ARCADIS

PFAS in

PERSPECTIVE:

Seven views of challenges and opportunities

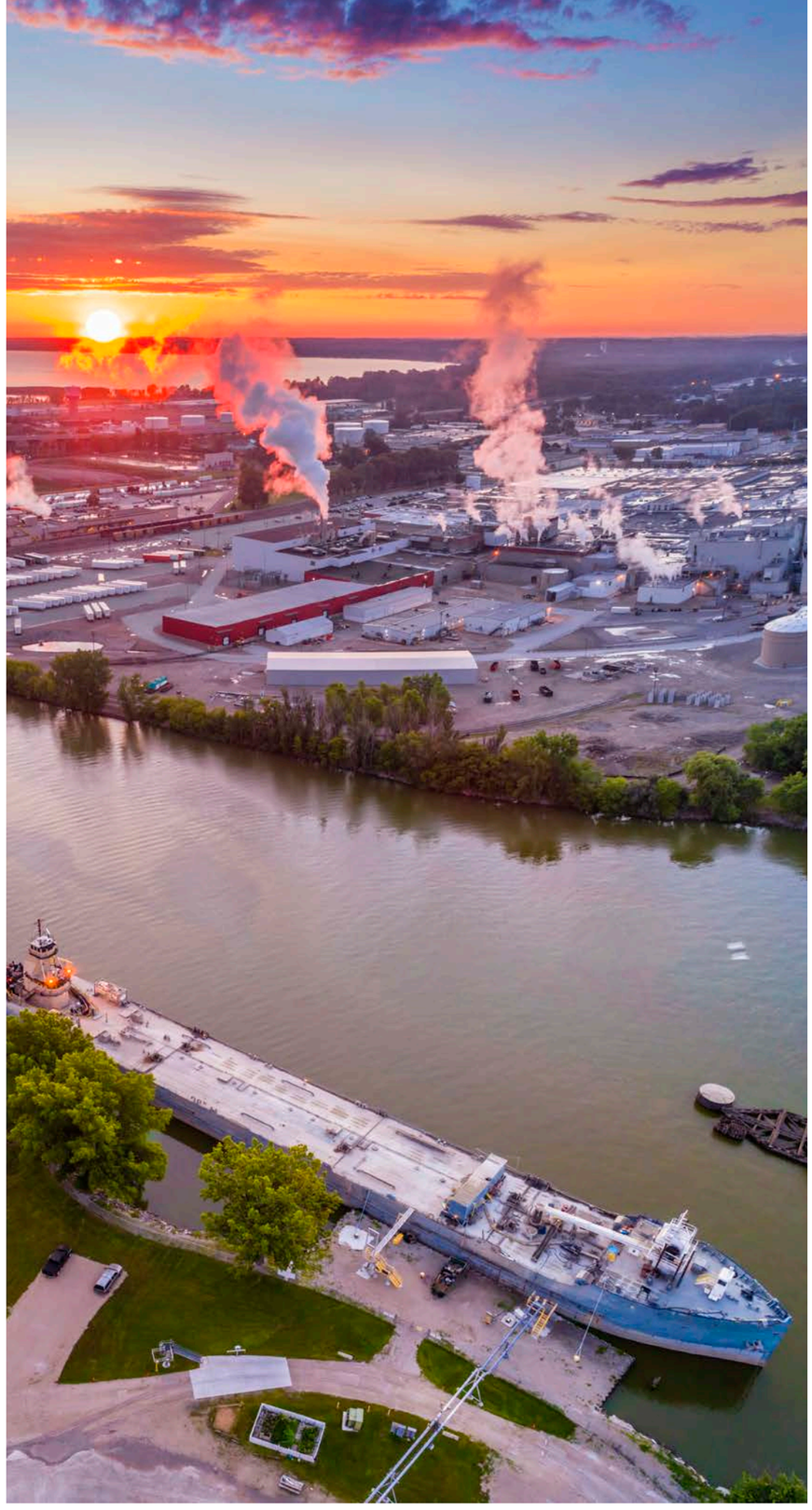
Per- and polyfluoroalkyl substances (PFAS) are a group of emerging contaminants with unique chemical features. They are a broad class of chemicals that, for decades, have been utilized in technical and consumer products for their oil, water and heat resistant properties.

