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 manufacturing and consumer products for their oil, water and heat resistant properties.

Human health and regulatory impacts

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 proactively.

At a Glance

1. PFAS in Industry

Having led PFAS-driven environmental projects for more than 20 years, our PFAS experts understand the challenges, sensitivities and risks that the industry is facing. Some risks are financial, including triggers to set reserves for publicly traded companies or to increase reserves reflecting evolving regulations, enforcement and reporting requirements. The primary risks and liabilities continue to be associated with drinking water and surface water, but concerns related to other exposure pathways are evolving, including, but not limited to ecological receptors, re-openers as well as third-party liabilities. Reputational risks associated with brand exposure and public relations are also increasingly in focus.

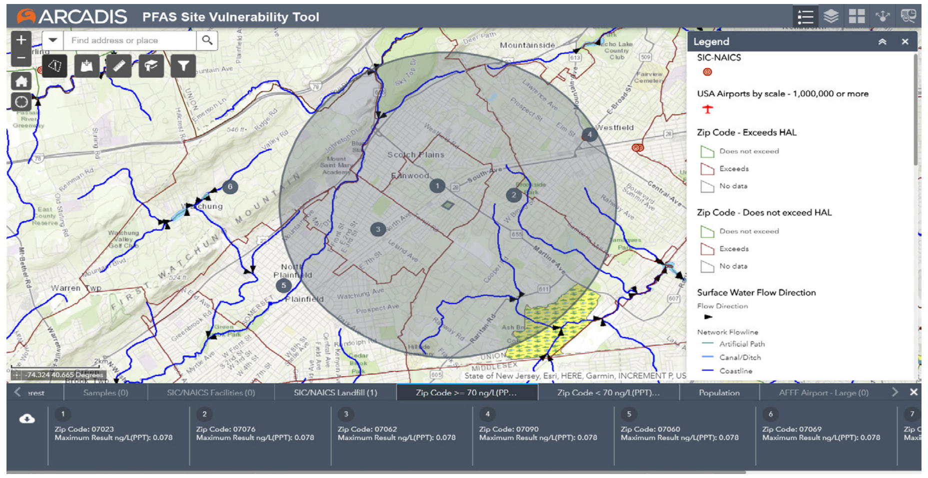
Companies looking to prepare for these risks and liabilities typically develop proactive and pragmatic PFAS strategies to comply with current regulations, but also reduce future potential liabilities associated with PFAS.

Take a proactive and pragmatic stance

A pragmatic approach to assessing an industrial site's PFAS risk is to assess its vulnerability. Such an evaluation includes several factors, including:

- 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 and available information on PFAS "background" concentrations.
- Location relative to private and municipal water supplies, surface water, and sensitive ecological receptors and available PFAS data associated with these potential receptors.

Arcadis' geographic information system (GIS) 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.

Proactively assessing risk: the Arcadis PFAS Vulnerability Tool

The Arcadis PFAS **Vulnerability Tool** maps the U.S. Environmental Protection Agency (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 water supplies 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.

Understanding the PFAS regulatory landscape

The science around most PFAS (e.g., PFOA, PFOS, perfluorononanoic acid [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., hexafluoropropylene oxide dimer acid [GenX], perfluorohexanesulfonic acid [PFHxS], perfluorobutanesulfonic acid [PFBS], perfluorohexanoic acid [PFHxA], etc.) adds additional complexity to the industry's 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).

Arcadis regulatory tracker

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 risk to receptors a challenge. Maintaining a thorough understanding of why standards vary regionally, within the U.S., as well as globally can make it easier to clearly convey information to stakeholders.

Assessing PFAS in TRI reporting

The U.S. Toxics Release Inventory (TRI) Reporting includes nearly 200 listed PFAS, with the list of PFAS subject to annual reporting continuing to expand. In addition, starting with TRI Form R submittals due July 1, 2025, the USEPA has removed the de minimis concentration threshold exemptions for TRI-listed PFAS.

