JOURNAL

OF THE NEW ENGLAND WATER ENVIRONMENT ASSOCIATION

VOLUME 55 NUMBER 2 / ISSN 1077-3002 **SUMMER 2021**

INNOVATION

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Contents

Page 60: Measurement unit conversions and abbreviations

NEWEA Journal ISSN #1077-3002
Published four times annually by New England Water Environment Association, Inc.
This is Volume 55 Number 2
Periodical postage paid at Woburn, MA 01801, and at additional mailing offices

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Send address changes to:
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OUR ASSOCIATION WAS ORGANIZED NINETY-TWO 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.

Executive Member—shall be an upper level manager interested in water quality and who is interested in receiving an expanded suite of WEF products and services.

Corporate Member—shall be a sewerage board, department or commission; sanitary district; or other body, corporation or organization engaged in the design, consultation, operation or management of water quality systems.

Regulatory Member—this membership category is a NEWEA only membership reserved for New England Environmental Regulatory Agencies, including: USEPA Region 1, Connecticut Department of Energy and Environmental Protection, Maine Department of Environmental Protection, Massachusetts Department of Environmental Protection, New Hampshire Department of Environmental Services, Vermont Department of Environmental Conservation, and Rhode Island Department of Environmental Management.

Academic Member—shall be an instructor or professor interested in subjects related to water quality.

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2021 RATES ($)

Professional	185
Executive	355
Corporate	420
Regulatory	50
Academic	185
Young Professional	70
PWO	110
Dual	45
Student	15

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New England Water Environment Association | Statement of Ownership, Management and Circulation

Publication Title	The NEWEA Journal
Publication	#24559
Issue Frequency	Quarterly (four per year)
Annual Subscription Price	$20 (included with membership dues)
Complete Mailing Address, Known Office of Publication, General Business Office, Editors and Owner (non profit organization)	NEWEA, 10 Tower Office Park, Suite 601, Woburn, MA 01801
Contact Person/Managing Editor	Mary Barry, NEWEA Executive Director
Tax Status	No change during the preceding 12 months

Issue date for circulation data below: 09/10/2018

Publication title: The NEWEA Journal	Extent and nature of circulation: Technical/ Educational/ Environmental	Average no. copies each issue during preceding 12 months	No. copies of single issue published nearest to filing date
Total number of copies		2,500	2,500
Legitimate paid and/or requested distribution	Outside country paid/requested mail subscriptions	0	0
	In-country paid/ requested mail subscriptions	2,200	2,200
	Sales through dealers & carriers	8	8
	Requested copies distributed by other mail classes	0	0
Total paid and/or requested circulation		2,208	2,208
Total nonrequested distribution		0	0
Total distribution		2,208	2,008
Copies not distributed		292	492
Total		2,500	2,500
Percent paid and/or requested circulation		100	100

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President's Message

One year ago in this space my predecessor Jennifer Kelly Lachmayr noted how drastically the world had changed due to COVID-19. Now, a year later, we are gradually starting to emerge from the restrictions this pandemic has imposed upon our professional and personal lives. The decision to conduct the recent Spring Conference as a virtual event was a hard one that involved many hours of discussion and analysis by the Meeting Management Council and Program Committee. In the end our responsibility to our members and society at large tipped the scales. However, plans for in-person events later in the summer are in full swing.

The Committee Member Appreciation Day is scheduled to be an in-person event on August 12, again at Kimball Farm in Westford, Massachusetts. This will be our first large-scale in-person event since the onset of the pandemic. The volunteers who donate their time to NEWEA are central to our success, and I hope to see all of you there to enjoy great food, ice cream, and camaraderie.

Another event being planned is the August 6 Operations Challenge Competition Training Day in New Haven, Connecticut, which is open to teams from all six New England states. The competition, which is traditionall conducted during the Spring Conference in June, will be held in August to provide the top three finishing teams time for additional practice prior to traveling to Chicago for WEFTEC in October, where they will compete against teams from all over the country.

Innovation, the theme of this issue of the Journal, is deeply entwined with the core mission of NEWEA. Indeed, one of NEWEA's most forward-looking recent decisions was the 2019 merger with the Northeast Water Innovation Network (NEWIN), which was brought into our organization as the Innovation Council. This new council is off to a great start under the leadership of Dr. Marianne Langridge. In addition to helping connect our members with others seeking their expertise, the Innovation Council also opens NEWEA up to a host of new members. While the traditional membership of NEWEA has been facility operators, regulators, educators, equipment vendors, and consulting professionals, this merger has welcomed members from the NEWIN community—businesses, entrepreneurs, and other organizations focused on innovative technologies for clean water. This represents a new membership category and corresponding rate structure to move the NEWEA community forward.

The Committee Member Appreciation Day is scheduled to be an in-person event on August 12, at Kimball Farm

In this regard, we are thrilled to welcome Watts Water Corporation to NEWEA as our first Innovation Thought Leader Business Partner and UHRIG as our first Ignitor Business Partner. Through this program our Innovation Council will support partners in connecting with the industry to further their business goals. An example of this is the collaboration of the Innovation Council, the Workforce Development Committee, and the Diversity, Equity, and Inclusion (DE&I) Committee in hosting a Workforce Innovation webinar. We look forward to the involvement of these partners in the Innovation Council, and we welcome their staffs to the NEWEA community.

Another exciting development of the Innovation Council is the recent creation of the Innovative/Alternative Onsite Water Treatment Systems (I/A OWTS) task force. The I/A OWTS helps overcome introductory obstacles and accelerate the entry of new parcel- and cluster-level OWTS technologies into the market, targeting effluent nitrogen levels in the less than 10 to 11 mg/L range. This new task force is collaborating with the EPA Southeast New England Program (SNEP), which includes Rhode Island, the southern coast of Massachusetts, and the islands of Nantucket, Martha's Vineyard, and Block Island. Ultimately, these systems will have applicability to all of New England and beyond. The chair of this new task force is Bruce Walton.

The ad hoc DE&I Inclusion Committee followed its highly inspirational and successful inaugural forum (conducted during the virtual NEWEA Annual Conference) with another interactive forum during the recent virtual Spring Conference. The latest event discussed personal disabilities, an often-overlooked area of the diversity spectrum. It is important that we foster awareness of impediments that may preclude people who are deaf, hard of hearing, blind, confined to a wheelchair, or reliant on assistive technologies from entering our professional workforce or participating in our events and activities. Many thanks to committee chair Marina Fernandes and vice chair Stephen King, and their work group on this thought-provoking forum.

Another exciting development of the Innovation Council is the recent creation of the Innovative/Alternative Onsite Water Treatment Systems task force

I am also pleased to announce the NEWEA Executive Committee approval of a newly created DE&I Award, which will recognize individuals, groups, or organizations in the wastewater field that have promoted and maintained the principles of diversity, equity, and inclusion in their organization, profession, or community. Nominations for this new award will be received by the NEWEA Awards Committee and reviewed by the DE&I Committee, with presentation during the Awards Luncheon at our January Annual Conference. The goal of this award is to highlight and recognize achievements in New England to further the principles of DE&I and to encourage further awareness and progress.

From the Editor

Happy summertime, NEWEA! I hope everyone is enjoying their time returning back to a somewhat more normal life, filled with dining indoors, traveling across state lines, and spending quality time with loved ones. This *Journal*'s theme is Innovation, which is particularly timely considering that the world witnessed perhaps the biggest medical breakthrough of our lifetimes—the development of the Covid-19 vaccine. Nine months! Historically uber-competitive Big Pharma companies broke down their walls to collaborate and share treatments and findings, regulatory authorities rolled out new pathways to accelerate QA/QC approval and issue advice, and the supply chain and service providers demonstrated mind-blowing agility and precision. A global pandemic sparked an unimaginable sense of urgency to find the cure: There's so much innovation to be acknowledged behind our newfound immunity.

Alexandra Greenfield (Bowen), PE
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Switching gears, What drives innovation in the water sector? As water environment professionals, we solve problems. Innovation is driven by complex challenges, and it's our job to continue to reinvent, reimagine, and find new solutions that are better, faster, or cheaper (the ideal innovation achieves all three of these objectives). Albeit trite, Albert Einstein really did say it best: "Insanity is doing the same thing over and over again and expecting different results." Innovations that excite me include the following:

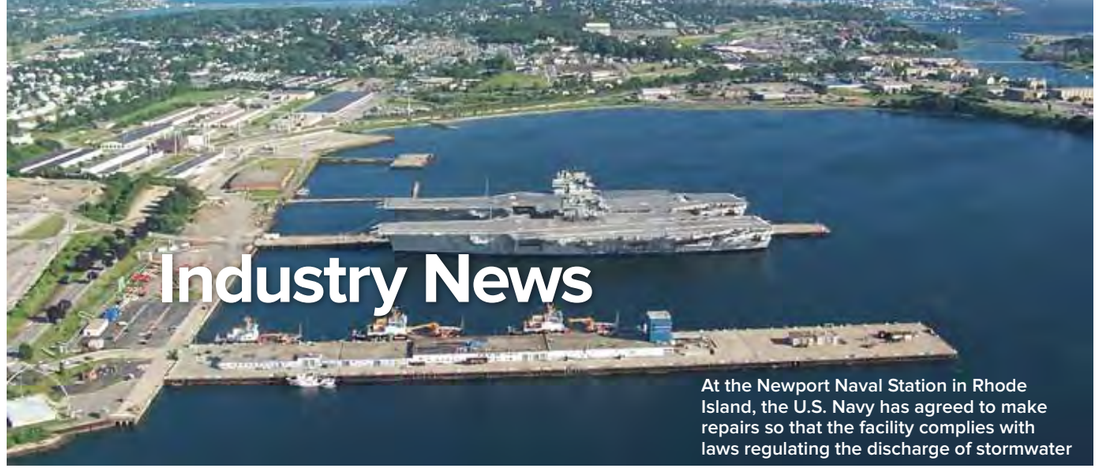
Nutrient recovery: My apologies to the drinking water community, but this is what separates wastewater professionals from that community. Wastewater process is so much more than just removing pollutants—we don't rely solely on the brute-force kill method (or should I say "inactivation"). Our region has grappled with low level nutrient limits over the past few decades. By shifting our perception from nutrient removal to nutrient recovery, innovations have emerged, and recovery technologies have come to market that convert nitrogen and phosphorus-rich streams into valuable fertilizer products.

Energy recovery: Biogas generation and recovery are remarkable. Technological advancements that have made this possible have shifted the perception of the "ye olde sewage plant with tall stacks emitting ominous dark plumes into the sky" into resource recovery facilities. Our poster child for energy recovery is our very own Greater Lawrence Sanitary District (GLSD), recipient of NEWEA's 2020 Energy Management Achievement Award. Converting food waste to energy is a real-world demonstration of "lemons to lemonade."

Water reuse: From purple pipe, to indirect potable reuse, to direct potable reuse, we are moving the needle of public perception when it comes to reusing water. Reclaimed water is not just used for irrigating arid golf courses in Arizona anymore. Owing to technological advancements, favorable quadruple bottom-line financial analyses, and improved support from the public, beneficial reuse is the way of the future.

Advanced instrumentation and controls: Perhaps the most rapidly evolving industry is automation. SCADA systems have been reimagined because of advancements in online analytical equipment that allow operations staff to proactively respond to changing influent conditions rather than react. Artificial intelligence shows real promise and opportunity to level existing control systems in both collection systems and water reclamation facilities alike.

This is my favorite part of what I do every day as a consultant. No project is the same, each environmental challenge is unique, and every owner's drivers are unlike any others. Parts of the country may perceive New Englanders to be painfully parochial. The articles in this *Journal* prove that our industry is anything but parochial. It's been more than one year since NEWEA's merger with the Northeast Water Innovation Network (NEWIN), and Innovation Council Director Dr. Marianne Landgridge gives a comprehensive report of what the new Council has been up to and how it is continuing to push the envelope to support the next generation of innovations throughout the region.



Industry News

At the Newport Naval Station in Rhode Island, the U.S. Navy has agreed to make repairs so that the facility complies with laws regulating the discharge of stormwater

EPA selects groundwater cleanup plan for Superfund site in Rhode Island

EPA has selected a final plan to address groundwater contamination at the Landfill and Resource Recovery, Inc. Superfund site on Oxford Road in North Smithfield, Rhode Island. The cleanup plan is documented in a "Record of Decision" (ROD) for the site.

The cleanup remedy includes the following:

- In situ (below ground) treatment and sequestration of groundwater contaminants using a two-stage reactive treatment zone
- Land use restrictions (called "Institutional Controls") to prohibit use of contaminated groundwater until cleanup levels are met and to require evaluation of the vapor intrusion pathway as part of new building construction
- Contingency implementation of active groundwater extraction and ex situ (above ground) treatment, if results from treatability studies indicate that the proposed remedy will not be effective in attaining cleanup levels at the site
- Restoration with native vegetation of any wetland habitat altered by the remedial action
- Long-term groundwater, surface water, and residential well monitoring
- Periodic reviews, at least every five years, to assess the remedy's protectiveness

EPA's cleanup remedy for Operable Unit 2 that addresses groundwater at the site is estimated to cost about $11.7 million and take two to three years to design and implement. Groundwater is estimated to achieve cleanup standards immediately downgradient of the remedy within approximately 20 years. Institutional controls will prevent exposure to contaminated groundwater at the site until cleanup levels are met.

Background

The 28 ac (11 ha) site is an inactive landfill that began as a sand and gravel operation. The landfill began accepting residential waste in 1927, and over its years of operation also accepted commercial and industrial wastes. Operation of the landfill stopped in January 1985 after several orders from the Superior Court of Rhode Island. EPA has estimated that more than 2 million gallons (7.6 ML) of hazardous chemicals including solvents, plating waste, asbestos, oils, and dyes were brought to the landfill for disposal. EPA issued a ROD selecting a remedy for the landfill in 1988. Construction of the landfill remedy was completed in 1995, and monitoring and operation and maintenance are ongoing.

Settlement will improve stormwater controls at Newport Naval Station

The U.S. Navy has agreed to make $39 million in repairs at the Newport Naval Station in Rhode Island so that the facility complies with laws regulating the discharge of stormwater into Coddington Cove, an embayment of Narragansett Bay.

Under a recent agreement with EPA, the Navy will complete stormwater discharge infrastructure improvements by 2030 at the former Derecktor Shipyard, settling EPA allegations that the facility was in violation of the Clean Water Act. The repairs include seven projects along the bulkhead, a retaining wall along the waterfront.

The Naval Station, located in the Rhode Island towns of Newport, Portsmouth, Middletown, and Jamestown, operates under a municipal stormwater permit issued by Rhode Island Department of Environmental Management. The facility includes the former Derecktor shipyard, a Superfund site.

The case stems from an inspection of the facility in August 2016 to evaluate the condition of the stormwater conveyance system that was contributing to erosion and discharge of soils to Coddington Cove. The inspection focused on the presence of sinkholes and the condition of stormwater infrastructure covered under the site's stormwater permit. EPA inspectors confirmed that the deteriorated condition of stormwater outfall pipes had caused or contributed to at least four large sinkholes near the permitted stormwater outfalls through a bulkhead running along the shoreline.

The facility's stormwater system and waterfront bulkhead at Derecktor Shipyard are deteriorated and not operating as intended. Some 25 sinkholes have been identified along the bulkhead. The Navy has also identified numerous holes in the bulkhead wall. The condition of the bulkhead has caused soil to be discharged without a permit into Coddington Cove, in violation of the Clean Water Act.

Under EPA's Superfund program, the Navy also maintains a soil and asphalt cover to prevent exposure to contaminated soils at Derecktor Shipyard, including along the bulkhead wall, under a cleanup plan issued by the Navy in 2014. The Navy is collecting soil and sediment samples in the area to assess the potential risks to human health and the environment from soil exposed by the sinkholes or from soil erosion into Coddington Cove.

Note: All EPA industry news provided by EPA Press Office

EPA has published a new resource to help states and Tribes develop scientific surveys to better protect aesthetic and recreational waterbody uses

EPA releases tools to help reduce nutrients in water, improve public health, and support ecosystems

As part of Water Week 2021, EPA released new tools and information that states, territories, and authorized Tribes can use to help protect people, animals, and aquatic life from harmful algal blooms and other adverse effects of nutrients in water.

N-STEPS Online

EPA's Nutrient Scientific Technical Exchange Partnership & Support (N-STEPS) program released a new web-based resource, N-STEPS Online, that provides technical assistance to states, territories, and authorized Tribes to help water quality scientists and managers derive numeric nutrient criteria. N-STEPS Online contains technical support documents, case studies, tools, and data sources. Through a user-centered design approach, N-STEPS Online better communicates the latest scientific information and technical approaches to EPA's partners. This resource includes information from existing EPA guidance, as well as examples from state and tribal numeric nutrient criteria development experiences. N-STEPS Online was developed through a multi-year process of collaboration with state and tribal stakeholders.

User Perception Surveys Primer

EPA has also published a new resource, "Development of User Perception Surveys to Protect Water Quality from Nutrient Pollution: A Primer on Common Practices and Insights," to help states and Tribes develop scientific surveys to better protect aesthetic and recreational waterbody uses. States and Tribes can use this information to develop numeric nutrient criteria for their water quality standards under the Clean Water Act. The primer draws from previous state user perception surveys, peer reviewed literature, and interviews with state and federal water quality professionals experienced with conducting user perception surveys. Other states, territories, and authorized Tribes can consider best practices to inform their survey design, implementation, and analysis.

Hypoxia Task Force Newsletter

EPA, which co-chairs the Hypoxia Task Force with the Iowa Department of Agriculture, supports best practices for nutrient reduction across federal, state, and tribal members to decrease the hypoxic zone in the Gulf of Mexico. The latest issue of EPA's Hypoxia task force quarterly newsletter highlights ongoing collaboration within the 12 member states to reduce nutrients in the Mississippi/Atchafalaya River basin.

Background

Nutrient pollution in water presents one of the country's most widespread environmental and public health challenges. Nitrogen and phosphorus concentrations in our waterways have steadily increased, degrading water quality, feeding harmful algal blooms, affecting drinking water sources, increasing public health risks, and contributing to costly impacts on drinking water treatment, recreation, tourism, and fisheries.

EPA is pursuing a "one-water" strategy to reduce nutrient pollution in our nation's waters, including working alongside the agricultural and industrial sectors, and assisting states,

territories, and authorized Tribes to help them protect the designated uses of their water bodies. EPA continues to advocate the development of numeric nutrient criteria, which provide measurable water quality-based goals that are easier to implement than the narrative criteria statements in many state water quality standards.

Senate passes bipartisan package of water infrastructure funding

– Source: This Week in Washington newsletter, WEF

On April 29, the Senate passed a bipartisan package of wastewater, stormwater, drinking water, and water reuse infrastructure funding by a vote of 89 - 2. The bill, known as the Drinking Water and Wastewater Infrastructure Act of 2021, S. 914, seeks to reauthorize many core federal water infrastructure funding programs. The bill includes several new programs that will help communities address pressing water infrastructure challenges.