In recent years, concerns around the human health impacts of certain PFAS have substantially increased the awareness and scrutiny of this class of chemicals.

Regulatory agencies in North America and around the world are setting limits for select PFAS compounds in drinking water, especially perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). In the U.S., some state agencies are casting wider regulatory nets to include more PFAS, and there are non-government organizations and interest groups encouraging agencies to regulate all PFAS.

The rapidly evolving regulations and innovation around measuring and treating PFAS make it difficult to chart the optimal management strategy for these chemicals. By examining our experiences working with PFAS from industrial, federal and public utilities perspectives, we hope to increase organizations' abilities to manage PFAS impacts proactively.

At a Glance



1. PFAS & INDUSTRY

After leading more than 15 years' worth of PFAS-driven environmental projects, our PFAS experts understand the challenges, sensitivities and risks that industry is dealing with. When the United States Environmental Protection Agency's (USEPA) promulgation of a health advisory level for PFAS in drinking water was released in May 2016, it created a host of additional risks for companies with U.S. sites.

Some risks are financial, including triggers to set reserves for publicly traded companies or to increase reserves as a result of growing regulatory awareness and enforcement. Other risks are related to third-party liabilities, which typically arise when PFAS travels outside a facility and threaten potential receptors. Finally, risks also include brand exposure and public relations concerns.

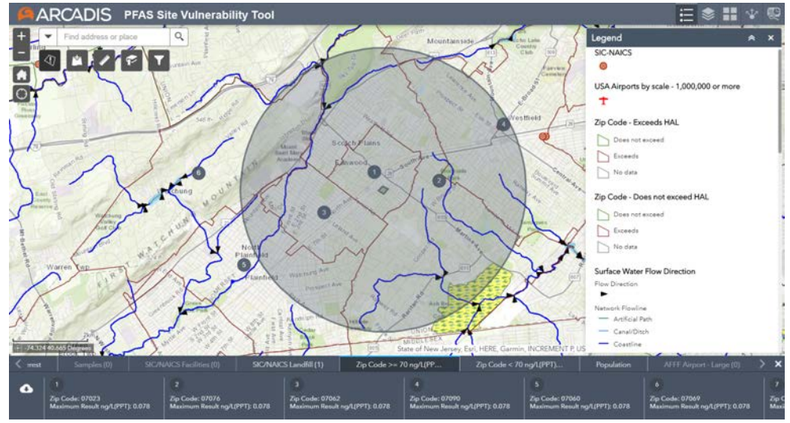
Companies looking to prepare for these risks must adopt proactive and pragmatic strategies for PFAS, understand and engage in the regulatory landscape, and consider alternatives to PFAS.

Take a proactive and pragmatic stance

A pragmatic approach to assessing an industrial site's PFAS risk is to assess its vulnerability. Performing a thorough vulnerability assessment involves evaluations of:

- The current and future regulatory environment
- PFAS presence in products, supply chains, and manufacturing processes
- The hydrogeology and physical setting of an individual site, including other potential PFAS sources

Digital solutions like Arcadis' geographic information system-based PFAS vulnerability tool can provide a head start on assessing and prioritizing actions without sampling or testing. The tool enables a focused and risk-driven approach for an individual site or a portfolio of sites with mixed risk profiles.



Arcadis' PFAS site vulnerability tool can provide a head start on assessing and prioritizing actions without sampling or testing.

Join the regulatory conversation

The USEPA is currently reviewing additional toxicity data for several individual PFAS, with findings anticipated as early as 2021. Organizations can actively review and comment on new rules before they become final. Arcadis has a history of supporting clients throughout rule-making processes, and we have learned firsthand how participating in regulatory conversations helps ensure realistic and science-based standards.

It maps USEPA data on PFAS and other chemicals in public water for all major water supplies, including permitted industrial discharges in the U.S. It also uses state data to perform another layer of assessment, identifying smaller public water supplies as well as locations of private potable wells, and providing additional information on nearby sites with their own PFAS impacts. Sites that are close to drinking water sources require more attention than those with minimal chance of impacting groundwater or surface water used for drinking water. The vulnerability tool can help identify sites that are within proximity to water supplies, including those with PFAS detections. Combined with a site-specific inventory of PFAS usage, it highlights the most vulnerable facilities and helps prioritize resources to focus on sites where PFAS may pose financial or regulatory risk.

