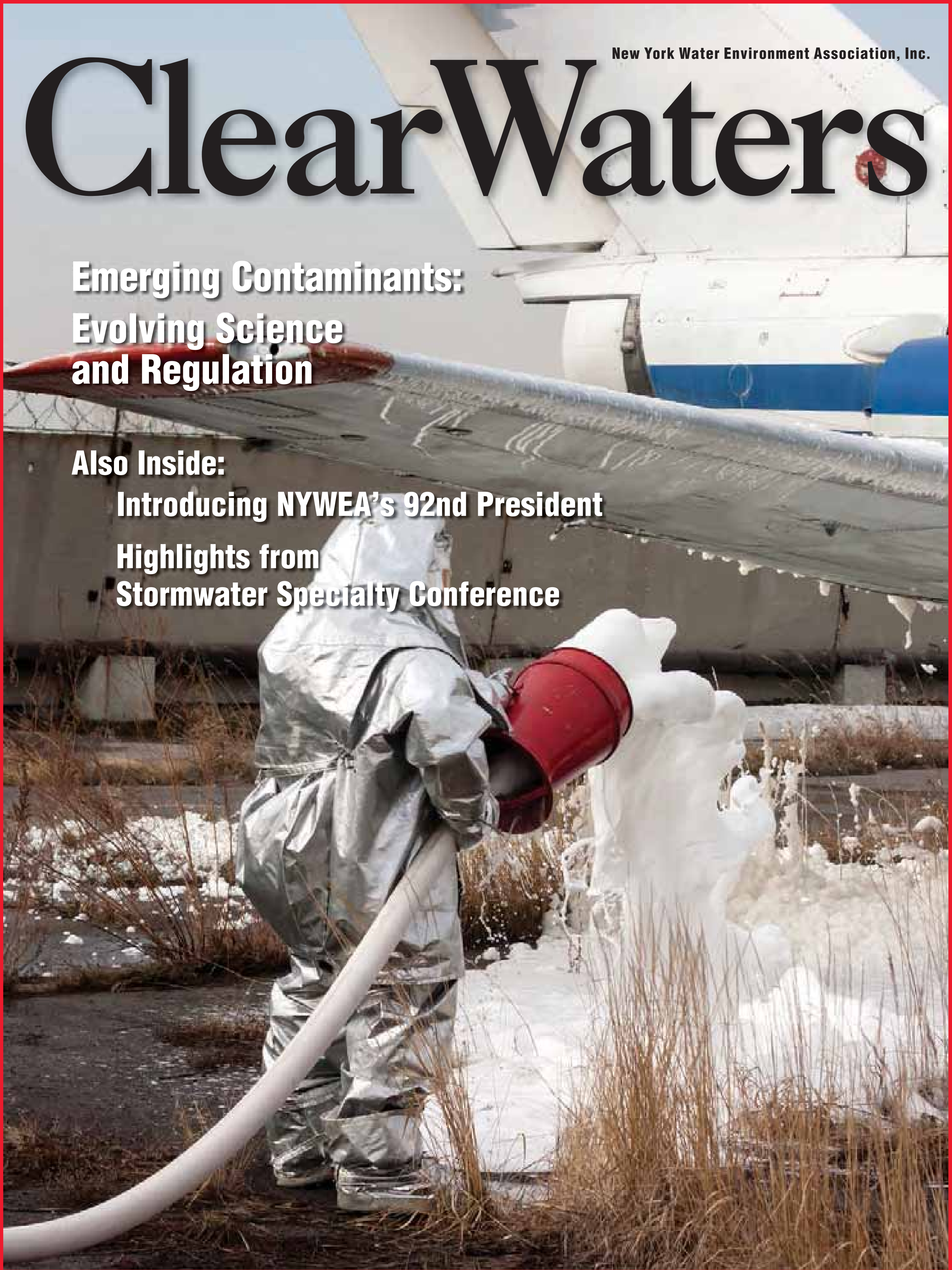
Winter 2019, Vol. 49, No. 4

New York Water Environment Association, Inc.

ClearWaters



Emerging Contaminants: Evolving Science and Regulation

Also Inside:

Introducing NYWEA's 92nd President

Highlights from Stormwater Specialty Conference

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Clear Waters

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Cover: A firefighter coats a plane with fire-fighting foam after an emergency landing. Aqueous film forming foam (AFFF) is a highly effective fire-suppressant used for fighting high-hazard flammable liquid fires such as gasoline, oil and jet fuel. AFFF contains fluorinated surfactants, which may include per- and polyfluoroalkyl substances (PFAS). PFAS are also used as a water-repellent agent on the gear firefighters wear. PFAS are among many of the emerging contaminants that are coming to the attention in the water quality arena. *Photograph: Dushliki (stock by Getty Images)*

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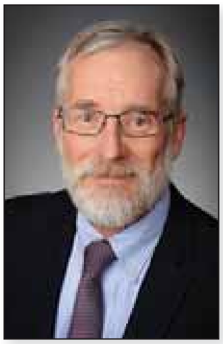
President's Message | Winter 2019



I was warned when I joined NYWEA's Executive Committee that the time passes quickly, particularly the year as President. As I write my final President's message for *Clear Waters,* I see how true that statement is.

Workforce Sustainability and Certification

Throughout this busy year, I have had the opportunity to focus on workforce sustainability issues. Recently I attended the New York Conference of Mayors Public Works School in Ithaca and presented with NYWEA's Executive Director Patricia Cerro-Reehil on *Developing a Sustainable Operator Workforce.* Attendees raised a few issues including certification experience requirements, civil service challenges, limited promotion opportunities for new operators, and conflicting promotional opportunities within a municipality. The discussion often focused on the time requirements for operators with a high school diploma to become certified at the Grade 3/3A or higher level.

The NYSDEC Operator Certification regulations outline the certification requirements, plant scoring, and the required grade of the chief operator and the assistant/shift operators. The regulations only address the requirements for the chief operator and assistant/shift operators. Requirements of other operators to be certified are part of the civil service job title requirements. These civil service requirements will vary with the grade of the water resource recovery facility and the municipality. Some municipalities require employees in an operator title to be certified at the grade of the facility. Others will require operators to be certified at the assistant grade and provide different civil service titles with higher levels of responsibility.

One way to address the limited opportunities to promote new operators is to take advantage of the multiple certification grades. After six months of experience and appropriate pre-certification courses, a trainee can apply for the Grade 1/1A exam. Upon passing the exam, the trainee is now a certified professional operator. After one year of experience and the appropriate pre-certification courses, the new operator can apply for the Grade 2/2A exam. This newly certified professional operator can now be assistant/shift operator for any Grade 3/3A plant. For Grade 3/3A and 4/4A facilities, these lower levels of certification provide opportunities to grant earlier promotional opportunities to the new operator without waiting the 4½ to eight years for an operator with a high school diploma to be certified at the higher grades. Certification at a lower grade may fulfill the requirements of an operator civil service title and provide quicker promotional opportunities.

This approach will allow the operator to become more familiar with the certification exam need-to-know criteria and increase their comfort with the taking of exams. My experience has shown that those candidates that take the lower grade exams, often have higher success rates with the higher-grade exams.

The approach of using multiple grades for operator titles does require working with your local Civil Service agency. The advantage is that it will be easier to provide promotional opportunities for new operators as they increase their level of certification to the grade of the facility.

Annual Meeting: Creating a Sustainable Operator Workforce

NYWEA's spring technical conference in June 2019 included a panel discussion of workforce efforts by New York municipalities. The upcoming 92nd annual meeting, *Creating a Sustainable Operator Workforce,* continues this discussion by including a panel of national experts on workforce sustainability. The panel members include Andy Kircun, Joseph Kane, Marianne Watson and Victoria Johnson:

- Andy Kircun is the Executive Director and Chief Engineer for the Camden County Municipal Utilities Authority, New Jersey, and served as chair of the WEF/AWWA Transformative Issues symposium on workforce. Mr. Kircun brings experience in changing organizational culture to optimize his utility's performance and providing opportunities to disconnected young adults to advance environmental stewardship and workforce development.
- Joseph Kane is a senior research associate and Associate Fellow with the Brookings Institute. Mr. Kane is a co-author of the Brookings Institute's *Renewing the Water Workforce* June 2018 publication, which provides innovative approaches for improving water infrastructure and creating a pipeline to opportunity.
- Retired Brig. Gen. Marianne Watson is the Director of Outreach for the Center for America. General Watson is involved with providing programs that improve hiring and networking success rates, assisting employers to connect with candidate referral organizations that help them hire veterans, National Guard members and Reservists.
- Victoria Johnson is a Workforce Development and Equity Program Consultant with Jacobs. Ms. Johnson's focus is on strategic program development and implementation for public agencies developing workforce, economic inclusion and supplier diversity programs to maximize investments in infrastructure to benefit diverse communities. She has worked with Louisville Metropolitan Sewer District, the City of Atlanta Department of Watershed Management, San Francisco Public Utilities Commission, and others.

I look forward to the insights that this fantastic panel can bring to the workforce discussion.

We have planned a great program for NYWEA's 2020 annual meeting with a record 30 technical sessions, vendor mobile sessions, awards and networking opportunities. I look forward to seeing you all in New York in February.

Robert Wither, PE, NYWEA President

WATER'S WORTH IT

Emerging Contaminants and Adapting in Life

As any water resource recovery operator will tell you (better than I), adaptive skills are one of the most important skills they use at their facilities. We are continually adapting in life to new circumstances, new technology, new regulations and new situations that make us work harder, think differently and bring about change.

This issue of *Clear Waters* is dedicated to Emerging Contaminants and includes articles that are written by some of the best technical experts in the field. Their willingness to share their knowledge is fundamental to the mission of NYWEA, and we extend our sincere appreciation to each one of them. This exchange of knowledge is tremendously valued and, as we just heard from those of you who responded to our membership survey, education, networking and knowledge transfer are of the utmost importance.

Unintended Consequences

As you will learn from reading these articles (or you might already know), many of the everyday products and cookware we use have unintended consequences to both our health and our environment. Through the advent of routine convenience products like nonstick cookware and water-repellent clothing, there is evidence that per- and polyfluoroalkyl substances (PFAS) can have adverse health effects on humans (*EPA 2018)*. Clearly an unintended consequence.

If we look at other emerging contaminants in the waters, those warm synthetic fleece jackets have a tremendous effect on water quality. As noted in a Washington Post article *(Cernansky 2016),* one fleece jacket can release 250,000 microfibers, or 2.7 grams, into the water, nearly the size of a golf ball! We are clouding the waters by the detergents we use and the materials we wash. These microfibers flow easily through the water resource recovery process and out to receiving bodies of water, where they can floc and appear as food to marine life. It is great to see organizations like Patagonia researching these unintended consequences. It is also heartening to learn about the work of inventors and entrepreneurs like Rachael Miller, co-founder of the Rozalia Project for a Clean Ocean, who developed a microfiber-catching laundry ball that traps microfibers in your washing machine. This device, the Cora Ball, was inspired by observing how corals feed by catching tiny particles in flowing water.

Until we have better solutions, we need to be part of the equation. As you will learn from the article provided by Adrienne Esposito (on page 42), we need to be educated on the best products to use at home and work, then we need to adapt and share that information broadly with the general public and with elected officials. By reading this issue, you are now more informed on the topic of emerging contaminants than many. It's up to us to share what we've learned.

Here's wishing you all a healthy and happy 2020! I look forward to seeing you at NYWEA's 92nd Annual Meeting where we will learn more about emerging contaminants in Session 2 on Monday, February 3!

Cernansky, Rachel. 2016. "Are Synthetic Fleece and Other Types of Clothing Harming Our Water?" The Washington Post, Oct. 30, 2016. https://www.washingtonpost.com/national/health-science/are-synthetic-fleece-and-other-types-of-clothing-harming-our-water/2016/10/28/eb35f6ac-752e-11e6-be4f-3f42f2e5a49e_story.html.

EPA. 2018. "Basic Information on PFAS." EPA PFOA, PFOS and Other PFASs. Dec. 6. Accessed Oct. 23, 2019. https://www.epa.gov/pfas/basic-information-pfas.

Patricia Cerro-Reehil, pcr@nywea.org

Introducing NYWEA's 92nd President

On Wednesday, February 5, 2020 William J. Nylic, III will become NYWEA's 92nd president and the youngest person to hold this position in the history of the organization.

Bill is an environmental engineer and project manager working for CDM Smith in its Long Island office. His most recent projects include the *Bergen Point Outfall Replacement, Odor Control Study and HVAC Upgrades at the Yonkers JWRRF* and *Long Beach Digester Cover Replacement*.

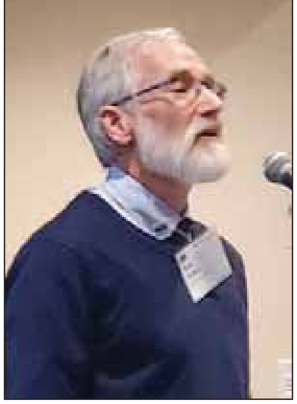
When asked about serving as president, Bill answered "I think of it less as serving a position with a title and more as continuing down a path of community service in a more focused way. I've always enjoyed volunteering and I find that NYWEA is an excellent blend of service, technical experts, education, and relationships formed with people who care about water quality throughout the organization. I'm excited for the opportunity to serve in this role and grateful that CDM Smith supports me to do so."

Bill enjoys spending time with his family that includes his wife, Melissa, and daughters Vera and Emilia (and their three dogs Harry, Pearl and Abe)! In his spare time, he enjoys working on home improvement projects.

Bill holds a Bachelor of Science in environmental engineering from Rensselaer Polytechnic Institute (RPI) and an Master of Science in environmental engineering from Manhattan College. He is a registered professional engineer (P.E.) in the State of New York. Bill's dedication to NYWEA is evidenced by the numerous volunteer positions he has held over the years, from the student chapter at RPI, to the local Long Island and Lower Hudson chapters, and in the statewide association. His contributions include: Student Chapter President; Public Education Committee; Young Professionals Committee; editor of the Long Island Chapter newsletter; board of directors; Young Professional Representative on NYWEA's board of directors. Bill received the Young Professionals Bronze Shovel from the Select Society of Sanitary Sludge Shovelers (SSSSS) in 2012; NYWEA Young Professionals Award in 2018; Chapter Achievement Award in 2018; and Silver SSSSS Shovel in 2019.

Bill succeeds Robert Wither, who steps down as NYWEA's president on the last day of the NYWEA 92nd Annual Meeting, February 5, 2020.

Bill Nylic with his wife Melissa, and daughters Emilia and Vera

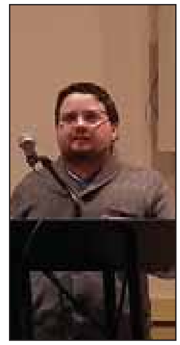


NYWEA President Robert Wither welcomes all to the conference.

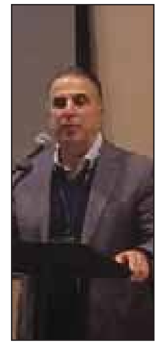
Stormwater Specialty Conference

Over 100 people attended the Stormwater Specialty Conference held Nov. 19 at the Syracuse Marriott Downtown, Syracuse, New York. Meeting attendees took part in a day of sessions on the theme of changes to stormwater regulations and innovative ways to comply. Many thanks to the members of the Committee, speakers, sponsors and downtown green infrastructure walking tour leaders.

Brian Gyory, NYSEFC, discusses the NYS Consolidated Funding Application process during the Stormwater Funding Roundable with Ryan Waldron, NYSDEC, left, and Khris Dodson, NYSEFC, center.

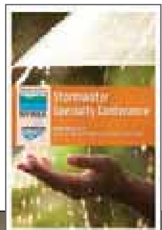


Roy Widrig, NY Sea Grant.



Frank Mento, Onondaga County WEP.

Jayme Breshard Thomann, NYSFSMA Chair.



Above, left: Meeting room is full of attendees.

Above, right: Michelle Virts, NYWEA Stormwater Committee Chair, welcomes attendees.

Conference attendees from Buffalo Sewer Authority, (l-r): Casterland Fanfan, Regina Harris, Scott Steigerwald, Rosaleen Nogle, and Kevin Meindl.

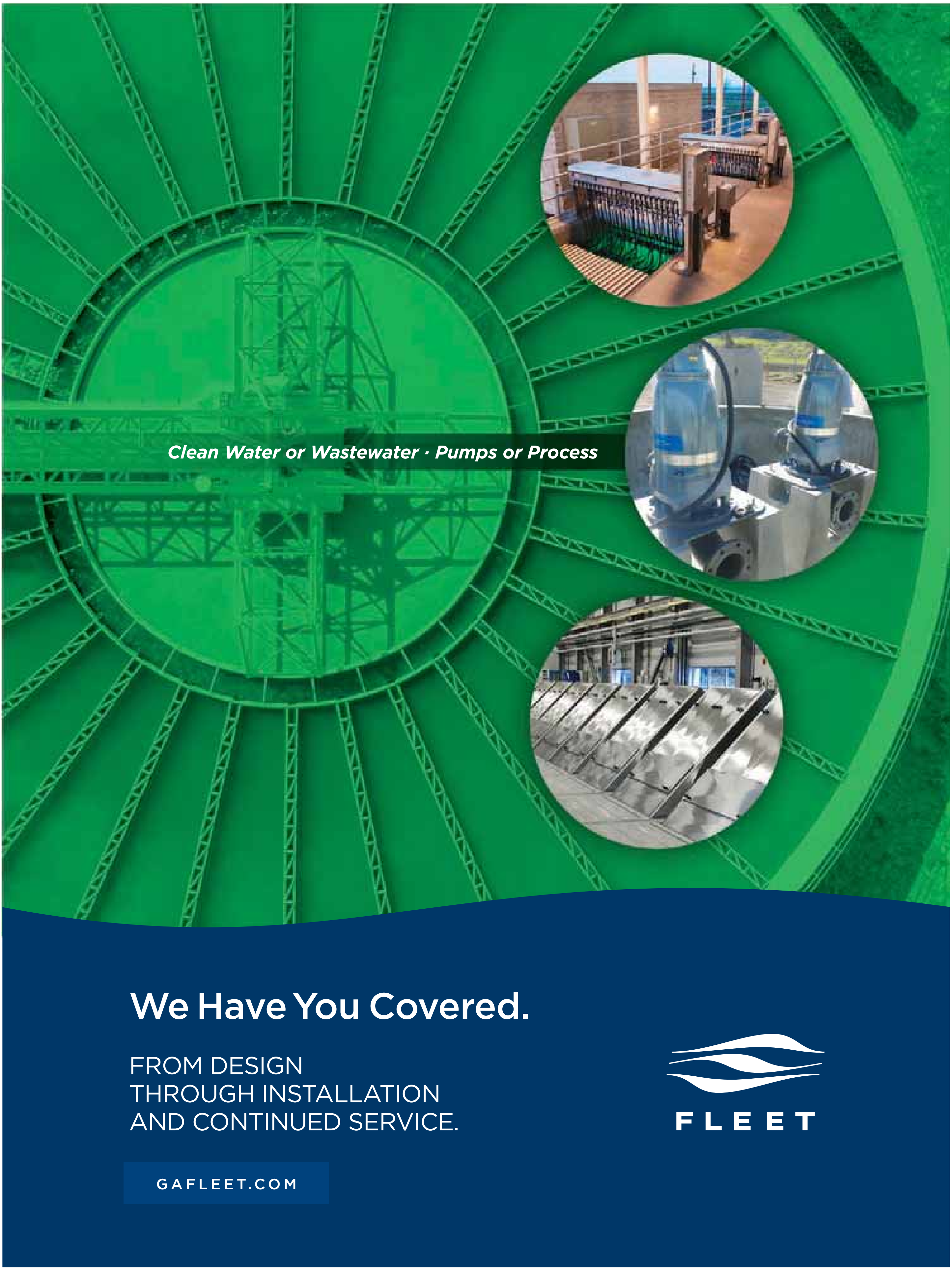
Right: Professor Doug Daley, center, with former student Andy Johnson, left, and Geoff Golick, right, a current student in Environmental Resources Engineering at ESF.

Below: GI walking tour leaders Zach Monge, Jacobs; and Adam Woodburn, Onondaga County WEP, speak to group about the comprehensive green street on the 300 block of Water Street in Syracuse.

Group photo of the green infrastructure walking tour on East Water Street green street project.

The tour continued along the Connective Corridor green street project on State Street in downtown Syracuse.

GI tour takes participants to the Save The Rain project along Bank Alley in downtown Syracuse.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Water Views | Winter 2019

Protecting New York's Drinking Water

Keeping public drinking water safe is a critical task, fundamental to DEC's public health mission. Over 9,000 public water supply systems serve nearly 95% of New York residents. New York has allocated over $3.4 billion for clean water infrastructure grants since 2015. Moreover, the Environmental Facilities Corporation provides about $1 billion in low-interest financing for water infrastructure each year.

The goal of source water protection is to prevent contamination of community drinking water supplies. Protection efforts can range from regulatory methods such as zoning, comprehensive plans and intermunicipal agreements, to nonregulatory methods such as acquiring buffer lands close to the supply, encouraging best management practices on the landscape, and public outreach and education.

Carefully guarding sources of drinking water protects residents' health and safety, and the environment. Experience has shown that protection is less expensive than treating a contaminated supply. The most famous example is the savings New York City receives through its comprehensive watershed protection program, which reduced the need for a $10 billion drinking water filtration plant.

The Drinking Water Source Protection Program (DWSP2) is a little-known initiative of New York's comprehensive clean water program. DWSP2 is designed to help communities protect their drinking water through science-based implementation plans to keep contaminants from ever entering our water.

The DEC and the Department of Health, in collaboration with the Department of Agriculture and Markets and Department of State, have launched DWSP2 to provide municipalities with tools and resources to proactively protect their drinking water sources. Known as the "DWSP2 Framework," it will soon be available to communities to build their own unique protection program. As part of DWSP2's initial roll-out, the state will select up to 30 municipalities who will work with a consultant to help them use the Framework to develop and implement Drinking Water Source Protection Plans. To learn more about DWSP2 visit: *https://www.dec.ny.gov/chemical/115250.html* or contact us at *source.water@dec.ny.gov.*

Communities that create Drinking Water Source Protection Plans can apply for funding through sources like DEC's Water Quality Improvement Project (WQIP) grant program to implement the protection measures in their plan. Since 2017, WQIP has included funding from the Clean Water Infrastructure Act for municipalities, not-for-profits, and Soil and Water Conservation Districts for land acquisition for source water protection. For example, approximately $28 million of WQIP funding was awarded for 26 land acquisition projects in 2017 and 2018. To learn more about WQIP Land Acquisition Projects for Source Water Protection visit the NYSDEC website at *https://www.dec.ny.gov/pubs/4774.html* or contact us at *WQIPsourcewater@dec.ny.gov.*

– James Tierney, Deputy Commissioner for Water Resources
NYS Department of Environmental Conservation

Focus on Safety | Winter 2019

Nanoparticles: Tiny but Mighty

When I think of nanoparticles, I think of something new, snazzy, cutting edge and high-tech. But these infinitesimal particles have been around since the Earth was formed, spewing from prehistoric volcanoes and fires. True, there are also nanos that are new, engineered and kind of mysterious. They are in all sorts of commercial and consumer products. Electronics are full of nanos to decrease weight, increase strength and reduce power needs. Consumer products that use nanos include deodorant, cosmetics, toothpaste, odor controlling clothing and stain resisting paint. These are all great uses of a material, as well as sources of exposure in various environments. Consumers are exposed through use of the product on their bodies or in their personal environment. When consumers wash away or dispose of nano-containing items, the nanos end up in the environment, exposing other organisms such as animals, insects and plants to these products.