The Senate bill both reauthorizes and amends many existing programs and creates new ones. According to the bill, the reauthorizations and changes include the following:

- The Clean Water State Revolving Fund (SRF) would get $14.65 billion over the next five years and allow a greater percentage of loans to be forgiven or be provided other favorable loan terms
- The Water Infrastructure Finance and Innovation Act would get $250 million over the next five years and require only one ratings agency opinion letter instead of two
- The EPA Sewer Overflow & Stormwater Reuse Municipal Grant Program would get $1.4 billion over the next five years
- The Alternative Source Water Pilot Program would get $125 million over the next five years

The bill also describes several new programs, including the following:

- The Rural and Low-Income Water Assistance Pilot Program would establish a new EPA program to provide 40 grants per year to utilities to assist low-income ratepayers
- The Wastewater Energy Efficiency Grant Pilot Program would get $100 million over the next five years
- The Clean Water Infrastructure Resiliency and Sustainability Grant Program would get $125 million over the next five years
- The Small Publicly Owned Treatment Works Efficiency Grant Program would be established with funding levels to be determined
- The Connection to Publicly Owned Treatment Works Grant Program would get $200 million over the next five years
- The Water Infrastructure and Workforce Investment Grant Program would get $25 million over the next five years
- The Stormwater Infrastructure Technology Program would get $25 million to create five Stormwater Centers of Excellence and $50 million for stormwater infrastructure planning/development and implementation grants

The bill includes a drinking water section that reauthorizes the Drinking Water SRF at levels equal to the Clean Water SRF, a drinking water resilience grant program and lead service line and lead in schools grants, per- and polyfluoroalkyl substances (PFAS) treatment grants, and several other drinking water sustainability grant programs.

Several water infrastructure packages have also been introduced in the House of Representatives over the last several weeks. These bills also seek to provide significant boosts in funding for wastewater, stormwater, and drinking water infrastructure programs. The House bills also are expected to pass through committees and reach the House floor in May. After the bills pass both House and Senate, they will then be negotiated with the goal of a final agreement by early summer. Once passed by Congress, the water infrastructure package will be eligible for inclusion in the expected major infrastructure package later this year.

EPA recognizes New England wastewater treatment entities and individuals

EPA's New England Office recently awarded 2020 Regional Wastewater Treatment Awards to New England wastewater facilities, programs, and individuals to recognize them for their commitment to improving water quality. The EPA Regional Wastewater Awards Program recognizes personnel in the wastewater field who have provided invaluable public service managing and operating wastewater treatment facilities throughout New England.

Regional Wastewater Treatment Plant Excellence

Woodstock, Vermont Wastewater Treatment Facility— The Woodstock Wastewater Treatment Facility, led by Chief Operator Kathy Welch, was recognized for exceptional work in maintaining and operating the wastewater treatment plant during the past year. This facility, and the two plants noted below, were the only three facilities across New England to receive this award.

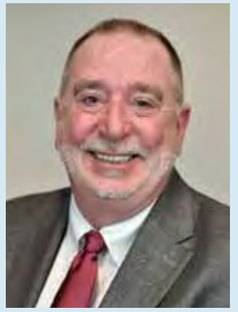
Jackman, Maine Wastewater Treatment Facility—The Jackman Utility District Wastewater Treatment Facility was recognized recently by EPA's New England Office for its commitment to improving water quality. The facility, led by Superintendent Sara Giroux, received the plant excellence award for exceptional work in operating and maintaining the wastewater treatment plant during the past year.

South Kingstown, Rhode Island Wastewater Treatment Facility—The South Kingstown Wastewater Treatment Facility, led by Superintendent Kathy Perez, was recognized for exceptional work in operating and maintaining the wastewater treatment plant during the past year.

Regional Industrial Pretreatment Program Excellence

City of Somersworth, New Hampshire Industrial Pretreatment Program—The City of Somersworth's Pretreatment Program staff, led by Stephanie Rochefort, were recognized for exceptional work inspecting, permitting, and sampling industrial users that discharge industrial waste into the collection system.

Fred McNeill Receives APWA National Award



NEWEA President-elect Fred McNeill has been honored as the 2021 American Public Works Association (APWA) Professional Manager of the Year in Water Resources. This award recognizes his 40-year career of outstanding achievements in water resources within the public works field and demonstrated excellence, leadership, and dedication to the public good.

Mr. McNeill began his career in water resource operations as a Peace Corps volunteer in Sierra Leone, West Africa, from 1981 to 1983, where he worked with the United Nations Development Program managing a rural water supply program that served an entire province from hand-dug wells in rural villages. Following the Peace Corps, he continued working internationally with CDM Smith, managing large-scale water resource projects. During three years in Cairo, Mr. McNeill was second on the construction management team for the Abu Rawash 106 mgd (400 ML/d) wastewater treatment plant (WWTP), and managed the design and construction of a 6-mile (9.5 km) open channel drainage system for disposal of over 150 mgd (570 ML/d) of effluent from two WWTPs. In Jordan, Mr. McNeill managed the design of water and wastewater systems for the arid desert community of Wadi Mousa, adjacent to the world-famous archeological site of Petra. Later, he worked in eastern Europe where, over a three-year period, he managed the design and construction of emergency water supply repairs in Armenia and Georgia. After returning to the United States, he continued with CDM Smith before moving to the public sector over 15 years ago. He now works as the chief engineer for the City of Manchester, New Hampshire Environmental Division.

Mr. McNeill has been active in professional associations for more than 30 years. He is a member in good standing of APWA, Water Environment Federation (WEF), American Water Works Association, and American Society of Civil Engineers, and he has long been active within the New England and New Hampshire chapters of these organizations. He is recognized as an industry leader who regularly appears at conferences and seminars, speaks to local colleges, high schools, middle schools, and local civic organizations, and is often called upon for his expertise from the local newspapers and NPR radio station.

He has long embraced work force development, always advocating for the next generation of water professionals, and advising and mentoring countless young engineers and operators, many of whom still work with him today. Outside the office, Mr. McNeill coached and administered youth sports for many years in his hometown of Chester, New Hampshire. After coaching he progressed to officiating and has been a certified high school basketball referee for the past 12 years, providing leadership on and off the court. An avid golfer, he has coordinated golf tournaments for the New Hampshire Water Pollution Control Association (NHWPCA) and the City of Manchester employees for well over a decade.

Among NEWEA circles, Mr. McNeill is perhaps best known as a dynamic and vocal member, past president of the NHWPCA, former New Hampshire NEWEA state director, recent WEF delegate from NEWEA, and current NEWEA president-elect. Congratulations to Mr. McNeill for this latest recognition by the APWA for his remarkable dedication and professionalism.

Regional Wastewater Trainer of the Year

Mike Caso, Nashua, New Hampshire—Mr. Caso, a volunteer at the New Hampshire Water Pollution Control Association (NHWPCA), was recognized for developing and delivering wastewater operator training programs all over New Hampshire on various industry-specific topics, such as ultraviolet disinfection. Mr. Caso is the sole recipient of this award across New England.

Regional Wastewater Treatment Plant Operator of the Year

Jim Pouliot, Epping, New Hampshire—Mr. Pouliot, chief operator of the Epping Wastewater Treatment Facility, was recognized for his outstanding work bringing the facility back into compliance following a 2016 administrative order. Mr. Pouliot, and the two recipients noted below, were the only three individuals across New England to receive this award.

Dylan Chase, Block Island, Rhode Island— Mr. Chase, superintendent of the New Shoreham Water Pollution Control Facility, was recognized for his outstanding work over the years operating and maintaining the facility.

Mark Batorski, Farmington, Connecticut—Mr. Batorski, chief operator of the Farmington Water Pollution Control Facility, was recognized for his outstanding work over the years in operating and maintaining the facility.

Lifetime Achievement Award

Don Kennedy, NEIWPCC—Mr. Kennedy, retired engineer of NEIWPCC (formerly known as the New England Interstate Water Pollution Control Commission), was honored for outstanding service throughout his career. Mr. Kennedy was recognized for his work providing training and technical assistance to wastewater professionals in New England during his many years of employment with NEIWPCC. Mr. Kennedy was well known for his enthusiasm while providing training to the wastewater employees, as well as encouraging the younger generation to become involved in the environmental sector through the "Youth and the Environment Program."

Collaboration is the key to innovation

MAYA CLIFFORD, Isle Utilities

ABSTRACT | Collaboration is defined as the act of working with someone to produce or create something. When it comes to the water industry, Technology Approval Groups (TAG) are innovation forums that can be found around the world. They were first launched in the United Kingdom in 2005 TAG accelerates the market update of "step-change" technologies by engaging the industry during the pre-commercial stages of development and by leveraging the power of collective leading end-users to collaborate around shared interests and priorities. TAG is a low-risk option for utilities looking to collect information not commonly found at conferences or other public forums. Even though such groups are not new, the concept is new to most New England utilities. The U.S. program comprises more than 75 utilities and is growing exponentially. The author's experience with these forums provides a unique perspective to the region's needs and the key drivers for those needs. Adaptation is the new normal since the beginning of the Covid-19 pandemic. New England utilities are focused on asset management, distribution and collection system maintenance, stormwater, and reservoir management. This paper will describe how the TAG model rooted in collaboration can assist utilities along with water and wastewater professionals throughout the region to think outside the box and learn about qualified solutions becoming available with each passing day.

KEYWORDS | Sustainability, innovation, collaboration, future, technology, technology approval groups, New England trends, asset management, stormwater, innovative

The water and wastewater industry is considered slow moving compared to other technologically based industries. Its growth is methodical and embodies tradition in every sense, especially in New England. During this difficult year of Covid-19, the water industry has proven resilient. Crews adapted and became mask advocates, improving safety standards and protocols across the country. Laboratory directors and managers continued to deliver high-quality results. Systems continued to operate without interruption and maintained regulatory compliance. Owing to the industry's adaptive nature and growth in the last few decades, the opportunity for increased risk in a highly risk-averse industry has become more likely. Innovation and growth in our daily thoughts, actions, and system decisions are no longer a distant dream, but a reality that all water and wastewater industry professionals can inhabit, if we work collectively to achieve it.

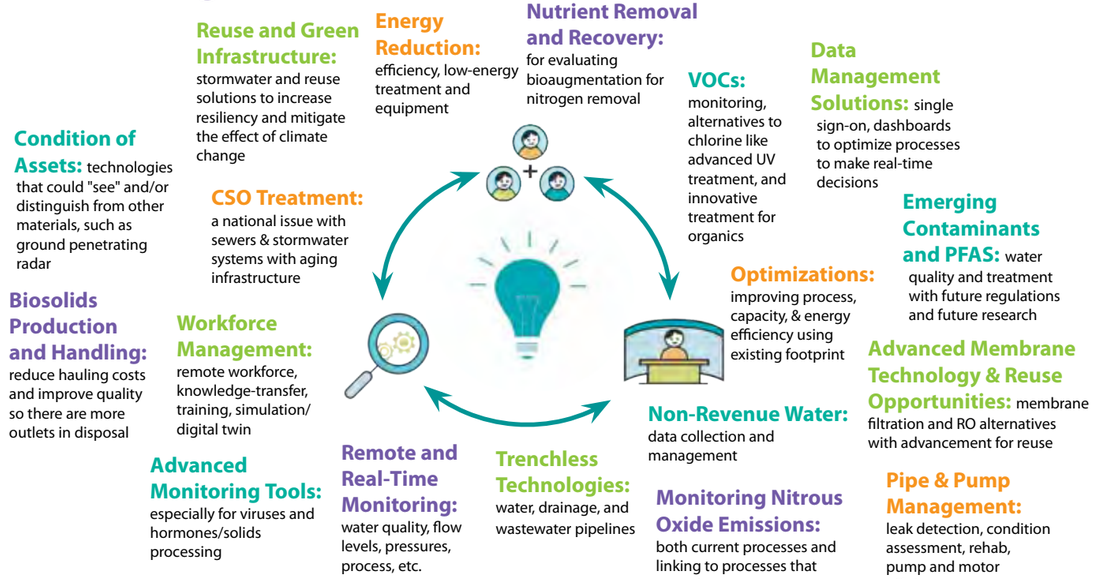
One of the pioneers of collaboration in the water industry is Piers Clark, who utilized collaboration to advantage while he was the commercial director at Thames Water—one of the UK's largest water utilities serving a population of over 14 million customers. Piers recognized that many utilities faced similar challenges and that more could be done to create peer-to-peer discovery of solutions and sharing of best practice. Under his guidance, the Technology Approval Group (TAG), was launched in the UK in 2005. TAG accelerates the market update of "step-change" technologies by engaging the industry during the pre-commercial states of development and leverages the power of collective leading end-users to collaborate around shared interests and priorities. TAG is a low-risk option for utilities looking to collect information not commonly found at conferences and other public forums.

TAG meetings are held several times per year in closed session. These meetings are to enable utility members to review emerging technologies; positive reviews may then be followed by technology demonstrations and collaborative trials to foster ultimate technology commercialization. The cycle begins with vendor referrals from utilities and information collected from a dedicated technical team, whose job is to find technologies from all sectors (e.g., agricultural, oil and gas, energy, etc.) that could apply to the top priorities of the water and wastewater industries. Once identified, the technology is assessed for commercial development, technical development, capital expenditure, operational expenditure, installation requirements, value proposition, competitive advantage, scalability potential, and inherent technological risks. If it passes all these checks, qualified vendors are aligned with regional needs, and utility participants vote to select the TAG presenters. A TAG workshop consists of the final few selected technologies and provides a cadence of regular peer-to-peer sharing. During these workshops, utilities provide updates on ongoing pilots, projects, and barriers end-users may be facing. A TAG establishes a strong foundation between utility peers looking to leverage the shared experience and collective expertise to effectively drive continuous improvement and innovation in their organizations. This foundation allows a culture of collaboration to be the basis of the TAG meetings.

The TAG model was brought to the United States in 2011 and since then has grown to engage over 75 water utility organizations. Even though the TAG concept is not new, it is still unknown to most New England utilities. Often utilities are not aware of the options available to assist them. Innovation can come from anywhere, and new technologies are born from a number of circumstances. Examples include an operator who became an entrepreneur and now markets a water quality sensor, an engineering firm that acquired a promising startup, and an established vendor that developed a prototype to meet a customer's need. TAGs consider all of these, giving perspective and a platform to various technology options around the world and the most innovative options at the same time.

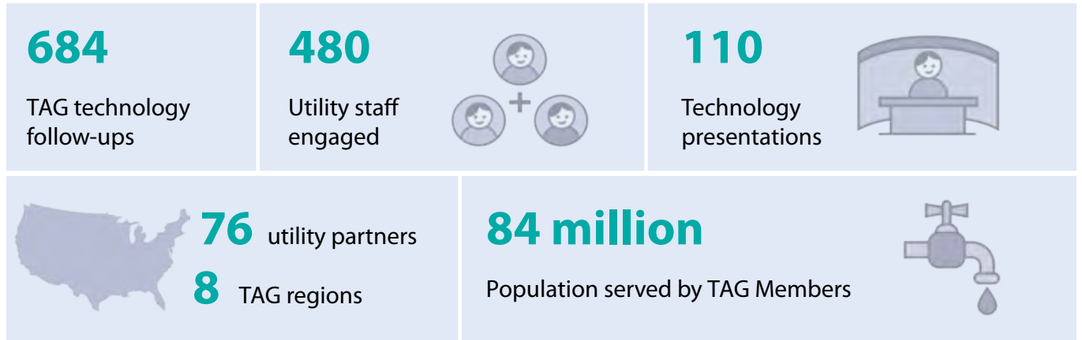
To illustrate the scale of the TAG program's impact in the United States, in 2020 alone there have been some 50 active pilots, 110 technology presentations facilitated, and 480 utility staff engaged, and the benefits of innovation collectively have reached 84 million customers/ratepayers.

According to Uta Wehn from the IHN Delft Institute, "The urgent need for water innovations is becoming increasingly clear, acknowledged, and responded to with accumulating sources and amounts of funding" (Wehn 2017). Innovation is changing, as the times are changing. Today, increases in sustainability planning, data management, flexible workforce communication tools, and even optimizations in capacity and energy using existing footprints are generating ongoing conversations among utilities. There are many ongoing barriers facing the industry as well; combined sewer overflow



Current technological needs across the United States and the key factors driving utility decisions

TAG Impact



Impact of the TAG program on members, the communities they serve, and the industry as a whole from 2019-2020

treatment, biosolids management, and treatment of volatile organic compounds in drinking water continue to be at the forefront of utilities' minds as regulations tighten. Conversations around radon, lead, and the efficacy of implementing remote monitoring provisions are not going away anytime soon either. However, today water and wastewater operations challenge old adages; no longer are operators who work in rural New England required to stay "in the box" they live in to receive training, input, or connection. Today, we are faced with new challenges. Thankfully, our workforce includes growing numbers of newly established professionals eager to meet those challenges with fresh perspective and enthusiasm. With this reinvigorated workforce comes a greater need for collaboration and the opportunity for more continuous dialogue in the virtual media age of Covid.

The TAG forums in the United States went virtual in the spring of 2020, and TAG partners around the country needed to adapt and grow. We have all come to a time of unbuilding in the way professionals connect and respond to daily challenges. Despite not being together in person, some TAG forums have grown both in size and number of interactions and conversations, particularly those regarding water resources. More people than ever before face water scarcity, or lack of reliable drinking water. Population increases conflict with our world's finite water supply. Conservation, resiliency, and sustainability are coloring the areas of automation, energy, and workforce management more than ever before. Municipalities and utilities across the United States are seeking advanced tools to help solve these advanced challenges. New England has faced more years of drought in the last 20 years than in the prior 100 years. Rebuilding the foundations of understanding, knowledge, and integrity to enable better stewardship of our communities has become no longer an option but a requirement over the last 12 months.

The success of the program is a testament to the commitment of the member utilities. Members of TAG forums receive the benefits not only of learning about new technologies throughout the world; they also learn of other utilities' experiences through implementation, maintenance, operations, and enterprise-wide challenges from around the country.

Perhaps you are wondering how utilities react to adopting technology they would not have known about without a collaborative program? One member in the Northeast credited the TAG program in helping them "get…focused on new possibilities and ways of tackling challenges," leading to the exploration of a myriad of new technologies in digital transformation.

Technologies that are "down the pipeline" are best approached collaboratively. There are options. Utilities have choices. Coming together and sharing our approaches, thoughts, and decisions will be the key to moving forward most effectively and efficiently. Realizing that, we are not beholden to past administrations and leaders. We can make our own way, carve our own path, and bring forward a new and brighter water world into the future.

ACKNOWLEDGMENTS

The author thanks the water and wastewater professionals who have enabled this work in the Isle Utilities TAG partnership network and allow for whole-hearted dialogue and communications. I also acknowledge Cristina Ahmadpour, Brittany Burch, Alex Fairhart, and our entire consulting team. Additional support by Bill Gower, Marianne Langridge, and Lisa Clifford was greatly appreciated.

