal Units (BTUs)	kilojoules (kJ) / watt-hours (Wh)	ton – aka short ton (tn)	metric ton or tonne (MT)
Velocity		**Pressure**	
feet per second (fps)	meters per second (m/s)	pounds/square inch (psi)	kiloPascals (kPa)
miles per hour (mph)	kilometers per hour (km/h)	Inches water column (in wc)	kiloPascals (kPa)
Gas		**Head**	
cubic feet per minute (ft^3/min)	cubic meters per minute (m^3/min)	feet of head (ft of head)	meters of head (m of head)

THANK YOU
TO ALL OUR 2023 ANNUAL SPONSOR PROGRAM PARTICIPANTS

Platinum
Dewberry
EST Associates, Inc.
Flow Assessment Services, LLC

Gold
AECOM
Aqua Solutions, Inc.
Brown and Caldwell
Carlsen Systems, LLC
Environmental Partners
F.R. Mahony & Associates
GHD, Inc.
Hayes Group
Hazen and Sawyer
HDR
Hoyle, Tanner & Associates, Inc.
INVENT Environmental Technologies, Inc.
Jacobs
MWH Constructors
The MAHER Corporation
Tighe & Bond, Inc.
Veolia
Weston & Sampson
Worcester Polytechnic Institute
Woodard & Curran
Wright-Pierce

Silver
Arcadis
CDM Smith
Fuss & O'Neill
Green Mountain Pipeline Services
Kleinfelder
NEFCO
SDE
Stantec
Synagro Northeast, LLC
Tech Sales NE

Bronze
ADS Environmental Services
BMC Corp
CUES, Inc.
Multiple Hearth Services
Vaughan Company, Inc.

Build relationships with water industry leaders *and* make a positive impact on the water environment

Join NEWEA's 2024 Annual Sponsor Program

NEWEA offers companies the opportunity to promote their products and services throughout the year by participating in multiple sponsorship activities. Annual Sponsorships include:

- NEWEA Annual Conference
- NEWEA Spring Meeting & Golf Tournament
- NEWEA Golf Classic
- A web presence on NEWEA.org's sponsorship program page
- The option to customize sponsorship levels by selecting to participate in up to eight additional unique NEWEA events plus additional activities

Sponsorship Benefits:

- Increased corporate visibility and marketing opportunities before a wide audience of water industry professionals
- Relationship-building access to key influencers involved in advancing water industry services, technology, and policy
- Recognition as an environmental leader among peers and customers

For more information contact Jordan Gosselin
Email: jgosselin@newea.org
Phone: 781-939-0908

NEWEA
WORKING FOR WATER QUALITY

Advertiser Index

Upcoming *Journal* Themes

Spring 2024—**Pretreatment**

Summer 2024—**Emerging Contaminants**

Fall 2024—**Wet Weather**

Winter 2024—**Biosolids Management**

NEWEA/WEF* Membership Application

Water Environment Federation — the water quality people
NEWEA — WORKING FOR WATER QUALITY

Personal Information (please print clearly)

First Name | M.I. | Last Name | (jr. sr. etc)

Business Name (if applicable) | Job Title

Street or P.O. Box | (☐ Business Address ☐ Home Address)

City, State, Zip, Country

Home Phone | Cell Phone | Business Phone

Email Address | Date of Birth (mm/dd/yyyy)

☐ Check here if renewing, please provide current member I.D.

☐ Check here if you do NOT wish to receive information on special offers, discounts, training and educational events, and new product information to enhance your career.

***NEWEA is a member association of WEF (Water Environment Federation). By joining NEWEA, you also become a member of WEF.**

ACQ. Code (for WEF use only) | WEF23

Membership Categories (select one only)

		Dues
☐ **Professional**	Individuals involved in or interested in water quality	$215
☐ **Young Professional**	Water quality professionals, with fewer than five years working experience and under the age of 35, are eligible to join. This program is available for new member applicants and Student Members and is available for 3 years..	$88
☐ **Professional Operator**	Individuals in the day-to-day operation of wastewater collection, treatment or laboratory facility, or for facilities with a daily flow of < 1 mgd or 40 L/sec. License # ____________	$127
☐ **Academic**	Instructors/Professors interested in subjects related to water quality.	$215
☐ **Student**	Students enrolled for a minimum of six credit hours in an accredited college or university. Must provide written documentation on school letterhead verifying status, signed by an advisor or faculty member.	$27.50
☐ **Executive**	Upper level managers interested in an expanded suite of WEF products/services.	$385
☐ **Corporate** (member benefits for one person)	Companies engaged in the design, construction, operation or management of water quality systems. Designate one membership contact.	$446
☐ **Dual**	If you are already a member of WEF and wish to join NEWEA	$50
☐ **Associate Membership**	This membership category is a NEWEA only membership reserved for the general public who have an interest in water and the environment but are NOT currently employed in the industry (e.g., attorney or supplier). Examples of Associate Members include: teachers; journalists who cover water quality issues; citizen samplers/members of various watershed/sportsman/conservation organizations, etc.	$45
☐ **New England Regulator**	This membership category is a NEWEA only membership reserved for New England Environmental Regulatory Agencies, including: USEPA Region 1, CT Department of Energy and Environmental Protection, ME Department of Environmental Protection, MA Department of Environmental Protection, NH Department of Environmental Services, VT Department of Environmental Conservation, and RI Department of Environmental Management	$50