One option may be to conduct a vulnerability analysis at the direction of external legal counsel, which may protect information from being externally disclosed.

Understand the PFAS regulatory landscape

The science around most PFAS (e.g., PFOA, PFOS, PFNA) that informs many regulatory discussions is still developing. The fact that states are proposing or have enacted enforceable regulatory standards for additional PFAS (e.g., GenX, PFHxS, PFBS, PFHxA, etc.) only further clouds the industry approach to managing these chemicals.

This evolving landscape brings with it the risks of regulatory re-openers, additional third-party exposure, and risks related to products and supply chains. Our teams have worked closely with clients to apply expertise in PFAS chemistry and product stewardship to evaluate product risks and help certify products for commercialization in various regions (e.g., REACH).

Tracking policy changes will be critical. Arcadis has maintained an international database for cataloging country (U.S., both federal and state, Canada, European Union (EU), and Australia) regulations and guidance pertaining to PFAS in all environmental media since 2010. It can help multi-state and multinational organizations understand where regulatory risks may be higher for certain PFAS chemistry at individual facility locations or regions. Often, the regulatory trends around health effects and toxicity observed in the EU and Australia influence U.S. state and federal regulations.

Regulatory variability can make conversations regarding public safety a challenge, as some litigants or the public might question why all sites are not adhering to the same standards. Maintaining a thorough understanding of why standards vary globally and within the U.S. can make it easier to clearly convey plans to customers, the public, and local communities.

Some fluorine-free foams have surpassed the highest levels of International Civil Aviation Organization extinguishment tests

Consider alternatives that lower PFAS risk

PFAS have been used for decades because of their unique and valuable chemical properties, and some companies may need to continue to manufacture or use PFAS in operations. Others, however, might be required to substantially remove it from their products or wish to do so voluntarily.

Many manufacturers have changed their production over time to reduce reliance on long-chained PFAS and substitute them for shorter chain PFAS, which are currently under less regulatory scrutiny. But the PFOS and PFOA replacement compounds may be subject to future regulation. For example, the PFAS that arise from newer firefighting foam formulations, such as C-6 compounds, are regulated in drinking water in some states, albeit at less stringent levels than PFOS and PFOA.

Firefighting foams warrant their own discussion. Typically, industrial users of firefighting foam are not required to use foams that contain PFAS, but they are valued for their proven ability to quickly suppress large fires. Comfort levels with aqueous film forming foam (AFFF) and the costs of replacing a fire suppression system might make PFAS-based firefighting foam the preferred choice. Still, there are opportunities to alter and adapt testing and training methods and facility infrastructure to minimize potential environmental releases.

For companies exploring industrial fire suppression alternatives, fluorine-free foams (F3) that do not contain PFAS may be suitable. These substitute foams have achieved certification under various firefighting foam certification programs (e.g., Underwriters Laboratories, LASTFIRE and International Organization for Standardization). Some have surpassed the highest levels of International Civil Aviation Organization extinguishment tests.

As the performance capabilities of F3 foams improve, adoption will increase. When contemplating a foam replacement, it is vital to partner with an organization experienced in removing PFAS from fire suppression systems. Any replacement – either with newer PFAS-containing foams or F3s – will require a system-wide cleaning with specialized chemicals to remove residual historical PFAS content.

2. PFAS in **LITIGATION**

Litigation related to real and/or perceived PFAS impacts is becoming more commonplace within and outside the U.S. The case types span a wide range: claims by one company against another; lawsuits involving state and local governments (either as the plaintiff or defendant); and class action suits against individual industrial facilities, airports, public utilities, fire departments and/or manufacturers. Arcadis litigation experts have supported numerous clients involved in (or preparing for the potential of) PFAS litigation, and the insights learned in those cases might be useful to organizations facing similar risks.

Pay special attention to high-risk sites

When your organization identifies a high-risk site, a proactive approach might help avert litigation. Arcadis teams recently investigated a U.S. site using a PFAS mobile laboratory that provided real-time data to inform our client and optimize their investigation strategy. The immediate insights into PFAS distribution led to a tailored, iterative approach to site characterization focused on identifying potential presence or absence of risk to receptors, and as appropriate, quickly developing strategies to rectify the issues. This approach also allowed for daily consultations with state and local regulatory agencies, which was key in managing potential community concerns.