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Selecting sustainable infrastructure projects—a qualitative approach to selecting the "right project"

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ABSTRACT | Sustainable infrastructure projects must consider and balance the three sustainability responsibilities of environmental stewardship, economic prosperity, and social well-being; focusing on one or two of the three responsibilities does not constitute a sustainable project. A project's life cycle impacts on each of the three responsibilities are largely cast and fixed because of the project selected. Therefore, owners and engineers must consider each of the three responsibilities closely during project screening and selection to choose the project that has the greatest overall value to stakeholders and one that avoids potential negative impacts. This paper discusses an innovative approach to the project screening and selection process and presents a map for developing a qualitative tool to evaluate and compare the sustainable aspects of alternative projects.

KEYWORDS | Sustainability, social well-being, environmental stewardship, economic prosperity, multi-criteria decision analysis

DEFINING A PROJECT

Engineers are problem solvers, and it is the "project" that defines the solution. While the solution to certain problems may appear to be similar, in reality no two projects are the same. And because a large portion of a project's life cycle impacts are fixed during the design phase, investment in project definition prior to design is imperative.

When defining the project, the team should first define the project function, followed by defining the fit and form of the engineering solution. The definitions of project function, fit, and form are as follows:

Function. The project function defines the purpose of the project and how the project will perform to meet certain design criteria. Projects often have several functional levels depending on the drivers. Take, for example, a stormwater retention basin with the primary function of attenuating peak storm flows (i.e., flow management): A secondary function may be to remove sediment and nutrients (i.e., quality management).

Fit. The project fit defines how the project interacts or becomes integral with its surroundings. When it comes to horizontal and vertical infrastructure projects, project fit is a concept that architects understand and incorporate into the project design. Continuing with the stormwater retention basin example, consider the differences between urban and rural settings. While the design requirements in both settings may be similar, how these structures fit or interact with their surroundings may not. In an urban setting, the design team may not have the space to design a deep, open rectangular basin and may need to consider a system that has smaller components that interact with the built environment.

> Fit: There is an old saying that "when all you have is a hammer, everything looks like a nail." Engineers must resist the urge to apply standardized solutions to meet project needs without considering how the project interacts (i.e., fits) with its surroundings.

Form. The form defines the project's appearance, such as the shape, size, mass, dimensions, and other physical characteristics. On infrastructure projects, the form is defined by the plans and specifications. It is important to emphasize that function and fit should drive the form, and not the other way around. Trying to apply standardized specifications to every project will directly affect the project fit. For example, as noted above, designing deep, open rectangular stormwater basins for every rural and urban project would not make sense.

Selecting the Right Project. The principles of "effective" and "efficient" project management are defined as the alignment of a project with the overall needs (i.e., a project that is effective) and the execution (i.e., a project that is efficient). Simply, effective is "what" the project is and efficient is "how" the project is executed. For a project to be considered effective *and* efficient, one must first decide to "do the right project" (i.e., do what is effective) and then must "do the project right" (i.e., do what is efficient). The American Society of Civil Engineers (ASCE) captures these principles in Policy Statement 418, "The Role of the Civil Engineer in Sustainable Development," which states that *"Civil engineers shall be committed to the following ASCE Principles of Sustainable Development:*

- *Principle 1—Do the Right Project. A proposed project's economic, environmental, and social effects on each of the communities served and affected must be assessed and understood by all stakeholders before there is a decision to proceed with a project. Consider non-structural as well as structural (built) solutions to the needs being addressed; and*
- *Principle 2—Do the Project Right. The civil engineer shall actively engage stakeholders and secure public understanding and acceptance of a project's economic, environmental, and social costs and benefits. To move toward conditions of sustainability, engineers must design and deliver projects that address sustainability holistically (from concept to demolition or reuse) rather than adding a variety of 'green' features onto a conventional project."*

Applying these principles in order is important. Depending on the project demands (e.g., scope, schedule, budget), there may be a tendency to dive into the project design and delivery. However, as the ASCE principles highlight, identifying sustainably conceived projects that are constructed sustainably requires stakeholder engagement throughout the process. Below insights are shared into the application of multi-criteria decision analysis (MCDA) techniques that incorporate sustainability criteria in project selection.

QUALITATIVE APPROACHES

Over the past three decades, a proliferation of research and quantitative analyses has occurred on the environmental impacts of human activity. While these data are essential, they are often difficult to apply in decision-making, leading to the need for more qualitative approaches to review alternative project design approaches. According to the Project Management Institute, MCDA uses decision matrices to establish criteria systematically and analytically. Various factors can be weighted to score the choices, or a more qualitative evaluation can also be made.

The MCDA approach can help develop a qualitative review process that considers the three responsibilities of sustainability (i.e., social, environmental, and financial), along with other tangible and non-tangible factors (e.g., design alternatives, ease of implementation, ease of maintenance, and end-of-life considerations). In applying the MCDA approach, it is important to identify project alternatives that look beyond the project's primary function by considering secondary functions as well as the fit and form of each alternative. Referring back to the primary and secondary environmental functions of a stormwater retention basin (i.e., flow and quality management), additional factors in the social well-being category may include public interaction, education, aesthetics, inclusion, or access to open space.

To compare design alternatives requires establishing an evaluation system that can rank and prioritize each alternative based on subjective terminology using a series of value systems. These value systems can be developed, defined, and assigned values using methods similar to those used to develop a rubric for grading student papers or projects. The main difference is that the defensibility of the engineering project rubric (i.e., the qualitative evaluation tool) is directly related to the level of stakeholder engagement obtained in defining value systems used to develop the tool. As emphasized by ASCE in Policy Statement 418, stakeholder engagement is critical to successful project selection and execution.

DEVELOPING A SUSTAINABILITY RUBRIC

The following sections provide an approach for developing a project evaluation tool (i.e., rubric), including the project definition, categories, criteria, grade levels, and criteria definitions for each grade level.

Project Definition. The project definition should state the overall project purpose and objective and focus on the project's primary function. It should also list secondary functions that may drive the project decision-making.

Categories. When developing the rubric, a category should be included for each of the three sustainability responsibilities—social well-being, environmental stewardship, and economic prosperity. Project life cycle aspects should also be considered by including two to three categories and/or criteria material to the proposed project, such as permanence, design approach, construction methods, operational considerations, or end-of-life considerations.

Criteria. The criteria assigned to each category should balance tangible and intangible aspects, emphasizing those having the most critical impact (e.g., public health/safety, carbon emissions, wetlands, stormwater, water quality, diversity, inclusion, community preservation). Stakeholder engagement in criteria identification is highly recommended and a wise investment. Consensus at this early stage will initiate discussions around criteria definitions and value systems that will align stakeholder perspectives/value systems, leading

to a more efficient ranking evaluation. Stakeholder groups should be involved in the following steps to establish criteria for each category:

- Brainstorm the list of criteria under each category
- Evaluate the criteria list for each category to determine if similar criteria can be combined
- Prioritize the list of criteria under each category from most to least important
- Consider reducing the list to a maximum of five criteria per category

After developing the list of criteria, a brief objective statement is included for each criterion. The objective statement will provide a common reference for consistency each time a project alternative is evaluated using the final rubric.

A list of categories and potential criteria for each category is presented below. This list is not intended to be comprehensive but more of a sample of potential criteria.

Environmental stewardship:

- Energy (carbon footprint, consumption, renewables, conservation)
- Water (consumption, emissions, stormwater, quality, quantity)
- Natural resources (consumption, restoration, direct and indirect impacts)
- Renewable resources (use, generation, end of life)

Social well-being:

- Local community (support, benefit, engagement, impact)
- Public safety (during construction and operation)
- Public health (during construction, operation, end of life)
- Surrounding communities (support, benefit, engagement, impact)
- Diversity, equity, inclusion, environmental justice

Economic prosperity:

- Pre-construction costs (acquisition, permitting, design, communication)
- Construction (materials, labor, equipment, traffic details)
- Operational (utilities, routine maintenance, warranties, repairs)
- End of Life (disposal, reuse, replacement)

Grade Levels. The grade levels are the scale used to assign a number to a qualitative value and typically extend across the top of the rubric. For comparing and ranking options, a simple scale of 1 to 5 is recommended, in which 1 is the lowest, 3 is average, and 5 is the highest. Depending on the category, terms can differentiate the extremes. For example, when defining grades under the environmental category, a 1 could be considered depletive, whereas a 5 could be considered restorative.

Grade Levels: The 1 to 5 grade level is typically preferred over 1 to 3 or 1 to 10 as it provides a manageable level of separation among grades. Providing too many grade levels (e.g., 1 to 10) may overcomplicate the tool, making it overwhelming and time-consuming, whereas providing too-few grade levels (e.g., 1 to 3) may oversimplify the tool, making it difficult to differentiate among options.

Grade Definitions. The grade definition captures what the assigned value means for each criterion. To define each criterion grade, the team should start by defining the average objective for each criterion as the average score (3). Then the team should define the extremes for that criterion. That is, What would define the lowest possible outcome as the minimum level of 1 and the best possible outcome as 5? Finally, define what would be slightly lower than average as 2, and slightly higher as 4. Figure 1 illustrates a sample evaluation tool rubric.

DEVELOPING AN MCDA TOOL

Once the evaluation rubric is developed for a specific project, an MCDA evaluation tool can be created using a simple spreadsheet program. The tool input screen should allow for numerical grades to be assigned to each criterion within each category for each alternative. For each grade assigned, the team should regularly refer to the objective statement in the rubric to maintain consistency when assigning grades. Additional tips for developing the input tool are as follows:

- Create a tool template that can be used for future projects
- List project alternatives across the top axis and the categories/criteria down the side
- Provide comment cells that allow for the justification of numerical grades assigned
- Require comments that justify all entries of 1 and 5
- Conditionally format the cells to highlight each cell based on the rating (For example, if a 1 is the lowest rating, format the cell shading to turn red when a 1 is input. This provides input data that is visually recognizable and comparable.)
- Sum the score for each category and compare it to the maximum potential score

Figure 2 shows a tool input screen for five hypothetical options using the criteria from Figure 1. (Alternatives and values entered are hypothetical and provided for illustrative purposes only.)

If the input cells are conditionally formatted, the input screen can be used to visually compare the criteria for each alternative to identify significant differences for a criterion across the alternatives. For example, referring to Figure 2, the team would see that major improvements to water quality would be realized by applying alternative methods (i.e., options 3, 4, and 5) over applying standard design approaches or doing nothing. Again, the defensibility to these data comes when stakeholders are engaged in developing the evaluation rubric and applying those rules

| SELECTING SUSTAINABLE INFRASTRUCTURE PROJECTS |

Environmental			Grading Levels				
Criteria			Min (depletive)		Average		Max (restorative)
Code	Title	Objective Statement	1	2	3	4	5
En1	Carbon Footprint	How will this project impact carbon emissions during construction and operations?	Uses non-renewable resources. No effort to improve	Complies with minimum energy codes	Complies with stretch energy codes and incorporates technology to reduce carbon emissions	Net-zero or carbon neutral	Sequesters carbon or generates surplus energy using renewable resources
En2	Resource Impact – Direct	How will this project impact natural resources surrounding the project site?	Significant impact on natural resources	Minor impact on natural resources	No measurable impact on natural resources	Protects natural resources	Significant benefit that restores natural resources
En3	Resource Impact – Indirect (Materials & Methods)	How will this project indirectly impact natural resources (e.g., material selection, construction methods, tradeoffs)?	No consideration given to how the selection of materials or methods will impact on NR	For minor aspects of project, sustainable materials and methods identified but not required	For minor aspects of project, sustainable materials and methods specified	For critical aspect(s) of project, sustainable materials and methods specified	Selection of sustainable materials that can be fully recovered at the end of life
En4	Water Quality	How will this alternative impact water quality (WQ)?	Negative impact on WQ that immediately impacts natural resources	Negative impact that deteriorates WQ over time	No impact on WQ	Positive impact that improves WQ over time	Positive impact on WQ that immediately leads to pristine conditions
En4	Permanence	How long will the environmental benefits of this project be realized?	Never, there are no benefits	Short term that will need to be addressed again within 5 years	Moderate term that will last between 5 to 10 years	Long term that will last between 10 to 25 years	Long term that will last greater than 25 years

Figure 1. Sample evaluation tool rubric—Environmental category

Environmental Stewardship			Alternatives					
Category	Criteria #	Criteria Name	Maximum Possible Score	Option 1	Option 2	Option 3	Option 4	Option 5
ENV	1	Carbon Footprint	5	3	3	3	4	4
ENV	2	Resource Impact (direct)	5	2	3	4	4	5
ENV	3	Resource Impact (indirect)	5	2	3	4	3	4
ENV	4	Water Quality	5	1	2	4	4	5
ENV	5	Permanance	5	3	2	4	5	4
		Subtotal—Environmental	**25**	**11**	**13**	**19**	**20**	**22**

Figure 2. Example of tool input screen—Environmental Stewardship category

Category	Maximum Possible Score	Average Score for Alternatives	Option 1 - Do_Nothing	Option 2 - Standard Design Approach	Option 3 - Alternative Method 1	Option 4 - Alternative Method 2	Option 5 - Alternative Method 3
Design Approach	25	16.6	12	15	18	18	20
Social Well-Being	25	16.8	10	15	17	20	22
Environmental Stewardship	25	17	11	13	19	20	22
Economic Prosperity	25	14.8	19	16	13	14	12
End of Life Considerations	25	16.8	12	16	17	20	19
Total Scores	**125**	**82**	**64**	**75**	**84**	**92**	**95**

Figure 3. Comparing alternatives—total raw score

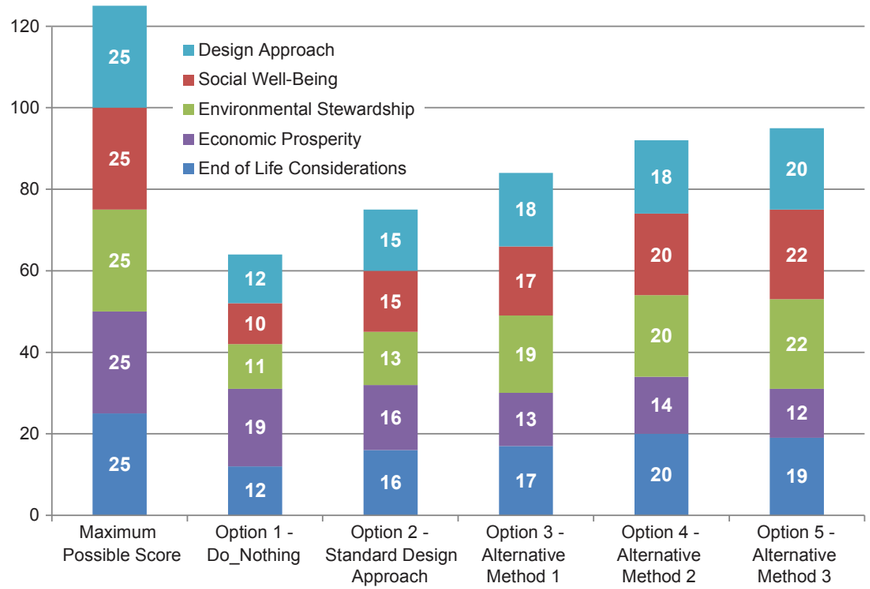

Figure 4. Graphically comparing alternatives—category raw scores

when assigning numerical grades to each criterion for each alternative.

In addition to the input screen to compare alternatives, the tool should aggregate and sum the total score for each alternative for comparison, as shown in Figures 3 and 4.

The output data depicted in Figures 3 and 4 are raw and unweighted and serve as a simple ranking and visual comparison of the alternatives. This type of graphic output allows for the high-level discussion of tradeoffs between alternatives based on category scores. For example, options 1 and 2 have the highest scores in economic prosperity but clearly lag behind the other alternatives in the remaining categories. Without the evaluation tool, option 2 may be a strong candidate based on the economic benefits over options 3, 4, and 5. However, by quantifying the benefits that options 3, 4, and 5 offer in the remaining categories, the team now has a basis for comparing the tradeoffs among alternatives.

One additional level of review compares the criteria scores within each category. For example, as shown in Figure 4, when comparing the alternatives based on their permanence, option 4 presents a major advantage over option 2 and a slight benefit over options 3 and 5. Even though the environmental score for option 4 (20) is less than option 5 (22) (Figure 4), the team may decide that the permanence, or long-term environmental benefits, of option 4 justifies the selection of this alternative.

Category	Rank	Category Weight
Design Approach	4	10
Social Well-Being	1	35
Environmental Stewardship	2	25
Economic Prosperity	3	20
End of Life Considerations	5	10
Total Scores		**100**

Figure 5. Assigning category weights

Applying Category Weights. As noted, comparing the raw total scores and raw category scores provides a high-level comparison of each alternative. The team can obtain additional perspective by assigning a weighting factor to each category. Because not every category can be the most important, this process engages the team in discussing the importance of each category. Category weights can be established by having the team rank the categories based on importance, and then assigning a weight to each category where the sum of all category weights should equal 100 (Figure 5). Then applying the category weight to each category score for each alternative provides a second level of perspective as shown numerically and graphically in Figures 6 and 7.

Applying Criteria Weights. One additional level of review can be conducted by weighting each criterion using a Criteria Significance Factor that applies a percentage of the that category's total weight to each criterion based on its perceived importance. The higher the perceived importance is for each criterion, the higher the Criteria Significance Factor, until it approaches 100 percent. This process allows for additional engagement and discussion related to the significance of various criteria. All criteria in the tool have some level of importance, and therefore the Criteria Significance Factor should not be zero for any criterion. The Criteria Weighting Factor is the product of the Category Weight and the Criteria Significance Factor, as shown in Figure 8 (next page).

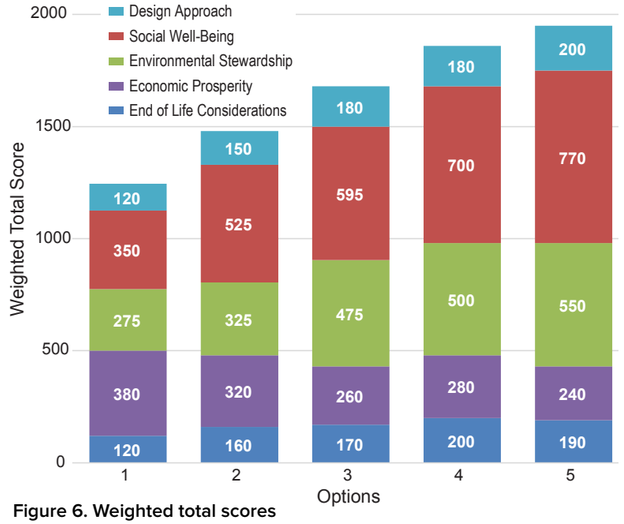

Figure 6. Weighted total scores

Applying the Criteria Weighting Factor to raw criteria scores considers the importance of each category (i.e., the Category Weight) and the significance of each criterion (i.e., the Criteria Significance Factor). This provides output results with greater ranges for comparison. For example, in option 4, the raw criteria scores for Carbon Footprint, Resource Impact-Direct, and Water Quality each received a score of 4, indicating that they should each be considered equally. However, applying the Criteria Weighting Factor for each of these criteria results in weighted criteria scores of 60, 80, and 100, respectively (Figure 9—next page), indicating that these criteria are actually different when evaluated more deeply.