While most facilities initially look for PFAS that may be present in Aqueous Film-Forming Foam (AFFF) used in on-site fire suppression systems, the TRI-listed PFAS can be found in other products and operations at a facility. Arcadis has identified more than 30 broad industrial and use groups where these individually listed PFAS currently or historically have been reported as used.

Our PFAS experts have searched more than 35 information sources, such as peer-reviewed publications and online technical databases, to better understand where PFAS might occur in industrial settings like that of your facility. Leveraging technical knowledge across several disciplines, the team assessed, and continues to research, the chemical structures of the PFAS associated with its uses. In several instances, we identify chemicals that are more likely to be associated with consumer use than manufacturing or processing. To our knowledge, this research represents the most extensive effort to date identifying uses and industry sectors associated with these chemicals.

FluoroChaser: Arcadis SDS Searchbot

Arcadis developed a digital tool that scans available supplier and raw material data and applies an array of PFAS-related search terms to identify potential fluorinated compounds. Following the search, our skilled PFAS experts review the output to confirm the positive identification of the chemical(s). We can customize interactive dashboards and incorporate search terms tailored to meet specific client needs.

Search terms can include:

- All surfactants, fluorine-containing chemicals, and SDSs with proprietary components
- USEPA TRI Reporting List
- USEPA TSCA Section 8(a)(7)
- ECHA REACH Annex XVII
- ECHA SVHC
- Internally developed search terms

What makes our team unique is our experts. .Our doctoral-level chemists and engineers have prior laboratory experience at USEPA Office of Research and Development (ORD). The team has extensive experience in measuring PFAS levels in a variety of sample types, and analyzing PFAS samples with liquid chromatography mass spectrometry (LC/MS). They expertly employ traditional PFAS analytical methods, and methods utilizing high resolution mass spectrometry for suspect screening and non-targeted analysis.

Join the regulatory conversation

Arcadis has a history of supporting clients throughout rule-making processes, and we have firsthand experience in participating in the regulatory conversations in support of pragmatic and science-based standards.

2. PFAS and Litigation

In parallel with the increased regulatory pressure, there is an increase in PFAS-driven litigation that extends beyond the primary PFAS manufacturers. The PFAS-driven litigation includes: claims and cost recovery by one company against another; lawsuits involving state and local governments and water utilities (either as the plaintiff or defendant); and class action suits against individual industrial facilities, airports, public utilities, fire departments and/or manufacturers.

Assessing PFAS emissions in ambient air

PFAS in air emissions are receiving increasing regulatory attention. A range of industrial and commercial facilities are being asked to assess potential PFAS in air emissions. Risk drivers have previously focused largely on impacts to drinking water, but increasingly ambient air quality, surface water and sediment impacts, and their potentially related fate and transport mechanisms are being considered as well.

Our team has completed PFAS air emissions assessments on multiple projects and has implemented USEPA stack testing methodologies, including OTM-45, to quantify PFAS emissions from stacks. To successfully measure low-level PFAS emissions in the stack, field procedures are carefully performed to minimize background contamination and properly handle samples. In-stack reporting limits are in the nanogram per cubic meter (ng/m3) range or parts per trillion levels in gas. Mass emission rates (g/ yr) are eight orders of magnitude lower than typically observed for other potential air contaminants such as pesticides and dioxins/furans. These extremely low reporting requirements make sampling, analysis, and data interpretation more complicated and adds a level of complexity that demands experience and high levels of quality control that Arcadis has delivered for clients.

Use PFAS forensics as lines of evidence

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 basis for defining the source of impacts. 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. Reviewing the data with respect to compound types (PFAS fingerprint), 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.

Multiple statistical tools are also available to assist in PFAS source apportionment. For example, positive matrix factorization (PMF) we can use positive matrix to generate unique factor profiles for multiple sources and quantify their contributions to impacted waters and soils.

Develop a line of evidence case

Successful navigation of regulatory inquiries and/or litigation is often driven by early engagement of PFAS experts who understand the regulatory and scientific nuances of this group of chemicals.