The process of manufacturing nano products includes some occupational exposure to workers. All these exposures are either dermal (contact with the skin or mucus membranes), inhalation (contact with the respiratory tract) or water exposure (contact through a liquid means). Research into the very fine particles of welding and diesel fumes, pharmaceuticals, nuclear power and cosmetics have provided a good basis to predict the health effects of these particles and the protection needed. Fortunately, for workers, exposure can be eliminated or lessened by using personal protective equipment (PPE). It should be no surprise that inhalation is the most likely route of exposure and that proper respiratory equipment will provide protection. Controlling the movement of nanos through the air by local exhaust ventilation, HEPA vacuums and wet cleanup methods is also recommended. Research also has shown that dermal exposure is a concern as some nanos can enter the body through damaged skin. Skin protection is therefore a necessary precaution, gloves especially.

So, what makes nanos any different from other particles that we don't want to breathe in or get on our skin? Turns out that while the particles are predictable, the actual substance behaves differently in nano form than it does in bulk form. Colors and boiling temperatures may change for some materials. Gravitational forces are practically eliminated for some materials, but the electromagnetic forces increase. Chemical reactions are easier, materials get stronger and, importantly for water treatment, surface-area-to-volume ratios increase dramatically. Life at the nano level is a different ballgame.

Water treatment operators have the unique opportunity to interact with nanoparticles, both as the contaminant to be treated and as the technology to assist in the treatment using engineered filtration products. In this one industry, nanoparticles are both the emerging contaminant and the emerging solution.

– Eileen M. Reynolds, Certified Safety Professional
Owner, Coracle Safety Management

PFAS: Planning for Additional Statutes? Recent Developments and Treatability Review

by Mark Greene and Bill Meinert

Introduction

Perfluorinated compounds are those containing carbon and fluorine atoms. A subset of these compounds, per- and polyfluoroalkyl substances (PFAS), are distinguished from other perfluorinated compounds, such as perfluorocarbons (PFC), in that PFAS also may contain oxygen, hydrogen, sulfur and/or nitrogen atoms ***(Figure 1)***. The most studied PFAS are perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS).

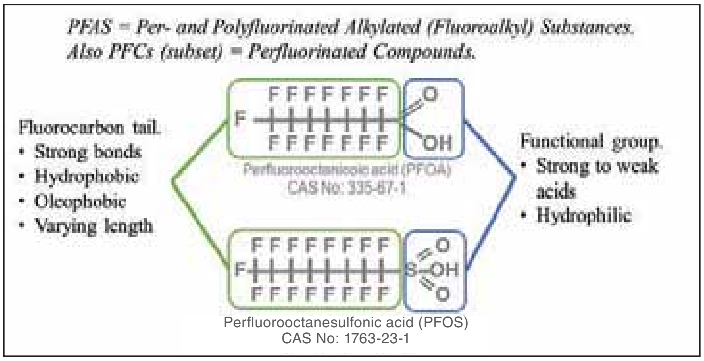

Figure 1. Basic chemistry of the per- and polyfluoroalkyl substances (PFAS). *WEF*

With one of the strongest chemical bonds known in chemistry (carbon-fluorine), PFAS have unusual chemical properties, including the ability to repel both grease and water. PFAS are used in food packaging, water-repellent fabrics (e.g., ski jackets), carpets, nonstick cooking pans, paints, adhesives, electronics, personal care products and firefighting foams. More than 3,000 PFAS have been or are currently on the global market. Building materials, including composite woods, were also recently identified as another source of PFAS *(NACWA/WEF 2019a; NACWA/WEF 2019b)*.

PFAS are transported around the globe, primarily through atmospheric circulation, and can accumulate in plants and crops. PFAS have also been measured in drinking water worldwide. Based on recent investigations, common environmental sources can include PFAS manufacturing and industrial processing facilities as well as airports and military installations that routinely practice firefighting *(NACWA/WEF 2019a; NACWA/WEF 2019b)*.

While perfluorocarbons are not toxic *(EPA 2019b)*, there is evidence that PFAS can have adverse human health effects *(EPA 2018)*. Health concerns for PFAS include cancer, reproductive and developmental effects, endometriosis, bioaccumulation, immunotoxicity, ulcerative colitis and thyroid disease.

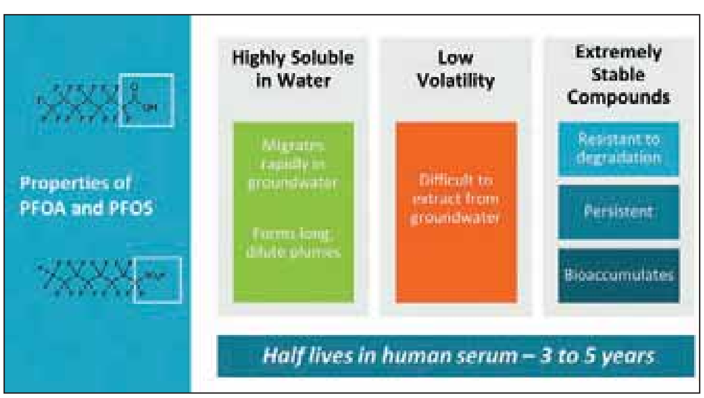

Figure 2. Properties of PFOA and PFOS in the environment. *Ramboll*

Although the major U.S. manufacturers of PFOS and PFOA voluntarily phased out production of these chemicals in 2002 and 2015, respectively, PFOS and PFOA remain a health exposure concern. These compounds are highly stable in the environment ***(Figure 2)*** and accumulate in red blood cells. Nearly every person measured has shown detectable levels of PFOS and PFOA in their blood.

For the public utilities dealing with water and wastewater, concerns can include public surface water and groundwater supply, water treatment solids, wastewater treatment, biosolids and leachate from landfills where PFAS materials have been disposed.

Regulatory Landscape

PFAS is an emerging regulatory issue at both the state and federal levels, as well as globally. For example, in the European Union, the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) program restricts the use of PFOS. The United Nations Environment Programme Stockholm Convention lists PFOS as a persistent organic pollutant; it has recommended that PFOA also be included on the list.

Federal Regulatory Activities

Certain PFAS have been on the Drinking Water Contaminant Candidate List (CCL) since 2009 *(CRS 2019)*.

Provisional health advisories were issued by U.S. Environmental Protection Agency (EPA) in 2009, at levels of 200 ng/L for PFOS and 400 ng/L for PFOA. In May 2012, six PFAS were included in the third Unregulated Contaminant Monitoring Rule (UCMR3) to be monitored by public water systems. These included PFOS, PFOA, perfluorononanoic acid (PFNA), perfluorohexanesulfonic acid (PFHxS), perfluoroheptanoic acid (PFHpA) and perfluorobutanesulfonic acid (PFBS).

Lifetime health advisories were issued by EPA in 2016, at 70 ng/L for PFOS and PFOA, individually and combined, in drinking water. Currently there are no enforceable standards at the federal level, although recent congressional activities suggest this may change in the near term. Remediation standards are being set for specific sites and projects.

During 2018, the EPA outlined drinking water treatment processes and developed groundwater cleanup recommendations for PFOA and PFOS. In February 2019, EPA released the PFAS Action Plan, which includes four management actions, three priority actions and several other short- and long-term actions. Of note, the fifth Unregulated Contaminant Monitoring Rule (UCMR5) is expected in late 2021, and it appears that a considerable number of PFAS compounds will be included in the monitor and report list of 30 contaminants.

State Regulatory Activity

At the state level, New York has been one of the most active states in the nation regarding PFAS ***(Figure 3)***. In December 2018, the New York State Drinking Water Quality Council recommended PFOA and PFOS maximum contaminant levels (MCLs) of 10 ng/L each, which were adopted July 8, 2019.

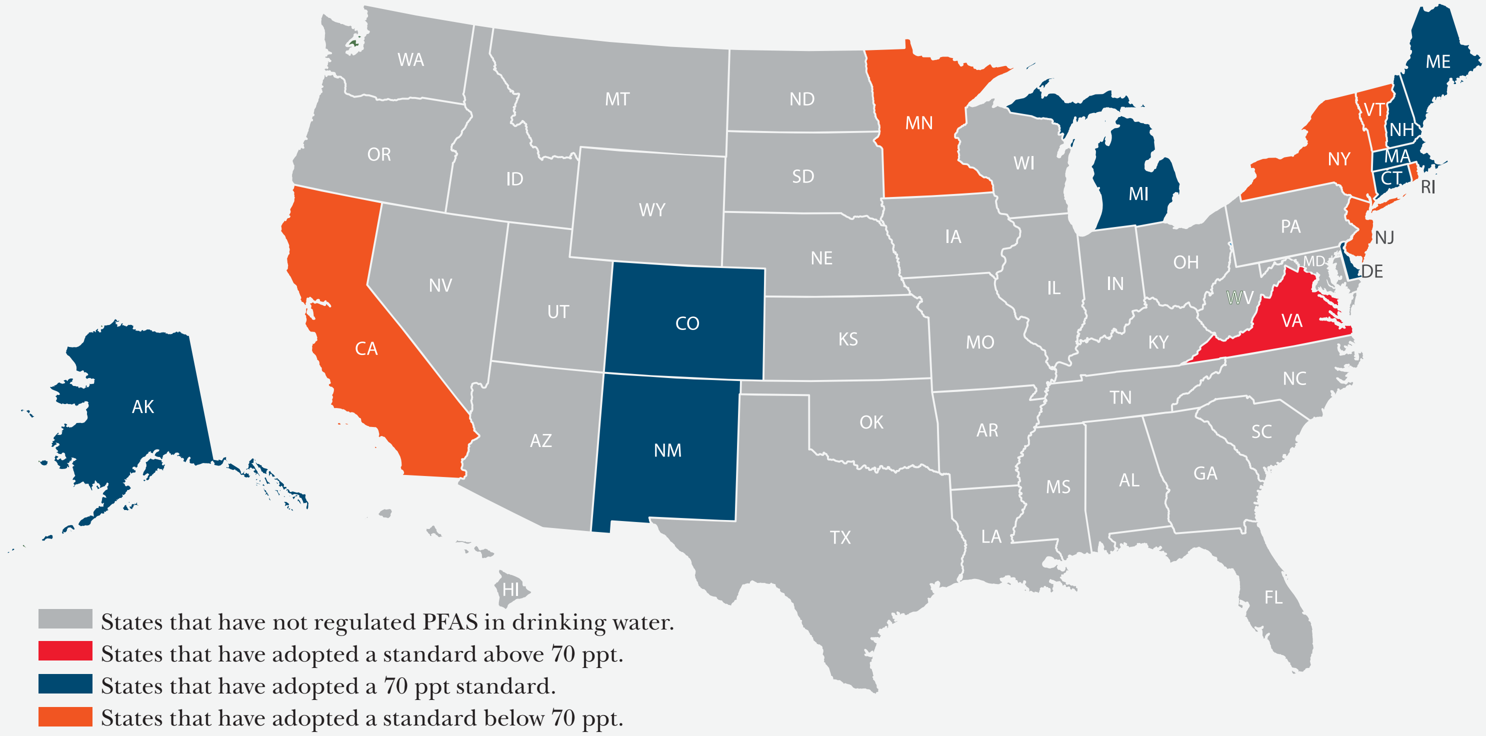

Figure 3. States with regulatory limits for PFAS in drinking water, as of July 1, 2019 ***(Lee and Kindschuh 2019)*****.** *Bryan Cave Leighton Paisner LLP*

Comparing initial and subsequent regulatory actions by various states, there has been considerable variability in approach, from no criteria to many more than EPA ***(Table 1)***. Some states have adopted EPA's lifetime health advisories. Some states have adopted EPA's lifetime health advisories, some have more stringent criteria for PFOA and PFOS, and some have criteria for other PFAS. Michigan, Minnesota, New Jersey, Vermont and New Hampshire are examples of states with both more stringent criteria and additional PFAS.

Many states are expanding the tracking of PFAS sources and testing by water and wastewater agencies. Evidence of this drinking water concern expanding into wastewater and biosolids includes activities in Michigan, North Carolina, Wisconsin and Maine. Michigan and Wisconsin have implemented PFAS testing of water resource recovery facilities. If testing of 24 PFAS compounds exceeds a certain threshold, investigation of pretreatment sources must be initiated. Maine is requiring all POTWs applying biosolids to land to test for PFAS, with screening concentrations (in mg/kg) established in solid waste management rules for PFOS, PFOA and PFBS.

Testing Methods for PFAS

There is at present no standardized test that can quantify all known PFAS compounds.

Method 537, EPA's first analytical method exclusively for the analysis of PFAS, was promulgated in 2009 *(EPA Method 537 version 1.1)*. EPA Method 537 was promulgated for drinking water in advance of UCMR3. It involves liquid chromatography followed by tandem mass spectrometry analyses (LC/MS/MS). The original method identified 14 compounds with reporting limits about 2 ng/L. Method 537 was updated to incorporate both the Technical Advisory EPA 815-B-16-021 published in September 2016 pertaining to PFOA analysis and the expanded list of 18 analytes published in November 2018 *(Method 537.1)*.

The analytical cost ranges from $200 to $350 per sample with standard turnaround time.

Unfortunately, Method 537 as written is for the analysis of drinking water only and should be performed with limited modification as allowed by the method. Recent investigations are extending the method to surface water and wastewater. Various labs have modified Method 537 and added a variety of extraction protocols

continued on page 13

Table 1. State Groundwater Standards and Guideline. *(Source: WEF 2018)*

State	PFOA	PFOS	Notes
Alabama, California, Colorado, Delaware, Florida, Maine, New Hampshire, New York and Rhode Island	70 ng/L, individually or combined		Adopted EPA Lifetime Health Advisory Level
Alaska and Illinois	400 ng/L	200 ng/L	
Massachusetts and Connecticut	70 ng/L, individually or combined		Includes sum of five PFAS
Michigan	420 ng/L	11 ng/L	
Minnesota	35 ng/L	27 ng/L	
New Jersey	14 ng/L	13 ng/L	
North Carolina	1,000 ng/L	—	
Texas	290 ng/L	560 ng/L	
Vermont	20 ng/L, individually or combined		Includes sum of five PFAs
West Virginia	500 ng/L	—	


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Clogged municipal wastewater collection systems can be costly in both time and operating expenses.
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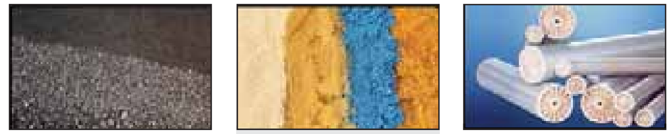

Figure 4. Examples of water treatment technologies for PFAS.
Evoqua Water Technologies

to accommodate testing of solids. If contracting with a lab using a modified version of Method 537, it is important to verify that the lab is producing high quality, defensible data.

In late June 2019, EPA released a draft Method 8327 (24 PFAS) for nonpotable waters, including wastewaters, under the SW-846 program; this method should be finalized in the coming months. Method 3512, a prep method that extracts the PFAS from non-potable water using organic solvents, was also released in draft form.

ASTM Method 7979 has been developed and validated for analysis of PFAS in nonpotable water, wastewater and sludge. ASTM Method 7968 has been developed and validated for analysis of PFAS in soils. However, it may be difficult to find labs that utilize the ASTM methods.

Make sure the lab doing your analysis has adequate detection and reporting limits. EPA analytical methods, such as Method 537, include procedures for laboratories to determine their method detection limits and reporting limits. However, if a lab's reporting limits are at concentrations higher than the regulatory standard or guideline (e.g., EPA's public health advisory level of 70 ng/L for PFOA and PFOS separately or combined), then analytical data from that lab has no value in making comparisons to advisory/screening levels or for demonstrating regulatory compliance. Consequently, it is important to determine if the applicable regulatory agencies have established required detection limits or health-based, regulatory standards/guidelines and it is recommended to only contract with labs that can meet those requirements.

There are challenges with obtaining robust data when the contaminants being analyzed are ubiquitous and the concentration levels of concern are in the parts per trillion (ppt, ng/L or ng/kg) range. The chance of false positives is relatively high during PFAS sample collection due to the potential for many sources of cross contamination, combined with low laboratory detection limits. Sample contamination is a significant concern with this type of analysis; therefore, a sampling plan that includes measures to prevent sample contamination is necessary.

Table 2. Summary of Treatment Options for Removal of PFNA, PFOA and PFOS. *(Source: EPA 2019a)*

		Removal Rates		
Treatment Option	**Description**	**PFNA**	**PFOA**	**PFOS**
Granular activated carbon (GAC)*	• Presumptive treatment method for drinking water and groundwater. • Competition for adsorption with other contaminants can reduce effectiveness in removing PFAS. • Most common treatment method for long-chain PFC removal, often faster breakthrough of short-chain PFAS compounds. • Thermal regeneration of GAC is effective.	>90%	>90%	>90%
Reverse osmosis/ nanofiltration (membrane filtration)	• Works well on many PFAS compounds, but expensive and requires management of a significant amount of high-concentration residual. • Mineral addition may be necessary.	>90%	>90%	>90%
Synthetic and other adsorbents (anion exchange)	• More expensive than GAC and works equally well on short-chain PFAS compounds. • Single-use systems require replacement and proper disposal, while regenerable systems produce brine that must be disposed of responsibly. • Competition with common ions for binding sites on resins can impact effectiveness of PFAS removal. • Organics, total dissolved solids and minerals can clog resins and reduce efficiency. • Requires on-site regeneration to compete with GAC.	>67%	10-90%	>90%
Advanced oxidation processes (AOP)	• Advanced oxidation processes are not energetic enough to break the PFAS C-F bond. • Low removal rate. • Can destroy pollutants to produce simpler compounds. • Other organic contaminants will compete for hydroxyl radicals and reduce efficiency.	<10%	<10%	<10-50%

Notes:
*Powdered activated carbon (PAC) may be useful in responding to spills, but the high concentrations of PAC required make this an infeasible option for treatment. PAC combined with waste residuals may create a challenge for the disposal of waste products.
Removal does not constitute destruction or disposal.
Conventional biological wastewater treatment results in negligible removal.

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Treatability

There are three ex situ treatment technologies ***(Figure 4)*** recommended for PFAS removal in water:

- Granular activated carbon (GAC).
- Reverse osmosis (RO)/nanofiltration (membrane filtration).
- Synthetic and other adsorbents (anion exchange).

Typical removal performance for common treatment options are summarized in ***Table 2***. Note that removal does not constitute destruction or disposal. Also, conventional wastewater treatment typically yields either negligible removal (less than 5% due to high solubility) or increases transforming precursors. Finally, PFAS, overall, are generally separated into "long chain" and "short chain" groups, the removal performance of which depends on the treatment method.

Technologies for concentration or treatment of high-strength PFAS residuals include:

- Pretreatment. Pre-conditioning the water or wastewater may improve removal (examples: pre-filter, coagulant feed).
- Plasma. Potential high-energy, on-site or off-site destruction for concentrated residuals or wastewater.
- Incineration. Off-site thermal destruction, but on-site is also possible (examples include spent carbon or RO brine).

The New York Experience and Beyond

It started with the Village of Hoosick Falls, New York, addressing a drinking water concern. Two other examples, one in New York and one in the mid-Atlantic, are offered to show community action responses to the detection of PFAS.

The Case of Hoosick Falls, New York

PFOA was discovered in the drinking water supply for the Village of Hoosick Falls, New York, in 2013 and 2014. Supply wells registered as high as 540 and 1,010 ng/L. Bottled water was provided as an interim measure to the village's 3,500 residents.

A large granular activated carbon treatment system was designed, constructed and commissioned to treat the public water supply. Private wells in the surrounding Town of Hoosick, not on a public water supply system, were sampled. Based on the results, hundreds of point-of-entry water treatment (POET) systems were installed (two-stage carbon and UV). It was more than two years from initial discovery to eliminating the need for bottled water.

In January 2016, EPA Region II established a site-specific PFOA level of 100 ng/L for Hoosick Falls, which was one quarter of the provisional health advisory value of 400 ng/L for PFOA set in 2009. In May 2016, EPA issued the lifetime health advisory level of 70 ng/L for PFOA and PFOS, individually and combined.

Statewide regulatory action on this issue began with emergency rulemaking Jan. 27, 2016. Chemical bulk storage regulations *(6 NYCRR Part 597)* were amended, and PFOA and PFOS were added to the list of hazardous substances with a reportable quantity of 1 pound. This affected practices in the storage and use of aqueous fire-fighting foams and enabled the use of the state Superfund to address the Hoosick Falls drinking water problem. The proposed final rule April 25, 2016, led to adoption of the final rule March 3, 2017.

On April 26, 2017, New York Governor Andrew M. Cuomo signed the Clean Water Infrastructure Act. The Act was an outgrowth of PFOA in Hoosick Falls and 1,4-dioxane on Long Island, securing $2.5 billion of funding for various activities related to drinking water quality with specific provisions for Gabreski Air National Guard Base (PFOS) and U.S. Navy/Northrop Grumman Bethpage site (1,4-dioxane). The Act requires all public water systems to test for emerging contaminants such as 1,4-dioxane, PFOA and PFOS, and established the New York State Drinking Water Quality Council.

The Case of Petersburgh, New York

In the small community of Petersburgh, New York, the water treatment plant treats its groundwater supply well water with chlorine prior to storage and distribution. Testing conducted by the New York State Department of Health and the Rensselaer County Department of Health detected PFOA in the wells, exceeding the 70 ng/L lifetime health advisory level in one well, but substantially below the advisory level in other wells. The town switched to using wells that had PFOA below the 70 ng/L advisory limit and added water treatment. The solution involved sediment pre-filters and lead/lag GAC vessels prior to chlorination. The 25-50 gallon-per-minute system utilizes GAC-treated water for backwash, with "forward-rinsing" of carbon fines. There is also a secondary upstream chlorine feed. The solution has been effective and online since 2017, with sampling ports for monitoring and carbon change-out.

The Case of Martinsburg, West Virginia

West Virginia has not been an active state with respect to PFAS. That said, the City of Martinsburg, West Virginia, Big Springs facility needed to implement a solution quickly. With a service area of 6,000 customers, Martinsburg operates two water filtration plants (WFP): the 4 million gallon-per-day (MGD) Kilmer Springs plant, and the 5 MGD Big Springs plant. The city's water source

Table 3. Treatment Options for PFAS Explored for the Big Springs Facility in Martinsburg, West Virginia.