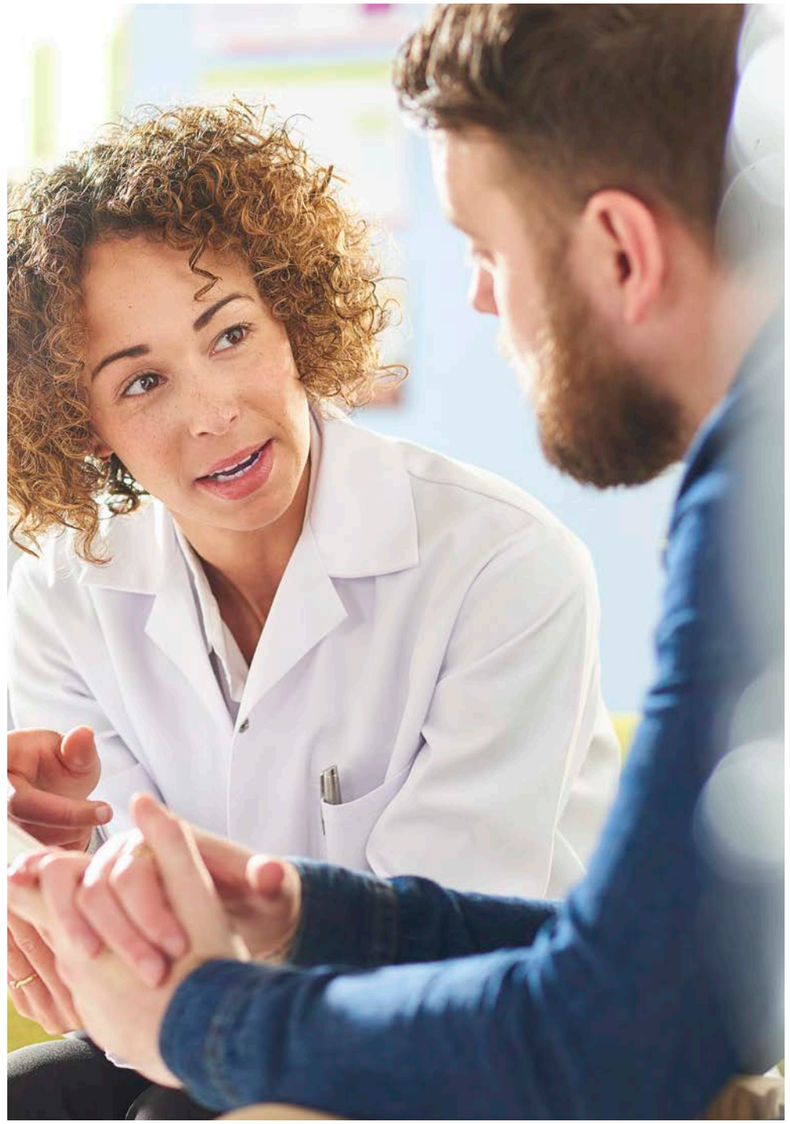
Using data-informed decisions and establishing a strong line of communication between our client and government stakeholders created a foundation of trust. With a strong partnership in place, Arcadis was able to rapidly mitigate potential receptor risks related to PFAS. This proactive technical approach, coupled with transparent stakeholder communications, kept the focus on the progress of site investigations and remediation and away from litigation options.

Our partnership with a PFAS mobile laboratory was recently demonstrated for the DOD's ESTCP program and the final report will be available in September 2020.

Use PFAS forensics as protection

When facing potential litigation, it is crucial to prepare a clear argument around the extent of potential PFAS impacts related to the site. There are typically many sources of PFAS in the environment. Analyzing samples surrounding the site can begin to provide the multiple lines-of-evidence needed to differentiate impacts from the site with those that might have been associated with another responsible party. Reviewing the data with respect to compound types, concentrations, branched and linear isomers, and even and odd numbered PFAS tells a story of where PFAS may have come from and when.

Forensic tools that include more advanced analytical laboratory methods can also be utilized. For example, Quantitative Time of Flight (QTOF) analysis is becoming more widely available on a commercial scale and can provide a detailed fingerprint based on the molecular weights and formulas of different PFAS products or suites used in different products. PFAS forensics can be leveraged as part of a lines-of-evidence analysis that includes hydrology and fate and transport analysis to build a sound scientific argument.