PFAS represents a unique challenge in part driven by the widespread PFAS usage in industry and commercial processes, the presence in the environment as “background,” the dynamic regulatory environment, very low standards and criteria, and stakeholder perception. Early involvement of PFAS experts can drive a focused defense strategy anchored in science for PFAS driven litigation.

In our experience providing litigation support, clarity in all filings and submissions is important. There have been situations where experts 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.

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

3. PFAS and Treatment Technology

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

Finding innovative solutions

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

Academic and industry experts are exploring new technologies that can cost-effectively separate and concentrate PFAS.

PFAS destruction

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 key areas:

- **Supercritical Water Oxidation:** Supercritical water oxidation (SCWO) is a destructive process which leverages the supercritical phase of water achieved by increasing temperature and pressure of a solution to a minimum of 374 °C and 218 atm, respectively. In this phase, oxygen is fully soluble, resulting in rapid and complete oxidation of organics, transforming the feedstock into carbon dioxide (CO_2), water, and inorganic salts. Arcadis is collaborating with 374Water and General Atomics to test their SCWO technologies on aqueous film forming foam (AFFF) stockpiles for the Engineer Research and Development Center (ERDC) in association with the United States Army Corps of Engineers (USACE). Additionally, Arcadis has partnered with Clean Earth as a Treatment, Storage, and Disposal Facility (TSDF) provider to host several PFAS destruction technology demonstrations and test a "hub-and-spoke" destruction model where technologies are deployed to a regional TSDF and PFAS-impacted wastes are transported to the destruction "hub" for treatment for the Defense Innovation Unit (DIU) in association with the Environmental Security Technology Certification Program (ESTCP). For this project, Arcadis has also partnered with 374Water to demonstrate their SCWO technology on several concentrated PFAS-impacted waste streams, including foam fractionate, ion exchange resin still bottoms, a media regenerant solution, spent granular activated carbon and ion exchange solid medias, and AFFF. Arcadis is also partnering with Revive Environmental in association with Battelle Memorial Institute for AFFF stockpile disposal on behalf of the United States Army Corps of Engineers (USACE) for the Multiple Award Task Order Contract (MATOC) for AFFF Support Services.
- **Subcritical Water Oxidation:** Subcritical water oxidation is also referred to as hydrothermal alkaline treatment (HALT). HALT is similar to SCWO in that it operates under high temperatures and pressures, but just under critical conditions (i.e., approximately 205 atm and 350 °C). It also requires the addition of a base, typically NaOH, to achieve the alkalinity necessary to destroy PFAS. Aquagga will be demonstrating their HALT technology under the DIU/ESTCP PFAS destruction demonstration program at a designated Clean Earth TSDF.
- **Photochemical Oxidation:** Photochemical oxidation is the process of PFAS adsorbing photons (typically produced by ultraviolet lamps) in the presence of a photocatalyst, causing decomposition of PFAS. Arcadis oversaw the feasibility testing and conceptual design development of a photochemical oxidation technology owned by Claros Technologies for a confidential industrial client. Claros' photochemical technology was demonstrated on a wastewater consisting of the liquid remaining after ion exchange resin regeneration and regenerant distillation.
- **Plasma:** Plasma is the process of applying electricity to a gas to induce the ionization of gas molecules and creating highly reactive oxidative/reductive species in the presence of water. The process results in elevated temperatures near the discharge point, in addition to shockwaves and UN light emissions to decompose PFAS into gaseous molecules and reformed into inert compounds. Cold plasma leverages the same principles of thermal plasma, but without elevating temperatures and consuming less energy.
- **Sonolysis:** Arcadis experts are developing a flowthrough acoustic treatment system (Patent Pending) to treat AFFF stockpiles for the Engineer Research and Development Center (ERDC) in association with the United States Army Corps of Engineers (USACE). The flowthrough system is a significant advancement over the previous batch iterations and is critical in scaling up the acoustic PFAS treatment for industrial applications. Arcadis's design incorporates learnings from the recent development and testing in academia by the University of Surrey in the UK and the University of California, Los Angeles, in the USA to refine sonolysis reactor design to achieve more cost-effective and complete PFAS treatment.
- **Ultrasonic:** Ultrasonic treatment of PFAS is the pushbutton treatment option that requires nominal technical expertise and has an advantage over other PFAS destruction technologies in terms of lower CAPEX and OPEX costs.