Treatment Option	Pros	Cons
Reverse Osmosis/Nanofiltration	• Good removal rates.	• Susceptible to fouling. • Pretreatment may be required. • Expensive.
Activated Carbon	• Good removal rates. • Moderate cost.	• PAC feed and/or GAC regeneration required.
Anion Exchange	• Good removal for PFOS. • Competitive cost of regenerated on-site.	• Pretreatment may be required. • Brine waste to manage.
Advanced Oxidation Processes		• Low removal rates. • Significant energy required. • Expensive.
Disposal	• Varies by treatment method.	• The cost for disposal is difficult to quantify without clear regulations.

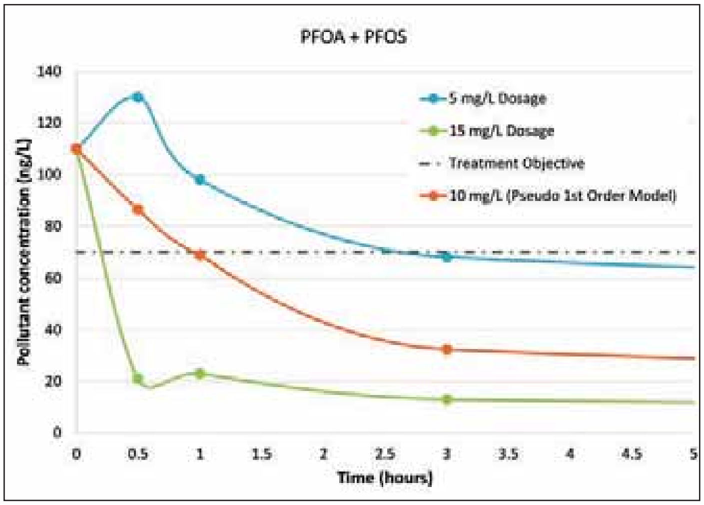

Figure 5. Batch test results with different PAC doses. *Ramboll*

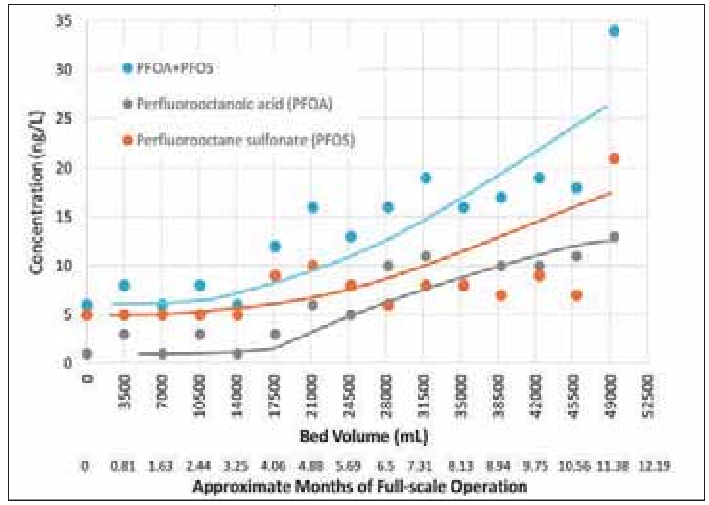

Figure 7. RSSCT results of PFOA/PFOS effluent concentrations over two weeks of testing. *Ramboll*

is groundwater characterized as "under the influence of surface water." Treatment consisted of conventional direct filtration using anthracite/sand.

On May 19, 2016, the city's Big Springs plant was shut down by the West Virginia Bureau of Public Health. PFOA/PFOS had been discovered at levels twice the lifetime health advisory level of 70 ng/L in a Big Springs well. During the shutdown, the Kilmer Springs plant was operated near capacity, with limited redundancy. The work at the Big Springs plant, including sampling, bench and pilot-scale testing, preliminary engineering, equipment pre purchasing, design, general construction bidding and implementation, was expedited.

The following water treatment options for Big Springs were explored ***(Table 3)***.

Figure 6. Figure 6. Rapid small-scale column test (RSSCT) column packing. *Ramboll*

Existing water quality was evaluated for process optimization. Bench scale testing included powder activated carbon (PAC) and GAC. PAC, using carbon isotherm to estimate adsorption capacity, achieved more than 80% removal, with impacts to the filters for a full-scale retrofit at the 1 MGD level ***(Figure 5)***.

Utilizing rapid small-scale column testing (RSSCT) ***(Figure 6)***, GAC was configured with a 10-minute empty-bed contact time, projected to achieve 20 to 35 ng/L after a year of operation ***(Figure 7)***. Actual full-scale performance achieved better results.

The alternatives of PAC addition, GAC contactors, replacement of the existing filters' anthracite with GAC, and a combination of PAC and anthracite-GAC replacement were evaluated. Based on this evaluation, the recommended approach involved units in lead/lag series, with sampling taps and a flow meter, to track PFAS breakthrough. This arrangement involved minimal impacts to the existing process, maintained rated WFP capacity, and appeared to have the lowest operation and maintenance (O&M) costs. GAC was incorporated into the existing treatment process ***(Figure 8, Figure 9)***.

Over the first 18 months of full-scale operation, Martinsburg assessed the effectiveness of its coconut-shell carbon, in terms of bed volumes treated before exhaustion. Both the vendor (TIGG) and the city funded the sampling program to monitor breakthrough at four ports in the GAC contactors. In the summer of 2019, the city collaborated with several GAC vendors to perform rapid small-scale column testing on bituminous, sub-bituminous and lignite-based GAC. Bid documents were issued to procure GAC replacement for two contactors. Acid-washed bituminous GAC by Cabot was selected, and the replacements were completed in September 2019, along with monitoring frequency of backwashing to confirm whether any pre-GAC treatment would be beneficial.

The absence of a federal PFAS program was evident with respect to project funding. The Big Springs WFP was shut down in 2016 due to PFOA/PFOS. The Air Force National Guard admitted in January 2017 that its base in Berkeley County was the source of the PFOA/PFOS in the groundwater. Martinsburg installed the treatment system in December 2017 and approached the federal government to recover its costs. The funding initially promised for capital and O&M costs was withdrawn by the Department of

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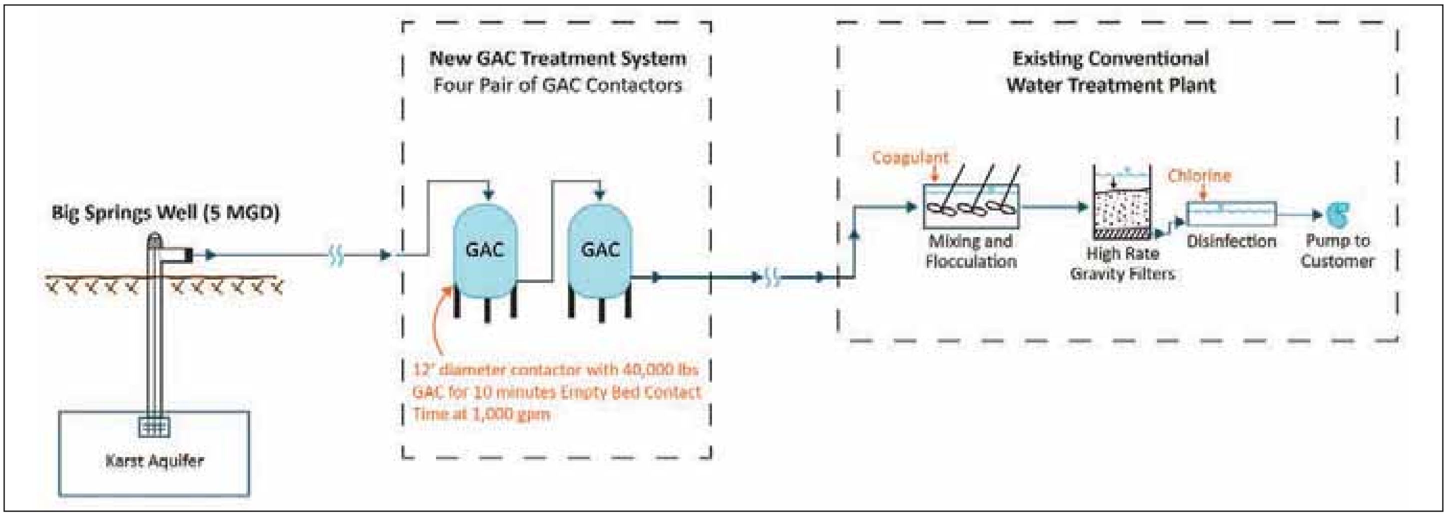

Figure 8. PFAS treatment system schematic. *Ramboll*

Figure 9. PFAS treatment system. *Ramboll*

Defense because it lacked the authority to issue the reimbursement. Congress eventually allocated funding, and the city received all their requested $4.9 million funding in May 2019.

The city is among a select group of communities participating in blood serum testing over time, to assess the exposure of the community to PFOA/PFOS.

General Thoughts on this Emerging Issue

The list of emerging contaminants seems to be growing faster now, and PFAS are not yet completely identified. Advances in analytical capabilities are intersecting with scientific interest and public concern. The chances of regulatory noncompliance are increasing, with 1 to 2 ng/L detection limits, state-by-state limits dropping lower, and an unspecified or growing list of PFAS compounds leading to development of more state or federal standards. Initial state-level surveys suggest that perhaps 90 to 95% of systems are below thresholds, but threshold levels and PFAS totalization methods may be changing.

Wastewater systems can transport PFAS via effluent or biosolids. What standards will apply to receiving streams and what will apply to water resource recovery facility influents and effluents, and the upstream wastewaters and hauled wastes received? Will publicly owned treatment works stop accepting some wastewaters?

Most water resource recovery facilities and biosolids management programs are not designed to address PFAS. Based on limited research and testing, PFAS precursors may bio-transform through biological treatment and aeration and may accumulate in sludge. The "total oxidizable precursor (TOP) assay" method may or may not be a good measure of PFAS potential. Pretreatment or centralized treatment options may need to be considered. Site-specific treatability will need to consider both the regulated and unregulated compounds, flow magnitude, pH, ionic strength, total and dissolved organic carbon competition, removal rates, treatment efficiency and capacity, and ultimate PFAS disposal and destruction. Water treatment residuals and wastewater biosolids disposal methods may be affected. State programs without the support of federal rulemaking can allow waste to be shipped out-of-state, or at least out of the service area, to "resolve" the issue, but not solve the problem.

Will PFAS go the way of PCBs and mercury, also requiring minimization programs of sorts? According to the Centers for Disease Control and Prevention's National Health and Nutrition Examination Survey (NHANES) of data from 1999 to 2012, blood concentration of PFOS and other PFAS have dropped over time. Recent efforts to stop or reduce production and use of PFOS and PFOA in consumer products appear to have lowered exposure to the general population. Will consumer product bans and treatment efforts, where needed, mean a one- or two-generational solution will be required until acceptable levels are reached?

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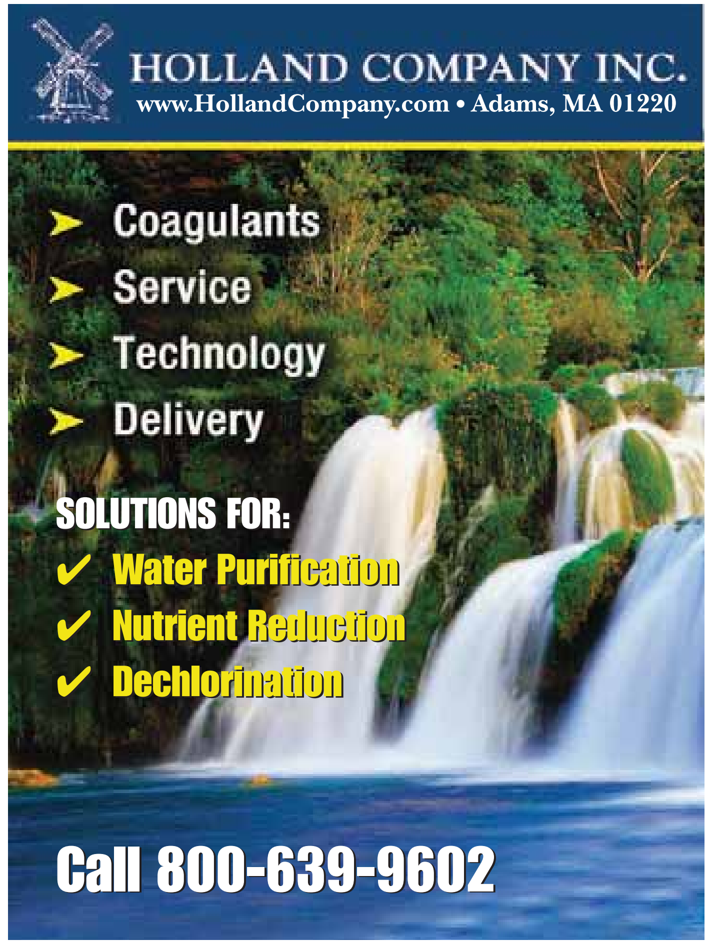
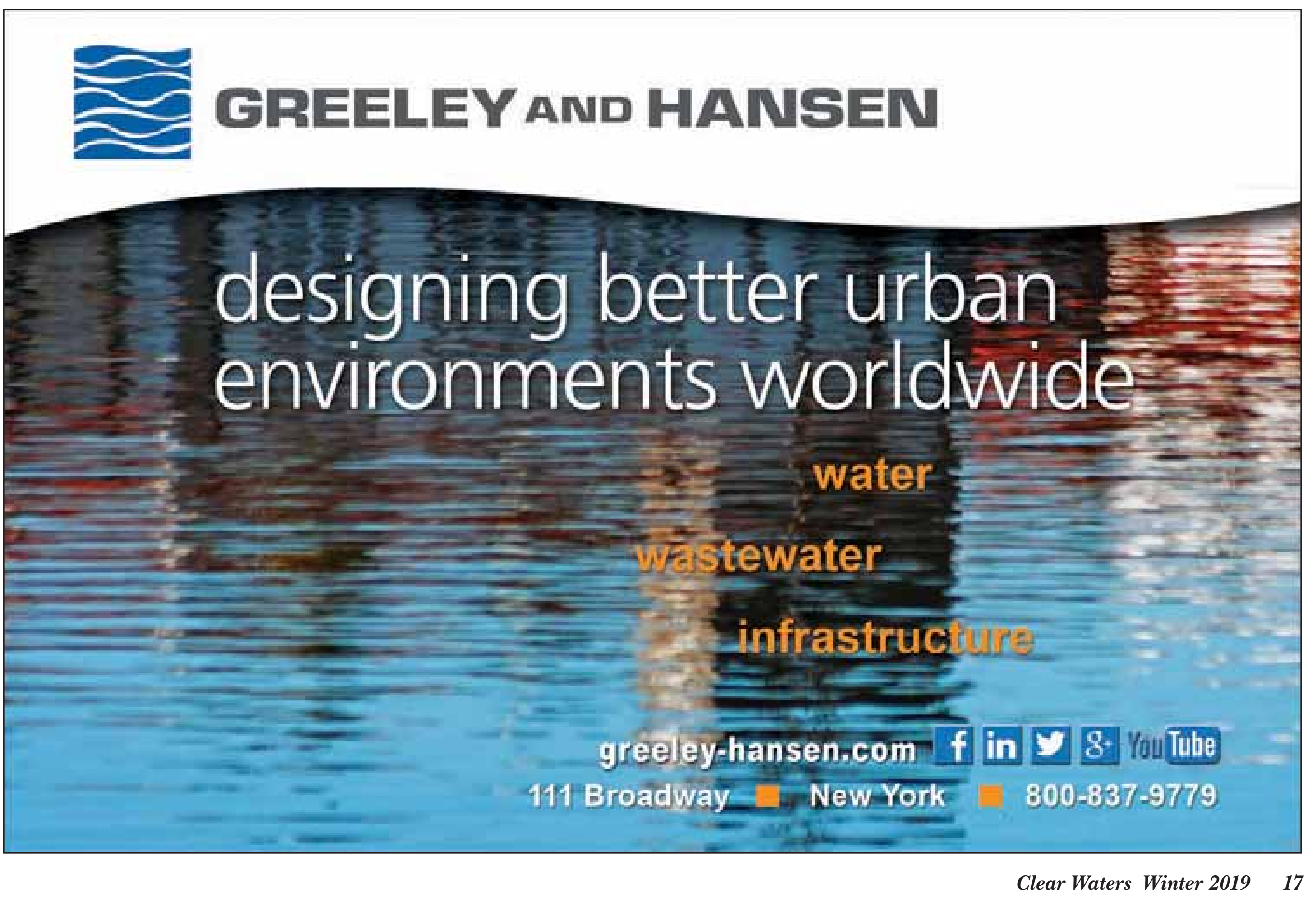




Researchers Seek PFAS Solutions as They Try to Break Down the 'Forever Chemical'

***by Keith Matheny** (Detroit Free Press. Reprinted with permission.)*

It's a daunting task: How to break down "the forever chemical?"

But scientists across the country are researching, with urgency, ways to bust apart or capture per- and polyflouroalkyl substances, or PFAS. State officials suspect the potentially harmful compound could be contaminating more than 11,000 sites in Michigan *(Matheny 2018)*, and hundreds more across the country.

Among the efforts:

- At Michigan State University, a technology using arrays of tiny diamonds and high voltage has shown promise in breaking apart PFAS molecules – but the huge energy demands involved make scaling it up for larger treatment a challenge.
- At Clarkson University in New York, a similar technology is using plasma – "tiny lightning bolts" – to break up PFAS molecules, a process that the U.S. Air Force has taken an interest in for its more than 400 contaminated bases.
- At the University of Cincinnati, researchers are having success with an iron-based catalyst that breaks down PFAS compounds and leaves behind much safer, easier-to-deal-with chemicals.

In addition, Michigan Technological University is examining how granular-activated carbon filters, the most common solution to dealing with PFS contamination, can be optimized for peak performance at the lowest cost.

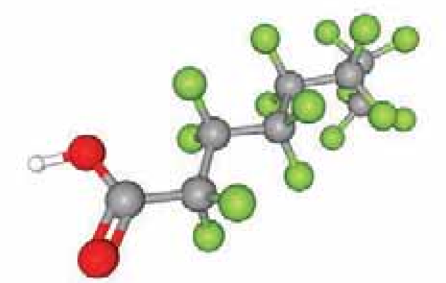
There's no federal-scale research initiative on cleaning up PFAS contamination. The U.S. Environmental Protection Agency, in its PFAS Action Plan *(USEPA 2019)* released in February, said it "plans to evaluate the effectiveness and cost of existing treatment and remediation technologies for a variety of PFAS contaminated sites and develop and test new technologies and approaches for cleaning up PFAS contamination." The agency stated it will accomplish this by working with the Department of Defense and states, industry, universities and others to help lead the science in this area.

PFAS was used in a host of industrial and consumer products, from aqueous firefighting foam to nonstick, Teflon pots and pans; Gore-Tex waterproof clothing; Scotchgard stain and water protectants; and even sandwich wrappers, microwave popcorn bags and dental floss. Scientists now, however, understand the chemicals don't break down in nature, and have been linked to health problems including cancer, thyroid and liver disorders, and more.

Some 47 sites across Michigan have PFAS levels in soil, groundwater and/or surface water that exceed the U.S. Environmental Protection Agency's lifetime health advisory number of 70 parts per trillion – a number above which a lifetime of exposure could be expected to harm health *(State of Michigan 2019)*. Nationwide, the Pentagon last year identified 401 military sites where there are known or suspected releases of commonly used PFAS compounds known as PFOS and PFOA, through the use of firefighting foam. A recent study by the Washington-based nonprofit Environmental Working Group, citing updated federal government data, identified 610 sites in 43 U.S. states or territories known to be contaminated with PFAS, including drinking water systems serving 19 million people *(Environmental Working Group 2019)*.

Why PFAS is the Nearly Unbreakable Compound

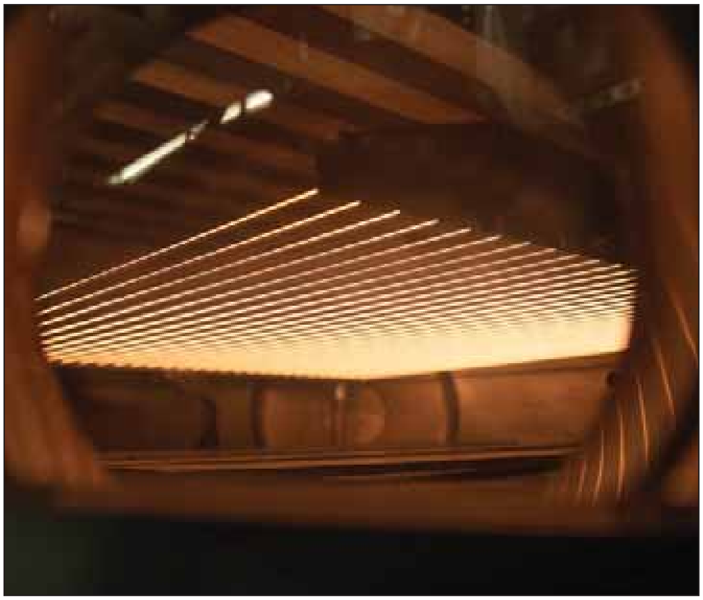
Per- and polyfluoroalkyl substances – PFAS – are made up of a chain of carbon atoms, surrounded by fluorine atoms.



The carbon-fluorine bond is one of the strongest in nature. This made PFAS super-slippery, and great for uses such as grease and

Engineers Juan Donoso (foreground) and Robert Rechenberg prepare a hot-filament diamond reactor to destroy PFAS compounds at Michigan State University's Fraunhofer Center for Coatings and Diamond Technologies on Sept. 13, 2018. *Derrick L. Turner/Michigan State University.*

A piece of steel rusting, which is a natural oxidation process in the presence of moisture. PFAS compounds, however, strongly resist such natural chemical changes and breakdowns. *Prostock-Studio (iStock by Getty Images)*



A hot-filament diamond reactor treats PFAS-contaminated water at Michigan State University's Fraunhofer Center for Coatings and Diamond Technologies on Sept. 12, 2018.

Derrick L. Turner/Michigan State University.

water resistance. But it also means natural processes that break down many other compounds – heat, radiation, humidity, dilution – don't really work on PFAS compounds.

Michigan State: Diamonds and Rust

What makes PFAS so problematic is its tightly connected carbon and fluorine atoms, one of the strongest bonds in nature. Natural processes that break down other compounds don't work on PFAS compounds.

At Michigan State University's Fraunhofer Center for Coatings and Diamond Technologies, researchers are finding success at breaking down PFAS compounds through an electro-chemical oxidation process using arrays of tiny diamonds and high voltage electrical charges.

"Imagine hundreds of thousands of single-crystal diamonds, 1 micrometer in size, less than the width of your hair," said Cory Rusinek, a scientist in the MSU Fraunhofer lab.

"Diamond is the most robust electrode material you can make. It's able to withstand the high voltage and high current you need for electro-chemical oxidation, which is basically what we use to destroy PFAS."

Arrays of thin electrodes covered with the tiny diamonds are introduced to PFAS-containing water, and then a high-voltage charge is applied.

"The PFAS molecules interact with the surface, they oxidize (lose electrons, an atomic component), and there's defluorination," Rusinek said.