Awareness of forensic tools and the ability to interpret the results are crucial to building a case grounded in science & law.

Present a clear case

Embed PFAS experts who understand the scientific nuances of these chemicals into your organization's legal team as early in the investigation process as possible. PFAS is different from environmental contaminants many environmental lawyers have dealt with in the past, so having experts involved at every stage of the actual or potential litigation process is essential.

In our experiences providing litigation support, clarity in all filings and submissions is of utmost importance. There have been situations where lawyers unfamiliar with the details of PFAS interpreted portions of PFAS reports in a manner completely contrary to the intent. Engaging with PFAS consultants consistently ensures that the science is clearly interpreted and described in connection with claims or potential claims.

3. PFAS & **TREATMENT TECHNOLOGY**

The development of PFAS treatment technologies involves multiple sectors. Many universities, consultants and technology companies are vying to create a game-changing treatment technology.

Arcadis views the PFAS challenge as too dynamic to solve in silos, believing it will take a combination of solutions to cost-effectively manage PFAS.

Recognizing there is no one-size-fits-all treatment for PFAS-impacted waste, soil, drinking water and natural water, stakeholders are collaborating on research and development (R&D). Even industry competitors are forming alliances to accelerate progress on PFAS treatment.

The R&D pipeline

Currently there are two primary forms of R&D associated with PFAS treatment technologies:

- Concentration/separation of PFAS from waste and water streams
- Destruction of PFAS

In the case of the former, the primary objective is optimization of commercially available methods. However, significant progress is being made to identify new separation/concentration techniques as well as destructive treatment options.

Achieving optimization

Many teams are testing ways to make the most of existing treatment technologies, including adsorbents such as granular activated carbon (GAC) and ion exchange resins. Seen as effective immediate response tools, optimizing these adsorbents through treatment trains could provide cost-effective treatments that companies are accustomed to implementing.

Finding innovative solutions

Some researchers are hoping to uncover new solutions or applications of existing technologies that will maximize PFAS treatment efficiency. Most of the current focus is developing ways to separate, concentrate and destroy PFAS.

Academic and industry experts are exploring new technologies that can cost-effectively separate and concentrate PFAS, especially in complex waste streams. Arcadis is playing an integral role in this field, and examples of current initiatives include:

- **Sub-micron powdered activated carbon and ceramic membrane filtration:** Arcadis experts are working with the United States Department of Defense (DOD), Aqua-Aerobic Systems, Inc. and Colorado School of Mines to refine sub-micron powdered activated carbon and ceramic membrane filtration for improved separation of PFAS from water. The technology will be validated on a combined stormwater and groundwater treatment pilot through the Environmental Security Technology Certification Program (ESTCP) starting in June 2020.
- **Ozone-based foam fractionation:** Arcadis has an exclusive agreement with Australia-based water treatment company EVOCRA to implement ozone-based foam fractionation technology to separate and concentrate PFAS from impacted water.
- **Synthetic adsorbents:** Arcadis has an exclusive agreement with ABS Materials, Inc. to provide synthetic adsorbents (Osorb®, PQ-Osorb®) that can provide advantages over traditional adsorbents regarding selectivity and adsorption efficiency. These materials can remove a broader range of PFAS chain lengths from water, while also providing a smaller remedial footprint given shorter EBCT requirements (i.e., residence times).

Destroying PFAS is energy intensive, and some accepted destruction processes carry risks of production of by-products. Many ideas related to possible PFAS destruction have not been considered viable technologies for other contaminants, but traditional destruction methods are not effective for PFAS. Innovation will continue to uncover and refine safe, energy- and cost-efficient ways to break down PFAS.

New destructive treatment options are being tested at the pilot and field scale and Arcadis is collaborating with academics in two key areas:

- **Sonolysis:** Arcadis experts are partnering with Surrey University in the UK to refine sonolysis reactor design to achieve more cost-effective and complete PFAS treatment.
- **eBeam:** Arcadis specialists are working with Texas A&M to tailor eBeam for PFAS destruction in solid and liquid wastes.

Both technologies have been applied to other contaminants, so the focus is optimizing the application to meet the PFAS challenge. Other researchers are focusing on electrochemical destruction techniques, which also show promise.