Creating an optimal treatment train

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.

Cost-effective management strategies are urgently needed which target soil vadose zones and shallow groundwater.

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.

Foam fractionation

Fractionation is a separation technology that uses micron-sized gas bubbles to remove contaminants, such PFAS from aqueous media. It can also work in conjunction with other water treatment systems to reduce PFAS waste. PFAS molecules have hydrophilic and hydrophobic properties attracting them to the gas-liquid interfaces present in fractionation as the injected gas bubbles move through water. Bubbles interact with PFAS and other constituents and are discharged as foam fractionate.

The Arcadis team has extensive experience with supporting the development of foam fractionation treatment equipment with and without oxidizing reagents such as ozone as well as with various performance-improving surfactants.

In-situ soil stabilization

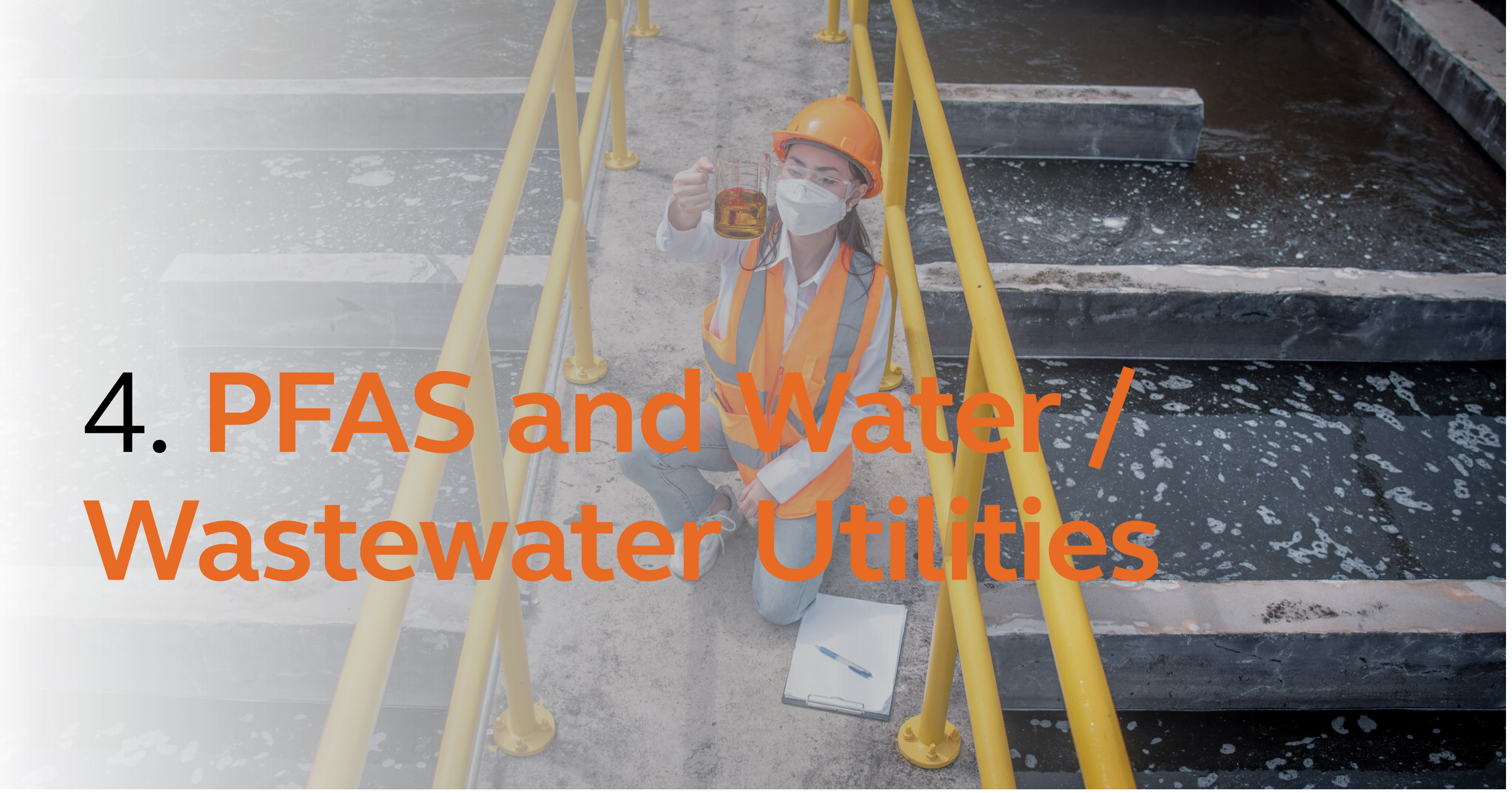
Soil stabilization provides an advantage of treatment in place as opposed to ex situ technologies which require waste handling and off-site disposal coordination. For in situ soil stabilization, adsorbents or complexing agents are mixed into saturated soil to reduce and/or eliminate PFAS migration through both chemical fixation and permeability from the source zones. Arcadis demonstrated in-situ soil stabilization with both Fluoro-Sorb (FS) and RemBind (RB) resulted in a >99% decrease in total PFAS leachability (mass basis; >98% mole basis) as confirmed by the total oxidizable precursor assay.