CONCLUSION

Selecting the right project from a series of alternatives often requires a decision largely based on non-quantifiable information from stakeholders with varying perspectives, interests, and backgrounds. An MCDA

Category	Rank	Category Weight	Total Raw Scores					Weighted Total Scores				
			Option 1	Option 2	Option 3	Option 4	Option 5	Option 1	Option 2	Option 3	Option 4	Option 5
Design Approach	4	10	12	15	18	18	19	120	150	180	180	200
Social Well-Being	1	35	10	15	17	20	22	350	525	595	700	770
Environmental Stewardship	2	25	11	13	19	20	22	275	325	475	500	550
Economic Prosperity	3	20	19	16	13	14	12	380	320	260	280	240
End of Life Considerations	5	10	12	16	17	20	20	120	160	170	200	190
Total Scores		**100**						**1245**	**1480**	**1680**	**1860**	**1950**

Figure 7. Applying category weights

Criteria Name	Weighting Factors: Category Weight	Weighting Factors: Criteria Significance Factor	Criteria Weighting Factor
Carbon Footprint		60%	15.0
Resource Impact (direct)		80%	20.0
Resource Impact (indirect)	25	60%	15.0
Water Quality		100%	25.0
Permanence		85%	21.3

Figure 8. Assigning significance to criteria for the Environmental Stewardship category

qualitative tool that incorporates sustainability criteria to evaluate project alternatives can remove stakeholder biases from decision-making, resulting in a more defensible and sustainable project selection. With the use of MCDA and sustainability criteria, the decision-making process offers the following benefits:

- Provides a platform to identify aspects and impacts of project alternatives
- Supports the incorporation and consideration of all three sustainability responsibilities, including social well-being, environmental stewardship, and economic prosperity in the review process
- Encourages stakeholder engagement in defining the importance and significance of evaluation categories and criteria
- Establishes a set of values that have been collaboratively established and vetted
- Provides options to evaluate alternatives at either a high level or a deeper one

And while the tool output provides numerical data for consideration, ultimately the discussions and collaboration in decision-making give an MCDA its value.

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Criteria Name	Criteria Weighting Factor	Raw Criteria Scores: Option 1	Option 2	Option 3	Option 4	Option 5	Weighted Criteria Scores: Option 1	Option 2	Option 3	Option 4	Option 5
Carbon Footprint	15.0	3	3	3	4	4	45.0	45.0	45.0	60.0	60.0
Resource Impact (direct)	20.0	2	3	4	4	5	40.0	60.0	80.0	80.0	100.0
Resource Impact (indirect)	15.0	2	3	4	3	4	30.0	45.0	60.0	45.0	60.0
Water Quality	25.0	1	2	4	4	5	25.0	50.0	100.0	100.0	125.0
Permanance	21.3	3	2	4	5	4	63.8	42.5	85.0	106.3	85.0
Subtotal—Environmental Stewardship							**203.8**	**242.5**	**370.0**	**391.3**	**430.0**

Figure 9. Applying criteria weighting factors for the Environmental Stewardship category

Evaluation of commercial peroxyacetic acid products for wastewater disinfection—considering feasibility of the on-site generation of peroxyacetic acid

An academic study performed by the Department of Civil and Environmental Engineering, Water and Energy Technology Center, University of Massachusetts Amherst

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ABSTRACT | Municipal wastewater is treated at publicly owned treatment works where it is subjected to physical, chemical, and biological processes for reintroduction to the natural environment. The final step before releasing the water to rivers, lakes, or oceans is "secondary effluent disinfection." Traditionally, chlorine is used as a disinfectant to inactivate harmful bacterial pathogens and viruses. Chlorine is relatively inexpensive, but it takes a toll on the environment through 1) formation, with organic matter, of carcinogenic disinfection byproducts and 2) high toxicity to aquatic organisms in the receiving water. For these reasons, the industry is moving away from chlorination, in favor of ultraviolet light, ozone, and peroxyacetic acid (PAA). This study examines the efficacy of peroxyacetic acid as a regulatory-compliant alternative to chlorine for disinfection. Of particular interest is the on-site generation of PAA at the point of use, to reduce transportation costs, increase shelf life, and optimize dosing. Advanced oxidation processes, in which combinations of disinfectants are believed to exhibit synergistic effects through the formation of highly reactive hydroxyl radicals, are also investigated.

KEYWORDS | Disinfection, peroxyacetic acid (PAA), onsite PAA generation, advanced oxidation process (AOP), chloramines, peroxide acetic acid reaction

INTRODUCTION

Peroxyacetic acid (PAA) is an EPA-approved, broad spectrum biocide made from acetic acid (CH_3OOH) and hydrogen peroxide (H_2O_2). Researchers at the University of Massachusetts (UMass) Amherst Water and Energy Technology (WET) Center performed controlled studies to evaluate the efficacy of several PAA-based biocide products, including PAA-OSG (on-site generated), for wastewater disinfection.

In the United States, publicly owned treatment works (POTWs) treat around 70 billion gallons (265 billion liters) of municipal wastewater per day. The wastewater is highly contaminated with biological pathogens and viruses, and those not removed through the POTW treatment processes must be destroyed (killed or inactivated) before discharge to the environment. Chlorine (gas or bleach) is the most common biocide used for this application due to its low cost and efficacy. However, chlorine has several disadvantages:

- Reactions with certain organic matter produce carcinogenic, bio-accumulative disinfection byproducts (DBPs), which include halo-acetic acids (HAAs), trihalomethanes (THMs), and absorbable organic halides (AOX)
- High levels of chlorine are toxic to aquatic life. This requires that chlorine residuals be monitored and/or removed before release to the environment
- Costly safety and security plans are required by OSHA and the Department of Homeland Security, especially for gaseous chlorine

Alternatives to chlorine for wastewater disinfection include PAA/H_2O_2 blends, ultraviolet light (UV), ozone, and chlorine dioxide. While UV light and ozone often require expensive and environmentally intrusive infrastructure modifications within the treatment plants, PAA is gaining traction in the municipal wastewater market owing to its effectiveness, cost, and minimal environmental impact. In the past few decades, global environmental protection agencies (e.g., Water Environment Federation [WEF], EPA, and European Environment Agency) have considered PAA as a replacement for chlorine in the disinfection of municipal wastewater. For example, WEF has created a PAA textbook, *Peracetic Acid Disinfection: Implementation Considerations for Water Resource Recovery Facilities* (2020), which evaluates PAA technologies in wastewater processes. EPA performed a pilot case study in collaboration with the Metropolitan Sewer District of Greater Cincinnati (Garg, 2019). Numerous studies by these agencies have also confirmed the efficacy of the chemistry for effluent disinfection, and recommendations have been made for its use. The use of PAA for wastewater disinfection is expected to increase significantly in the next few years.

PAA products are based on traditional "equilibrium" formulations where concentrated acetic acid and H_2O_2, are mixed, in various ratios, with water. The chemical reaction that forms the PAA is very slow and may take up to a week to reach equilibrium. The dilute products must be manufactured and shipped. This study highlights a new method for using PAA: a safe, economical, and unique three-precursor system for PAA-OSG. In contrast to traditional or "equilibrium" acidic PAA, the PAA-OSG product is alkaline, non-corrosive, and odor free.

Most PAA is produced in chemical plants from which it is shipped overland to the points of use. Given that these PAA solutions are less than 25 percent (weight by weight) PAA, most of the shipping weight is water and packaging material, which both contribute to a high carbon footprint. The proposed technology generates PAA onsite and on demand from concentrated precursors, eliminating the need to ship dilute solutions.

Many functioning treatment facilities have simply outgrown their disinfection capacities because of their current technology's limits, not necessarily because they need a new plant or costly upgrades and maintenance for UV or ozone. PAA-OSG can be implemented using most already-existing plant effluent chemical-based disinfection systems.

EXPERIMENTAL

Testing was conducted under three conditions:

1. Bench-scale disinfection
2. Pilot-scale flow-through disinfection
3. UV+PAA/H_2O_2 disinfection

All experiments used secondary effluent from the Town of Amherst, Massachusetts wastewater treatment facility, which is adjacent to the UMass WET Center. Three commercially available PAA products were tested, consisting of varying compositions of PAA and H_2O_2 , including PAA generated on-site using concentrated reagents and a proprietary mixing process. Control tests were performed using H_2O_2 and sodium hypochlorite (NaOCl). Table 1 shows the formulations of the solutions. For the disinfection tests, total coliform (TC) and Escherichia coli (*E. coli*, EC) were used as indicator organisms. The disinfection was measured by the inactivation of TC and EC after a designated contact time in units of "most probable number per 100 mL" (MPN/100mL), in which "MPN" is equivalent to "CFU," or "colony-forming units." TC and EC were measured with the enzyme substrate coliform test method (*Standard Methods for Examination of Water and Wastewater, Method 9223B – Enzyme Substrate* Test). The calculation for the degree of disinfection of TC and EC is as follows:

Log inactivation = $-\log_{10}(N/N_0)$

N_0 is the MPN/100mL of TC or EC in the 2°C (35.6°F) effluent (control), and N is the MPN/100mL of TC or EC for the 2°C (35.6°F) effluent post-treatment.

Table 1. Disinfectant formulations

Product Name	% PAA	% H_2O_2
PAA-18	18	27.5
PAA-15	15	10
PAA-OSG (on-site generated)	2.5	1.5
H_2O_2 solution	0	30
Sodium hypochlorite (NaOCl)	(5.65% as Cl_2)	0

OXIDANT DEMAND STUDIES

Oxidant demand is the amount of an oxidizing agent consumed by reactive components in water before a measurable residual is established. These can be dissolved or suspended compounds in the water and/or sessile materials bound up in biofilm and debris. This concept is critically important in that these side reactions compete with the intended purpose of oxidizing biocides which is to disinfect the effluent. Demand tests are routinely performed to determine the suitability of an application's given oxidizer, estimate oxidant usage rates, establish required contact times for the disinfectant to be effective, and size equipment properly.

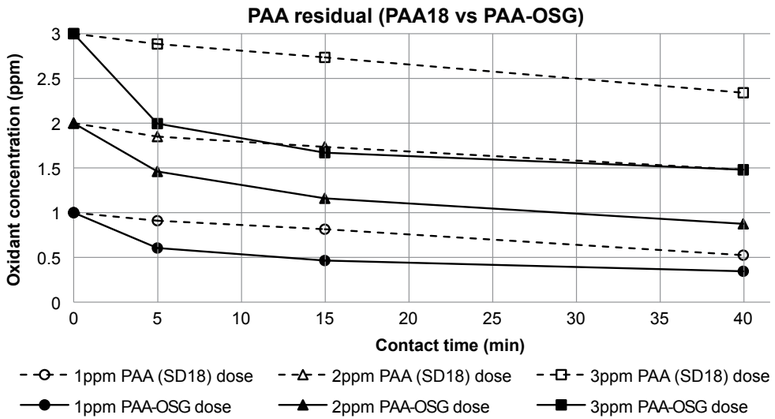

Figure 1. Demand and oxidant residual tests for PAA-18 and PAA-OSG at applied doses of 1.0, 2.0, and 3.0 ppm

Table 2. Oxidant demands for PAA-18 and PAA-OSG at applied doses of 1.0, 2.0, and 3.0 ppm

Product Name	PAA Dose (mg/L)	PAA Demand (mg/L)		
		T = 5 min	T = 15 min	T = 40 min
SD 18.0	1	0.09	0.19	0.48
	2	0.15	0.27	0.52
	3	0.12	0.27	0.66
PAA-OSG	1	0.40	0.54	0.66
	2	0.54	0.84	1.13
	3	1.01	1.33	1.52

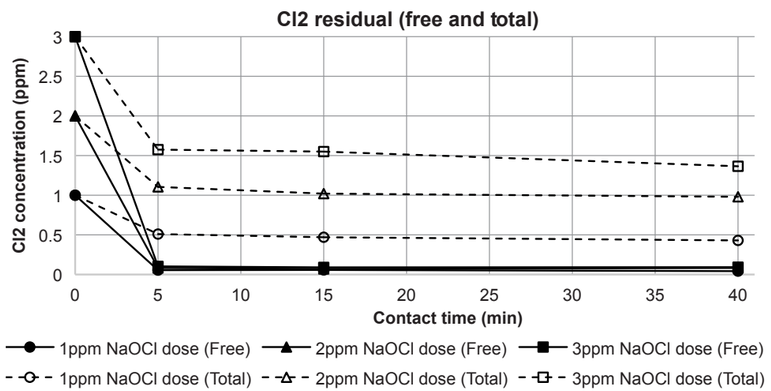

Figure 2. Demand tests for free chlorine at 1, 2, and 3 ppm

Demand tests were performed as a function of time, for PAA-18, PAA-OSG, and sodium hypochlorite.

Figure 1 shows the results from bench-scale secondary effluent oxidant demand tests. Results indicate that the wastewater demand for PAA-18 was approximately 0.5 ppm while the demand for PAA-OSG was between 1.1 and 1.5 ppm (higher demand). This can be explained by the difference in H_2O_2 concentration between the two products (Table 2). For example, when the sample was spiked to 3 ppm of PAA from PAA-18, the PAA was accompanied by 4.6 ppm of reactive H_2O_2 while a 3.0 ppm solution of PAA-OSG contained only 1.6 ppm of the peroxide. The "demand reactions" are non-specific so it is hypothesized that H_2O_2 satisfies part of the oxidant demand.

Ammonia concentration in these tests was measured at 2.2 mg/L. Figure 2 shows that free chlorine is quickly depleted by oxidant demand, and residual chlorine is converted to "combined chlorine," also referred to as total chlorine. This is due to the "oxidant demand" exerted by reduced nitrogen compounds such as ammonia, nitrate, and nitrite. In these tests, the free chlorine demand cannot be established because it was completely consumed. However, the reaction between chlorine and ammonia yields chloramines (primarily monochloramine in dilute solution), which provide biocidal activity. EPA's National Pollutant Discharge Elimination System (NPDES) discharge permits require that total residual chlorine (TRC) is monitored and levels above 1.0 ppm must be removed (neutralized). These data clearly indicate that the 2.0 and 3.0 ppm samples would require neutralization before discharge in a real-world application.

Chloramine formation is common in many wastewater treatment plants that do not fully nitrify (microbial conversion of reduced nitrogen compounds to elemental nitrogen), resulting in a 2 to 5 ppm residual of ammonia-nitrogen and/or nitrite in the secondary effluent. Both ammonia and nitrite react quickly with chlorine, creating an additional undesirable chlorine demand. Previous studies have shown that significant PAA demand is not exerted by inorganic nitrogen compounds (Domínguez Henao, 2018).

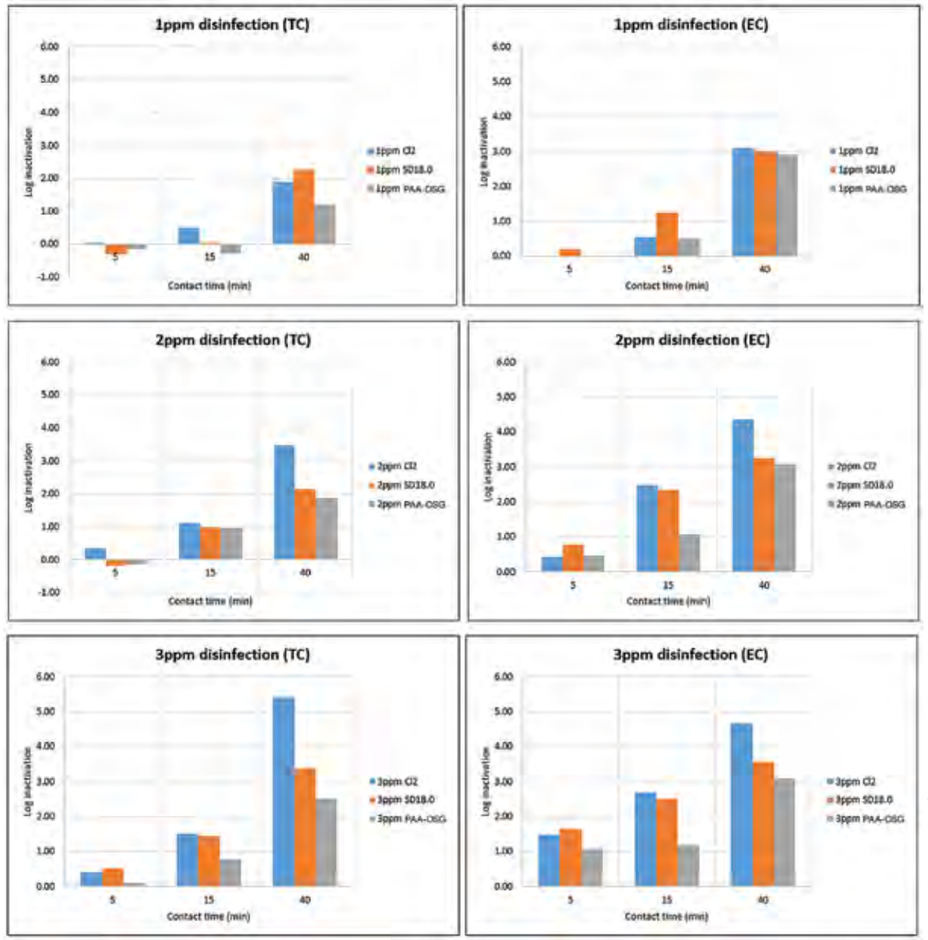

Figure 3. Inactivation of total coliform and *E. Coli* by PAA-18, PAA-OSG, and chlorine as functions of concentration and contact time

Chloramines are less reactive and more corrosive than chlorine. Plants with significant ammonia or nitrite levels in the secondary effluent should consider alternative disinfectant techniques that do not create chloramines or are not consumed by nitrogenous species.

BENCH-SCALE DISINFECTION

PAA products, H_2O_2, and free available chlorine were spiked into 300 mL biochemical oxygen demand (BOD) bottles with secondary effluent and evaluated for disinfection efficacy at contact times of 5, 15, and 40 minutes. Spiking levels were 1, 2, and 3 ppm of oxidant, either as PAA, H_2O_2, or Cl_2. H_2O_2 showed little efficacy against TC and EC at 1, 2, and 3 ppm and is not shown in the presented results.