Creating an optimal treatment train

There will not be a technological “silver bullet” that solves every PFAS problem. A cost-effective treatment train of two or three technologies can convert large volumes containing low PFAS concentrations into small volume, high concentration waste streams that can be more efficiently managed or destroyed.

The types of technology needed to create the small volume, high concentration waste stream will depend on the type of material (and bulk chemistry) being treated for PFAS. Arcadis is supporting clients in developing industrial pretreatment solutions for a wide range of wastewater applications in connection with refineries, airports, industrial/manufacturing facilities, and in the life sciences sector.

For example, foam fractionation may be a preferred option for removing PFAS from saline water, sewage or impacted wastewaters, while GAC or resins might work best for diffuse, higher volume treatment for drinking water. With a range of innovative options, methods can be combined to leverage multiple strengths to achieve the ideal treatment solution.

There won’t be one silver bullet of technology that solves every problem.

4. The Federal PFAS Response: **AMERICA**

The U.S. Department of Defense is leading the way

The U.S. DOD is striving to develop a systematic approach for managing PFAS across all its sites. At the request of DOD Secretary Mark T. Esper, the federal PFAS Task Force was created in August 2019. Its goal is to systematically treat PFAS while taking care of the families and communities whose drinking water has been affected by DOD installations.

The DOD sits at the leading edge of the PFAS response, as demonstrated by its proactive assessment of PFAS impacts at DOD installations across all military branches. DOD programs have provided millions of dollars to fund research of PFAS chemistry, treatment, and fate and transport. The DOD is also working to transition away from PFAS-containing foams by funding research on F3 foams that can safely meet the firefighting needs of the DOD.

The DOD is doing more than just research and analysis. For example, it has hired Arcadis and is working collaboratively to perform preliminary assessments and site inspections at 85 U.S. Army installations using a programmatic approach. Similarly, other branches of the DOD are systematically reviewing their portfolios, identifying and mitigating offsite risks, and moving the sites toward CERCLA-compliant remedial investigations. The DOD has also taken swift actions to protect people from PFOS- and PFOA-impacted drinking water by providing bottled water and water treatment filters, establishing new connections to unimpacted drinking water supplies and adding treatment to existing water treatment systems.

Pending USEPA standards

While the DOD is already conducting investigations and taking interim actions, it is awaiting promulgation of USEPA standards to further guide its programmatic remediation response actions. Congress has multiple pending legislative actions related to PFAS, and while the USEPA does not currently have any PFAS drinking water or groundwater standards, it announced that it will develop maximum contaminant levels (MCLs) within the next four years.

National Defense Authorization Act (NDAA)

Congress drafted language in the Fiscal Year 2020 NDAA to address PFAS associated with DOD operations. As part of the legislation, the DOD is now required to ensure proper disposal of PFAS containing materials, and enter into cooperative agreements with states for testing and remediation of PFAS releases associated with DOD operations. In addition, this legislation identified specific PFAS to be added to the USEPA's list of chemicals included in the Toxic Release Inventory (TRI).

5. The Federal PFAS Response: **CANADA**

Most federal attention and funding in Canada are focused on sites with fire suppression systems, firefighting training areas, and areas where known firefighting responses occurred. Canada's federal agencies and the military have responsibility for many of these sites.

Canadian federal PFAS-impacted sites are at various stages of investigation, risk management, and treatment. Canada is largely operating on a risk-based approach, placing the highest priority on sites that have impacted drinking water supplies. Until federal standards are in place, this risk-based approach will likely remain status quo.

Developing regulatory standards

Health Canada recently released guidance around nine PFAS compounds that could lead to other Canadian governmental agencies setting formal guidelines. Health Canada does not create or enact policy, but it does typically inform federal standards.

Some provinces are forgoing federal guidance and putting their own regulations in place. British Columbia has enacted its own regulatory standards for PFAS, and Ontario might soon follow. Province-by-province policies, however, could create the same issues as with the state-by-state policy differences in the U.S.

6. PFAS & **AIRPORTS**

PFAS-based firefighting foams were historically used in airport hangar fire suppression systems, onsite firefighting training facilities, and emergency responses to aircraft fires. American airports historically followed U.S. military guidelines for firefighting foams, which mandated the use of PFAS-based foams. But like the DOD, airports in the U.S. and Canada are concerned with environmental liabilities and are moving to non-fluorinated foams that provide equivalent fire safety.