Reactive caps for in-situ sequestration of PFAS in contaminated sediments

Reactive caps are permeable beds with the reactive media incorporated into a flow-through matrix emplaced over near-shore or bedded contaminated sediments. Depending on the site conditions, reactive caps are constructed in situ by emplacing a mixture of sand and amendments in deep water bodies or by emplacing in shallow water bodies pre-constructed mats or liners that are comprised of reactive media sandwiched between layers of geotextile fabric. The reactive media can be varied depending on the contaminant being removed. The use of reactive caps with sorbents specific to PFAS for treating contaminated sediments and porewater has not been widely demonstrated. For implementation, the cap is constructed over the sediment bed to stabilize and physically and chemically isolate contaminated sediments from overlying water column. A protective cover or armoring of riprap is installed atop the chemical isolation layer in the cap to counteract natural forces. The permeability of the reactive caps is such that water passes through freely, while dissolved phase constituents sorb to the reactive media within the cap. The dosing of reactive media is such that a cap can remain effective for decades. Given the finite sorption capacity of amendment in the reactive caps, they are often implemented in a treatment train, including upland source control approaches, to passively treat residual contaminant mass being discharged to sediments and surface water for cost-effective site management.

As PFAS regulations become increasingly more stringent and new discharge limits are being set for National Pollutant Discharge Elimination System (NPDES) and other discharge permits, the curtailment of PFAS mass-flux across the sediment-water interface becomes essential to inform decisions around passive in-situ management of impacted sediments.

The reactive capping approach holds much potential to significantly benefits sites in preventing exposure risks, curtailing offsite migration, and reducing liabilities and costs, thereby protecting surface water quality. Based on low capital and operational costs, this passive in situ technology offers significantly reduced life-cycle costs over sediment dredging and disposal, and surface water treatment alternatives. Scaled up across the portfolio of sites, this could result in substantial cost savings, while enabling more sustainable management of liabilities.



4. PFAS and Water / Wastewater Utilities

Some water utilities are finding PFAS in their source water supplies, but many do not have treatment processes that will remove these compounds.

In April 2024, the USEPA finalized the National Primary Drinking Water Regulation (NPDWR) for six PFAS in drinking water, including stringent limits on PFOA and PFOS at 4 ng/L, a threshold lower than any current state standards. The finalized rule also outlines requirements for systems to conduct compliance monitoring and abide by public notification requirements. Pubic water systems will have 3 years (2027) to complete initial monitoring and 5 years (2029) to implement treatment solutions that reduce PFAS concentrations. Utilities are taking action to stay below this level, including treatment, blending, and/or removing impacted sources from service.