In a separate UMass WET Center study, PAA was observed as the primary disinfecting agent in the PAA products. H_2O_2 by itself was not effective at inactivating TC and EC in secondary effluent. However, the peroxide levels in the higher H_2O_2:PAA (PAA-18) formulations would meet some of the overall oxidant demand that would otherwise consume PAA, making the PAA unavailable for disinfection.

Figure 3 shows log reductions of TC and EC by free available chlorine, PAA-18, and PAA-OSG at various dosing rates and contact times. As expected, higher dosing rates and longer contact times resulted in greater reductions. At a contact time of 40 minutes, PAA doses above 1.0 ppm (PAA-OSG and PAA-18) achieved ≥ 2.5-log inactivation of total coliform and a ≥ 3-log inactivation of *E. coli*. PAA-18 appeared to outperform the PAA-OSG product for TC and EC inactivation at contact times of 5 and 15 minutes. The reason may be that the higher H_2O_2 levels in the PAA-18 met some of the oxidant demand of the sample. At contact times of 5 and 15 minutes, PAA-18 had similar log removals of TC and EC to chlorine.

Figure 4. Pilot flow-through disinfection setup

At 1 ppm of oxidant (PAA and Cl_2), all three products showed a log inactivation of EC between 2.9 to 3.1 with a 40-minute contact time. As oxidant dose increased, chlorine showed a higher log removal than PAA and H_2O_2. At 2 and 3 ppm Cl_2, chlorine achieved a TC inactivation of 4.2 and 5.7 log, respectively. This may be due to the persistence of chloramine, which is less reactive than PAA. TRC residuals, assumed to be mostly chloramine, were measured at 1.0 ppm and 1.4 ppm after the 40-minute contact time.

Increased doses of PAA at the bench scale inactivated more TC and EC. At a contact time of 40 min, PAA-OSG dosed at 3.0 ppm PAA and 5.0 ppm PAA provided approximately 3-log inactivation and 4-log inactivation for total coliform and *E. coli*, respectively (not shown in Figure 3).

Considering the demand results discussed earlier, the effective dosing rates for PAA-18, PAA-OSG, and free available chlorine are shown in Table 3.

Table 3. Effective dosing rates considering oxidant demand

Oxidant	Demand (mg/l)	1 ppm Effective Dose (mg/l)	2 ppm Effective Dose (mg/l)	3 ppm Effective Dose (mg/l)
Chlorine	-----	1 (TRC)	2 (TRC)	3 (TRC)
PAA-18	0.5	0.5	1.5	2.5
PAA-OSG	1.3	-----	0.7	1.7

Some of the oxidant demand is hypothesized to be due to the oxidant reacting with microorganisms, but comparing efficacy results for residuals maintained after the demand was met is pertinent when considering dosing rates and system sizing.

PILOT-SCALE DISINFECTION

PAA-OSG was tested using a pilot-scale setup as shown in Figure 4.

PAA-OSG was dosed at various concentrations (1, 2, 3, 4, and 5 ppm) as PAA into 1 gpm (4 Lpm) of secondary effluent pumped from the Amherst wastewater treatment facility. Four sample locations were designed and selected to establish various contact times: a baseline control, 0, 3, and 43 minutes contact time. After dosing PAA-OSG, wastewater flowed into a 5 gal (19 L) bucket, followed by a 55 gal (208 L) drum. Time 0 sample was taken immediately following dosing and static mixing. A 3-minute contact time sample was taken following the 5 gal (19 L) bucket, and a 43-minute contact time sample was taken following the drum. Contact times were determined volumetrically, where hydraulic retention time (HRT) is defined as vessel volume (V) divided by volumetric flow rate (Q); (HRT= V/Q).

As before, higher dosing rates and contact times were more effective against EC and TC, and the best results were for the 5 ppm PAA at 43-minute contact time. EC and TC log reductions were 3 to 4 log and 1 to 4 log, respectively. Overall, PAA was observed to likely be more effective in inactivation of *E. coli* than total coliform. It was also observed that, at the same PAA dosing rates, the flow-through system showed lower kill rates for both TC and EC compared to the bench-scale run. Again, these data will help determine real-world treatment parameters.

UV+PAA/H_2O_2 DISINFECTION—ADVANCED OXIDATION PROCESS

UV irradiation is a common alternative to chemical disinfection in wastewater treatment. Typical UV doses

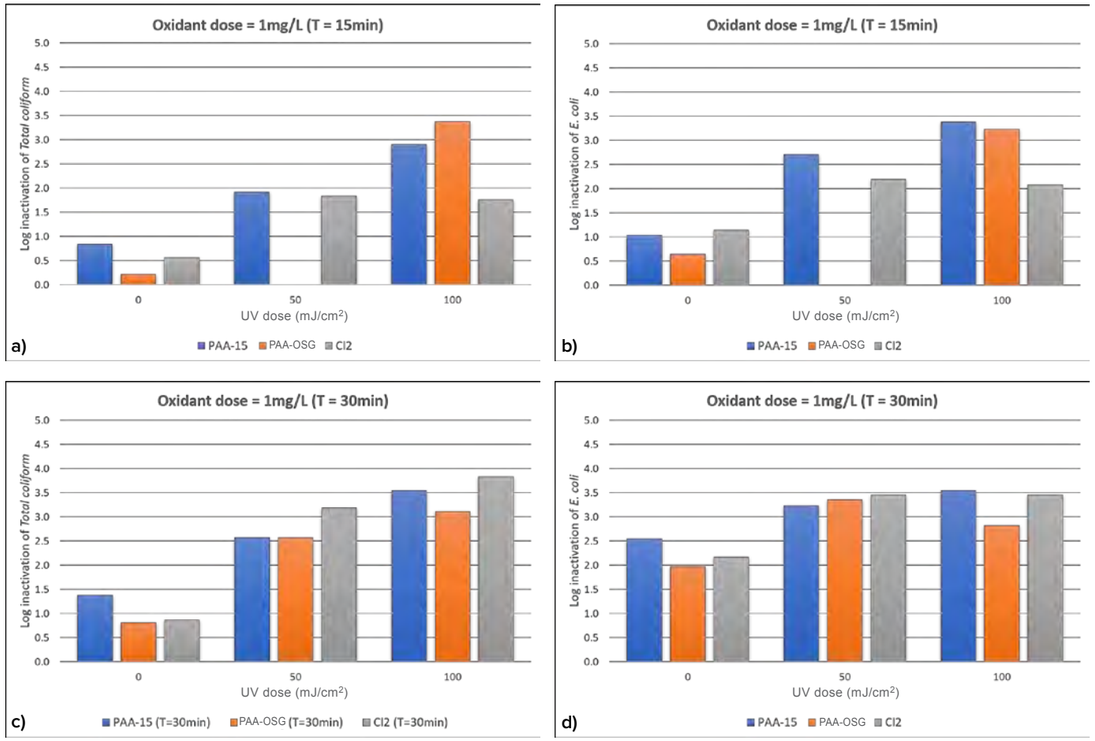

Figure 5. Log inactivation of total coliform (TC) and *E. coli* (EC) corresponding to UV dose (50 and 100 mJ/cm²):
a) log inactivation of TC at oxidant dose = 1 mg/L, oxidant contact time = 15 min
b) log inactivation of EC at oxidant dose = 1 mg/L, oxidant contact time = 15 min
c) log inactivation of TC at oxidant dose = 1 mg/L, oxidant contact time = 30 min
d) log inactivation of EC at oxidant dose = 1 mg/L, oxidant contact time = 30 min

for disinfection range between 10 to 400 mJ cm² When UV is combined with PAA or H_2O_2, an advanced oxidative process (AOP) may occur where hydroxyl radicals are formed and break down organic matter and pathogens. To achieve an advanced oxidation, UV light must be dosed at higher irradiances than are typically used for disinfection. However, it is hypothesized that the addition of PAA/H_2O_2 in a system that uses UV alone would improve disinfection.

Experiments were completed with a bench-scale collimated beam reactor using a medium pressure UV lamp. The fluence rate of the UV lamp, as determined by an iodide–iodate chemical actinometer, could provide 23 mW/cm² to a 20 mL sample. PAA-OSG and PAA-15 were dosed in secondary effluent with contact times from 0 to 60 minutes. After the designated contact time, the sample was dosed at either 50 or 100 mJ/cm² (UV), and TC and EC were measured. Figure 5 shows the log inactivation for each treatment and control (TC and EC inactivation with PAA only or UV+PAA).

AOP RESULTS

At 1 ppm PAA dose (30-minute contact time), the log inactivation by PAA-only treatment using PAA-15 was 1.4 for total coliform and 2.5 for *E. coli*, while the log inactivation using PAA-OSG was 0.8 for total coliform and 2.0 for *E. coli*. A higher PAA dose increased the log inactivation for PAA products. At the same PAA dose, PAA-15 showed higher log inactivation for both total coliform and *E. coli* compared to PAA-OSG. The UV-only treatment at 50 and 100 mJ/cm² UV dose had a log inactivation of 1.4 for total coliform and 2.8 for *E. coli*. The combined treatment with PAA followed by UV showed increased log inactivation for both total coliform and *E. coli* in comparison to PAA-only or UV-only treatment. PAA+UV treatment is likely to be more effective in disinfection than sole PAA or UV treatment. However, further inactivation by synergistic effects of combined PAA+UV to form AOP radicals was not observed at these UV doses. The log inactivation by PAA+UV treatment was close to a sum of the log inactivation by PAA-only and UV-only treatment at these UV doses. A previous

study found that the order of PAA and UV addition had negligible difference in the log inactivation of *E. coli* (A.H. Hassaballah et al., 2020). To understand the AOP performance by PAA+UV, an additional test was performed by significantly increasing the UV dose in the presence of PAA. PAA was degraded by 50 percent and 80 percent at 2,000 and 7,000 mJ/cm^2, respectively, demonstrating that a very high UV dose is required to activate AOP processes.

CONCLUSIONS

The efficacy of the PAA disinfectants, PAA-18 and PAA-OSG, was similar to chlorine in the ability to deactivate TC and EC reference organisms in real wastewater. PAA products contain both PAA and H_2O_2, and PAA was determined as the primary disinfectant. However, the peroxide did consume some of the oxidant demand, conserving the PAA for disinfection action. Of the products tested in this study, chlorine showed the highest level of efficacy at higher dosing rates and longer contact times, ostensibly due to the formation of stable and persistent chloramines. In practice, these chloramine species would need to be tracked and removed prior to discharge.

PAA is a potential alternative to chlorination and UV light under certain circumstances, and it does not form eco-toxic disinfection byproducts or require costly and environmentally intrusive infrastructure modifications to POTWs. The advent of PAA-OSG now facilitates the on-site generation of non-acidic and odor-free PAA solutions, eliminating the need to ship dilute PAA solutions in favor of concentrated precursors.

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ACKNOWLEDGMENTS

We thank the team at Biosafe Systems (East Hartford, Connecticut) for providing PAA formulations and necessary equipment to produce PAA onsite.

ABOUT THE TEST FACILITY

The UMass Water and Energy Technology (WET) Center is a multipurpose research and water piloting test facility on the UMass campus. Researchers at the UMass WET Center have extensive experience with commercially available peroxyacetic acid (PAA) and more recently have been working with PAA which is on-site generated (PAA-OSG) using a proprietary reactor and concentrated precursor chemicals.

ABOUT THE AUTHORS

- Patrick Wittbold holds a B.S. in Environmental Engineering from Manhattan College (2011) and an M.S. in Civil Engineering from the University of Massachusetts Amherst (2014). During his graduate studies Patrick worked as a research assistant on projects studying innovative strategies for monitoring natural organic matter and disinfection byproduct precursors. Prior to joining UMass Patrick worked as project engineer for Cooperstown Environmental in Andover, Massachusetts, focusing on soil and groundwater remediation projects.
- Soon-Mi Kim is a PhD candidate at UMass Amherst in the Department of Civil and Environmental Engineering, where she has participated in numerous environmental research projects and has previously co-authored research papers on subjects such as carbon dioxide capture and analysis of passive remediation of contaminated groundwater.

The innovation life cycle and product development

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ABSTRACT | This paper discusses the innovation life cycle as a theoretical framework. It reviews practical considerations about customer-facing design practices, identification of market opportunities, assessment of innovation magnitude, practical application of innovation to product development, and how competitive forces shift the value of innovation.

KEYWORDS | Innovation, design, product development, competitive forces

FRAMEWORK

Innovation is defined as the process of creating value from ideas, and product development is one method for creating a tangible embodiment of the dormant value held by an idea (Tidd & Bessant, p. 3).

To that end, product development, as a form of innovation, follows the innovation life cycle. In this review, we will discuss considerations of product development in each phase of the innovation life cycle, with an overview as follows:

- **In the pre-innovation phase**, personal insights, technology, and systems frame new ideas and opportunities for products that satisfy human needs
- **In the innovation phase**, a commitment is made to develop new ideas into products; this is where proper product development processes occur
- **In the post-innovation phase**, ideas have matured and are subject to outside forces. To remain viable, new innovation is required, thus completing the life cycle (Mckeown, pp. 82-84)

PRE-INNOVATION

Human-centered Design

Good products originate from human-centered design (HCD) processes. In his seminal text, *The Design of Everyday Things*, Don Norman proposes that HCD processes develop useful products that achieve a specific purpose. To that end, HCD processes are concerned with two requirements:

- First, any given product must solve a problem and therefore meet a human need
- Second, the product must account for human preferences and capabilities, and satisfy them with a positive, enjoyable experience (Norman, p. 219)

In the context of human-centered design, it thus makes sense to consider both customer needs and customer satisfaction.

Customer Needs

Human needs can be expressed in various ways, and Maslow's hierarchy of needs is one available framework (Olsen, p. 43). In Maslow's model, human needs fall into three tiers:

1. The first tier, basic needs, includes demands such as food, water, warmth, rest, security, and safety
2. The second tier, psychological needs, embodies concepts such as relationships, prestige, and accomplishment
3. The third tier, and perhaps the most difficult to achieve, involves a need for self-fulfillment, where an individual's psychological potential is realized

A good product attempts to understand and address one or more of these areas for its intended customer.

Customer Satisfaction

Equally important is that a good product leaves its customer feeling satisfied, a key theme in Nir Eyal's book *Hooked*. Mr. Eyal describes how customer satisfaction is a function of user experience, embodied by the lasting connections and habits users form.

He contends that products that satisfy their customers will be used consistently. Consistent use creates product-centered habits, in turn compelling further use and a lasting mental association.

As a product association develops into an affinity, customer loyalty can result, a highly valued consumer trait that improves the likelihood of repeat business, allows greater pricing flexibility, and creates a preferential advantage over competitors' products (Eyal, pp. 2, 36).

In addition to meeting a customer need, therefore, a good product will satisfy a customer and engender loyalty.

Opportunity—Intersection of Customer Need and Satisfaction

When an important customer need exists and users are not satisfied with the options to fulfill that need, a market opportunity is created.

This is expressed in Olsen's importance vs. satisfaction framework, which suggests that product developers should identify high-priority needs where solutions do not exist (Olsen, p. 47).

A customer need that exists without competition imparts value and thus creates an opportunity which, once identified, allows innovation and product development to begin.

INNOVATION

Types of Innovation and Product Development

Product development gradually moves ideas into application. It comprises multiple problem-solving steps. At each step market or technology-related information is incorporated until a final implementation is achieved (Tidd & Bessant, p. 181).

As stated, product development aims to be a human-centered process. Once customer needs have been identified, ideas to fulfill that need are generated, screened, developed, and evaluated for how well they fit with a business's core competencies (Jain, p. 246).

In general, there are two types of product innovation, incremental and radical:

- Radical innovation is embodied by sudden major changes
- Incremental innovation, on the other hand, is a more deliberate, evolutionary process comprising multiple iterative changes (Norman, p. 279)

Specific processes for incremental and radical innovation can be termed as sequential feedback and iterative-integrative feedback, as discussed below (Jain, pp. 246-248).

Incremental Innovation—Sequential Feedback

The sequential feedback process consists of a series of steps in which ideas and concepts are iteratively generated and then evaluated based on technical and commercial criteria (Jain, p. 246).

The iterative steps of idea generation and refinement are based on the concept of dynamic balance, termed as divergent and convergent ideation (Puccio, p. 58).

Sequential feedback is perhaps best embodied via Norman's double diamond process, comprising four dynamic balance steps—discover, define, develop, and deliver (Norman, p. 220).

The first iteration of the double diamond process is intended to "find the right problem." It seeks to discover issues and define a specific problem, serving as the input to the second diamond.

The second diamond then seeks to "find the right solution" by developing ideas to address the problem, thereby delivering an effective solution.

Incremental Innovation—Generic Product Development Process

When practically applied to product development, incremental innovation is embodied by a linear process (Ulrich, p. 14).

Generic product development begins with an initial planning phase and proceeds sequentially through concept, design, testing, and production, as follows:

- In Phase 0, planning, customer needs and product specifications are identified and established
- In Phase 1, concept development, product concepts are generated and evaluated
- In Phase 2, system-level design, systems are defined, along with processes for assembly
- In Phase 3, detailed design, fabrication methods and controlling documentation are finalized
- In Phase 4, testing and refinement, prototypes are fabricated and tested for final performance
- In Phase 5, production ramp-up, the product is fabricated using the intended final assembly process

Radical Innovation—Iterative-integrative Process

In contrast to sequential feedback processes, integrative-iterative processes are more organic, as they are intended to develop and reframe ideas through iterative discussion. For this reason, they are also more likely to result in radical innovation, as new information is consistently introduced with each iteration (Jain, p. 247).

Norman's iterative cycle of human-centered design is an example of an integrative-iterative process. It draws upon the concepts of dynamic balance, and consists of four steps: observation, idea generation, prototyping, and testing.

In the iterative cycle, observations are used first to roughly define a problem. Ideas to address the problem are divergently generated and drive convergent prototype fabrication.

Prototypes are then tested, generating divergent information which is used to refine and reframe the initial observations, spurring additional iteration.

Designers using the iterative cycle are free to shift between steps as needed and at any given stage can reframe and integrate peripheral information from other sources.

Analogous to Norman's iterative cycle is Ries's build-measure-learn (BML) wheel, which explicitly reflects the integrative-iterative principle of continuous reframing.

In Mr. Ries's process, observation and testing are consolidated into the measure step, while idea generation and prototyping are consolidated into the build step. When applying the BML wheel, designers continuously

learn and thus integrate information as it is obtained (Mckeown, p. 176).

Radical Innovation—Spiral Product Development Process

When radical innovation processes are incorporated into traditional product development, they are generally termed as spiral product development. Multiple iterative-integrative loops replace the third and fourth phases in generic product development and thus impart its "spiral" nature.

DISCUSSION—POST-INNOVATION

Competitive Forces

In today's globalized economy, manufacturers experience severe competitive pressure, since only a few areas for differentiation exist, including price, features, and quality (Norman, p. 259).

As stated, market opportunities occur when a customer need exists and users are dissatisfied with the available options. Companies may then develop products with specific features to pursue these opportunities.