Regulatory paths could be clearing the way; the Federal Aviation Administration (FAA) Reauthorization Act of 2018 requires the FAA remove PFAS-based foams as a requirement for meeting performance standards at Part 139 airports (a type that includes most major commercial airports) by October 2021. Similarly, Transport Canada published updated Aircraft Fire Fighting at Airport and Aerodromes Standards in June 2019 to enable transitions to F3 foams.

Airports worldwide are beginning to replace PFAS-based foams with F3 foams. Transition plans include decontamination of historical foam material, responsible disposal of foams, equipment and infrastructure upgrades/replacements, and training. They also require thorough evaluations of fire protection engineering, fire safety strategies and fire risk assessments.

Working with large airports across the globe, Arcadis has developed a service model that covers the entire foam replacement and transition lifecycle.

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Key steps in the fire protection and foam lifecycle

- Assessment of needs
- Advice on risk management of legacy foam issues, inventory and transition planning
- Decontamination of PFAS foam delivery infrastructure, waste disposal/treatment
- Environmental compliance, discharge monitoring and pretreatment and remediation
- Site specific foam usage risk assessment
- Foam concentrate procurement specification and procedures
- Storage and stock management
- Supplementary supplies (e.g. Mutual Aid)
- Containment/environmental assessment
- Decontamination of equipment and systems on site
- Foam treatment/disposal

The costs of changing foam delivery infrastructure must be weighed against potential future environmental liabilities associated with continued use of firefighting foams that contain PFAS.

7. PFAS & **WATER UTILITIES**

Some water utilities are finding PFAS in their source water supplies, but many do not have installed treatment that will remove these compounds. And like the DOD, water utilities are struggling with a lack of federal standards.

In 2016, the USEPA released a Lifetime Health Advisory of 70 parts per trillion for PFOA and PFOS in drinking water. There are utilities taking action to stay below this level, but many water purveyors are hesitant to use tax revenues given the lack of more formal (state or federal) standards, including the absence of any required MCLs.

Some private water utilities, much like companies with sites in multiple states, want to implement uniform responses. Differing state-by-state regulations will make that a challenge, and the inconsistency will make it harder to talk about PFAS with the public. Despite no clear federal and state standards, an increasing public awareness and the potential of litigation and/or actual lawsuits are driving PFAS cleanup efforts at municipal water facilities.

Most larger water supplies have completed some initial PFAS testing. The next step for water utilities with positive detections will be to conduct additional monitoring to understand how the occurrence of PFAS in their individual supply wells or intake locations varies throughout the day and year. Understanding the variability of PFAS occurrence will be useful in designing the appropriate management or treatment option.

Build a foundation of data

Any effort will start with data collection. While the regulatory framework is still developing, there are still opportunities to conduct due diligence around potential PFAS in water sources. Early assessments allow for better planning and efficient use of resources, should treatment be required.

Treatment options are limited

Today, the most common approach to achieving drinking water standards is through dilution and blending of different water sources. When treatment is required to remove PFAS from drinking water, it is usually done using GAC filtration. GAC is effective at removing some PFAS, particularly the longer chained PFOS and PFOA. Plus, GAC and ion exchange are broadly understood treatment technologies that are readily deployable and will be more easily accepted as viable treatment options by state regulatory agencies.

If utilities have the means, more expensive treatment options, such as nanofiltration and reverse osmosis, are available. However, cost-effective management of rejectate volumes with concentrated PFAS remains an obstacle. Many of the advanced treatments employed by industry and federal agencies are not currently feasible for water utilities. Besides disposal challenges, volume differences – large utilities might treat 100x more water each day than industrial sites – make some solutions impractical to implement.

Partnerships and innovation will help

In the future, industrial dischargers to public wastewater facilities may be required to pre-treat for PFAS. This is now required in a few U.S. states, but the trend is expected to increase.

Currently, many wastewater utilities are not equipped to treat PFAS. Arcadis supports various industrial dischargers by helping them lower PFAS in their waste streams/conveyance, as well as providing cost-effective end-of-pipe solutions. These efforts can help resolve problems before discharges impact drinking water supplies.