What's left are common elements and compounds that are far easier to deal with than PFAS, such as carbon dioxide and fluoride, he said.

The treatment has shown great success in the laboratory and on a small scale, Rusinek said. The problem, however, is the amount of electricity needed: 25 to 70 watt-hours per liter of contaminated water. For a wastewater treatment plant or a system controlling contaminants flowing from a landfill or polluted area, dealing with tens of thousands, hundreds of thousands or even millions of gallons of water, it's too big of a power bill.

"Instead, the treatment might work with other methods that absorb, isolate and concentrate PFAS, such as some very fine, membrane filtration systems. The diamond-electric treatment then would be applied to a much smaller volume of water with a much higher concentration of PFAS contamination.

"The Michigan State project, only started about 18 months ago, is now moving to a larger-scale laboratory study and mini-pilot studies to determine what the cost of a system might be," Rusinek said.

Clarkson University: "Small Lightning Bolts"

At Clarkson University in New York state, electric discharge plasma – "think of them as small lightning bolts," said engineering professor Tom Holsen – is being used to break apart PFAS compounds, and the U.S. Air Force has taken interest.

In this process, gas is bubbled through PFAS-contaminated water, concentrating the compounds at the surface. "They're surfactants – they're like soap," Holsen said. "They want to be at the water-air interface."

Then, metal electrodes transmit electricity through a layer of gaseous argon. The electricity flow forms a high-energy plasma at the electrode tips. (Ever see a decorative plasma ball, with which you can touch the outer glass orb and have a little lightning bolt dance to where your finger is touching? Clarkson's "enhanced contact electrical discharge plasma reactor" operates via the same concept.)

The plasma creates short-lived "free radicals," unstable atoms with only one electron, "that can break the carbon-fluorine bond, which is the backbone of the PFAS molecule," Holsen said.

"It continually unzips the molecule, keeps chopping down to fluoride ions, carbon dioxide" and other products "that are much less toxic," he said.

The process for treating PFAS was discovered "kind of by serendipity," Holsen said. "The university lab was working on treating general contaminants in water, while looking at how PFAS is accumulating in and affecting the Great Lakes as part of another project.

"We happened to put some PFAS in the reactor along with some other contaminants, and discovered it was removed better than the other contaminants," he said.

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An enhanced contact electrical discharge plasma reactor treats PFAS-containing water in experiments at Clarkson University in New York, in this Nov. 2017 photo. *Tom Holsen/Clarkson University*

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The Air Force in 2017 provided $1 million in funding for the continuation of Clarkson's project.

"We have some (plasma) reactors in the back of a 20-foot trailer," Holsen said. The university will move from the lab to the field, testing its technology on 55-gallon drums of PFAS wastewater from Air Force sites contaminated from years of use of PFAS-containing firefighting foam.

"There's a large potential for this being a viable approach to PFAS contamination," he said.

University of Cincinnati: Catalyst for Change

At the University of Cincinnati, researchers are developing a technology to remove fluorine from PFAS compounds and oxidize it, ending with its "conversion to environmentally friendly byproducts," said researcher Wael Abdelraheem.

"Carbon-fluorine is a very strong bond," he said. "We've established an iron-based catalyst in our lab that has a very strong reducing power. It can defluorinate the PFAS."

Abdelraheem said he couldn't provide many more details, as a patent is pending on the technology.

Researchers are now working on scaling up the project, verifying that they can reproduce their results, and assuring their process is not creating undesirable byproducts, Abdelraheem said.

Michigan Tech: Filter Fine-Tuning

At Michigan Technological University in Houghton, researchers are working with the most common protective product in use today for PFAS – granular activated carbon filters. But the focus is on how to make them most effective.

The carbon filters don't destroy PFAS compounds, they only capture them. But filtration needs might vary in size from a home system to a large-scale system for a municipal water treatment plant. Michigan Tech's research is on granular-activated carbon filters.

"What we're trying to do is create ways to tell other engineers how they can treat PFAS with granular-activated carbon," said Alan Labisch, an environmental engineering student working on the project under the supervision of Michigan Tech environmental engineering professor Eric Seagren and Professor Emeritus David Hand.

The modeling technology "accounts for everything," Labisch said – the amount of water, flow rates, the amount of PFAS and other contaminants and organic matter in the water.

Designing a system that's exactly right sized is important for local governments and others who need to control costs," he said.

"If you know what's in our water, we can tell you how big you need to make your absorber," Labisch said.

"Remediation approaches to the emerging PFAS contamination problem nationally and worldwide probably won't focus in one place," said Rusinek at Michigan State.

"All of these technologies have little caveats," he said. "There's really no one, true solution. It's going to be a puzzle of a few different remediation options. It's just finding that right combo."

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NEBRA Perspective on PFAS

by Janine Burke-Wells and Ned Beecher

Introduction

If you work in the clean water profession and haven't heard of PFAS (per- and polyfluoroalkyl substances), you really need to get out more. These contaminants have emerged with a big bang in the last couple of years. The North East Biosolids & Residuals Association (NEBRA) has been keeping a weather eye on the developing PFAS issue, including regulatory initiatives and the possible implications for water resource recovery facilities (WRRF) and management of biosolids.

A Bit about PFAS

PFAS are a class of fluorinated compounds that have been used in numerous commercial and household applications since the 1940s. The original chemicals are long-chain compounds featuring numerous carbon-fluorine bonds, which are one of the strongest of chemical bonds. That's why PFAS are nicknamed "forever chemicals." PFAS have many beneficial uses thanks to properties such as exceptional resistance to heat, water and oil. PFAS is commonly found pretty much everywhere due to its use in a variety of commercial products such as nonstick cookware; stain-resistant furniture, carpets and clothing; and water and grease repellents used in cosmetics, paints, microwave popcorn bags and pizza boxes.

The most concerning of these chemicals, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) were phased out of production in the U.S., and already the levels of PFAS in our blood has gone down more than 70% ***(Figure 1)***. Similar reductions seem to have occurred in wastewater and biosolids. Eliminating these substances and getting them out of consumer products (e.g., source reduction) is the most cost-efficient and practical way to reduce any potential risk these chemicals may pose in the environment.

With advances in analytical methods and capabilities, PFAS compounds can now be detected at extremely low levels, in parts per trillion (ppt). It is hard for people to understand what that means. There are numerous analogies used to describe parts per trillion in terms that can be visualized, including:

- One second in 31,700 years.
- One drop of water in 20 Olympic-size pools.
- One drop in a pool the size of a football field and 30.7 feet deep.
- One square-foot tile in a kitchen floor the size of the State of Indiana, which just happens to be right around 1 trillion square feet.

Even with analogies, it's still hard to imagine the tiny scale of parts per trillion.

WRRFs are considered the receivers of these contaminants. As with all wastewater contaminants of concern, WRRFs can become targets for end-of-the-pipe regulation. But in the case of PFAS, tried-and-true clean water policies and regulations of WRRF effluents are an extremely inefficient way of addressing the PFAS problem. PFAS are found in low levels in many places besides the wastewater stream. For example, *Science Daily* recently reported on a study that attributes the bioaccumulation of PFAS at a Norwegian ski resort to the use of ski wax *(American Chemical Society 2019)*. Current

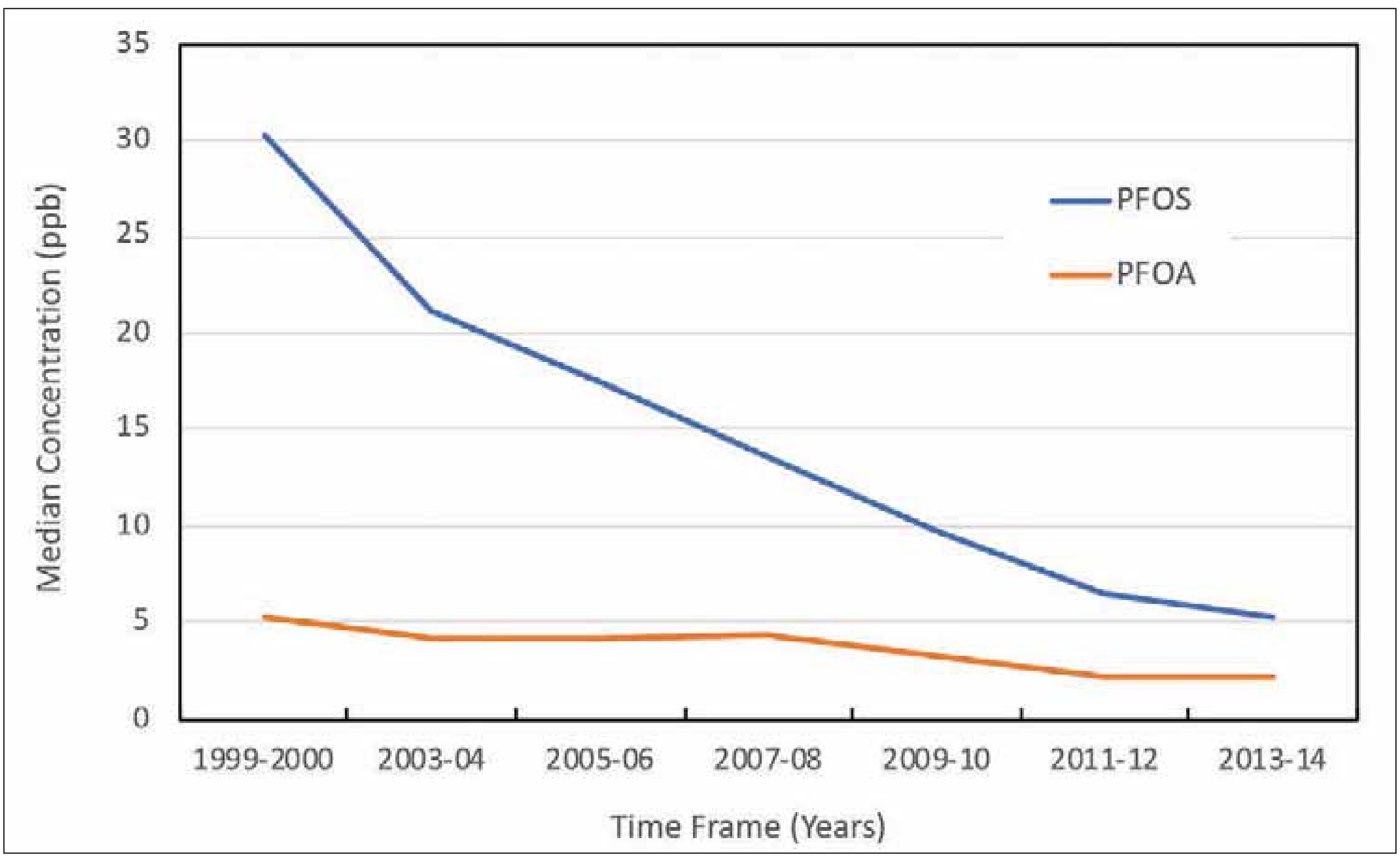

Figure 1. Median concentrations of selected perfluorinated compounds (PFCs) in blood serum over time (1999-2012) in the United States.
Data source: Centers for Disease Control and Prevention National Health and Nutrition Examination Survey (NHANES). *Centers for Disease Control*

public policy around PFAS is well-intentioned, but the outcomes, at least for WRRFs, will be expensive and could create more problems.

NEBRA's PFAS Work

NEBRA was created in 1997 as a spin-off from the New England Water Environment Association (NEWEA) to focus exclusively on the solids management aspects of wastewater treatment. NEBRA is an association of professionals involved in the generation, management, reuse and disposal of biosolids in the six New England states as well as the eastern Canadian provinces. Several NEBRA members work in New York as well.

As a result of some serious contamination of local drinking water wells due to significant sources of PFAS, such as military bases and manufacturing facilities, several of the New England states were forced to move quickly ahead with PFAS limits and regulations. Many of these focused on biosolids and, more specifically, the beneficial reuse of biosolids for fertilizer, compost and agricultural land application. NEBRA recognized early on that the regulations being discussed to rein in these harmful PFAS contaminants were going to have a major negative impact on the management of municipal wastewater biosolids.

Since January 2017, NEBRA has provided its members, as well as a growing list of biosolids professionals across the continent, with current science, legislative, and regulatory developments related to PFAS in biosolids and residuals. NEBRA has engaged with national water associations and other biosolids organizations in collaborative efforts to understand the implications of the fast-moving developments in PFAS policy, especially at the state level. Some of these developments have led to interruptions and disruptions in biosolids management programs, especially in the states where land application is more prevalent. NEBRA is trying to help its members by collecting relevant information about PFAS, wastewater and residuals, and about the liabilities, potential costs, latest testing methods and more related to compliance with developing PFAS standards. NEBRA has also compiled sampling guidance and has held training sessions on PFAS basics, PFAS in wastewater-related matrices, and sampling biosolids for PFAS. In collaboration with the Maine Water Environment Association, NEBRA initiated a scientific modeling effort on the potential for leaching of PFAS from land-applied biosolids.

NEBRA's public-facing PFAS page is *https://www.nebiosolids.org/pfas-biosolids*, and additional PFAS information is in the member-only area. NEBRA continues to host regular webinars with the PFAS Advisory Group it established, which includes national PFAS and biosolids/residuals stakeholders. NEBRA's joint conference with the NEWEA in October 2019 featured one day dedicated to presentations on the PFAS topic. These presentations are available online at *https://www.nebiosolids.org/annual-conference*.

Regulatory Landscape

The U.S. Environmental Protection Agency (EPA) has developed an Action Plan *(EPA 2019)* for PFAS and continues to develop the science and toxicological information to assess human health and environmental risk, as well as to potentially come up with standards for these new chemicals in drinking water and/or other matrices. EPA's Action Plan includes setting Maximum Contaminant Levels (MCLs) for PFOA and PFOS, considering regulations for a broader class of PFAS in drinking water, increasing PFAS monitoring of drinking water, cleaning up PFAS-contaminated sites, and making PFAS subject to various provisions of the Toxics Substances Control

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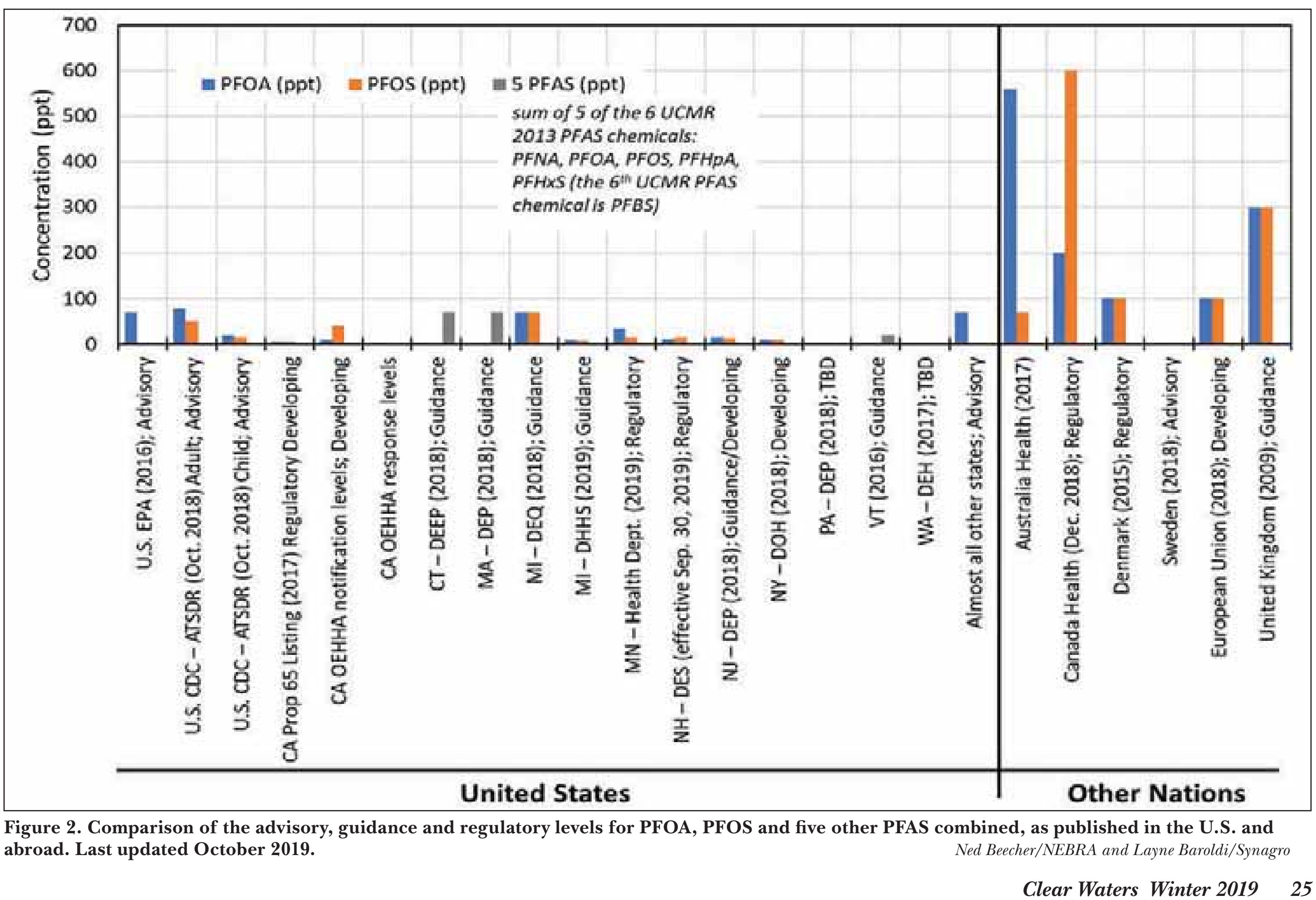

Figure 2. Comparison of the advisory, guidance and regulatory levels for PFOA, PFOS and five other PFAS combined, as published in the U.S. and abroad. Last updated October 2019. *Ned Beecher/NEBRA and Layne Baroldi/Synagro*

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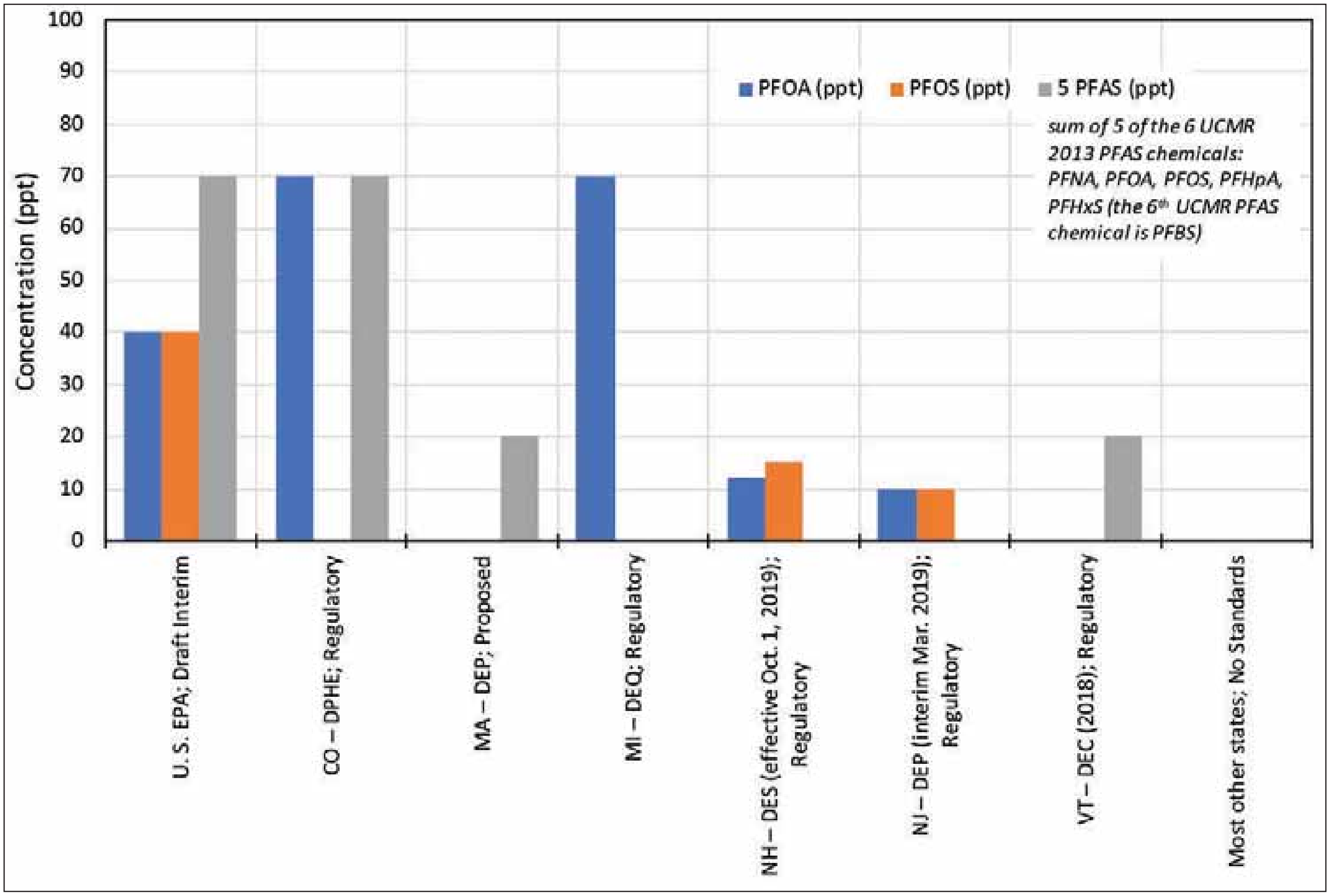

Figure 3. Comparison of the state PFAS levels for groundwater. Last updated October 2019. *Ned Beecher/NEBRA and Layne Baroldi/Synagro*

Act (TSCA), including reporting requirements under the Toxics Release Inventory (TRI) program. It is also EPA's job to expand analytical methods to test for PFAS and develop/approve new methods for media other than drinking water, including wastewater, sludge, biosolids and soils.

In May 2016, EPA published a public health advisory level for drinking water of 70 ppt for two PFAS chemicals: PFOA and PFOS. In the absence of national standards and in the face of public pressures, several state legislatures and agencies have moved ahead in regulating PFAS. That is especially true in New England, where there have been several high-profile cases of site-specific PFAS contamination of drinking water wells. Many of the New England states, as well as New York, are moving ahead with setting proscriptive MCLs for various PFAS in drinking water ***(Figure 2)***.

Why should WRRFs care about new drinking water standards? If you've been around, you know the way it works. Drinking water standards become surface water and groundwater standards ***(Figure 3)***, which make their way into WRRF discharge permits. Also, PFAS can obviously become more concentrated in the wastewater solids, which could interfere with land application programs due to new screening levels being established in some states ***(Figure 4)***.

State MCLs

The State of New York is proposing some of the most stringent MCLs of all the states: 10 ppt for PFOA and 10 ppt for PFOS. Deputy Commissioner Brad Hutton, of the New York State Department of Health (NYSDOH), estimated the costs to comply, just on the drinking water side, at about $1 billion *(NYSDOH 2018)*. If these MCLs become groundwater standards, limited research and data show that applications of biosolids and composts to soils can sometimes impact groundwater with PFAS at these very low levels. Other common activities can, too. It could be very costly if wastewater and solids management are disrupted as a result.