All memberships receive these:
- Water Environment & Technology
- Water Environment Research Online
- WEF Conference Proceedings Archive Online
- WEF SmartBrief
- Complimentary WEF Webcasts

WEF Utility Partnership Program (UPP): NEWEA participates in the WEF Utility Partnership Program (UPP) that supports utilities to join WEF and NEWEA while creating a comprehensive membership package for designated employees. As a UPP Utilities can consolidate all members within their organization onto one account and have the flexibility to tailor the appropriate value packages based on the designated employees' needs. Contact upp@wef.org to join.

Payment

☐ **Check or money order enclosed**
Made payable to NEWEA
10 Tower Office Park, Suite 601
Woburn, MA 01801
For more information: 781.939.0908
Fax 781.939.0907
www.newea.org

Charge
☐ Visa
☐ American Express
☐ Master Card
☐ Discover

Card # | Security/CVC

Signature | Exp. Date

Name on Card (please print)

Billing Address (☐ check here if same as above) | Street/PO Box | City, State, Zip

Depending upon your membership level, $10 of your dues is allocated towards a subscription to the NEWEA Journal.
By joining NEWEA/WEF, you acknowledge the WEF Code of Conduct (www.wef.org/wef-member-code-of-conduct) is applicable for all members.

NEWEA/WEF Membership Application

MEMBERSHIP PROFILE

Please take a few moments to tell us about your background and professional interests.

What is the nature of your ORGANIZATION? (select only one–required) (ORG)

1 Consulting, Contracting, Planning Services
2 Educational Institution
3 Industrial Systems/ Plants
4 Manufacturer or Distributor of Equipment & Supplies (including representatives)
5 Non-profits/NGOs
6 Finance, Investment, and Banking
7 Laboratories
8 State or Federal Government
9 Utility: Wastewater
10 Utility: Drinking Water
11 Utility: Stormwater
12 Utility: Wastewater, Drinking Water, and Stormwater
13 Utility: Wastewater and Drinking Water
14 Utility: Wastewater and Stormwater
15 Other ________ (please define)

What is your Primary JOB FUNCTION? (select only one) (JOB)

1 Executive Level
2 Management Level
3 Elected or Appointed Official
4 Educator
5 Student
6 Consultant/Contractor
7 Engineering/Design
8 Operator
9 Scientist/Researcher
10 Legislator/Regulator
11 Analyst
12 Sales/Marketing
13 Manufacturer's Representative
14 Communications/ Public Relations
15 IT/OT
16 Other ________ (please define)

What are your KEY FOCUS AREAS? (circle all that apply) (FOC)

1 Air Quality and Odor Control
2 Biosolids and Residuals
3 Climate
4 Collection Systems and Conveyance
5 Disinfection and Public Health
6 Drinking Water
7 Energy
8 Finance and Investment
9 Industrial Water Resources
10 Intelligent Water Technology
11 Laboratory Analysis and Practices
12 Nutrients
13 Operations
14 Public Communications and Outreach
15 Regulation, Policy, Legislation
16 Research and Innovation
17 Resource Recovery
18 Safety, Security, Resilience
19 Small Communities
20 Stormwater and Watershed
21 Utility Management and Leadership
22 Watershed Management
23 Wastewater Treatment, Design, and Modeling
24 Water and Wastewater Treatment
25 Workforce

Demographic Information (Check box) The following is requested for informational purposes only.

Gender: ☐ Female ☐ Male ☐ Non-binary

Education: ☐ Doctorate ☐ MA/MBA/MS ☐ BA/BS ☐ AA/AAS ☐ Technical School ☐ High School

Race/Ethnic Origin (Check box) The following is requested for informational purposes only.

☐ African-American (Not of Hispanic Origin) ☐ American Indian or Alaskan Native ☐ Asian ☐ Caucasian ☐ Hispanic/Latino ☐ Pacific Islander or Native Hawaiian ☐ Other

How Did You Learn About NEWEA/WEF?

Referring member's name: ________________ Referring member's email: ________________