Another growing concern is the management of PFAS-impacted biosolids from conventional wastewater treatment. More industrial users are taking steps to reduce and eliminate PFAS discharges to limit future liability as this issue becomes a public concern.

Potable reuse can alleviate strain on stressed water supplies, but PFAS add new challenges to implementing many of the advanced treatment processes required for reuse, such as oxidation and reverse osmosis membranes. Oxidation could convert precursors into perfluoroalkyl substances, and while membranes can concentrate PFAS successfully, utilities are not typically equipped to handle the resulting concentrations of PFAS residuals.

As the water sector embraces Intelligent Water, there might be new strategies for PFAS. For example, machine learning and predictive analytics could leverage public data to map out problem areas and potential treatment strategies according to which compounds are present and to what extent. Innovation like this might be the difference in overcoming PFAS challenges.

While the regulatory framework is still developing, there are still opportunities to conduct due diligence around potential PFAS in water sources.

Keys to **PLANNING** for PFAS

Approaches to managing PFAS impacts are rapidly advancing. Industry, researchers, federal agencies, airports, and water utilities are all grappling with how to manage PFAS risks. No matter what sector your organization operates in, there are four keys to planning for PFAS:

Being proactive. Assess potential risks related to PFAS by desktop evaluations of potential historical PFAS usage, vulnerabilities, receptors and liabilities prior to sampling or testing.

Remaining pragmatic. Prioritize actions at sites most likely to impact drinking water supplies. Monitoring and implementing strategies that prevent PFAS from migrating to water supplies is the most prudent approach to managing these sensitive sites.

Prioritizing agility. **Regulations around PFAS are evolving, as are approaches to managing this issue. As your organization implements interim measures, consider this evolving context to develop a flexible risk management or remediation strategy.**

Embracing collaboration. **Companies, researchers, regulators, federal agencies, and the water sector must combine strengths and share lessons learned to accelerate progress. There will not be a single treatment strategy for all PFAS impacts, and collaboration is more likely to produce a range of options that can be tailored to individual sites.**

PFAS is a new challenge for many. Depending on where your company sits in the market, your PFAS strategy will likely vary. It might be uncharted territory, but the right partnerships can expedite progress and prepare an optimal approach for your organization. Arcadis is always geared up and ready to lend our full suite of expertise in assessing, characterizing and mitigating PFAS.

PFAS is a new challenge for many, and your PFAS strategy will be unique to your organization's needs.

Global PFAS Remediation Experts

Arcadis has a long history of managing PFAS. Beginning with our first projects in Belgium, Germany and the UK more than 15 years ago, we have worked on more than 400 projects in 12 countries. Our strength is centered on our knowledge of complex PFAS chemistry, combined with significant expertise in environmental risk assessment and our long-standing involvement with remedial technology research and development.

It is worth noting that while the majority of regulator and stakeholder concerns are currently focused on the presence of PFAS in drinking water, Arcadis is also a leader in the assessment and mitigation of PFAS presence in air, natural waters, sediments, and wastewater.

Contact us to learn more about our specific PFAS services and how we can help your organization carefully chart a path forward in this evolving landscape.

Industry and Litigation

Jeff Burdick
Global Leader Site Evaluation and Restoration
jeff.burdick@arcadis.com

Erika Houtz, PhD, P.E.
Sr. Environmental Engineer
Global Analytical Lead
erika.houtz@arcadis.com

Johnsie Lang, PhD
Staff Environmental EIT
johnsie.lang@arcadis.com

Allan Horneman, PhD
Principal Scientist
Assoc. Vice President
allan.horneman@arcadis.com

Federal

Joseph Quinnan, P.G.
Senior Vice President
joseph.quinnan@arcadis.com

Water

Rebecca Slabaugh
Drinking Water Practice Lead
rebecca.slabaugh@arcadis.com

Remediation, R&D, Technology Development

Jeff McDonough, P.E.
Principal Environmental Engineer
Assoc. Vice President
jeffrey.mcdonough@arcadis.com

Shannon Dunn, P.G.
Technical Expert
shannon.dunn@arcadis.com

Corey Theriault, P.E.
Principal Water Engineer
corey.theriault@arcadis.com

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Arcadis North America | Arcadis North America | @ARCADIS_US