The first set of formal, enforceable MCLs in the country went into effect in New Hampshire Sept. 30, 2019. They address PFOA and PFOS and two other PFAS, and the limits range from 11 to 18 ppt. By New Hampshire law, the MCLs are also groundwater standards. Water and wastewater utilities and municipalities are highly concerned, for two reasons:

- First, many wastewater and residuals management activities could result in exceedances of such low groundwater standards, through no fault of the utilities, who receive PFAS from our daily living environments. Even home septic systems, which have no industrial inputs, release traces of PFAS that are close to these new New Hampshire groundwater standards *(Schaider, et al. 2014)*.
- Second, if wastewater and solids management operations cause, or have in the past caused, impacts that must be remediated, there's the potential to be held responsible for site investigation and remediation costs. Already in New Hampshire, the state has designated a septage management operation as a responsible party for high levels of PFAS in adjacent drinking water wells and the business is now defunct.

Biosolids in Maine

In Maine, the Department of Environmental Protection (MEDEP) imposed a moratorium in March 2019 on biosolids recycling to soil because of a widely publicized issue at a farm where municipal

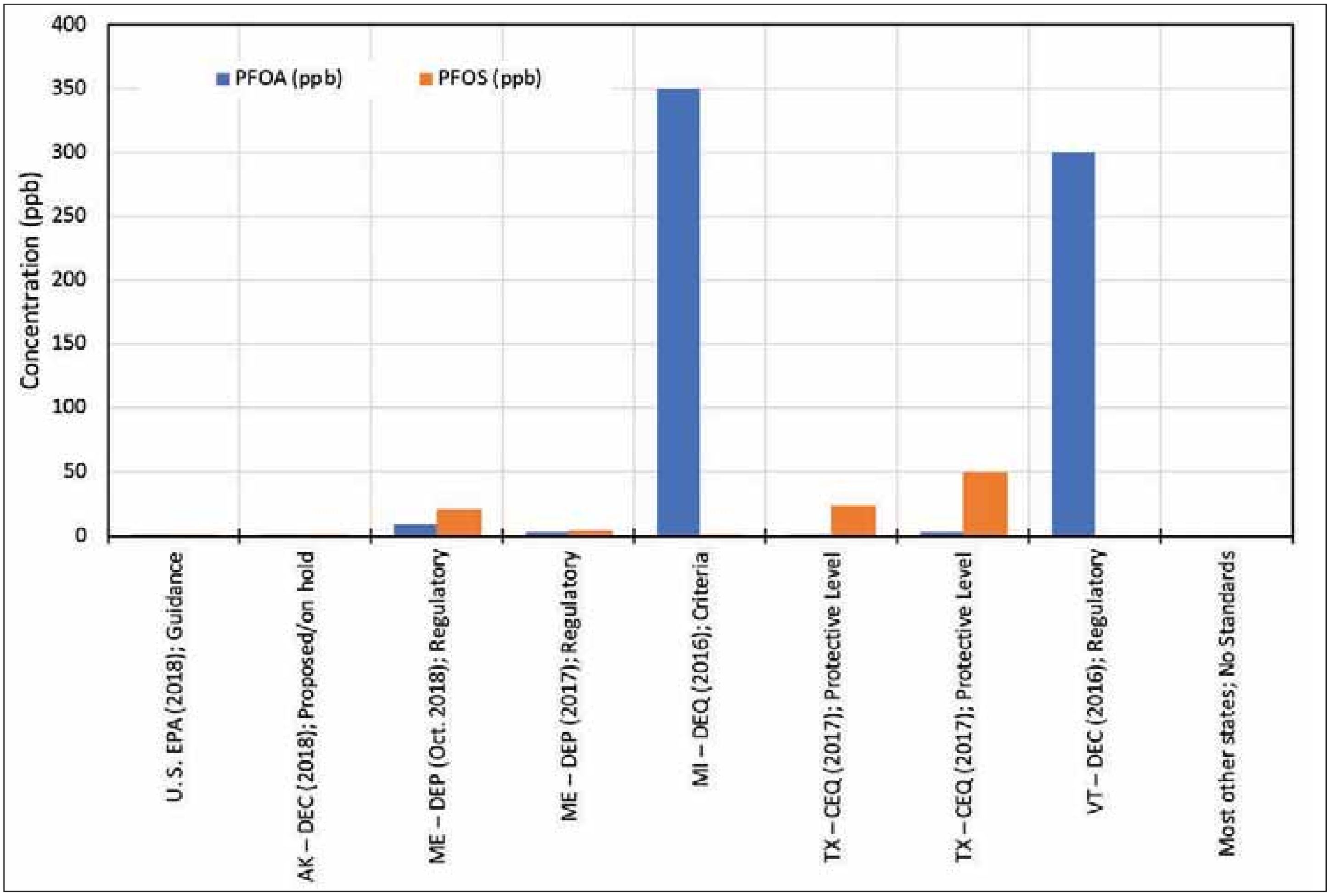

Figure 4. Comparison of the state screening criteria for soils and other materials. Last updated October 2019. *Ned Beecher/NEBRA and Layne Baroldi/Synagro*

biosolids and some industrial materials had been land-applied over three decades. In a lawsuit brought by the farm, which generated a lot of media coverage, only municipal biosolids were mentioned; the industrial material was left out. The MEDEP site investigations later concluded that the industrial material was likely the main source of the PFOS that is causing the issues on the farm *(Beecher 2019)* but by then it was too late. MEDEP applied biosolids screening limits that NEBRA and others have argued are scientifically indefensible: 2.5 ppb for PFOA and 5.2 ppb for PFOS. There are almost no biosolids anywhere that meet these limits. After all but one of Maine's WRRFs' biosolids failed to meet the screening limits, MEDEP allowed for loading rate calculations and approved all composts and pelletized biosolids to continue to be used.

Most fields in Maine, where bulk biosolids have been land-applied, were found to exceed the limits in the soil and have been closed off to further applications. Several wastewater facilities have been scrambling to find outlets for their biosolids. Landfills are overwhelmed, and prices for solids management have doubled for some utilities. Meanwhile, the data collected in Maine is showing what other data have shown: municipal biosolids applied to soils, even annually for 30 years, are not impacting waters at levels near the EPA health advisory drinking water value of 70 ppt. That might not be the case with MCLs like the ones in New Hampshire. NEBRA's modeling work on the fate and transport of PFAS in biosolids indicates that biosolids would have to have above 40 to 60 ppb PFOA or PFOS to cause possible groundwater issues.

Refocusing on Risk

The New York State Department of Environmental Conservation (NYSDEC) and other state agencies have since focused their PFAS attention on the highest risk PFAS issues: drinking water testing and MCLs, and reducing industrial and firefighting releases of PFAS, e.g., collecting PFAS-containing firefighting foam and surveying businesses and other facilities about use of PFAS. In September 2019, EPA awarded a major grant to the NYSDOH to study landfills as sources of PFAS in groundwater.

Federal Regulatory Status

Finally, there is much activity at the federal level on PFAS as well. As of this writing, there is a conference committee trying to synchronize Senate and House versions of the National Defense Authorization Act. The House version contains several amendments that should be quite concerning to clean water professionals:

- Representative Debbie Dingell of Michigan proposed to add PFAS regulation for water to CERCLA, commonly known as the "Superfund" law. Biosolids in particular could be impacted under CERCLA's strict and retroactive liability requirements.
- Representative Chris Pappas of New Hampshire proposed an amendment requiring EPA to develop effluent and pretreatment standards for PFAS via the Clean Water Act by Jan. 1, 2022.

Once again, the "receivers" may have to deal with the problem created by manufacturers of these products.

Treatment and Remediation Technologies

There are commercially available technologies for removing PFAS from drinking water. The most widely used is granular

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activated carbon (GAC). Ion exchange resin and reverse osmosis methods are also used. All technologies have their advantages and constraints, which must be carefully considered in determining the best one for a particular facility. Solutions will have to balance costs against performance.

There is much work going on in developing PFAS solutions for biosolids. But the options are limited. There is no current technology to remove PFAS from solids, either before or after dewatering. Oxidation or thermal destruction hold potential, but these and other treatment processes are known to create shorter chain PFAS, which is another problem. Most sewage sludge incinerators do not operate at temperatures high enough to destroy PFAS, which is greater than 1000 degrees Celsius. But some do. For example, the multiple hearth furnaces at Buffalo, New York, exceed 1000 degrees Celsius, according to William Lill of the Industrial Furnace Company. Engineers are working on further process modifications that hold promise. Some states are considering regional sludge disposal facilities, but that option will not be immediately available. Those will take time to site and design. There are still a lot of unknowns.

Challenge with Communicating Relative Risks

You are not alone if you are grappling with how to communicate PFAS issues with your customers, the public and policy makers. Until recently, NEBRA and its sister organizations in other regions of the country were the loudest in voicing concerns about PFAS regulations and developing information for use by biosolids managers. Thankfully, national organizations such as the Water Environment Federation (WEF) and the National Association of Clean Water Agencies (NACWA) are stepping up their efforts. Still, nothing substitutes for local voices. Local utilities can go a long way in educating their community members about PFAS issues and the relative risk of exposure from various everyday sources.

NYWEA, NEWEA, WEF, NACWA and other organizations can assist operators with pubic information materials and talking points to help put PFAS issues in perspective and voice your concerns about the impacts of PFAS regulations on your operations, especially the costs and potential liability of dealing with PFAS at the end of the pipe. NEBRA has a huge amount of information compiled on its special PFAS webpages. You will find all sorts of resources there including Interim Best Practices and guidance for pretreatment and source control programs. Contact *info@nebiosolids.org* for access.

It's important to educate yourself about this family of emerging contaminants, because it is not going away. Wastewater operators and engineers need to be involved in the discussions. As receivers of PFAS chemicals at our treatment facilities, we can be a big part of the solution in helping reduce upstream discharges, promoting further phase-outs of the most concerning PFAS, and maybe figuring out how to cost-effectively intercept them before they get back into the environment.

Amid all this PFAS-related chaos, it is good to remind ourselves why we would go to all the trouble of recycling biosolids to the soil. It is because of the many known and demonstrated benefits including lower net greenhouse gas emissions, use of local resources, closing the nutrient and carbon loops, increasing community sustainability, replacing fossil-fuel-based fertilizer and helping local agriculture, among others.

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Biosolids: Understanding the Invisible Evils that Keep Us Awake

by William E. Toffey

The urgent need to mitigate and adapt to climate change ought to be opening creative options for use of biosolids. After all, how can designers of a "circular economy," in response to climate challenges, escape the logic of recovering nutrients, energy and water from wastewater? Decades of agronomic research and practical field experience have demonstrated unfailing restorative benefits of biosolids to soils, especially through carbon replenishment *(O'Connor et al. 2005)*. But a persistent worry about biosolids derives from a distinctly noncircular use of sewers for disposal of substances whose fate seems, by some critics, inadequately understood *(Harrison and McBride 2009)*.

We are completing a fifth decade since federal policy gave a thumbs-up to land application for biosolids management. Over these many years, issues of heavy metals, radioactivity, dioxin, PCBs, flame retardants, odors and pathogens have waxed and waned, and in response well over 200,000 science articles have reported on aspects of biosolids. Through all of this, over half of global biosolids production has been satisfactorily used on land, with no credible reports of harm to human and environmental health *(Buonocore et al. 2018)*.

Nevertheless, a fresh set of concerns are arrayed in front of us today, demanding our attention and seeking to thwart the resource recovery role of biosolids in a circular economy. The hottest of these issues is PFAS *(Navarro et al. 2018)*, but other emerging issues include plastics *(Mahon et al. 2017)*, antibiotic resistance *(Lu Yang, Liu, et al. 2018)* and fate of unregulated persistent organic pollutants (POPs) *(Zennegg et al. 2013)*. Research careers have been launched, textbooks have been written and nongovernmental organizations have been formed to address these new topics, so what position can a responsible and concerned wastewater professional take in the face of these concerns? For now, hold fast to the wisdom of your biosolids predecessors and do not be discouraged. To help you do so, here is a review of the current hot topics.

Perfluoroalkyl Substances and Biosolids

PFAS is the hottest topic in biosolids today. PFAS, aka perfluorinated alkyl substances, is the name given to a large group of over 4,000 polymers that are the priority contaminant of concern in biosolids. Ned Beecher, at North East Biosolids and Residuals Association (NEBRA), is our leader for tracking how state regulators around the U.S. are responding to public pressure to eliminate risks from PFAS. The website *https://www.nebiosolids.org/pfas-biosolids* is chock-full of everything you need to know, and more *(Beecher and Rainey 2018)*.

I have checked out the NEBRA website, and have done hours of reading and listening, from which I have developed a few personal judgments about PFAS. PFAS compounds are everywhere because they have been in use for 60 years to confer water and stain resistance to fabrics, to provide nonstick properties to cookware and to yield life-saving heat-resistance to firefighting foams *(Kotthoff et al. 2015; Papadopoulou et al. 2017; Wang et al. 2017)*. Over the decades, PFAS compounds have dispersed to all corners of the world.

While we have improved our analytical capacity to measure PFAS down to the nanogram per liter concentrations in water, our ability to understand the risk of harm to people, animals and plants has not expanded equivalently. We know PFAS compounds are leachable, that they can bioaccumulate in virtually every species on Earth, and that they persist in the environment for generations. While the long-term picture is a reduction in human exposure over recent years as PFAS is removed from consumer products *(Hurley et al. 2018)*, against this trend is the increased public and scientific awareness of the vast extent of the distribution of released PFAS compounds as in food packaging, clothing and household dust *(Domingo and Nadal 2017; Lang et al. 2016; Schaider et al. 2017; Tian et al. 2016; Mitro et al. 2016; Papadopoulou et al. 2017)*. The most alarming PFAS exposure is through ground-sourced drinking water *(Cousins et al. 2016; Dauchy 2019; Szabo et al. 2018)*.

Regulators are rightfully focusing on hot spots, legacy dumps of PFAS materials and the contamination of underlying public water supply aquifers, because nearby residents and water consumers show elevated blood levels and body burdens, which last for years even after the source is removed. The message is that we ought to stop the production and use of PFAS immediately, but we are not going to be rid of the widely dispersed PFAS already in the environment and within our own bodies.

Yes, PFAS compounds are in biosolids, too. Their detection in biosolids is a consequence in most cases of release from consumer products to sewer drains and, in a few significant cases, releases from legacy industrial site disposal *(Sinclair and Kannan 2006; Venkatesan and Halden 2013)*, municipal landfills *(Allred et al. 2015)*, and fire training facilities *(Hu et al. 2016; Dauchy et al. 2019)*. The loadings of PFAS to water resource recovery facilities (WRRFs) and the consequent concentration levels in most biosolids are low *(Armstrong et al. 2016; Navarro et al. 2018; Sinclair and Kannan 2006)*. Yet, there is concern that the PFAS present in biosolids will be leached from the soil after land application and add to existing PFAS loads in the groundwater *(Venkatesan and Halden 2014)*. The current opinion of environmental scientists in the wastewater industry and of many public officials is that the concentrations of PFAS in biosolids are not at levels constituting an environmental or human health risk, and that uptake into plants is not significant *(Navarro et al. 2018; Navarro et al. 2017; Navarro et al. 2016)*. But the science and epidemiology of PFAS remain incomplete, and the political pressure to take regulatory action, even without the science, is strong.

Pressure is building in Maine and several other states to impose a ban on land application of biosolids because PFAS occur in biosolids. This is, in my opinion, nonsense, because biosolids are not a conduit nor a source of PFAS, and other biosolids disposal options may pose worse risks:

- Disposal of PFAS-bearing biosolids, or carbon filters from drinking water scrubbing operations for that matter, at landfills likely concentrates PFAS release via the leachate, which is not good.
- If you take the PFAS-bearing residuals to incinerators, the PFAS, designed to be a heat-resistant chemical, may remain unaltered in the ash or in emissions, which is also not good.

It is true that biosolids bear PFAS, and it is true that this PFAS may be leached into groundwaters below the land application site. But it is highly diluted in such a case. What is more, PFAS has not been conclusively shown to be a human health hazard, so a regulatory ban on biosolids is not an action that will meaningfully reduce community health risk. That is my prejudice at this point, though I remain open to ongoing dialogue.

Microplastics and Biosolids

I will lay this wager: microplastics are the next hot issue in biosolids. What are microplastics and how do we control them? No clear

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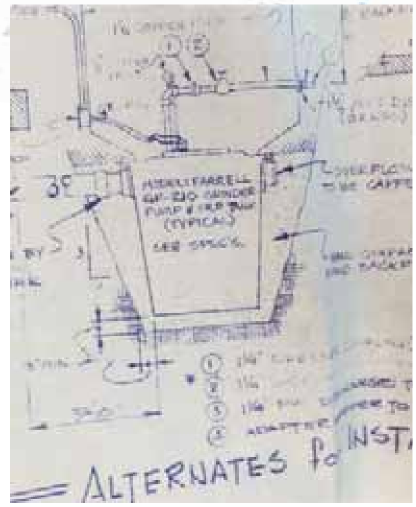
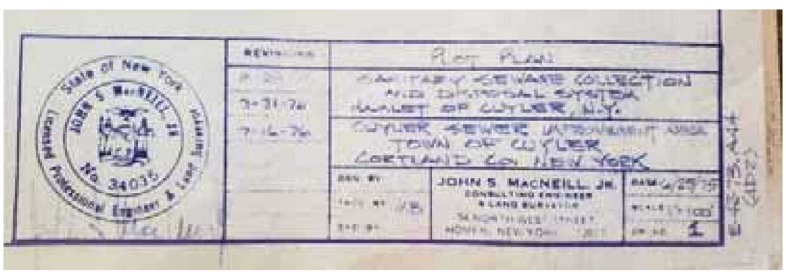
CASE STUDY

43 Years Later...

The town of Cuyler, NY is the site of the first Environment One low pressure sewer system in New York State. In 1976, 50 of the original model 200's pumps were installed.

Paul Farrell, the inventor of the low pressure sewer system, engineered and performed startup on this job. Pictured right is the 1976 drawing by Paul, featuring the "Farrell GP-210 Grinder Pump". Below is a photo of the original plot plan for Cuyler Sewer Improvement Area.





Still Going Strong.

Of the original 50 pumps installed in 1976, roughly half are still going strong. The rest of the pumps have slowly been upgraded over the years to the E/One Extreme Series grinder pump. The upgrades are utilizing the original basins. Doug Randall is more than pleased that the upgrade units fit into a system that was supplied over 40 years ago.

Testimonial courtesy of Doug Randall, local resident and full-time farmer. Doug handles the pump repairs.

Please contact your local Siewert Outside Sales Engineer to discuss your low pressure sewer application.

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answers here, yet. We do not yet have standard ways of measuring and expressing their concentration and occurrence. And we have suspicion, but no solid evidence, of human or environmental health effects. But it is an emerging hot topic, evidenced by the very first workshop sessions at national and international water conferences:

- Water Environment Federation's *Annual Technical Exhibition and Conference,* September 2019, "Occurrence, Removal, Fate and Transport of Microplastics in Wastewater and Drinking Water Treatment," in Chicago, Illinois.
- International Water Association's *Leading-Edge Conference on Water and Wastewater Technologies,* June 2019, "Microplastics – concern of water sector?" in Edinburgh, Scotland.

Reports of plastic pollution are genuinely alarming. Like PFAS, plastics have been a major product of human creativity since World War II. A 2017 survey article estimates that 6 billion tons of plastic waste have been produced globally, with about 80% in landfills or sitting on lands or in waters *(Geyer, Jambeck and Law 2017)*. The plastic waste ranges in size from large fragments down to nano-scale particles *(Geyer, Jambeck and Law 2017)*. A major use of plastics is for clothing, of which 150 billion garments are produced annually around the world. The washing of those items releases microfibers, which are released to the environment in wastewater effluent and in biosolids *(Libiao Yang et al. 2019)*. On top of this, we have microbeads from lotions, facial scrubs and other personal care products *(McDevitt et al. 2017)* and we have deteriorated plastics from bags and containers washing off streets, gutters and waterways *(Kramm and Völker 2018)*. During conventional treatment, plastic that passes through headworks screens are typically macerated *(Kim, Lee and Kim 2018; Libiao Yang et al. 2019; Sun et al. 2019)*.

Wastewater-carried plastics are largely discharged to the environment. One destination is the aquatic environment via effluent, and the other is the soil environment via the biosolids *(Nizzetto, Futter and Langaas 2016; Armstrong et al. 2018; Talvitie et al. 2017; Estahbanati and Fahrenfeld 2016)*. When biosolids are land-applied to farm soil, biosolids-borne microplastic become part of the soil-plant system, one of the several sources of plastic contamination that is now routinely incorporated in farm soils *(Ng et al. 2018)*. The effects of macro- and microplastics in the soil-plant system in agriculture are the subject of blossoming research, but the effects on soil properties and animal and plant life are still being worked out *(Dongdong et al. 2017; Chae and An 2018; Steinmetz et al. 2016)*. As more becomes known, the comparative importance of biosolids-borne plastics will be more completely discerned. Whether biosolids is a significant contributor may likely remain a matter of dispute *(Nizzetto, Futter and Langaas 2016)*.

The bottom line for me is that, if plastics prove to be a fundamental and significant risk to human and environmental health, biosolids will not be a central pathway of exposure, and biosolids treatment processes, including soil incorporation, may prove a reasonable barrier to harmful environmental releases. But the storyline is still unfolding on this emerging issue.

Antibiotic Resistance Genes in Biosolids

Here is a big sleeper question with biosolids: does the presence of antibiotic resistance genes (ARG) in biosolids pose a human or environmental health risk when spread across the landscape? "We don't think so" is about as good as we can guess today. The notion is scary that pathogens from hospital patients, who have presented with antibiotic-resistant disease, are carried via public sewer to our WRRFs where ARGs are propagated laterally to other microbes and then released to the wider environment via effluent and biosolids *(Tong et al. 2019; Barancheshme and Munir 2018)*.

The decreasing effectiveness of antibiotics and the growing incidence of antibiotic-resistant pathogens is among the very scary stories in today's health news, and ARGs from wastewater feeds into this scare. An array of deadly disease variants may be tied to ARG dissemination *(Tiedje et al. 2019)*. You can readily find science articles that assert WRRFs are breeding grounds for ARGs *(Zhang et al. 2009; Michael et al. 2013)*. But the far more significant evolution of ARGs is occurring much closer to home, in our hospitals and nursing homes, and in impoverished, unsewered urban settlements *(Rodriguez-Mozaz et al. 2015; Hocquet, Muller and Bertrand 2016)*.

Sewers and wastewater treatment are more likely serving as barriers to ARG risk *(Zhao and Liu 2019)*. Biosolids-borne ARGs seem to be highly vulnerable to wastewater treatment processes generally *(Xue et al. 2019)* and by anaerobic digestion in particular *(Miller 2014)*, especially when followed by composting, or by incorporation into a well-aerated soil microbiome *(Ezzariai et al. 2018; Youngquist, Mitchell and Cogger 2016)*, where the ARGs are readily degraded *(LaPara 2016)*. This conclusion is not held by all, as others believe the remaining risk is significant *(Christou et al. 2017)*. As soil is the original domain of many antibiotics, ARGs are a natural part of the soil microbiome, whether amended with biosolids or not, and preeminent scientist Dr. Ian Pepper believes the risks are low *(Pepper, Brooks and Gerba 2018)*.