Mckeown's bloody-beautiful-paradise framework helps identify three product categories:

- Bloody products—easy to technically execute and understand
- Beautiful products—difficult or moderate to execute and understand
- Paradise products—difficult to execute and understand

Innovative products with features that are difficult to execute and understand have achieved nirvana; they hold great value and are less subject to competitive forces (Mckeown, p. 101).

Over time, even products in paradise are overtaken, however, as competitors' abilities to imitate and execute increase. As such, competitive forces are one reason all products must re-enter the pre-innovation phase of the innovation life cycle.

Shifting Requirements

As an output of product development, all products can also be evaluated for how well they satisfy customers and meet their needs.

Initially, good products will accomplish both and thus present a high value to their customers. Over time, however, customer needs and satisfaction shift and, without further innovation, product value decreases as a result (Olsen, p. 103).

To that end, changes in customer requirements are a second reason why all products must re-enter the innovation life cycle.

CONCLUSIONS

As initially stated, product development is a form of innovation, as both are concerned with creating value from ideas.

Value in product development is created through human-centered design, which is a function of customer need and customer satisfaction.

Product development itself generates and iteratively improves upon ideas, ultimately creating a product with value.

All products are subject to outside forces and, as time passes, they decrease in value, thus creating a need for further innovation.

As established throughout, product development is bound by the innovation life cycle, a continuous, perpetual process for the creation of value.

We close with a quote from Mckeown:

"It's a mistake to believe that any innovation is the secret of perpetual victory. Many people have become complacent with the popularity of a successful innovation. The tyranny of success either makes people think that they cannot lose or that they must always win in everything they do." (Mckeown, p. 102)

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The foundation for innovation

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ABSTRACT | The water sector overcomes challenges every day to provide quality levels of service to the community and the environment. To be resilient to future new and unknown challenges, utilities are interested in fostering cultures of innovation today. Two projects at the Water Research Foundation (WRF) developed a supporting framework to guide utilities in cultivating internal innovation, including concepts of engagement and partnership. WRF further supports innovation through a seamless pipeline from basic research to pilot and demonstration projects and finally full-scale installations. WRF's innovation team has identified four critical topics to support—water reuse, nitrogen reduction, energy efficiency, and per- and polyfluoroalkyl substances (PFAS) destruction.

KEYWORDS | Innovation, leadership, engagement, partnerships, strategy, pilot projects, resilience

INTRODUCTION

The Water Research Foundation (WRF) has been delivering cutting-edge research and innovation to support the water sector for over 50 years. As new challenges emerge with increasing frequency, water utilities must apply new technologies and processes—essential extensions of research—to evolve and excel.

INNOVATION RESEARCH

Through *Fostering Innovation within Water Utilities* (Carter et al. 2017), a global collaboration of 50 utilities developed a knowledge base of current innovation management practices along with detailed case studies. From this work, the team identified eight key disciplines that were embraced by innovative utilities and grouped them into three areas of utility operations: leadership, process, and culture. Since then, a second phase, *Leading Water and Wastewater Utility Innovation* (WRF project 4907), has continued the work and refined the eight disciplines as follows:

- Leadership disciplines include the actions to **visualize**, **focus**, and **measure**
- Process disciplines include the actions to **invest** and **scale**
- Culture disciplines include the actions to **engage**, **partner**, and **communicate**

The eight disciplines form the basis for the Utility Innovation Framework (the Framework). The Framework has been used to benchmark utility innovation programs from around the world as well as guide utility-led efforts to build effective innovation programs that increase the value delivered to their organization, customers, and surrounding community.

While the Framework is a powerful planning resource, practical guidance to support implementation is also needed. Three critical areas of focus were identified to successfully launch an innovation program: engagement, partnership, and strategy. WRF project 4907 is underway with a team of 76 utility partners and other collaborators from around the world. This project will compile global experiences, including tactics and tools, for utility leaders to effectively connect their internal workforce, build powerful external partnerships, and maintain momentum through meaningful innovation strategies. Project deliverables will be published later in 2021. Both phases are built on engaging workshops and field demonstrations of tactics, alongside a wide range of stakeholder perspectives including manufacturers, accelerators, entrepreneurs, digital companies, regulators, and universities.

Research is the process of systematically investigating an issue or topic to identify new conclusions. In the context of utilities, research is part of a continuous improvement process to support organizational success through an ever-changing environment and bolster resilience. WRF supports resilient water utilities through a seamless pipeline that starts with basic research, which is then translated into bench-scale, demonstration-scale, and full-scale innovation implementation.

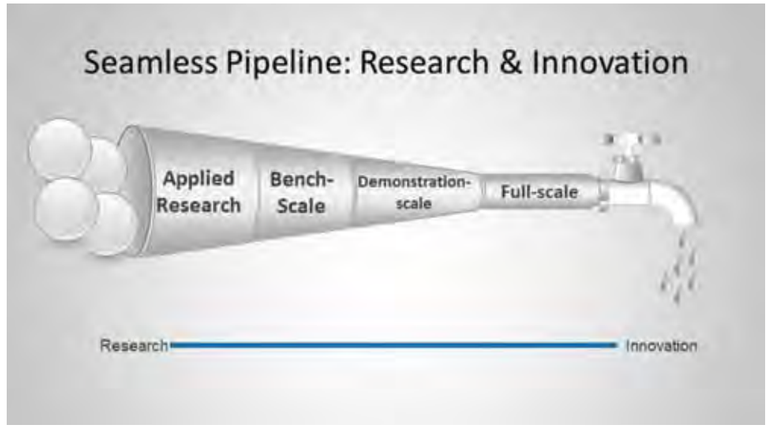

Figure 1. WRF provides a seamless pipeline from critical basic research to full-scale applications of innovation that support water utility management and performance

INNOVATION IN ACTION

Utilities aproach innovation through numerous local, regional, and sector-wide drivers. The non-sequential phases of innovation (Figure 2) include seeking and gaining new knowledge, learning, and testing new ways of doing business. Water managers and operators are often engaged in multiple phases of the innovation process and need tools and programs to improve processes without risk to their business and customers. WRF's Innovation Program supports each phase of the innovation cycle through its programs and initiatives:

- **Find It**: *Discover the most timely and relevant innovations.* WRF maintains a database of technologies relevant to utilities and ready for piloting.
- **See It**: *Explore new technologies firsthand and understand the relevance for your utility.* WRF connects utilities for in-person and virtual site tours of innovative installations.
- **Try It**: *Evaluate the applicability of the innovation for your context.* WRF coordinates utilities and technology providers for site-specific pilot demonstrations.
- **Do It**: *Implement the innovation within the water business.* WRF members benefit from consortia of experts to support new and innovative undertakings.
- **Share It**: *Spread knowledge gained across the water sector.* Through WRF's broad

Figure 2. The five non-sequential phases of the innovation cycle

communications network, WRF Innovation facilitates knowledge transfer among utilities both nationally and globally.

Try It is arguably the most critical part of the innovation cycle. Testing at pilot scale enables water utilities to explore new technologies safely. Through rigorous data collection and evaluation, utilities can perform site-specific assessments of social and techno-economic viability and performance for water and energy efficiency. Information and case studies from pilot projects enable the larger water sector to select and invest in new processes and infrastructure that will improve performance and provide better service to the community and the environment. WRF's pilot projects are supported by a consortium of utilities, researchers, and agencies to provide topical expertise and an engaged community. Currently, the Innovation Program focuses on the following for water sector innovation:

- Energy efficiency
- Water reuse
- Nitrogen reduction
- Per- and polyfluoroalkyl substances (PFAS) destruction

CONCLUSION

Considering the rapid pace of change facing water utilities, investment in innovation for the water sector is urgently needed. WRF's Innovation Program fosters communication and collaboration among key stakeholders, both of which are critical for research outcomes to be implemented at scale across the water sector. Investment in innovation will support smart decision-making when assessing options for critical infrastructure upgrades and will enable communities to benefit from resilient, affordable, and sustainable infrastructure.

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- *WRF's Innovation Program*, https://www.waterrf.org/innovation.
- *WRF TechLink,* https://wrftechlink.waterrf.org/.

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Innovation Council

NEWEA's Innovation Council, led by Dr. Marianne Langridge, fosters connections between innovators in public, private, non-profit, and academic organizations to bring new solutions to sustaining water quality. Since its inception in January 2020, the Innovation Council has organized networking and knowledge-sharing events that highlight water innovation in New England: "Reverse Pitch" nights, the Innovation Pavilion at the Annual Conference, and written communication such as the strengths, weaknesses, opportunities and threats (SWOT) reflection provided below.

REVERSE PITCH NIGHTS

The Innovation Council has been hosting a series of Reverse Pitches, which bring together leading water industry representatives to discuss industry challenges, innovative strategies, and solutions. Each Reverse Pitch event focuses on one industry challenge, with curated relevant innovations. Our first industry challenges were identified through a survey to NEWEA members; the survey revealed that most are interested in emerging contaminants, the workforce, funding, and water reuse. In response, the Reverse Pitch webinars in the fourth quarter of 2020 focused on these challenges and connected NEWEA members with creative and triable solutions.

The Reverse Pitch events will continue in 2021, and we are excited that we have expanded our membership base and begun to collaborate with the regulatory community, funders and investors, and private business as we establish ourselves as trusted partners.

INNOVATION PAVILION

This January the Innovation Council hosted a virtual Innovation Pavilion at the Annual Conference. The event included panel discussions addressing startup success factors, as well as tips on building connections across the innovation lifecycle. A recording of the event, including valuable insights from water professionals with diverse perspectives including entrepreneurs, accelerators, utilities, and research program leaders, can be accessed on NEWEA's website.

STRATEGIC VISION AND SWOT

As the Innovation Council continues its evolutionary journey, we are eager to establish a strategic direction and create a plan to serve NEWEA members. A useful strategic planning tool is a SWOT analysis to reflect on where we are today in relationship to where we want to be. Here, we present a SWOT analysis of innovation in the water industry to provide insight into what it will take to "promote innovation" as called for in NEWEA's mission statement.

First, defining innovation is important. The *Merriam-Webster Dictionary* defines innovation[1] as follows:

1. a new idea, method, or device: NOVELTY
2. the introduction of something new

Much focus is given to the first definition, with an expectation that to be innovative something must be novel. Here, we focus on the second definition, introducing something new to a group or organization in the water and environment industry. There are many technologies, ideas, and approaches that have been proposed and introduced years, or even decades, ago, but that do not have broad awareness or consideration. This includes proven technologies in other parts of the world that are new to the United States and to our New England region. The Innovation Council wants to ensure that we do not disregard ideas that came before their time, due to economic, social, political, or other reasons.

Introducing something new creates change. Most people and organizations shy away from change because it disrupts our sense of comfort, even when we are not satisfied with the status quo. It makes sense that if innovating is creating change, and we are uncomfortable with change, we are not going to be comfortable innovating. It is work. Yet, change is inevitable. The case for innovation is that it empowers us to direct change to achieve the outcomes we desire. NEWEA's members inherently understand this. NEWEA, WEF, and myriad sister organizations exist because we are driven to improve the health of our environment and communities. So, while there are challenges, there are reasons to be optimistic as well.

STRENGTHS

Several factors support optimism for innovation in the water industry. Three relevant ones are people, research, and innovation supporting organizations.

1. People. Our greatest strength is the passionate community of water professionals committed to protecting and preserving this vital resource. Many find their way to this field because water and the environment are their calling. Water professionals are trained problem-solvers. According to the 2018 study by the Brookings Institution, "Water workers embody the definition of skilled trades. On average, water workers use 63 different tools and technologies each, compared to the six tools and technologies typically used by workers in all occupations nationally."[2]

2. Research. New England has an extensive network of world-class academic research institutions that conduct water research, and our members have connections to academic programs across the country and the world. This includes public and private universities and a national network of research institutions, including the Water Research Foundation, the Bill & Melinda Gates Foundation, U.S. Department of Energy, U.S. Geological Survey, EPA, and the National Science Foundation. Collectively this is a powerhouse of insights and resources for ensuring sustainable water supplies.

3. Innovation Supporting Organizations. The need and potential for innovation in the water industry is widely recognized, and many organizations have been formed to provide support. NEWEA's Innovation Council was formed in 2020 through the merger with the Northeast Water Innovation Network (NEWIN), one of the original water clusters created with EPA in 2011.[3] There are several water clusters in the United States and internationally that are potential partners and collaborators. In addition, there is an increasing number of green technology incubators, consultants, and investors, even some that focus solely on water, that will foster bringing promising new solutions to market. Finally, most professional organizations, including WEF, the American Water Works Association (AWWA), and the U.S. Water Alliance, have recognized the need to support innovation and are creating resources and programs to support their members. This includes events like WEFTEC's Innovation Pavilion and AWWA's creation of a manual of practice for innovation in water utilities.

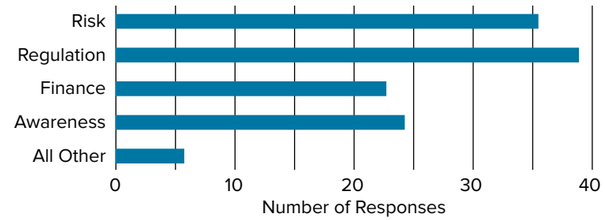
WEAKNESSES

The four root causes for the weaknesses in adopting innovations are fragmentation, undervaluation, regulation, and risk aversion.

1. Fragmentation. The flip side of all water organizations is that they are not purposefully coordinated. Networks do exist, yet there is no central catalog of the research, funding, piloting, adoption, and professional support related to water innovation. Lack of awareness of options and resources inhibits collaboration and results in inefficiencies in bringing new ideas to market.

Fragmentation is deeply embedded in most professions. In water, it begins in school. While younger grades learn holistically about the water cycle and its place within the planetary and earthly ecosystems, by the time students advance to college and graduate they must specialize, and the context of the whole system is often put aside. This can continue further as people embark on professions and join different organizations with specific foci within water.

NEWEA membership survey, June 2020:
What obstacles hinder your implementation of innovation?



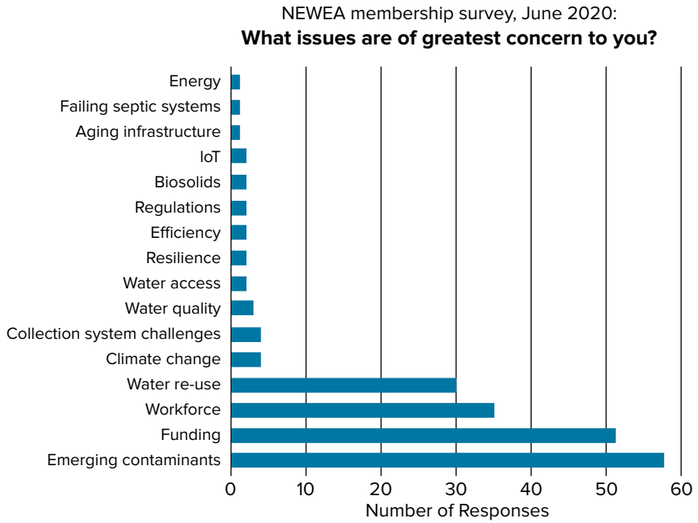
The weakness is that once these divisions are created, much effort is required to reconnect. Day-to-day activities and to-do lists take over. Anyone who intends to attend an interesting webinar from a professional association, only to get pulled away by the latest fire drill, has experienced this. Projects are underway to help overcome this,[4] and NEWEA's Innovation Council is also focused on overcoming this.

2. Undervaluation. There have been many local, national, and international campaigns to raise attention and understanding on the value of water. This includes WEF's 2018 Water's Worth it Campaign (watersworthit.org/) and U.S. Water Alliance's ongoing Value of Water program (thevalueofwater.org/). Yet, most people pay more for their cell phone than they do for water, and they complain more loudly when their water rates are raised. While our infrastructure deteriorates and threats to the quality and availability of clean water persist, many water utilities cannot charge the rates necessary to address their needs sustainably for their communities. According to AWWA's 2019 *State of the Water Industry Report*, fewer than 30 percent of utilities felt they could cover the full cost of service in five years.[5]

Because of this, water utilities typically operate without the time and money to try new things. Many can only meet basic service delivery standards. Finding solutions takes time and money, and the introduction of change into an organization also takes time and money. Without proper valuation of water, utilities will not be able to devote the attention needed to exploring solutions proactively.

3. Regulation. Regulations aim to protect the health and wellness of our communities. Changes to regulations take time, and require scientific, policy, and economic research. In addition, variations in regulations across states add to the complexity of solution development. What may be acceptable in one state may not be in another, adding complexity to innovators' efforts to bring solutions to market.

Important to note is that regulatory standards are not viewed as the primary issue—the lack of communication and collaboration among utilities and regulators is. Recent surveys of utilities and regulators



have indicated that more funding for utilities and regulators could help overcome regulatory complexities. This weakness is closely related to the prior two, fragmentation and undervaluation.[6]

4. Risk Aversion. Risk aversion is human nature. Trying something new requires change and accepting uncertainty. The fear of failure is high in the water industry because the stakes are high. In many cases it seems safer to stick with the status quo, even when the known issues are extreme. Water quality deterioration because of failing septic systems and emerging contaminants are examples of known issues with measurable negative impacts but where the testing and adoption of solutions continue to be slow. The Innovation Council survey conducted last summer noted risk as a key factor inhibiting innovation. The best way to overcome risk aversion is through collaboration and pooling knowledge and experiences, and by building trust. Many frameworks exist to facilitate the understanding of the risks of the status quo compared to those of acting under uncertainty, yet it takes time and resources to apply them.

OPPORTUNITIES

Weaknesses can be overcome by taking advantage of opportunities. There are many positive trends, including availability of financing, abundance of promising technologies, and individuals, private, public, and non-profit organizations across the world that care about water and the environment and want to be part of the solution.

Financing. In March 2021, the Biden Administration indicated an intent to dedicate billions of dollars to water infrastructure funding. Major non-profit organizations such as the Bill & Melinda Gates Foundation have committed billions of dollars to climate change and sanitation. An increasing number of investors are looking for "green tech" entrepreneurs to fund, and a new wave of younger investors feel strongly about investing in businesses that align with their interest in preserving our environment. Large businesses are also responding. In 2019, the Business Roundtable stated, "We believe the free-market system is the best means of generating good jobs, a strong and sustainable economy, innovation, a healthy environment and economic opportunity for all."[7] These factors stated above indicate that money is available.

Abundance of Promising Technologies. New solutions are being developed globally through various organizations including universities, federal agency R&D programs, consulting firms, private business, and public utilities. You need only look at the number of water organizations, published papers, and presentations at industry conferences to recognize that many people are creating solutions to the industry's challenges. Complementing this are powerful information technology tools that can aid decision-making through machine learning, data analytics, and modeling.

People Care. There is an increased awareness of, and support for, environmental protection. According to a 2020 survey by the Pew Research Foundation, 64 percent of Americans said protecting the environment should be a top priority for the President and Congress, up 20 points from a decade ago.[8] Many surveys and studies indicate that the Millennial and Gen Z generations are even more attuned to the environment than prior generations, and that they are willing to spend more to support sustainable products.[9] This indicates that support for environmental activities, including water, will continue to grow as these generations expand their influence on policy and economics.