Background water quality characteristics of each location are unique, and the Arcadis Team will leverage their local and global experience to find the right solution for each client. A variety of criteria will influence the suitability of the candidate treatment techniques, including effectiveness for removing the specific target PFAS, finished water targets for meeting PFAS MCLs, capital and operating costs, other water quality benefits, and potential drawbacks or challenges (e.g. residual solids disposal). PFAS treatment alternatives include the integration of new treatment processes or modification of existing treatment processes to align with the PFAS compliance strategy.

For those with positive detections, the next step involves additional monitoring to understand how PFAS levels vary in their supply wells or intake locations throughout the day and year. This understanding of PFAS variability is crucial for designing effective management and treatment strategies.

Build a foundation of data

With both the Fifth Unregulated Contaminant Monitoring Rule (UCMR 5) and the new NPWDR currently obligating PFAS sampling at public water systems around the country, demand for analytical services has increased both the cost and turnaround time associated with PFAS monitoring. However, for source water characterization, passive sampling can be a viable, low cost option. Arcadis developed the Sentinel™ Passive Sampler which reduces monitoring costs by decreasing sample collection time, sample volume and shipping costs. The small size of the Sentinel™ passive sampler further reduces sample shipping weight, which saves cost and reduces the carbon footprint.

Drinking water treatment

The most economical approach to achieving drinking water standards is through dilution and blending of different water sources, If possible. When treatment is required to remove PFAS from drinking water, it is usually done using GAC filtration and/or ion exchange (IX). GAC is effective at removing some PFAS, particularly the longer chained PFOS and PFOA. IX provides a method to address smaller chain PFAS and often serves as a polishing step post-GAC. 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.

Although reverse osmosis is also a designated best available technology (BAT) for PFAS treatment cost-effective management of the concentrate may be an obstacle. Many of the advanced treatments employed by industry and federal agencies for remediation are not currently feasible for municipal scale public water systems due to high cost, energy-intensive operation, and/or inability to accommodate large flows on the order of millions of gallons per day.

Wastewater considerations

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 will 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.

5. Federal PFAS Response - Americas

The U.S. Department of Defense (DOD) is striving to develop a systematic approach for managing PFAS across all of their 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 and selection of acceptable F3 foams that can safely meet the firefighting needs of the DOD and through on-going foam transition programs managed by the USACE.

The DOD is also active in investigating its active and inactive facilities worldwide. 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. Arcadis is also working with the Army, US Air Force, Army and Air National Guards in Phase I and II remedial investigations across the U.S.

Many branches of the DOD are systematically reviewing their portfolios, identifying and mitigating offsite risks as they move sites through 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 point of entry treatment systems (POETs), establishing new connections to unimpacted drinking water supplies and adding treatment to existing water treatment systems. Arcadis is supporting these efforts at multiple facilities across the US by testing, designing, and installing remedial measures to manage PFAS impacts and water treatment to mitigate drinking water impacts.

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).

6. 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 with the highest potential risk to human health and the environment and include sites that may be impacting drinking water and the great lakes. Until federal standards are in place, this risk-based approach will likely remain status quo.

Developing regulatory standards

Health Canada (HC), Canadian Council of Ministers of the Environment (CCME), and Environment and Climate Change Canada (ECCC) are federal agencies that currently provide guidelines, screening values, and/or objectives for select PFAS. Recently, HC and ECCC released a draft State of PFAS report and Risk Management Scope which provide a qualitative assessment of the fate, sources, occurrence, and potential impacts of PFAS on the environment and human health to inform decision-making on PFAS in Canada and propose risk management actions to protect Canadians and the environment.

Some provinces are forgoing federal guidance and putting their own regulations in place. British Columbia, Alberta, Ontario, and Atlantic Canada (New Brunswick, Newfoundland and Labrador, Nova Scotia, and Prince Edward Island) all have proposed or have implemented PFAS guidelines in one or more media (ground water, soil, sediment, surface water, or drinking water. Province-by-province policies, however, could create the same issues as with the state-by-state policy differences in the U.S.