While the arc of the ARG story in public health is still unfolding, biosolids most likely will be a sidebar conversation.

Persistent Organic Pollutants (POPs) in Biosolids

Do the POPs carried in wastewater constitute a threat to human and environmental health when effluents and biosolids are recycled? We don't think so, but it is a complicated issue.

POPs, organic micropollutants (OMPs), compounds of emerging concerned (CECs), trace organic compounds (TOrCs) – these all are terms of art for the astonishing array of substances that are flushed to our sewers from households and businesses. These include pharmaceutical and personal care products (PPCPs), soaps and detergents, pesticides and solvents. While some media reports point to our WRRFs as "sources" of pollutants and persistent micro-organic compounds, WRRFs are more correctly interpreted as conduits for pollutants. Indeed, the WRRFs are locations at which degradation and mitigation of a vast proportion of POPs occurs, a topic that has been a central focus of industry-sponsored research into household and personal products. One overview reference, available as an e-book from IWA Publishing, is *Contributions of Household Chemicals to Sewage and Their Relevance to Municipal Wastewater Systems and the Environment (Drewes, Dickenson and Snyder 2009)*.

As environmental stewards, we biosolids practitioners necessarily need to support sound scholarship into POPs. For two decades the Organisation for Economic Co-operation and Development (OECD), comprised of 36 member countries spanning the globe from North and South America to Europe and Asia-Pacific, has led the way in the testing for degradability of chemicals with a guidance document listing seven types of tests *(OECD 1992)*. For example, one test deploys a "301C sludge," an "activated sludge precultured with synthetic sewage containing glucose and peptone." Another is the 314-test that simulates transformations of chemicals in a sewer system. In the U.S., the Water Research Foundation, formerly the Water Environment Research Foundation, leads the research into

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POPs. One product of this effort is *Trace Organic Compound Indicator Removal during Conventional Wastewater Treatment (WERF CEC4R08)*, available from IWA Publishing *(Salveson et al. 2012)*. Yet, we still need to do more.

If control is to be influenced over the risk of human or environmental exposures from POPs, it will need to be at the product and consumer use part of the pathway, not the biosolids.

The study of the fate of POPs needs to be holistic, from home to farm. If we still believe the sewerage system is a mere collector, how wrong we are! One paper shows that "biodegradation in the sewer has a substantial impact on levels of surfactants and surfactant metabolites that ultimately reach wastewater treatment plants" *(Menzies et al. 2016)*. Another researcher, hoping to track illegal drug use, complained "in sewage epidemiology, it is essential to have relevant information of the sewer system"*(Thai et al. 2014)*.

The fate of organic micropollutants within the treatment plant has proved enormously difficult to characterize. Classes of compounds degrade through different mechanisms, with water solubility being a key discriminator for biosolids-borne or effluent-borne organic micropollutant discharges. Plant configurations vary, with the cycling of aeration, anoxic and anaerobic processes apparently having great influence on degradation. One article pointed out that "biotransformation parameters are impacted by in-situ carbon loading and redox conditions" *(Su et al. 2015)*. An early review of this topic explained: "We were also able to compare various processes and pointed out activated sludge with nitrogen treatment and membrane bioreactor as the most efficient ones" *(Kowalczyk et al. 2015)*.

Composting is a particularly effective treatment approach for POPs. The good news is that fairly rudimentary composting techniques yield good results: "low-level manure management, such as stockpiling, after an initial adjustment of water content may be a practical and economical option for livestock producers in reducing antibiotic levels in manure before land application" *(Wu et al. 2015)*. Composting has consistently shown strong results in mitigating risks. One journal article concluded "concentrations of all 12 micropollutants decreased during composting, and degradation was statistically significant for 7 of the 12 micropollutants" *(Wu et al. 2015)*. A review of digestion and composting processes for biosolids was provided in a recent report *(Aemig et al. 2019)*. Another recent study confirmed this finding, "Windrow composting of this sludge, however, resulted in an efficient removal (up to 100%) for most analytes" *(Biel-Maeso, Corada-Fernández and Lara-Martín 2019)*.

In these examples, aggressive aerobic treatment was the significant factor, but composting is not the only method to accomplish this. Unit processes in a municipal WRRF each can be evaluated for contributions to degradation of POPs. See, for example, the work by Jian Lin Chen and others *(2018)* on the changes in estrogenicity and micropollutant concentrations across unit processes in a biological wastewater treatment system. The bottom line is that we can look forward to future plant designs intentionally optimized for POP degradation.

The soil to which biosolids are applied can be rightfully understood to be part of the treatment process as well. Soil is a vibrant bioreactor, with microbial communities capable of degrading many POPs. Soil minerals and organic matter, in synergistic relationships with microbial communities, trap and degrade a wide range of compounds, including surfactants and pharmaceuticals *(Ren et al. 2018; Facey et al. 2018; Sidhu, O'Connor and Kruse 2019)*. This process is well treated in a state-of-the-science review by Christopher P. Higgins and others *(2010)*.

The risk of biosolids-borne POPs to the environment is low. From among many dozens of recent journal articles in this domain, one review article on plant update of PPCP *(Wu et al. 2015)* concluded: "Field studies showed that the concentration levels of PPCPs in crops that were irrigated with treated wastewater or applied with biosolids were very low." In another pertaining to potential human health risks, "our assessment indicates that the majority of individual PPCPs in the edible tissue of plants due to biosolids or manure amendment or wastewater irrigation represent a de minimis risk to human health"*(Prosser and Sibley 2015)*. Nevertheless, in recognizing the enormous complexity of biological and chemical systems, another researcher recommended risk modeling *(Clarke et al. 2016)*.

All this said, a few notorious compounds persist through the entire treatment system, from sewer to wastewater treatment to biosolids stabilization to soil. Some classes of contaminants are recalcitrant, resisting conventional treatment systems and soil degradation, for example some specific antibacterial agents such as triclosan *(Al-Rajab et al. 2015)*. Others include triclocarban *(Lozano et al. 2018)*, PCBs *(Needham and Ghosh 2019)*, fluroquinolones *(Lu Yang, Wu, et al. 2018)*, polybrominated diphenyl ethers (PBDEs) *(Andrade et al. 2017)*.

If control is to be influenced over the risk of human or environmental exposures from POPs, it will need to be at the product and consumer use part of the pathway, not the biosolids. Arguing that the issue is larger than our industry acknowledges, Dr. Rolf Halden, manager of the U.S. National Sewage Sludge Repository at Arizona State University *(Venkatesan, Done and Halden 2015)*, points out that widespread use of industrial chemicals ensures that new questions about these chemicals will arise continually and science will always be playing catch-up to understand their potential effects on human and environmental health *(Halden 2015)*.

Final Word

Bottom line: we ought to feel good about wastewater treatment as a barrier to risks of harm and about the value of biosolids for building soils. Biosolids can continue to be the valuable resource for environmental improvement and climate change resilience that it has been in the past, and we can continue to have faith in a bright tomorrow for biosolids.

Imagine a future in which you "dial-in" options for source control, sewer maintenance, in-plant processes, biosolids stabilization methods and land treatment protocols, all of which, when taken together, accomplish nearly complete removal of organic micropollutants from pathways of human and environmental exposure. To accomplish so grand an endpoint, however, means making the degradation of PFAS, POPs, reduction of plastic pollutants and control of antibiotic resistance genes an intentional and central goal of wastewater treatment and biosolids management, not an incidental consequence. That is the future we need to help create for our industry.

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Full references for this article are available in the digital version of Clear Waters.

Emerging Contaminant PFAS: NEWMOA's Perspective

by Terri Goldberg

Poly- and perfluoroalkyl substances (PFAS) are an emerging environmental and public health issue that regulators, consultants, and academic researchers are working hard to address. Perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) are the most well-known PFAS and have received a considerable amount of public attention in recent years. The public has an opportunity to learn more about PFAS and its challenges through a major motion picture, Dark Waters, released in November 2019 *(Focus Features 2019)*. The film portrays the drama surrounding the original legal case concerning PFAS in drinking water systems in West Virginia.

The Northeast Waste Management Officials' Association (NEWMOA, at *www.newmoa.org*) has been working hard holding workshops and webinars in the region covering a wide array of PFAS topics, including background information on the chemicals and their uses, toxicology, fate and transport, treatment and remediation, case studies, policy developments and lessons learned. NEWMOA is also coordinating with other regional organizations to hold a conference in spring 2020 designed to promote information-sharing among experts and others on the science of PFAS related to public health and in the environment.

What Are PFAS?

PFAS are a large class of chemicals that have been used in numerous consumer products and industrial processes due to their oil and water-resistant properties and their exceptional stability. PFAS can be found in:

- Food packaged in PFAS-containing materials, processed with equipment that used PFAS, or grown in PFAS-contaminated soil or water.
- Commercial household products, including stain- and water-repellent fabrics, nonstick products (e.g., Teflon), polishes, compostable food service-ware, waxes, paints and cleaning products.
- Firefighting foams, a major source of groundwater contamination at airports and military bases where firefighting training occurs.
- Workplaces, including production facilities or industries involving chrome plating, electronics manufacturing or oil recovery that use PFAS.
- Drinking water, typically localized and associated with a specific facility such as a manufacturer, landfill, wastewater treatment plant or firefighter training facility.

What Are the Health Concerns?

If humans or animals ingest PFAS, by eating or drinking food or water that contain PFAS, the PFAS are absorbed and can accumulate in the body *(U.S. EPA 2019)*. People can be exposed to PFAS by:

- Drinking contaminated municipal water or private well water.
- Eating fish caught from water contaminated by PFAS, PFOS in particular.
- Accidentally swallowing contaminated soil or dust.
- Eating food that was packaged in material that contains PFAS.
- Using some consumer products, such as nonstick cookware, stain-resistant carpeting and water-repellant clothing *(ATSDR 2019a)*.

PFAS stay in the human body for long periods of time. As a result,

Groundwater samples are collected to test for chemicals.
Adrian Wojcik (stock by Getty Images)

as people get exposed to PFAS from multiple sources over time, the level of PFAS in their bodies may increase to the point where they suffer from adverse health effects.

According to the Agency for Toxic Substances and Disease Registry (ATSDR), the potential health effects of PFOS, PFOA, Perfluorohexanesulphonic acid (PFHxS), and Perfluorononanoic acid (PFNA) have been more widely studied than other PFAS. Some, but not all, studies in humans with PFAS exposure have shown that certain PFAS may:

- Affect growth, learning, and behavior of infants and older children.
- Lower a woman's chance of getting pregnant.
- Interfere with the body's natural hormones.
- Increase cholesterol levels.
- Affect the immune system.
- Increase the risk of cancer *(ATSDR 2019b)*.

Scientists are still learning about the health effects of exposures to mixtures of PFAS.

Fate and Transport of PFAS

The same properties that make PFAS so useful in consumer products and for firefighting make them challenging to remove from soil and water, including drinking water supplies. PFAS are diverse, so they possess a range of fate and transport properties that depend heavily on the individual compounds. Fate and transport of the compounds at sites are also dependent on the source(s) of the release to the environment and hydrogeologic and other physical and chemical conditions. Understanding the chemicals' environmental behaviors and remediation and treatment options to meet state and federal drinking water guidelines is challenging.

Regulatory Status for PFAS

The U.S. Environmental Protection Agency (EPA) has established a health advisory of 70 parts per trillion (ppt) for these chemicals in drinking water because of the potential neurologic and other health effects related to exposure to them. Some states have, or are in the process of, adopting even lower standards. For example, in December 2018, a New York Drinking Water Quality Council (DWQC) provided Maximum Contaminant Level (MCL) recommendations to the New York State Health Commissioner for PFOA and PFOS. The recommended levels for PFOA and PFOS are 10 ppt for each compound individually. The New York State Department of Health and Department of Environmental Conservation continue to work on establishing the state's MCL.

How Are Communities Responding?

Communities throughout the Northeast and the rest of the country have sites where drinking water is impacted by this class of chemicals. State environmental agencies in the region have undertaken extensive sampling of wells and are working on installing treatment systems or alternative water supplies for residents in areas where the results have exceeded the states' action levels.

Hoosick Falls and its neighbors are among the most well-known communities in New York that have faced a crisis of contaminated drinking water from PFAS compounds. In 2016, PFOA was detected in the Village of Hoosick Falls' public drinking water supply, as well as the Town of Hoosick's private drinking water wells, above EPA's health advisory level. The presence of PFOA in the groundwater was linked to past manufacturing sites in the Hoosick area. Since the discovery of the contamination, the towns and the state have been busy monitoring and sampling the environmental media, undertaking various cleanup projects under a legal agreement with the manufacturers that were involved with the sites where the releases occurred, and working with communities and residents to address their concerns.

NEWMOA's Outreach Efforts

Starting in 2016, NEWMOA has been holding frequent regional conversations and educational events covering a wide array of PFAS topics for government officials in the northeast U.S. *(NEWMOA 2016)*. NEWMOA held a series of workshops titled "PFAS in the Northeast: State of Practice and Regulatory Perspectives" in several locations in 2017 *(NEWMOA 2017)*. The sessions covered background information on the chemicals and their uses, toxicology, fate and transport, treatment and remediation, case studies, policy developments, and lessons learned from communities that are facing this problem.

2020 Conference

Over the past year, NEWMOA has partnered with the New England Interstate Water Pollution Control Commission (NEIWPCC), the Northeast States for Coordinated Air Use Management (NESCAUM), the Northeast Recycling Council (NERC), and others to organize a "Northeast Conference: The Science of PFAS: Public Health and the Environment." The event will take place March 31-April 1, 2020, at the Framingham Hotel and Conference Center in Framingham, Massachusetts *(NEWMOA 2019a)*.

The goals of the conference are:

- Ensure that local, state, and federal action to address PFAS contamination is informed by the most current and reliable science.
- Facilitate networking and information-sharing among key stakeholders on PFAS topics.
- Identify important gaps in the science and policy to help inform future research.

The conference organizers expect conference attendance to include local, state and federal government officials; academic researchers and students; consultants and vendors; companies that use, make, or sell products that contain PFAS; and nongovernmental and environmental organizations.

The conference will include plenary and concurrent sessions and an exhibit and poster area. The concurrent sessions are anticipated to cover some or all of the topics in ***Figure 1***.

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Figure 1. Anticipated Topics of the 2020 Northeast Conference: The Science of PFAS: Public Health and the Environment

Health Impacts and Environmental Behavior	Treatment, Remediation and Disposal	PFAS Uses and Alternatives	Environmental Sampling and Analysis
• Toxicology and human health effects. • Risk communications strategies. • Fate and transport of PFAS in the environment. • Impacts on biota and wildlife. • Bioaccumulation and impacts on the food chain. • PFAS in leachate and groundwater. • Interactions among air, land and water quality impacts. • Degradation products. • Sources of PFAS in the environment. • Latest research on alternative short chain PFAS compounds.	• Results of recent testing of environmental media – drinking water, soil, groundwater, landfill leachate, biosolids, compost, surface water, air emissions and wastewater treatment plant discharges. • Drinking water treatment systems. • Effective site remediation strategies. • State and federal standard setting efforts. • Disposal strategies for contaminated media and product collections, including incineration. • Treatment of soil, groundwater and other environmental media. • Treatment and destruction of residuals.	• Historic and current PFAS uses. • Results of product testing. • Alternatives assessments for aqueous film-forming foam (AFFF). • Alternatives assessments for PFAS in compostable food ware and packaging.	• Latest methods for testing drinking water. • Methods for sampling/testing soil. • Methods for sampling/testing air releases. • Sampling/testing surface and ground water. • Overcoming quality assurance/quality control challenges. • Methods for testing products. • Methods for testing food. • Methods for testing biosolids.

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Conference Sponsors

NEWMOA is seeking sponsors for the conference. Sponsors will have high visibility before and during the conference. NEWMOA will include the sponsors' names and logos on its conference webpages and social media postings, as well as on handouts and signs during the conference. During the conference, the sponsors will be prominently displayed on PowerPoint slides during the plenary sessions and will be acknowledged during those sessions and others. There are four levels of sponsorship, ranging from $1,000 to $5,000. Conference sponsors as of December 2019 include:

Platinum: SGS North America, Inc.
Gold: Vista Analytical Laboratories
Weston and Sampson
CDM Smith
Silver: ECT

Conference Exhibitors

NEWMOA is also seeking exhibitors for the conference. Many of the attendees buy products and services, and would benefit from knowing more about:

- Analytical instruments and services.
- Monitoring and sampling equipment and services.
- Remediation and treatment equipment and services.
- Consulting services.
- Training and education products and service.

A limited number of exhibit spaces are available. For more information on sponsoring or exhibiting, contact Jennifer Griffith, *jgriffith@newmoa.org*.

For more information, visit: *www.newmoa.org/pfasscienceconference/*.

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Communicating with the Public on Emerging Contaminants

by Adrienne Esposito

Dangerous chemicals known as "emerging contaminants," including the PFAS compounds PFOA, PFOS and 1,4-dioxane, have been discovered in drinking water supplies in communities across New York, often at levels above federal health guidelines. This is due to both legacy pollution and the products we use every day. PFAS chemicals are used in firefighting foam, food packaging and in many water-resistant, stain-proof and nonstick products. 1,4-Dioxane is found in personal care products such as baby products, shampoos, body wash and lotions, as well as in many laundry detergents.

The everyday use of these products exposes the public to harmful contaminants and continues to threaten our drinking water. PFAS enter waterways by runoff of firefighting foam and through the disposal of contaminated landfill leachate at wastewater treatment facilities, while 1,4-dioxane is being washed down the drain every day throughout the state. Once in our water, both PFAS and 1,4-dioxane are highly soluble making them persistent, long-term threats to our water resources.

PFOA and PFOS Drinking Water Contamination

Perfluorooctanoic acid (PFOA) and Perfluorooctanesulfonic acid (PFOS) are a part of a group of man-made chemicals known as Per- or polyfluoroalkyl substances (PFAS). PFAS are often referred to as the "forever chemicals" due to their persistence in our environment and bodies, which means that they don't break down, so they accumulate over time. PFOA and PFOS in drinking water demonstrate a threat to public health and are associated with a host of significant adverse health impacts, including cancer.

PFAS is being detected in numerous water systems in New York, including high-profile cases in Newburgh, Suffolk County and Hoosick Falls. New York state officials estimate that 21% of public water wells in New York need treatment for PFOA and PFOS under a new proposed standard of 10 parts per trillion (ppt) for PFOA and 10 ppt for PFOS *(NYSDOH 2019)*. Exposure to PFOA and PFOS are associated with many serious health effects, such as hormone disruption, liver and kidney damage, developmental and reproductive harm, changes in serum lipid levels and immune system toxicity. Some of these adverse health effects occur at extremely low levels of exposure. According to a recent report by the Natural Resources Defense Council (NRDC), even extremely low levels of exposure to PFOA and PFOS may cause health effects, such as immune suppression and serious adverse developmental effects *(Reade, Quinn and Schreiber 2019)*. The U.S. Environmental Protection Agency (EPA) found that PFOA and PFOS demonstrate "suggestive" carcinogenic potential *(USEPA 2016)*.

1,4-Dioxane Drinking Water Contamination

1,4-Dioxane was originally used as an industrial solvent stabilizer found in paints, varnishes, degreasers and inks. While it has since been phased out of some of these applications, its legacy of pollution continues to plague our water supplies. Unfortunately, 1,4-dioxane does not easily degrade or break down in our environment and is highly mobile in soil and groundwater. This toxic chemical is also hidden in many cleaning and personal care products we currently use every day. It is estimated that 89 wells across the state need treatment for 1,4-dioxane *(Schwartz 2019)* with the majority on Long Island, although that count will likely rise as more testing occurs.

The Agency for Toxic Substance and Disease Registry (ATSDR) found that even at low concentration levels, 1,4-dioxane exposure through inhalation or dermal contact irritates the skin, eyes and respiratory tract *(ATSDR 2012)*. Acute exposure to elevated levels of 1,4-dioxane may cause severe kidney and liver impacts and possibly death. Chronic inhalation exposure of 1,4-dioxane primarily targets and damages the liver, kidneys and nasal cavity. Liver tumors have been observed in rats and mice following chronic drinking

Figure 1. CCE's map of 1,4-Dioxane across Long Island, by highest level detected within each water district/distribution area. All data are the latest as provided by the public water suppliers, unless otherwise indicated. Data for all areas served by the Suffolk County Water Authority are as given from their 2016 Water Quality Report (data from 2015 testing).

Citizens Campaign for the Environment

water exposure. Nasal tumors were also observed in rats following chronic inhalation or drinking water exposure. Given the results of the studies conducted on rats and mice, the ATSDR concluded that 1,4-dioxane is likely to be carcinogenic to humans *(ATSDR 2012)*. Based on evidence from numerous scientific studies, the EPA has classified 1,4-dioxane as likely to be carcinogenic to humans by all routes of exposure *(USEPA 2017)*, and in 2010, the EPA set a health-based guidance of 0.35 parts per billion (ppb) for drinking water. The International Agency for Research on Cancer determined that 1,4-dioxane is possibly carcinogenic to humans *(IARC 1999)* and the U.S. Department of Health and Human Services considered 1,4-dioxane as reasonably anticipated to be a human carcinogen *(USDHHS 2016)*.

Given the results of studies conducted on rats and mice, the ATSDR concluded that 1,4-dioxane is likely to be carcinogenic to humans. (ATSDR 2012)

New Yorkers Deserve Clean Water

Since our inception in 1985, protecting clean drinking water for the public has been a top priority for Citizens Campaign for the Environment (CCE). CCE led efforts in New York to remove methyl tert-butyl ether (MTBE) as a gasoline additive in 2004, and supported efforts to establish a drinking water maximum contamination level (MCL) for the dangerous chemical a few years later. Our organization has most recently led efforts to sound the alarm about 1,4-dioxane water pollution, particularly on Long Island, which has the highest levels of 1,4-dixoane water pollution in the nation. For over three decades, CCE has worked in communities across New York and we have witnessed firsthand the public's expectation and desire for clean water. Public education and engagement in protecting our water supplies from these harmful emerging contaminants is essential in driving statewide action.

In 2017, CCE conducted an evaluation of public water suppliers across Long Island. We used EPA data and information supplied by water suppliers. We found that Nassau and Suffolk County water supplies contained the highest levels of 1,4-dioxane contamination in the nation. CCE launched an interactive map ***(Figure 1)*** and report, which documented elevated levels of 1,4-dioxane detected in 39 water districts, which represents 75% of Long Island's population served. These water districts had maximum detections above 0.35 ppb, the EPA health reference standard. The highest levels were found in Hicksville (33 ppb), Water Authority of Western Nassau (12 ppb), and Town of Hempstead (10 ppb) *(Citizens Campaign for the Environment n.d.)*. The Hicksville well has been shut down.