THREATS

The three important threats to making progress in the adoption of innovative solutions in the water industry are lack of trust, being overwhelmed by issues, and climate change.

Lack of Trust. The water industry has worked to stay out of the public eye for decades. When the public is made aware of activities it is often due to catastrophic failures including large pollution discharges, tainted drinking water, and billing issues. This contributes to a lack of understanding of the role of water utilities in our communities, resulting in lack of trust. Many people also distrust government, and because most water utilities are public entities there can be distrust there as well. Innovating requires a willingness to try new things, and that requires trust. Therefore, fostering trust among all stakeholders is a critical first step for innovation.

Being Overwhelmed by Issues. Many challenges face our communities today, including social and racial justice, economic uncertainty, the persistent pandemic, and climate change. It is easy for any individual, organization, or community to become overwhelmed. The threat is that being overwhelmed causes people to shut down. If you feel helpless, for example, that the problems are too great and the resources too few, you will disengage from problem-solving. It is important that in communications a sense of purposeful hope is always maintained. We must share our belief that challenges within the water industry are solvable so our communities can thrive, and we need to put water in context across all the issues the world faces today. Water is vital for life, for equity, and for economic prosperity, and clean water makes our environments places where we can recover from being overwhelmed.

Climate Change. The impact of climate change on our water systems is not entirely clear. However, all signs indicate that the water cycle is being significantly affected.[10] This will affect water availability and water quality. In New England, as with many coastal communities, this could continue to result in more severe storms and disruptions to service delivery, as was seen to our south after Superstorm Sandy. Resiliency planning is critical so that our industry can continue to protect human health and the environment by providing clean water as conditions change. This should be central in communications with the public, in building trust and understanding, and in prioritizing investment decisions.

Overall, this SWOT provides useful guidance for the Innovation Council and NEWEA members. The Innovation Council has an important role in addressing the weaknesses and capitalizing on the opportunities by building on our strengths while recognizing the threats. As immediate next steps, the Innovation Council plans to do the following:

- Bring people and organizations together to reduce fragmentation and build understanding and trust
- Create a virtual repository to reduce being overwhelmed and make it easier for members to access the vast resources available to find solutions and partners based on their specific needs

PLANS FOR 2021

In addition to continuing the Reverse Pitch webinars and the Innovation Pavilion, the Innovation Council will continue to collaborate with the other NEWEA committees to make the connections necessary to overcome fragmentation. The Innovations in Workforce event in March and the new Innovative/Alternative Onsite Water Treatment Systems task force are two examples of this.

New for 2021 will be creating a repository of resources where members can navigate the innovation lifecycle. This will be done in partnership with organizations such as WEF and the Water Research Foundation, and we are grateful for the seed funding from Watts Water to begin. If you are interested in supporting this effort and learning more, please contact Dr. Langridge (marianne@sustiainablesynthesis.com). We are optimistic about the future of water because we know we have dedicated, creative problem-solvers on our team, and water is worth it.

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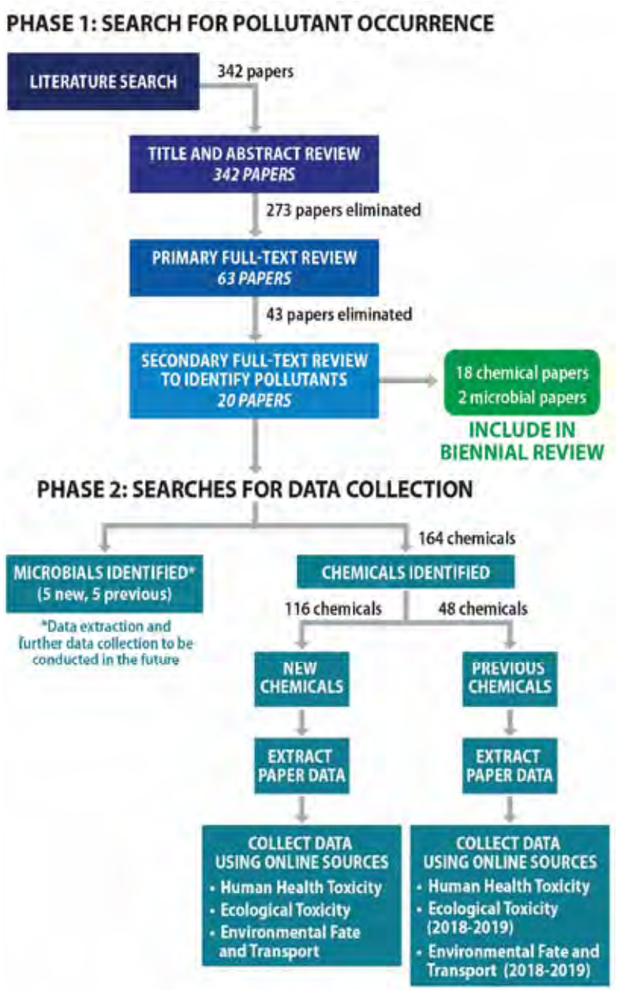
NEBRA Highlights

EPA releases biennial review of pollutants in biosolids

To comply with Section 405 of the Clean Water Act, EPA must, every two years, review the biosolids regulation (Part 503) to identify additional pollutants and regulate them if there is sufficient scientific evidence to do so. EPA's recently published *Biennial Report No. 8* is the first step in that process, which also assesses the pollutants for potential risk and developing regulations if appropriate.



Overview of the 2018–2019 EPA biennial review process

The *Biennial Report No. 8* was prepared by EPA's biosolids program, which is in the Office of Science and Technology under EPA's Office of Water. As part of this biennial review, the biosolids program searched for publicly available literature published between January 2018 and December 2019 related to the occurrence and fate/transport of pollutants in biosolids as well as human and ecological toxicity information that could form the basis for further risk assessments. EPA looks to its own available databases such as ECOTOX and EPI (Estimation Program Interface) and numerous other sources as part of its review.

The 2018–2019 biennial review identified 116 new chemicals including 50 new polychlorinated biphenyl (PCB) compounds, 19 flame retardants, 8 per- and polyfluoroalkyl substances (PFAS) including fluorotelemers, several pharmaceuticals, and one new metal (cesium). Not much data exist on toxicity, fate, and transport of PFAS in biosolids. The report provides the findings in tabular form and in numerous appendices. EPA's biosolids program has added the data from *Biennial Report No. 8* to the publicly available Biosolids List in EPA's CompTox chemicals dashboard. According to Liz Resek, EPA's biosolids lead, upon completion of peer review of EPA's risk assessment approach (scheduled for 2021), data in the dashboard will be evaluated to determine if it can be used in biosolids risk assessments. If data are appropriate for risk assessment, EPA will use the information to begin screening chemicals for risk.

Biennial Report No. 8 is posted on EPA's biosolids website under the banner "What's New" (epa.gov/biosolids).

The census for biosolids—national biosolids data project updates

Slowly but surely, biosolids data are coming in. The national biosolids data project (NBDP) launched its biosolids survey for water resource recovery facilities (WRRFs) in January. State biosolids coordinators have been kindly providing state-by-state biosolids information, but we are only at 25 percent of the goal of collecting 2018 data from about 1,500 U.S. WRRFs. There is still time to submit your data if you have yet to do so. Please go to NEBRA's NBDP project page to get started: National Biosolids Survey 2018 Data — NEBRA (nebiosolids.org).

The NBDP Advisory Committee met in March to help NEBRA and team finalize the report format.

The committee has previewed the new website (biosolidsdata.org) for the data and detailed state reports. Data and reports from several states are available now. More are being added, with a national summary expected once all the data have been collected. NEBRA is excited about learning what has changed since the last national survey in 2007; there are no definite trends yet, but we are beginning to see glimpses.

Here are a few teasers based on WRRF survey responses so far:

- **How are biosolids used and disposed in the United States?** That is the reason for this survey! The team is still collecting 2018 data (the most recent complete data), so stay tuned. So far, it looks like recycling remained at 50 percent to 60 percent.
- **What crops are grown with biosolids?** Mostly hay/grass, including pasture and rangeland; corn for animal feed; soybeans; wheat.
- **How much green electricity is produced?** Based on data reported from just 29 WRRFs to date, they are producing enough electricity to power more than 33,000 average U.S. homes each year. There are more than 20 WRRFs that each produce all the electricity they need.
- **Biosolids is expensive and a core part of wastewater treatment.** Expected investments in the next five years in biosolids program infrastructure and operations at WRRFs that responded to the survey will total over $4.5 billion. Extrapolate that nationwide and that is a projected $13.9 billion or more—just for biosolids!
- **Program pressures?** Securing long-term biosolids use options. Rising costs.
- **Key issues driving decisions?** Costs. Compliance. Biosolids recycling not being part of the core mission of many WRRFs.

NEBRA is grateful for the companies and organizations who have contributed financially to make the Biosolids Data Project possible:
Brown and Caldwell
California Association of Sanitation Agencies
Carollo Engineers, Inc.
CDM Smith
Charlotte Water
DC Water
Denali Water Solutions LLC
Hazen and Sawyer, P.C.
Illinois Association of Wastewater Agencies
Jacobs Engineering
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Merrell Bros., Inc.
Metro Wastewater Reclamation District of Denver
Michael Bullard
Mid-Atlantic Biosolids Association
Milwaukee Metropolitan Sewerage District
Metropolitan Water Reclamation District of Chicago
National Association of Clean Water Agencies
New England Fertilizer Company
Renda Environmental
Synagro
Virginia Biosolids Council
Waste Management
Water Environment Federation

New Hampshire kicks off study of PFAS in soils and biosolids

The New Hampshire Department of Environmental Services (NHDES) has kicked-off an extensive study of PFAS leaching from soils to groundwater that is being conducted by the U.S. Geological Survey (USGS) under a joint funding agreement approved in September 2020. NHDES has committed $420,000 to this project, with the USGS contributing $180,000 in matching funds. The project is studying the occurrence and behavior of PFAS in New Hampshire soils and biosolids and assessing the risk of groundwater contamination.

As part of the project, NHDES is providing funding of $800,000 for the extensive sampling and analysis by the USGS. The data collected will be used to develop a sediment/water distribution coefficient (K value) specific to New Hampshire soils that can be used in appropriate models for the transport of PFAS pollutants through soils.

Phase I of the NHDES/USGS PFAS study began on January 25 and field sampled PFAS for 100 randomly selected sites. Phase II that started in May will sample five biosolids products and five major soil types, and that data will be used to calibrate the leaching models. NHDES will use the field data from Phase III of the study to validate the K value and leaching model for New Hampshire soils. The project is scheduled to be completed in early 2022. All of the NHDES funding is from the state drinking water and groundwater trust fund.

NHDES has already done much PFAS sampling from which data are available for viewing in a map form (NHDES PFAS sampling, arcgis.com). The biosolids PFAS data are not yet included in the mapper but will be. Anthony Drouin of the NHDES residuals management section has monies allocated to continue sampling biosolids under the sludge quality certification (SQC) program. NHDES also has funding to assist municipalities with sampling for PFAS upstream to identify sources of PFAS in their systems.

UMaine kicks off research project on PFAS in residuals, with NEBRA as a stakeholder

With USGS funding, the University of Maine's (UMaine's) Mitchell Center for Sustainability Solutions has initiated a research study, "Integrated Assessment of Alternative Management Strategies for PFAS-Contaminated Wastewater Residuals." The project kick-off stakeholders meeting was held on May 10. NEBRA has signed on as a stakeholder and will contribute in-kind funds to the project. Other stakeholders include the Maine Department of Environmental Protection (MEDEP), UMaine Cooperative Extension (agriculture and farming), Defend Our Health (formerly the Environmental Health Strategy Center, an environmental health advocacy organization), and NEBRA.

With all of the focus on PFAS contamination at farms in Maine, especially dairy farms, this project will take a holistic look at residuals management and how best to address PFAS contamination. Through the stakeholder process, UMaine hopes to identify key policy issues in managing PFAS-contaminated wastewater residuals. The current focus by WRRFs on PFAS source reduction will greatly reduce the risk of PFAS-contaminated biosolids, but MEDEP is looking for more legacy sites. EPA has recommended landfilling and thermal treatment for solid materials high in PFAS. This study will look at the range of options for managing these materials and the environmental, social, and economic consequences of each.

NEBRA creates two new committees as part of strategic plan update

NEBRA's Board of Directors has created two new ad hoc committees to position NEBRA for the future. The board has met monthly to update NEBRA's strategic plan for 2022–2027. At the March meeting, the board moved ahead with creating the new committees that line up with its vision for the future of NEBRA.

The first new ad hoc committee, the Residuals Committee, will focus on recycling/reusing non-biosolids residuals. It will be chaired by board member Lise LeBlanc, a professional agrologist, and will identify opportunities to expand NEBRA's role in providing expert advice and information in support of programs that produce by-products that can be recycled for beneficial use. Creating such a committee led to a discussion about carbon and nutrient trading programs as a major incentive for farmers and other end users to look to biosolids and "designer" residuals to replace traditional fertilizer as well as other farm products. The objective of the second new committee, the ad hoc Carbon and Nutrient Trading Committee, is to identify opportunities for NEBRA to provide expert advice and information so that various residuals/waste resources are recognized and included in developing carbon and nutrient trading opportunities.

The new committees started meeting in May. If you are a NEBRA member and would like to join either of these committees, please go to nebiosolids.org/join-a-committee.

New biosolids communications toolkit available from WEF

The Water Environment Federation (WEF) hosted webcast training on February 4 to share its new biosolids communications tool kit that will help WEF members talk about biosolids in their communities. Attendees were challenged to get out into their communities—or invite them in—using the WEF guidance to work with the traditional media as well as newer social media platforms. The tool kit contains many free graphics, frequently asked questions (and answers), and a cheat sheet for responding to negative press or publicity. WEF members can download the toolkit at wef.org. The webcast recording and slides are available as well. You can also check out a relevant blog at WEF-waterblog, "Benefits of Biosolids Provides an Opportunity to Boast."

Upcoming events

- **A Conversation with Bill Toffey**, Executive Director of the Mid-Atlantic Biosolids Association (MABA), June 25
- **North East Digestion Roundtable** discussion with Michael Boerman of Natural Upcycling, July 9
- **Lunch & Learn about Urine Diversion** (with the Rich Earth Institute), July 23
- **Lunch & Learn about WRF Project #5307**, Evaluation of SSO Feedstock Pretreatment & Management Practices (Hazen & Sawyer), August 27
- **Lunch & Learn about the new Biosolids Gasification Facility** in Linden, New Jersey (Aries Clean Energy), September 24
- **Lunch & Learn about high temperature pyrolysis** to eliminate PFAS and generate hydrogen from biosolids (Char Technologies), October 22

Janine Burke-Wells, Executive Director
603-323-7654 / info@nebiosolids.org

For additional news or to subscribe to NEBRAMail, NEBRA's email newsletter, visit nebiosolids.org

nebra
North East Biosolids & Residuals Association

WEF Delegate Report

Water Environment Federation (WEF) Member Association (MA) delegates represent MAs and at-large delegates represent other constituencies from across North America on WEF's House of Delegates (HOD). HOD is the deliberative and representational body of WEF, advising the WEF Board of Trustees on strategic direction and public policy development. Throughout the year, delegates are involved in HOD committees and workgroups.

The number of delegates per MA is determined by the size of the MA, and NEWEA, with its more than 2,000 members, has three WEF delegates. Each delegate serves three years that span from WEFTEC (WEF's technical exhibition and conference) to WEFTEC. Because NEWEA officers' terms run from NEWEA's annual conferences in January, at this time of year we have four delegates—Sue Guswa (third-year delegate), Jim Barsanti (second-year delegate), Peter Garvey (first-year delegate), and Ray Vermette (incoming delegate). We also have two NEWEA members who are serving as at-large delegates: Susan Sullivan (third-year delegate) and Matt Formica (first-year delegate).

Through the pandemic experience, our WEF delegates have the hang of virtual conferences and meetings, and we have been busier than ever! Special thanks are due to Messrs. Barsanti and Garvey for presenting at the April 22 Virtual WEFMAX (WEF Member Association e'X'change) about NEWEA's Use of Innovation to Engage New Members. The following are other highlights from the viewpoints of WEF delegates regarding their spring activities.

Sue Guswa

I serve on the HOD Steering Committee, which reviews and prioritizes information from HOD committees and workgroups and advises HOD leadership. We have been busy synthesizing the recommendations from the various workgroups who have been more productive than ever because of the engaged leadership from the speaker of the HOD, Nikita Lingenfelter.

As a member of the HOD Diversity, Equity, and Inclusion (DE&I) workgroup along with Mr. Formica, I have been working with the group on a new toolkit. The HOD DE&I workgroup is completing three tasks this year:

1. Evaluating and making recommendations about establishing a permanent HOD DE&I Committee
2. Developing and sending a survey to MAs about their DE&I activities
3. Creating a toolkit for MAs to support DE&I programs

This toolkit should be available at wef.org/dei later this year. It is exciting to support NEWEA's new DE&I Committee and help link NEWEA and WEF activities.

Finally, I chair one of the subgroups in the umbrella HOD Advocacy workgroup, which is chaired by our own Ms. Sullivan. The subgroup I chair aims to increase membership in WEF's Water Advocates program (wef.org/advocacy/water-advocates). As Ms. Sullivan notes below, the advocacy program is an easy way to engage with your congresspeople and make sure your voice is heard. If we do not advocate for water, who will?

As I near the end of my term, I have found it incredibly gratifying to serve NEWEA as a WEF delegate. I have appreciated the opportunity to connect with delegates from across North America and to advocate and educate nationally. Seeing the diversity of programs and approaches makes me proud to be a NEWEA and WEF member.

Peter Garvey

It has been an active start to the year for me. As a member of the organizing committee for WEFMAX conferences, planning for the four WEFMAX events this year and for those in 2022 has required regular meetings with the committee and host MAs. The WEFMAX conferences were held in April and May, and they remained virtual for 2021; these annual events furnish a great forum for MAs to share ideas, initiatives, and best practices. Notwithstanding the virtual aspects, this year's host MAs (Water Environment Association of Utah, Pennsylvania Water Environment Association, Pacific Northwest Clean Water Association, and Atlantic Canada Water and Wastewater Association) have instilled a specific flavor of their region for their respective events. I partnered with Mr. Barsanti to present to the April 22 Pennsylvania event on behalf of NEWEA—showcasing NEWEA's focus on innovation to engage our membership.

For 2022, three WEFMAX events are expected to be in person, with one remaining virtual. WEFMAX events are free, but they do require registration. For more information, look at wef.org/membership/wef-member-associations/wefmax. It is exciting that NEWEA will host a WEFMAX event in 2023.