Additionally, the Canadian Food Inspection Agency recently released a notice of an interim standard for PFAS in biosolids being sold or imported in Canada. The interim standard is the first of its kind in Canada and is expected to come into effect in late 2024, with a limit of 50 ppb for PFOS.

7. PFAS and Airports

PFAS-based firefighting foams were historically used in airport hangar fire suppression systems, on-site 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.

A dynamic regulatory environment has motivated foam users to transition from foams containing PFAS (C8/C6) AFFF to PFAS free firefighting formulations, now widely available and approved under Mil-Spec (MIL-PRF-32725).

Airports worldwide are beginning to replace PFAS-based foams with F3 foams. Transition plans include cleaning 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.

PFAS build-up on fire suppression system surfaces in contact with aqueous film forming foams (AFFF) containing C8/C6 PFAS to form water resistant layers in foam systems. Replacing existing AFFF in foam equipment and suppression systems requires removal of residual PFAS because these compounds can rebound into replacement PFAS free firefighting formulations causing risk of continued environmental liability.

Arcadis has developed and is using an effective biodegradable cleaning agent (Fluoro Fighter™) to remove PFAS buildup in fire suppression systems. Fluoro Fighter™ in conjunction with Arcadis' proven procedure for PFAS cleaning has demonstrated removal of PFAS by disrupting self-assembled layers on foam-wetted surfaces, minimizing PFAS impacts to fresh replacement F3 foams.

Working with large airports and the U.S. DOD, Arcadis developed a service model for the entire foam replacement and transition life cycle.

Key steps in the fire protection and foam life cycle

- Assessment of needs
- Advice on risk management of legacy foam issues, inventory and transition planning
- Cleaning 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
- Cleaning equipment and systems on site
- Foam treatment/disposal

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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.

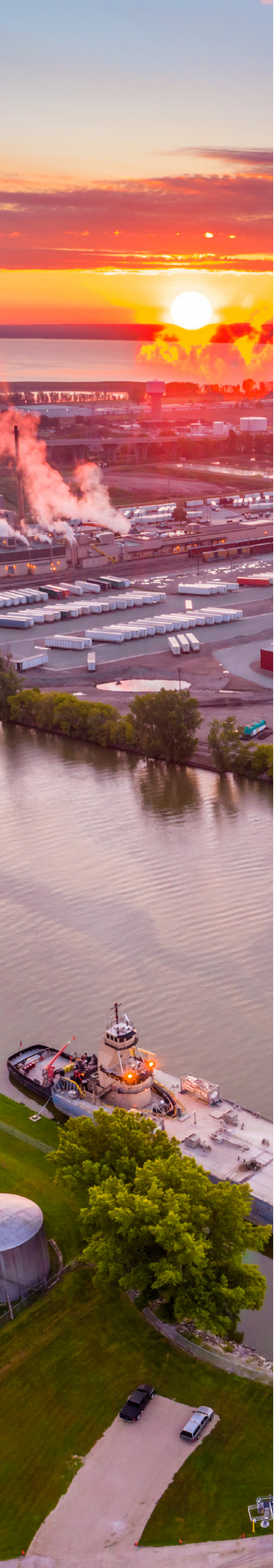
Remaining pragmatic.
Prioritize actions at sites most likely to impact drinking water supplies. Monitoring and implementing strategies that prevent PFAS from migrating to water supplies is the most prudent approach to managing these sensitive sites.

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. With deep 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.

Jeff Burdick
Global Leader Environmental Restoration

jeff.burdick@arcadis.com

Johnsie Lang, PhD
PFAS Analytical and Forensics Expert

johnsie.lang@arcadis.com

Allan Horneman, PhD
US PFAS Commercial Lead

allan.horneman@arcadis.com

Bryan Bailey, PE
PFAS Treatment Expert

bryan.bailey@arcadis.com

Rebecca Slabaugh
Drinking Water Practice Lead

rebecca.slabaugh@arcadis.com

Shannon Dunn, PG
Sediments Technical Expert

shannon.dunn@arcadis.com

Joseph Quinnan, PG
US Emerging Contaminants Growth Leader

joseph.quinnan@arcadis.com

Arcadis. Improving quality of life