This report generated numerous consumer responses requesting information and guidance to avoid buying products containing 1,4-dioxane; however, 1,4-dioxane is not technically an ingredient, therefore manufacturers are not mandated to list the compound on the label. CCE was unable to advise the public on what products were safe, leaving consumers in the dark and at risk of exposure. The frequent calls to our office lead us to conduct independent testing of common household products for 1,4-dioxane.

CCE contracted with a certified independent laboratory in New York to test 80 products, including laundry detergent, baby products, body washes and shampoos, compiling the most comprehensive independent testing of products for 1,4-dioxane in the nation. This testing revealed the prevalence of 1,4-dioxane in consumer products with more than 80% of cleaning and personal care products containing the likely carcinogen. It was clear from these results that the products we use every day and wash down the drain are contaminating our water resources. With this information we were able to develop and release an accurate consumer's guide for members of the public ***(Figure 2)***. The public's response to our shopper guide has been immense. CCE continues to get calls for copies of the report not only from the public but also from health and environmental agencies across the country.

1,4-Dioxane Crisis in California and Why This Matters for New York

California is finding dangerous levels of 1,4-dioxane in treated sewage effluent, sparking concerns over drinking water, water reuse and "Toilet to Tap" programs. ***Table 1*** summarizes the results of sewage effluent testing in Los Angeles and Sacramento counties for the period from 2011 through 2019.

Throughout New York, hundreds of sewage treatment plants discharge into drinking water sources, such as the Great Lakes, the Finger Lakes, the Hudson River, Long Island's sole source aquifer system and New York City's reservoirs. Long Island has over 180 small sewage treatment plants that discharge to our groundwater and over 500,000 septic systems that discharge to groundwater. Sewage treatment plants and septic systems are not designed to filter out contaminants like 1,4-dioxane, making our water systems very susceptible to contamination. Amounts of 1,4-dioxane detected in treated sewage effluent can pose a threat to drinking water sources throughout New York. The presence of this compound in sewage effluent clearly links the contamination to consumer products we rinse down the drain.

Water Suppliers Facing Challenges in Treating for Emerging Contaminants

Regrettably, there are no federally enforceable drinking water standards for these emerging contaminants, putting our drinking water and health at risk. In absence of federal action, the New York State Department of Health (NYSDOH) recently proposed an MCL of 1 ppb for 1,4-dioxane and 10 ppt for PFOS and PFOA, individually. If adopted, New York will have among the most stringent, enforceable drinking water standards for these emerging contaminants in the nation.

Adopting the strongest MCL for 1,4-dioxane and PFAS is necessary to protect the public health and our drinking water quality; however, we recognize the challenges water suppliers face in meeting these proposed and impending standards. Many water suppliers will need expensive upgrades to their treatment facilities to filter

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Table 1. Results of Sewage Effluent Testing for 1,4-dioxane in Two Counties in California. *(California Environmental Protection Agency n.d.)*

Metric	Los Angeles County	Sacramento County
Number of samples tested	820	723
Percent of results that were positive for 1,4-dioxane	73%	40%
Of results positive for 1,4-dioxane, percent at or above 1 ppb.	40%	55%
Highest detected concentration of 1,4-dioxane in samples	4 ppb	6.3 ppb


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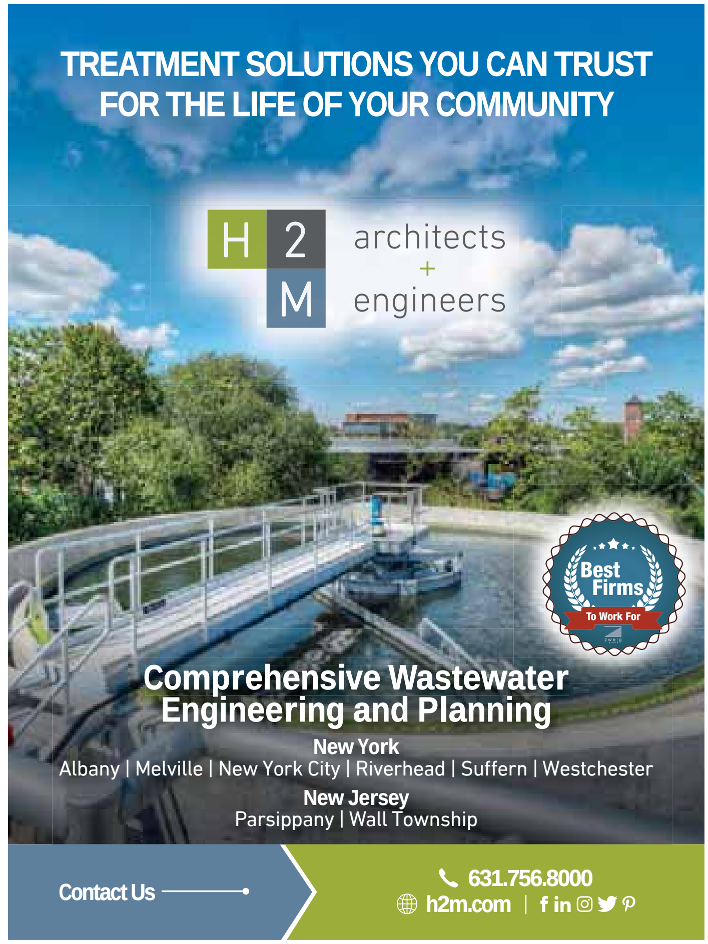
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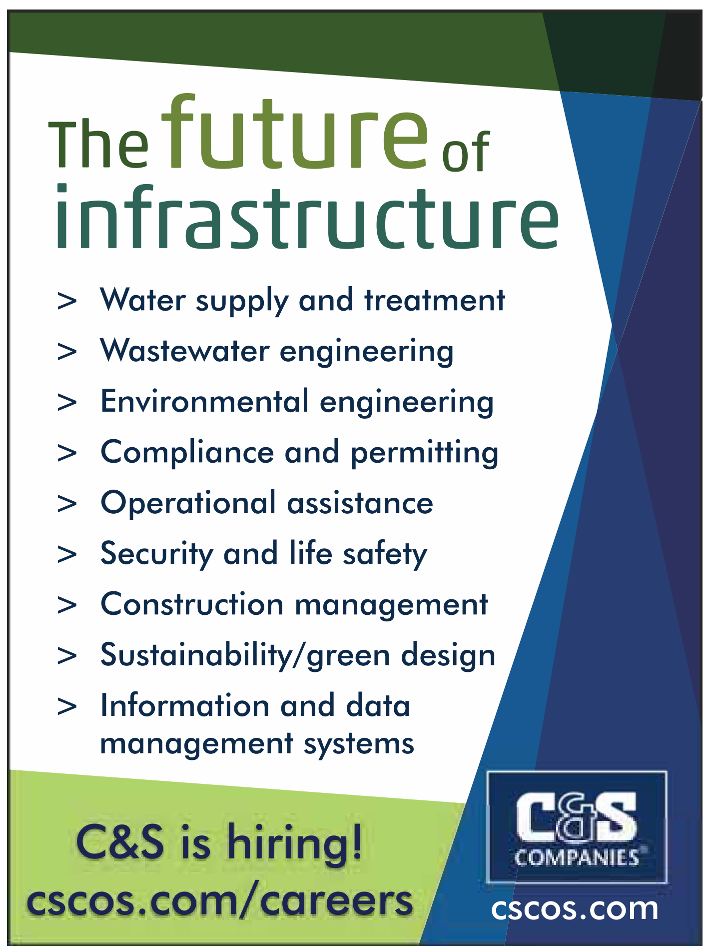
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Figure 2. The Dirty Dozen. Products with elevated levels of 1,4-dioxane are presented in a shopper's guide to inform consumers.
Citizens Campaign for the Environment.

and remove emerging contaminants. Treating for emerging contaminants has proven difficult and expensive given we are dealing with emerging and evolving technologies.

New York has approved an effective new treatment technology for 1,4-dioxane called Advanced Oxidative Process (AOP), which is being utilized by several water suppliers on Long Island, including the Suffolk County Water Authority. This technology is the only approved method of removing 1,4-dioxane from drinking water. AOP technology is new and expensive; however, it is necessary when public health is threatened by unsafe levels of 1,4-dioxane in drinking water to expeditiously remedy the exposure and reduce the public health threat.

Now more than ever, we need unprecedented collaboration to address emerging contaminants. Government leaders, agency representatives and water professionals must work together to address the most effective ways to filter our water and prevent future contamination from these chemicals. In October 2019, water suppliers, wastewater treatment operators and environmentalists came together for the third Clean Water Roundtable, held in Albany, New York, to discuss the growing challenge of emerging contaminants and efforts to protect public health. Understandably, there are many challenges for water suppliers when treating for emerging contaminants, however, we are confident that they will rise to the occasion and provide consumers with the safest drinking water. We are all working together to achieve the undisputed goal of clean water.

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Biosolids Planning from an End-Use Perspective

by Natalie Sierra, Steve Wilson and Perry Schafer

When faced with aging infrastructure, utilities will often use a master planning process to map out a long-term future for on-site, solids treatment assets. Biosolids management, however, has become increasingly complex due to a confluence of factors including local/regional regulation, market trends, public perception, environmental concerns, and ambitious utility goals around biosolids beneficial use. By including biosolids end-use considerations in the planning process and determining viable end-use markets for the planned biosolids product(s), utilities can weigh all relevant factors and avoid stranded assets.

Beginning a master planning effort with an analysis of biosolids markets allows the utility to evaluate the market potential for biosolids products, generated either directly at the water resource recovery facility (WRRF) or off-site at a merchant or other facility supporting the utility's biosolids management program. The market assessment can also be incorporated into an adaptive process as selected treatment alternatives are better defined.

Establishing Baseline Conditions

As a starting point, the quality of the existing biosolids product must be understood. This includes not only heavy metals and total solids analyses, typically performed by utilities, but critically must also include other measures such as nutrient content and pollutants of more recent concern. Current and projected biosolids volumes will inform market research related to the capacity of individual market sectors. If substantially different products are under consideration, such as a cake product, compost or thermally dried product, the quantity and quality of those products must also be established. General information about the suitability of different products with individual market sectors helps focus market outreach efforts. This should include a review of existing facilities and companies providing biosolids management services in the region.

While the federal regulations overseeing biosolids beneficial use (Chapter 40 Part 503 of the Code of Federal Regulations [40 CFR 503]) have been stable over the past two decades, changes in state and local regulations can exert pressures or influence on the biosolids marketplace. For example, some states have passed measures to encourage the diversion of organics from landfills. This can create market pressures as products made from recovered organics (e.g., food waste compost) can compete with comparable biosolids products, resulting in depressed prices or reduced capacity of those markets to manage material. In the Northeast and other portions of the country, winter conditions make land application impossible for a significant portion of the year, necessitating incorporation of storage or other management options (e.g., landfill) as part of the planning process. The type of crops grown in the region will exert a separate seasonal impact on land application practices. Each region will have its own unique combination of regulatory factors that influence the ability to beneficially use biosolids.

Market Assessment

To better define available markets for the prospective biosolids products, as well as determine the products' value and marketability, market research on the regional horticultural (i.e., lawn/garden), agricultural, and fertilizer industries should be completed. Demographic data can be collected regarding available and productive farm acreage for relevant crops, as well as a high-level assessment of the size of the individual industries. In addition, opportunities for land reclamation, forestry, erosion control and green infrastructure may be relevant at the local level. While these markets are less developed for biosolids use, they may present opportunities to use products locally and can help diversify a utility's biosolids management portfolio.

Initially, market surveys can be performed via telephone by staff experienced in either data collection and/or biosolids product sales. To obtain more detailed data, end-users familiar with or open to biosolids use can be interviewed in person and shown samples of relevant products. These face-to-face contacts can be leveraged later in the process to help foster long-term relationships for biosolids management.

Bringing Market Analysis into the Planning Process

Once complete, the market analysis can be used to screen and evaluate the biosolids products, which can be carried forward into an analysis of prospective on-site and off-site technologies. In other words, the alternatives recommended from the market analysis can be paired with specific solids treatment technologies for the creation of end-to-end alternatives. These end-to-end alternatives can then be screened using a traditional net present value analysis. Use of triple-bottom line criteria for final selection can further incorporate market considerations as well as utility specific goals. The implementation plan should then incorporate the findings of the market assessment.

Case Studies

Beyond the local market, individual utility preferences and goals can shape the selection of both solids processing and management. Considerations such as degree of flexibility and diversity desired, risk perception, product consistency, and unique contracting limitations can and should be used in the final process selection. Several case studies presented here describe how the intersection of regulation, market assessment and utility-specific factors led to process selection, including selection of a Class A or a Class B treatment method.

San Francisco Public Utilities Commission

The San Francisco Public Utilities Commission (SFPUC) underwent a master planning effort to address vulnerable, aging solids handling infrastructure throughout its wastewater treatment system. The SFPUC owns and operates two secondary WRRFs, both of which currently generate Class B biosolids through anaerobic digestion. The SFPUC's biosolids management has traditionally consisted of both land application and landfill daily cover, with a small percentage of biosolids sent to a Class A merchant facility. The SFPUC began experiencing rising end-use management costs that, coupled with regional factors such as unavailability of land application sites during the winter months, restricted beneficial use. In addition, local ordinances restricted the areas in which the SFPUC could land-apply its biosolids ***(Figure 1)***. The ability to diversify the biosolids end-use management portfolio for the utility was thus identified as a priority of the master planning effort.

An array of biosolids products were evaluated in a two-part market assessment. Both phone interviews and in-person meetings

California's local ordinances exert a strong influence on regional biosolids management, including bans on land application in several large, agricultural counties. *California Association of Sanitation Agencies*

were held to determine the acceptability of compost, thermally dried products and Class A cake. While markets exist for dried products and compost, the value of those products in Northern California is affected by competition from other sectors.

Soil blending was identified as an urban use that could be used to manage Class A biosolids within the San Francisco Bay Area, as a large soil blending industry already exists. The ability of the thermal hydrolysis process (THP) to produce a lower odor, more granular/acceptable, Class A digested cake was ultimately a key factor in its selection for the SFPUC's largest secondary WRRF. Further market research evaluated the acceptability of THP/digested biosolids among Bay Area soil blenders. Using feedback from the market assessment, this concept continues to be developed by the utility in advance of the construction of the new solids handling facilities ***(Figure 2)***.

San José, California

The San José-Santa Clara Regional Wastewater Facility (RWF) treats wastewater from the cities of San José, Santa Clara, Milpitas and several area sewer districts. Located at the south end of the San Francisco Bay, the RWF utilizes digestion, lagoons and drying beds for solids treatment. Air-dried solids are hauled to a nearby landfill for use as alternative daily cover. This low-cost arrangement nevertheless had its challenges. At the time that the City of San José initiated its master plan, complaints of odors from the lagoons and drying beds were identified as one of several undesirable odor sources in the community. Additionally, the landfill receiving the solids had notified the city that it would be closing within the near-term.

Figure 2. San Francisco is building on market assessment work by testing soil blends made from regionally available recovered organics.
Natalie Sierra

A preliminary market and regulatory assessment then led the City of San José to use a Request for Information (RFI) process to gauge market interest and ability to manage Class B biosolids from the RWF. Information received from the RFI process led the city to conclude that an immediate driver for Class A production did not truly exist. In part, the city's easier access to a large agricultural county and the utility's own risk perception drove a different conclusion from that determined by the SFPUC case. However, the city wanted to maintain a pathway for Class A in the future ***(Figure 3)***. The decision was thus made to rehabilitate the existing anaerobic digesters into a Class B temperature-phased anaerobic digestion (TPAD) configuration, incorporating the ability to add Class A batch tanks to the TPAD system in the future, should a need for Class A arise. Were the city to produce Class A biosolids in the future, it already possesses the acreage, operator skill set, and major equipment to perform soil manufacturing on-site. Thus, the near-term solution would be to land-apply biosolids and continue to leverage the lower cost landfill, while keeping an eye on regulatory and market trends that could trigger future upgrades.

Recently, changes to California organics regulations related to landfill diversion have prompted a new assessment of how to best manage biosolids from the RWF. However, the flexibility incorporated into the master plan has allowed for a nondisruptive adjustment in approach.

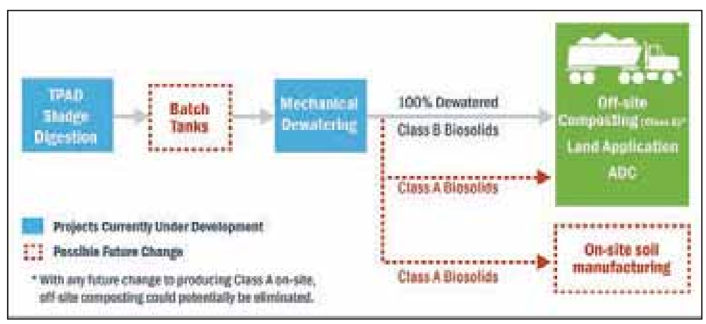

Figure 3. San José's selected alternative allowed for future flexibility, including on-site soil manufacturing.
Brown and Caldwell/San José-Santa Clara Regional Wastewater Facility

Metropolitan Sewer District of Greater Cincinnati

The Metropolitan Sewer District of Greater Cincinnati (MSDGC) collects and treats wastewater from Cincinnati and other communities within Hamilton County, Ohio. The system includes seven WRRFs, the largest of which is the Mill Creek Wastewater Treatment Plant, where solids treatment is centered around fluidized bed incinerators (FBIs). Raw sludge from the remaining six WRRFs is dewatered at one of two midsize WRRFs and landfilled.

The utility undertook a comprehensive solids master plan to address systemwide needs associated with aging infrastructure and a need to control costs, as well as a desire to provide regional benefits and flexibility for future growth and regulatory and policy change. In addition, several of MSDGC's WRRFs have residential neighbors or are near community assets, such as a well-used bike path. Thus, solutions developed had to address solids management needs while improving odors.

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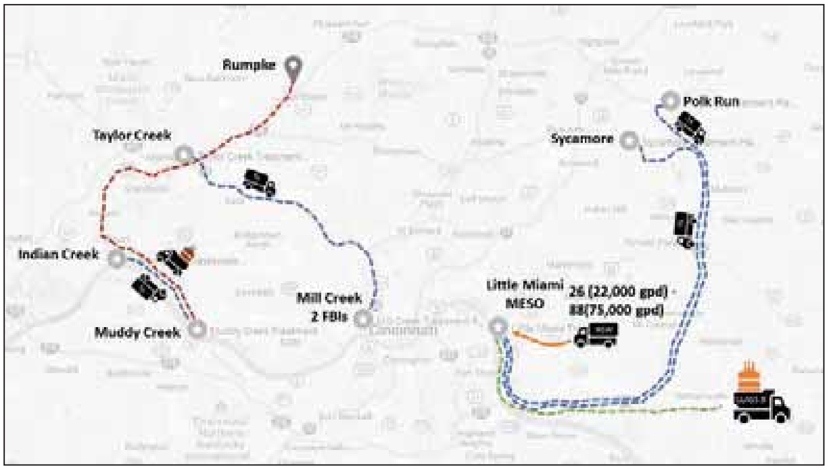

Figure 4. The final recommendation from MSDGC's Master Plan included diversification in solids management across its seven water resource recovery facilities. *Brown and Caldwell/MSDGC*

One unique feature of MSDGC's service area is the large number of food processors. While some liquid high-strength wastes (HSW) are currently received at the Mill Creek facility, not all can be accommodated by the liquid stream process. During the master planning process, a need for regional HSW processing was identified. A preliminary market assessment was conducted, which indicated that a large amount of land application acreage was available in the region, particularly in the neighboring states of Kentucky and Indiana. Winter storage or an alternative outlet (e.g., landfill) would, however, be required by the State of Ohio if MSDGC were to engage in land application.

When these market and regulatory factors were brought into the economic analysis, it was demonstrated that maintaining and making upstream improvements to the FBIs at the Mill Creek facility would be critical to systemwide cost effectiveness. But diversification through the construction of anaerobic digestion at the largest of the east-side WRRFs would mitigate some key risks associated with the current management approach. In addition, the inclusion of anaerobic digestion allows MSDGC to provide a service, through beneficial use of HSW, to a key industry in the region *(Figure 4)*.

Conclusions

While market assessment/analysis is an important first step in the biosolids master planning process, it can continue to pay dividends throughout the planning process. By examining the intersection of regulations and local market factors, the value and desire to use a given biosolids product – from cake to pellet, for example – can be assessed before expending significant effort evaluating alternatives that may not have viable end uses. The market assessment results can then be fed into a net present value analysis to better understand life cycle cost impacts of a given solids processing alternative. Finally, the initial market analysis can be leveraged to develop end-user relationships prior to startup of a new process, to gain better assurance that the anticipated biosolids product will be well received from the beginning.

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MBR Equipment Room with operators (l-r), Ellie Patton, John Barton, Mike Herbert and Kyle Schmidt. *Vincent Apa*

Moments of Reflection: An Operator Homage

by Vincent L. Apa

I am writing this article on a high-speed train from Seoul to Ulsan in South Korea, en route to stay overnight at a Buddhist temple built in 646 AD. It is a moment to push the pause button and reflect, so timely indeed. The story to be told is one that encompasses great transition, from one of the simplest to most complex plant upgrades I have worked on in my almost 23-year career.

Loch Sheldrake WRRF

The plant is nestled in the Catskills at 1,500 feet above sea level in the Hamlet of Loch Sheldrake, Town of Fallsburg, New York. For those not familiar with this place in Sullivan County, it has a plethora of pristine trout streams, little industry and a large Hassidic community from New York City. There is also a tough and unpredictable winter "micro climate" that can pose extra challenges for construction and operations.

The water resource recovery facility (WRRF) here was constructed in 1938 and was upgraded in the mid-1980s to a design-flow capacity of 0.70 million gallons per day (MGD) to accommodate a large expansion of the collection system/service area. The WRRF built in the 1980s was not designed to nitrify, denitrify or remove phosphorus. The WRRF serves a separate sanitary sewer system. Flow is delivered to the plant by three pump stations (Browns, New Hope and Vacation Village) and gravity sewers. In the early 1990s, a mass-based phosphorus limit of 2.9 pounds per day (lb/day) was included. The town installed a simple chemical-feed system where sodium aluminate is added at the end of the aerated grit tanks for phosphorus reduction.

Shot of plant looking from headworks downstream. *Vincent Apa*

The former wastewater treatment process included manual bar racks, aerated grit chambers, primary settling, rotating biological contactors (RBCs), secondary settling, gaseous chlorine disinfection and cascade aeration with discharge to the nearby Evans Lake, which flows to the Neversink River and eventually the Delaware River. In terms of solids handling, the WRRF had two anaerobic digesters and seven outdoor/uncovered sludge drying beds. Secondary sludge was co-thickened in the primary settling tanks.

21st Century Upgrades

A Facility Plan was completed in March 2008, which recommended a phased approach to upgrading the WRRF. In 2009, the Town of Fallsburg projected that the area serviced by the WRRF would experience an increase in population growth over the next two decades. The initial projections were expected to increase the WRRF influent flow from 0.7 to 1.45 MGD. However, after the housing market collapse in 2010, the town reduced the anticipated growth and the future flow was increased to just over 1.0 MGD. The design work was terminated at just before the 30% stage and cost reductions evaluated for the lower flows and loads.