The Covid-19 pandemic has greatly affected the financial health of many MAs. As members of the WEFMAX Financial Diversity workgroup, we have been tasked with collecting information from MAs across the nation to determine their financial situations and then assessing their plans for returning to "normal." The workgroup sent a survey to MA leadership, and we await responses so we can review and analyze them.

In all, it has been an engaging 2021 so far, and I am looking forward to an in-person WEFTEC in Chicago in mid-October.

Jim Barsanti

Despite our personal and professional challenges of the Covid-19 pandemic, I have found the last several months serving as a WEF delegate to be dynamic and productive. As a member of the WEFTEC Advisory Committee, I have helped plan WEFTEC 2021 in Chicago. This year's conference will be a fully live event and will include all the elements you would expect, including cutting-edge technical sessions, the Young Professionals (YP) community service project, and Operations Challenge. Much of our planning has been to redefine and reimagine the WEFTEC experience for members. We are happy to hear that our colleagues from MAs across the country are preparing to attend and are excited to travel again. As one would expect, the opportunity to reconnect with each other in a live setting and not virtually is the overwhelming reason many members are planning to attend.

A comment from one of our committee members, Steve Sanders from New York Water Environment Association, really hit home. He emphasized that the in-person experience is emblematic of our being part of something bigger in our water community, and meeting in person gives us a sense of belonging and common purpose. It keeps us energized and invested in our water industry and inspires our spiritual growth. Our committee fully understands the personal, professional, and financial challenges of an in-person WEFTEC, but we encourage you to consider attending, and I expect it will be an experience that we will be talking about for years.

I am also vice chair for the Conference Resources workgroup. Our workgroup determines and prioritizes WEF's resources for helping MAs with their annual conferences, and we collect approaches and innovative solutions to conference challenges from MAs to facilitate learning and sharing. The work group has developed an infographic to describe best practices and lessons learned from virtual conferences. The infographic will include tips that MAs can use regarding virtual platforms, live vs. pre-recorded formats, preparation, follow-up, sponsorships, etiquette, and successes. We are also interviewing our MAs to learn about their virtual experiences and will be compiling the WEF responses to review and ultimately pass on to all of WEF's MAs.

I am also involved with several WEF standing committees. I am a reviewer of award nominations for the Public Communication and Outreach Committee, and I chair the Collection Systems Committee's Operation and Maintenance technical practice group. We are preparing a WEF fact sheet to promote the importance of a well operated and maintained collection system. We expect a draft in October for review by the WEF Collection Systems Committee. I also serve on the Biosolids Products Use and Communication subcommittee for the Residuals and Biosolids Committee. As you would expect, testing and disposal or reuse of biosolids remains a hot topic with this group, and I expect to have much more to report as our work evolves.

Susan Sullivan

As chair of the WEF House of Delegates Federal Advocacy workgroup, I am pleased to report that President Biden and Congress are working on a major infrastructure package, and increased funding for water infrastructure is under consideration. A survey by the Congressional Management Association found that 95 percent of Congress is highly influenced when they hear from constituents regarding issues about which the members are undecided; your congressional representatives are eager to hear from you! It is extremely important that now, more than ever, water professionals contact members of Congress to urge that increased funding for water infrastructure be included in the infrastructure package.

The WEF Water Advocates program is a quick and easy way for all NEWEA members to send an email to your senators and representatives. WEF has drafted the letters for you to send. The WEF Federal Advocacy workgroup has identified increased participation by WEF members in the WEF Water Advocates program as a proven effective and impactful way to increase federal funding for water infrastructure. Please visit the WEF Water Advocates page today and make your voice heard loud and clear in the halls of Congress and the Senate!

Student Design Competition

by Nick Tooker, PE, Student Activities Committee chair

Our second virtual NEWEA Student Design Competition (SDC) was a fantastic success again this year! We had a total of three teams, each representing different universities around New England. This competition, organized by the Student Activities Committee (SAC), promotes "real world" design experience for students interested in pursuing education or careers in water engineering and sciences. There are two categories, one for wastewater that includes design work for a treatment facility, and one for water environment that includes just about anything else related to water in the environment.

The competition tasked teams of NEWEA student members to design a project that they worked on together. Most of the teams based their written reports and presentations on their senior capstone design project. The teams presented their designs in front of judges, peers, and mentors during the SDC presentations, held on May 3 via video conference.

The teams evaluated to have the best combined report and presentation will represent NEWEA at the national competition held with WEFTEC in Chicago this October. Congratulations to all of the teams for a robust competition. The participating teams are as follows:

Wastewater Category

- **Northeastern University**
  "Water Resource Recovery Facility Design for a Vermont Creamery" Students: Aidan Travers, Emily Eastman, Jeffrey Ling, and Taylor Labbe. Faculty advisor: Annalisa Onnis-Hayden. Professional Mentor: Anna Mehrotra (CDM Smith)

Water Environment Category

- **University of Connecticut**
  "Mansfield Elementary Stormwater Management System" Students: Mary Pizzuto, Jordan Trzcinski, Caleb Wurster, Natalie Chmielewska. Faculty Advisors: Randi Mendes and Timothy Vadas
- **Worcester Polytechnic Institute**
  "Acid Leachate Active Treatment Pilot System for Cooledge Brook, MA" Students: Emma Burleson, Annemarie Eastwood, Lauren Mitchell, Molly Youngs. Faculty Advisors: John Bergendahl and Carrick Eggleston

The winning teams were from Northeastern University (wastewater division) and Worcester Polytechnic Institute (water environment division).

The Northeastern wastewater team's project was on the design and modeling of a water resource recovery facility (WRRF) for an anonymous Vermont-based creamery (referred to as ABC Dairy). The project goals were to design a sustainable recovery process that recovers energy, nutrients, and a high-quality effluent for reuse within ABC Dairy's facility. The design team completed a comprehensive technology review, and three WRRF processes were proposed. Further analysis and comparison identified the following technologies for the final process: upflow anaerobic sludge blanket (UASB) reactors, four-stage Bardenpho reactors, a sludge centrifuge for biosolids dewatering, and an ultrafiltration/reverse-osmosis system (UF/RO).

The proposed process recovers energy by converting organic matter in the wastewater into biogas through mesophilic UASB reactors coupled with heat and power cogeneration. A four-stage Bardenpho reactor train combined with sludge thickening and dewatering removes nutrients effectively from the liquids stream and recovers nutrients by producing biosolids to use as a fertilizer. Final polishing is achieved through ferric chloride addition and UF/RO, producing a high-quality effluent that meets standards for reuse within the dairy production facility for equipment washing. This preliminary design includes equipment sizing, chemical requirements, and cost estimates.

The Worcester Polytech Institute water environment team's project was on designing and testing a pilot treatment system for an acid rock drainage (ARD) contaminated site at Cooledge Brook in Northborough, Massachusetts. Cooledge Brook was affected by runoff from sulfidic fill rock at a nearby property, resulting in a pH of 4.5 and high levels of dissolved metals in both the groundwater and surface water. The team designed, built, and operated a pilot-scale batch reactor system to assess the feasibility of a large-scale treatment system at the site. The pilot system successfully increased the pH of the contaminated water from 4.5 to 7.5 using a sodium hydroxide solution and a pH-metered chemical proportioning pump. The solution was aerated to encourage coagulation, decreasing the concentration of dissolved metals in the solution.

The Worcester Polytech Institute team working on its acid leachate active treatment pilot system for Cooledge Brook

The pilot system drew water from a contaminated well using a solar-powered pump and was treated in a 10 gal (37.9 L) batch reactor. An electric mixer was used with a chemical proportioning pump to add diluted NaOH, neutralizing the pH. After settling, the water had a neutral pH and lower levels of dissolved metals, and was discharged back to the environment. Sludge was produced from the overall reaction and was collected and disposed of.

The winning teams will receive a travel allowance to attend WEFTEC 2021 in Chicago where they will compete against other teams from around the world. Good luck to the teams; we know you will do a great job and make NEWEA proud!

A huge thanks to our volunteer judges for the competition: Sabrina Castaneda (Environmental Partners), Helen Gordon (Environmental Partners), Adam Higgins (Wright-Pierce), Jim Li (Virginia Tech), Ben Stoddard (Kleinfelder), Austin Weidner (Tighe & Bond), and Will Yan (Tighe & Bond).

We also recognize and extend our gratitude to the companies that sponsored this event:

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Webinars and Virtual Events

Young Professionals Summit

The Young Professionals (YP) Committee from NEWEA and New England Water Works Association (NEWWA) held the 5th Annual YP Summit on February 11, 18, and 25, 2021. The virtual multi-session summit focused on diversity, inclusion, and environmental justice in the water and wastewater industry.

Session 1 : Environmental Justice—Equity in Law and Policy, February 11, 2021
The summit kicked off with a two-hour session on Environmental Justice—Equity in Law and Policy, which was moderated by Colin O'Brien, Past NEWEA YP committee chair and Renee Lanza, NEWWA YP committee chair. The event featured a panel discussion with Jameson Davis, Vermont Law School; Leah Bamberger, City of Providence, Rhode Island; and Neenah Estrella-Luna, StarLuna Consulting. This was followed by networking and breakout discussions.

Session 2: Diversity, Equity, and Inclusion (DE&I)—Actions for Young Professionals February 18, 2021
The second session focused on Diversity, Equity, and Inclusion (DE&I)—Actions for Young Professionals. which was moderated by Adrian D'Orlando, Brown and Caldwell, and Mary Danielson, Tighe & Bond. The event featured a panel discussion with Erica Lotz, PE, ENV SP, Stantec; Andrea Hall, PHR, SHRM-CP, Brown and Caldwell; Rachel Gilbert, PE, Woodard & Curran; and Michael Jefferson, The Metropolitan District. This was followed by networking and breakout discussions.

Session 3: Environmental Justice The Role of Regulations and Research February 25, 2021
The final session focused on Environmental Justice—The Role of Regulations and Research which was moderated by Isabella Cobble, Tighe & Bond, and Adrian D'Orlando, Brown and Caldwell. The event featured a panel discussion with Deneen Simpson, Massachusetts Department of Environmental Protection; Erica Kyzmir-McKeon, Conservation Law Foundation; and Osamu Kumasaka, MIT Department of Urban Studies & Planning. This was followed by networking and breakout discussions.

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Poo & Brew #27 featured a virtual tour of the Field's Point Wastewater Treatment Facility in Providence, Rhode Island

Innovation Webinar

NEWEA's Innovation Council held a free webinar on Workforce Development on March 25, 2021, which discussed opportunities to innovate within organizations and through strategic partnerships. The presentation highlighted youth programs, collegiate outreach, professional development, and innovation training courses to over 180 water quality professionals.

POO & BREW #27

The YP Committee held its famous Poo & Brew Event with a virtual twist on past May 14, 2021. Over 40 attendees enjoyed a virtual tour of Field's Point Wastewater Treatment Facility in Providence followed by networking breakout rooms.

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2021 SPECIALTY CONFERENCE & WORKSHOP SERIES

COPING WITH CHANGE: REGULATIONS, COVID, AND CLIMATE CHANGE

CSO/Wet Weather Issues Specialty Conference & Exhibit

September 29–30, 2021
Sheraton, Portsmouth, NH
and Virtual option

The New England Water Environment Association (NEWEA) presents a two-day CSO/Wet Weather Specialty Conference & Exhibit sponsored by the NEWEA Combined Sewer Overflow (CSO)/Wet Weather Issues Committee—LIVE—in-person, and virtually.

The theme for this conference is "Coping with Change; Regulations, COVID, and Climate Change". The Federal and State regulatory environment on wet weather flow continues to change, sometimes creating overlapping enforcement requirements on CSO communities. Acceptance of integrated planning and new fiscal affordability approaches are allowing CSO operators to make reasonable, balanced, and cost-effective decisions relating to CSOs, SSOs, and CMOM topics. In addition, climate change and the resiliency of systems to protect against it continues to be an emerging issue. Finally, adapting to the COVID pandemic forced many communities to make permanent changes. The virus impacted the daily operation of our wet weather collection systems but compliance requirements remained stringent.

This two-day, in-person and remote conference is an opportunity to share our national and regional working knowledge and experience to discuss how to meet these challenges.

Program and registration information will be posted to newea.org/events/specialty-seminars-events/cso-wet-weather-conference/ in the coming months.

NEWEA
WORKING FOR WATER QUALITY

New Members December 2020–May 2021

Brice Bond
Kennebunk Sewer District
Kennebunk, ME (PRO)

Scott Neesen
Londonderry, NH (PRO)

Nicole Klebauskas
Narragansett Bay Commission
Providence, RI (PRO)

Nicholas Messina
Scarborough, ME (PRO)

Christopher Dracoules
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David Crockett
Taunton, MA (PRO)

Maggie Theroux Fieldsteel
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John Thompson
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Goffstown, NH (PRO)

John Smith
Edgartown, MA (PRO)

Lindsay McCarthy
Arcadis
White Plains, NY (PRO)

Matthew Marsh
Medford, MA (PRO)

Bob Klybas
East Windsor, CT (PRO)

Thomas Rondeau
Lincoln, RI (PRO)

Nick Antonopoulos
Suez WTS USA
Southborough, MA (PRO)

Steve Bosse
Saint Agatha, ME (PWO)

Shelby Farnham
Town of Fairfield WPCF
Fairfield, CT (PWO)

Bruce Morriseau
Lowell, MA (PWO)

Cory Seekins
Swanville, ME (PWO)

Patty Burke
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Brett Leavitt
North Andover, MA (PWO)

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Megan Barstow
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Denis Souza
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William Yan
Southampton, MA (YP)

Ariana Carr
Boston, MA (YP)

Kyle Johnson
Boston, MA (YP)

Katherine Ronan
Boston, MA (YP)

Logan Werner
Woodard & Curran, Inc.
Brookline, MA (YP)

Academic (ACAD)
Affiliate (AFF)
Complimentary (COMP)
Corporate (COR)
Dual (DUAL)
Executive (EXEC)
Honorary (HON)
Life (LIFE)
Public Official (POFF)
Professional (PRO)
Professional WW/OPS (PWO)
Student (STU)
Young Professional (YP)

Upcoming Meetings & Events

LABORATORY PRACTICES CONFERENCE
Virtual
June 24, 2021

OPERATIONS CHALLENGE TRAINING EVENT
Greater New Haven, CT WPCA East Shore Water Pollution Abatement Facility
August 6, 2021

COMMITTEE MEMBER APPRECIATION EVENT
Kimball Farms, Westford, MA
August 12, 2021

GOLF TOURNAMENT BENEFIT
TBD
September 2021

CSO/WWI CONFERENCE & EXHIBIT
Sheraton Portsmouth, NH
September 29–30, 2021

WEFTEC21
McCormick Place, Chicago, IL
October 17–21, 2021

JOINT COLLECTION SYSTEMS & PNCWA WEBINAR
Virtual
November 9, 2021

AFFILIATED STATE ASSOCIATIONS AND OTHER EVENTS

RICWA GOLF TOURNAMENT
Potowomut Country Club, Warwick, RI
June 21, 2021

NHWPCA ANNUAL GOLF TOURNAMENT
Beaver Meadow Golf Course, Concord, NH
August 5, 2021

MWUA SUMMER OUTING
The Landing (old Bruswick Navel Base) Brunswick, ME
August 12, 2021

RICWA FALL ANNUAL CLAMBAKE AND EXHIBITION
Twelve Acres Banquet Facility, Smithfield, RI
September 5, 2021

CWPAA FALL TRADE SHOW
New Life Church, Wallingford, CT
September 9, 2021

NEWWA ANNUAL CONFERENCE
Omni Mt. Washington, Bretton Woods, NH
September 7–10, 2021

GSRWA GOLF TOURNAMENT
Country Club of NH, North Sutton, NH
September 13, 2021

GSRWA FALL TRADESHOW
Mt. Sunapee, Newbury, NH
September 14, 2021

MEWEA FALL CONFERENCE & GOLF TOURNAMENT
Sunday River, Newry, ME
September 16–17, 2021

NEW ENGLAND INDUSTRIAL PRETREATMENT CONFERENCE
UMASS Lowell, Lowell, MA
October 26–28, 2021

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 2021 ANNUAL SPONSOR PROGRAM PARTICIPANTS

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

Join NEWEA's 2022 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:

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- NEWEA Golf Classic
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- Increased corporate visibility and marketing opportunities before a wide audience of water industry professionals
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For more information
contact Jordan Gosselin
Email: jgosselin@newea.org
Phone: 781-939-0908

NEWEA
WORKING FOR WATER QUALITY

Advertiser Index

Upcoming 2021 *Journal* Themes

Fall—**Environmental Justice**

Winter—**Operator Ingenuity**

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)

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

City, State, Zip, Country

Home Phone | Cell Phone | Business Phone

Email Address

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

***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 | WEF 21

Membership Categories (select one only)

		Member Benefit Subscription	Dues
☐ **Professional**	Individuals involved in or interested in water quality	■ *Water Environment & Technology* ■ *Water Environment Research* (Online)	$185
☐ **Young Professional**	Water quality professionals, with fewer than five years working experience and under the age of 35, are eligible to join WEF as an Active Member, while participating in the NEWEA/WEF Young Professionals Program. This program allows up to 50% off of the Active Member dues, valid for the first three years of membership. This program is available for new member applicants and Student Members.	■ *Water Environment & Technology* ■ *Water Environment Research* (Online)	$70
☐ **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 # _____	■ *Water Environment & Technology* ■ *Water Environment Research* (Online)	$110
☐ **Academic**	Instructors/Professors interested in subjects related to water quality.	■ *Water Environment & Technology* ■ *Water Environment Research* (Online)	$185
☐ **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.	■ *Water Environment & Technology* ■ *Water Environment Research* (Online)	$15
☐ **Executive**	Upper level managers interested in an expanded suite of WEF products/services.	■ *Water Environment & Technology* ■ *Water Environment Research* (Online) ■ *WEF SmartBrief* ■ Complimentary WEF Webcasts and more	$355
☐ **Corporate** (member benefits for one person)	Companies engaged in the design, construction, operation or management of water quality systems. Designate one membership contact.	■ *Water Environment & Technology* ■ *Water Environment Research* (Online) ■ *WEF SmartBrief* ■ Complimentary WEF Webcasts and more	$420
☐ **Dual**	If you are already a member of WEF and wish to join NEWEA		$45
☐ **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

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 WEF for questions & enrollment (703-684-2400 x7750).

Payment

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

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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.

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 ManagementLevel

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

5 Disinfection and Public Health

6 Drinking Water

7 Energy

8 Finance and Investment

9 Industrial

10 Intelligent Water Technology

11 Laboratory Analysis and Practices

12 Nutrients

13 Plant Operations and Maintenance

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

21 Utility Management and Leadership

22 Watershed Management

23 Wastewater Treatment, Design, and Modeling

24 Water Reuse and Reclamation

25 Workforce

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

Gender: ☐ Female ☐ Male

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

Did Anyone Recommend that You Join WEF?

Referring member's name: _____ Referring member's email: _____

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