The Phase I upgrades were completed in 2012 and addressed some limitations in the WRRF's ability to process and treat solids. A new gravity thickener, belt filter press, and sludge dewatering building were installed, along with anaerobic digester improvements such as covers, heating, mixing and biogas handling.

The Phase IIA upgrades were completed in 2017 and focused on some sanitary and storm sewer improvements to reduce peak flows to the WRRF and repair sagging/damaged lines, while Phase IIB addressed the WRRF liquids train to meet more stringent permit limits at a higher flow.

Addressing Permit Limits

There was coordination with both the New York State Department of Environmental Conservation (NYSDEC) and the Delaware River Basin Commission (DRBC) regarding draft permit limits, which will require a much higher level of treatment than existing limits.

With limited room on the existing site, a membrane bioreactor (MBR) configuration was proposed to allow for smaller reactors operated at higher mixed liquor suspended solids (MLSS) concentrations. The new processes include a coarse bar rack; 6-millimeter bar screen; upgraded aerated grit system with conical grit washer; rehabilitated primary settling tanks; two new 2-millimeter fine screens; three-stage bioreactors (first anoxic, first aerobic, second anoxic zones); rehabilitated final settling tanks; new MBRs; new chlorination and dechlorination systems; a high-strength feedstock

Membranes being installed in the MBR tanks. *Vincent Apa*

Bioreactors – One of three first stage aerobic zones of BNR system. *Vincent Apa*

Table 1. Excerpt of New Permit Limits for the Loch Sheldrake WRRF.

		Year-round			Seasonally (May to Sep.)		Seasonally (Oct. to Apr.)	
Parameter	Metric	Limit	Sampling Frequency	Sample Type	Limit	Sample Frequency	Limit	Sampling Frequency
Flow	30-day mean	1.0 mgd	Continuous	Totalized				
Ammonia	Monthly average as N			24-hour composite	16 lb/day	1x/week	31 lb/day	1x/week
Total Kjeldahl Nitrogen (TKN)	Monthly average as N			24-hour composite	36 lb/day	2x/month	72 lb/day	2x/month
Nitrate and Nitrite as N					20 lb/day	2x/month	39 lb/day	1x/month
BOD5 (1)	30 day mean	9.9 mg/L 82 lb/d	1x/wk	24-hour composite				
	7 day mean	45 mg/L 380 lb/d	1x/wk	24-hour composite				
TSS (1)	30 day mean	24 mg/L 200 lb/d	1x/wk	24-hou composite				
	7 day mean	45 mg/L 380 lb/d	1x/wk	24-hour composite				
Settleable Solids	daily max	0.3 mL/L	2x/day	Grab				
Total Dissolved Solids	Monitor			24-hour composite	1,000 mg/L	Quarterly	1,000 mg/L	Quarterly
Dissolved Oxygen	daily min	5.0 mg/L	1x/wk	Grab				
Phosphorus average as P	Monthly 1.7 lb/d	0.2 mg/L	1x/wk composite	24-hour				
pH		6.0 - 9.0 SU	2x/day	Grab				
Fecal Coliform (2)	30 day mean			Grab	200/100 mL	1x/week		
7 day mean					400/100 mL	1x/week		
Total Chlorine Residual (2)	daily max			Grab	0.05 mg/L	2x/day		

(1) Effluent values shall not exceed 15% of influent values for BOD5 and TSS, respectively.

(2) Effluent disinfection per NYSDEC from May 1 through Oct. 31.

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Bioreactors. Aerial view looking at first stage anoxic zones and mixers of BNR system. *Vincent Apa*

facility to receive and feed a local cheese waste to the anaerobic digesters; and numerous chemical systems including alkalinity, supplemental carbon, phosphorus reduction, MBR organic and inorganic fouling.

After years of coordinating with two regulatory agencies, permit limits for effluent total phosphorus were changed at 90% design from a mass-based limit of 2.9 lb/day to a concentration-based limit of 0.2 milligrams per liter (mg/L). See ***Table 1*** for an excerpt of the new permit limits.

This change required a quick evaluation and slight design modification to provide two sets of chemical feed pumps and piping for a dual-point addition system so as not to remove too much phosphorus upstream of the bioreactors and also not to produce too many solids in the MBR tanks, which could foul the membranes more rapidly.

The Phase IIB construction began in late 2016 by three prime contractors plus a systems integrator hired by the town. Punch list items are being completed now.

WRRF Staffing

The various new systems were brought online and embraced by the staff at the plant. During the week, the plant is staffed eight hours per day by three people, and four to eight hours by one to two people on weekends. None had activated sludge experience, let alone working knowledge with MBRs. Even though the plant is small, it includes many large-plant processes and complexities such as anaerobically digested dewatering return streams and co-digestion.

Cheese waste being loaded for delivery to Loch Sheldrake WRRF by plant staff. *Vincent Apa*

With some introductory training, the operators quickly came up the curve and did exceptionally well running the new systems. One cost-saving feature removed equalization from the project, but repurposed the existing final settling tanks (FST) with a new FST return activated sludge (RAS) pump and controls to work with the existing secondary sludge (now WAS) pumps during the interim six months before the MBRs were placed into service. This required precise knowledge in process control, especially since we were intentionally building biomass with high MLSS concentrations just above 5,000 mg/L during startup and solids loading to the FST exceeding recommended guidelines. Plant staff became well-versed with microscopic evaluations, aerobic solids retention time-based control, sludge settleability, RAS pump adjustment, and aeration tank settling when necessary to keep solids in the system.

The plant nitrified very well during this time frame, even with construction obstacles such as when the electricians did not finish a duct bank transition as anticipated. As a result, the FST sludge collectors were off for two days while the electricians responded to an emergency on another project. Fortunately, the FST RAS pump was operating, just not receiving much solids while the collectors were off.

The MBRs were commissioned with potable water and brought online with wastewater during the polar vortex in January 2019, as there was no other choice. This presented challenges the first two days of operations; hair dryers were needed to thaw frozen sensors. The upgraded system has performed extremely well with typical effluent quality:

- Total suspended solids of 1 to 2 mg/L.
- Turbidity of 0.04 NTU.
- Total phosphorus less than 0.2 mg/L.
- Ammonia of less than 1 mg/L.
- Nitrate + nitrite of less than 4 mg/L.
- Biochemical oxygen demand of 10 to 15 mg/L.

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Homage to the Operators

Throughout the entire project, I got to know the plant staff, working side-by-side with them through construction, startup and afterward with process optimizations. It gives me great satisfaction to see the teamwork employed by all, especially considering the average age was well under 35 and their level of experience with similar systems. With a small plant like this, each person is a major part of the facility's success. There is nowhere to hide and no room for indolence. Each person offers a unique talent that they bring to the table:

- John Barton has a photographic memory in terms of seeing mechanical things in 3D and can repair or build about anything including portable mixer supports, pumps, sampler pads, a kitchen cabinet with plumbing, a conference table and bookshelves.
- Carlo Pittaluga loves fishing and appreciates sharing his knowledge in the laboratory with his son by showing him pictures from the microscope or creating analogies to waste removal in his fish tank.
- Ellie Patton does operations and laboratory work very well in a humble manner and enjoys taking his daughter skiing.
- Kyle Schmidt is a recent addition from the Town of Liberty and is an avid fisherman of bass and trout.
- Mike Herbert is a working foreman, overseeing not only the staff at the Loch Sheldrake WRRF, but four other plants and pump stations besides. He started with the town in September 2018 after a staffing transition in a trial-by-fire introduction. I cannot commend him enough for his efforts. If I texted him at 5 a.m., I got an immediate response.

That is the kind of work ethic I have observed by all, including others within the town at other plants or the collection system.

I also now often see plant staff studying for their operators' exams with a sense of pride and excitement for their careers. It is my hope that our industry will showcase the efforts of these people more, including their aptitude, intelligence, diligence, cleverness and sense of humor, and that wages better reflect the skills and education needed to run these utilities of the future. Many got started through a connection from a family member or friend. We need more people to pass the torch and train the next generation. The time to act is now.

***Vincent L. Apa** is an Associate with CDM Smith and may be reached at ApaVL@cdmsmith.com.*

John Barton's woodcraft skills transformed scrap pallet wood from a shipment of membrane cassettes into a kitchen cabinet that transformed the ambiance of the WRRF's control room. *Vincent Apa*

Membrane effluent in FST. MBR effluent flows through the FST influent channel and tanks to prevent freezing of these wet weather tanks in winter. *Vincent Apa*

The cold weather brought by the polar vortex in January 2019 posed challenges during start-up operations of the new MBR. *Vincent Apa*

Tackling the Regulatory Challenges of PFAS

by Emily Remmel

Over the last year, the water utility sector has been fully immersed in a transformative learning trajectory on everything related to per- and polyfluoroalkyl substances (PFAS). This educational path has required us to delve into the complex chemistry of fluorinated compounds to understand the countless sources of these emerging chemicals found in our everyday consumer products. We must also advocate for an appropriate role for the water sector in crafting a solution, which some have argued should involve treatment and removal of the vast number of PFAS compounds to significantly low, part-per-trillion levels. PFAS is a truly complex environmental policy issue that the public clean water community is actively responding to. But it is also an in-depth issue that deserves a thorough and thoughtful scientific approach to ensure we make the right management decisions. Even more so, it requires consensus that the costs associated with the treatment, removal and cleanup of these chemicals should be borne by the PFAS sources that profit off its manufacturing and use.

The U.S. Environmental Protection Agency (EPA) detailed myriad regulatory steps forward in its February 2019 PFAS Action Plan *(USEPA 2019)*. However, as this federal process inches forward, state regulatory authorities are outpacing EPA's efforts, creating a frenzied patchwork of requirements that are already impacting the water sector. Michigan and California are leading the PFAS-sampling front and requiring influent/effluent monitoring by clean water utilities, whereas Maine set extremely low biosolids screening levels that effectively amounted to a moratorium on land application *(EGLE 2019, SWRCB 2019, MEDEP 2019)*. Meanwhile, Wisconsin requested voluntary reporting from publicly owned treatment works, and Colorado is beginning the process of establishing narrative water quality standards *(WDNR 2019, DPHE 2019)*. Other states are forming task forces and getting up to speed on where and at what levels PFAS chemicals are found within their state borders.

Until EPA approves analytical techniques for PFAS in wastewater and biosolids, and finalizes its risk assessment for biosolids, the clean water community will continue to face growing public pressure and questions from local and state regulatory authorities, not to mention increased federal legislative attention from Congress *(NACWA 2019a)*. To assist clean water utilities in better grasping these initial pressures, the National Association of Clean Water Agencies (NACWA) published A Clean Water Utility's Guide to Considering Source Identification, Pretreatment, and Sampling Protocols for PFAS *(NACWA 2019b)*. NACWA hopes this Guide provides utilities with a helpful path forward to begin to address local PFAS concerns.

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WEF Headquarters: Reimagine Credentialing with the Professional Operator Program

by Lisa Dirksen

Two letters after a name can have a big effect on a career – just look at the RN or PE. Those designations add a level of credibility to the professional, affect the pay scale, and indicate the knowledge necessary to perform to the best of one's ability.

With the support of the American Water Works Association (AWWA; Denver, Colorado) and the Water Environment Federation (WEF; Alexandria, Virginia), the Association of Boards of Certification (ABC; Ankeny, Iowa) recognized the need for a similar designation that gives water and wastewater operators credit where credit is due.

Operators are front-line protectors of human health, either through ensuring safe drinking water or the safety of waterways through effective wastewater management. They are the lifeblood of every community and deserve a way to be showcased as professionals.

And so, built by operators for operators, the Professional Operator (PO) program was born.

Join a Community

POs are an elite group of like-minded individuals, deeply committed to serving the public and growing in the water sector. Having a supportive community for sharing professional knowledge is absolutely invaluable. The designation opens doors for international networking, connects operators with opportunities to be water sector advocates, and qualifies operators to attend events along the way.

Grow as a Professional

Becoming a certified PO signals to employers that the operator is an achiever, committed to their profession long-term and ready to go above and beyond.

"I became a Professional Operator because of the chance to test my knowledge and accelerate my career," said Brian Faist, Professional Operator in Rivergrove, Oregon. "The PO designation has made me a more appealing candidate for promotion."

Whether looking to grow within a company or trying to find a job, being a PO makes an operator stand out in a crowd.

Ensure Accountability

The PO program is the first internationally recognized professional designation for water and wastewater operators. With the designation, peers, customers and the public can feel confident that a PO has mastered the most rigorous standards.

"I wanted a challenge and I tackled it," said Georginna Lockett, PO in Atlanta. "Being a PO certifies me in the industry as a top-level operator and that has been my goal since I started in the field."

All POs must also adhere to a code of conduct, which bolsters an operator's reputation and builds additional community trust.

Increase Mobility

Water sector adopters of the PO program are continuing to grow and it's helping to mold an expansive future for operators.

"Broad acceptance of a standard certification can make water professional credentials portable across state or country lines," said Paul Bishop, President and CEO of ABC. "With many benefits and potential solutions also come some challenges, but industry leaders at WEF, AWWA, and ABC are up to the task."

The PO program is a great leap toward an industry credential standard. It includes uniform and transparent credentialing that is recognizable by any employer or certification body.

Begin Your Journey

PO certification is offered to operators in four levels (from Class I through Class IV) for water treatment, water distribution, wastewater collection and wastewater treatment. Joining the PO movement is simple, and the entire process can take as little as a few weeks.

- Step 1: Create an Online Profile.
  The path to becoming a PO starts by creating a profile online at *portal.abccert.org*. An operator will be asked to provide information such as work and education history.
- Step 2: Submit an Application.
  The operator applies and ABC reviews the operator's profile to ensure basic criteria have been met. Applications are accepted from anywhere in the world, any day of the year.
- Step 3: Take the Exam.
  In some cases, operators may have already passed a certification exam that ABC will accept. If not, the operator will schedule a time to take an ABC certification exam. Once the exam is passed, the operator will receive a certificate, be invited to a **PO**WER event to be formally recognized and join the PO community.

For questions or additional information, visit *www.ProfessionalOperator.org* or send your questions to *Info@ProfessionalOperator.org*.

Lisa Dirkesen is Director of Communications and Public Affairs at ABC (Ankeny, Iowa). She can be reached at ldirksen@abccert.org. The PO program is administered by the Certification Commission for Environmental Professionals (C2EP), an organization of volunteer water environment operations subject matter experts created by the Association of Boards of Certification (ABC).

Protecting Water Quality Has Positive Trickle-Down Effects for the New York City Water Supply

by JoAnne Castagna

A team of engineers is gathered on a long, empty country road in the Town of Harpersfield, New York. All that's heard is the steady drum of rain on their umbrellas. They are looking over a new culvert they constructed that runs under Odell Lake Road and transports Lake Brook from one side of the road to the other. The persistent rain is a nuisance but welcomed by the team from the U.S. Army Corps of Engineers because it's proving that the culvert is successfully performing its job. If it were weeks earlier, the road would have been flooded because the previous culvert was damaged.

But the success of this project has much bigger implications. By controlling flooding, the culvert is also improving the water quality of the brook for aquatic life and New York City's water supply.

After Lake Brook travels through the culvert, it eventually flows into the West Branch Delaware River, which eventually streams into the Cannonsville Reservoir in Delaware County. This reservoir supplies almost 97 billion gallons of water to the New York City water system. A damaged culvert can jeopardize the quality of this water.

The previous culvert was undersized for its location and suffered damaged due to years of stormwater impacts. During storm events, high water from Lake Brook streamed and plugged the undersized culvert, which triggered the water to overtop and flood Odell Lake Road. When this happened, it caused stormwater runoff. This is when water from the road sweeps up contaminants and transports them to bodies of water, such as brooks, adversely affecting the water.

Stormwater runoff can also damage roads and accelerate streambank erosion. When streambanks are eroded, it makes it easier for soil and pollutants to travel from roads into bodies of water. This pollution can have a damaging effect on the stream's health and the quality of the water that eventually makes its way to the water supply.

A new, larger culvert was constructed to replace the undersized, damaged culvert, and the culvert's streambank was restored as part of the Army Corps' New York City Watershed Environmental Assistance Program.

"This program funds projects that are protecting the water quality of New York State's watersheds that provide drinking water to millions of New York City residents and businesses," said Rifat Salim, project manager, U.S. Army Corps of Engineers, New York District.

To perform this work, several agencies collaborated with the Army Corps including the Delaware County Soil and Watershed Conservation District, New York State Department of Environmental Conservation, New York City Department of Environmental Protection, and the Town of Harpersfield.

The new culvert is larger, allowing a greater amount of water to flow through and reduce the chances of road flooding during storm events.

Graydon Dutcher, stream program coordinator with the Delaware County Soil and Water Conservation District said, "The previous culvert was two circular pipes with a total diameter of 72 inches. The new culvert is almost seven times larger."

He added, "The new culvert is designed to withstand a 100-year storm event, plus 20% additional water flow." This is a flood whose strength and water height are predicted to occur, on average, about once in 100 years.

Less flooding means a safer community. Dutcher said, "During storm events, the old undersized culvert would plug up with woody debris, causing water to overtop the culvert and flood Odell Lake Road, making the road an unreliable access route in an emergency. Odell Lake Road can now provide access for people and emergency responders to Stamford and areas north in the county when the West Branch of the Delaware River and its tributaries flood the lower valleys."

Less flooding also means less stormwater runoff, resulting in a healthier brook and cleaner water supply.

To further control stormwater runoff, the streambanks along the culvert were restored and stabilized. Rock was placed along the banks to hold down the fine sediment from running into the brook. With the previous culvert, the stormwater movement over time carved or scoured out a pool in the bed of the brook, further increasing the flow of sediment into the brook. The rock placement

A photograph from 2016 of the old culvert, which had two 36-inch diameter pipes, for a total width of 72 inches. Pictured are Rifat Salim (left) and JoAnne Castagna, Public Affairs. *Graydon Dutcher*

The old culvert's stream banks filled with shrubs and debris in 2016. *JoAnne Castagna, Public Affairs* is stabilizing the banks, preventing this from occurring in the future. To provide additional stabilization, native vegetation was planted along the banks including willows, dogwoods and apple trees.

Dutcher said, "Floodwaters will drain from the road and filter through this vegetation before entering the brook."

The plants' roots stabilize the soil to protect against streambank erosion, trap sediment and pollutants, and absorb nutrients like phosphorus and nitrogen, improving the water quality of the brook downstream. Shade from the vegetation helps maintain the brook's temperature and fosters healthier fish and aquatic habitats.

A healthy environment for aquatic life also includes the ability to migrate and breed. Dutcher said, "The old culvert did not allow for fish passage up stream of the culvert. The new culvert has a natural stream bottom through it and allows for all organisms to freely pass under the road."

This project also addresses the future threat of climate change. "With the possibility of increasing storms events, climate resiliency knowledge like this is needed. This project serves as a great reference on how to replace undersized structures," said Dutcher.

With the new Odell Road culvert in place, the sound of heavy rain is no longer a threat of flooding for the Harpersfield community. Instead, it's a reminder that their new culvert is helping to keep their community safe, as well as improve the water quality of their brooks and streams for aquatic life and New York City's water supply.

Dr. JoAnne Castagna is a Public Affairs Specialist and Writer for the U.S. Army Corps of Engineers, New York District. She can be reached at joanne.castagna@usace.army.mil.

Graydon Dutcher looking over the new culvert that is successfully transporting flow in torrential rain conditions in November 2018.

JoAnne Castagna, Public Affairs

The project team looking over the new culvert as it works successfully in torrential rain conditions in November 2018.

Graydon Dutcher

Operator Quiz Winter 2019 – Health and Safety

The following questions are designed for trainees as they prepare to take the ABC wastewater operator test. It is also designed for existing operators to test their knowledge. Each issue of *Clear Waters* will have more questions from a different section of wastewater treatment. Good luck!

1. The first step the maintenance staff should take in properly locking and tagging out a piece of equipment is to______.
   a. Alert the operator on duty.
   b. Turn the equipment off at the motor control center (MCC).
   c. Pull the switch on the electrical panel to "OFF."
   d. Fill out the tags.

2. When working in an area with two or more floor coverings, be sure that they are always______.
   a. Overlapping one another.
   b. Secured together.
   c. Separated from one another.
   d. At the entrances and exits only.

3. When manually lifting any object, be sure to______.
   a. Hold it at arm's length.
   b. Keep your back bent and hold it low.
   c. Keep it close to your body and use leg strength.
   d. Keep your knees locked and bend at the waist.

4. Oxygen deficiency becomes a concern when the oxygen level in a confined space is less than______.
   a. 19.5%.
   b. 22.5%.
   c. 25.5%.
   d. 28.5%.

5. Which of the following provides safety information for potentially hazardous or toxic materials?
   a. CERCLA.
   b. OSHA.
   c. CFR.
   d. SDS.

6. The threshold limit value concentration for chlorine vapor is______.
   a. 0.1 ppm.
   b. 0.3 ppm.
   c. 0.5 ppm.
   d. 1.0 ppm.

7. When working in confined spaces where flammable gases may be present, use only tools made of______.
   a. Stainless steel.
   b. Lead.
   c. Iron.
   d. Beryllium.

8. In addition to the worker entering a confined space, what is the minimum number of people required to be present during a confined space entry?
   a. One.
   b. Two.
   c. Three.
   d. Four.

9. Hearing protection must be made available to all employees exposed to noise levels above______.
   a. 85db, averaged over eight working hours.
   b. 75db, averaged over eight working hours.
   c. 75db, at any point in an eight-hour workday.
   d. 85db, at any point in an eight-hour workday.

10. Recommended personal hygiene practices to minimize the risk of being infected by wastewater pathogens include:
   a. Only rubbing your eyes while working if you are wearing impervious gloves.
   b. Washing your hands before the beginning of your shift.
   c. Changing out of your work clothes and showering before leaving work.
   d. Reading the material safety data sheets for all chemicals used at the plant.

Answers on page 62.

For those who have questions concerning operator certification requirements and scheduling, please contact Tanya May Jennings at 315-422-7811 ext. 4, tmj@nywea.org, or visit www.nywea.org.

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Operator Quiz Winter 2019

Answers from page 61:

1. (a) Always alert the operator on duty before shutting down any equipment so as to prevent the possibility of harming personnel or affecting process performance as a result of the shutdown.
2. (b) If two or more floor coverings are required, secure them together to prevent trips and falls from the coverings separating.
3. (c) When lifting any object manually, use your legs and keep the object close to your body in order to minimize the risk of back injury.
4. (a) Levels below 19.5% can lead to injury, loss of consciousness or death.
5. (d) SDS (Safety Data Sheets) provide information on chemical hazards, and health, safety and environmental concerns of chemicals.
6. (c) 0.5 ppm.
7. (d) Beryllium.
8. (a) One, an entry supervisor or an attendant must be present during any confined space entry in addition to the entrant.
9. (a) 85db, averaged over eight working hours.
10. (c) Changing out of your work clothes and showering before leaving work.

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