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Energy and Sustainability | Sustainability Services

February 7, 2023
Industry Report

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"Forever Chemicals":

A Deep Dive Into the Evolving and Rapidly Growing PFAS Market

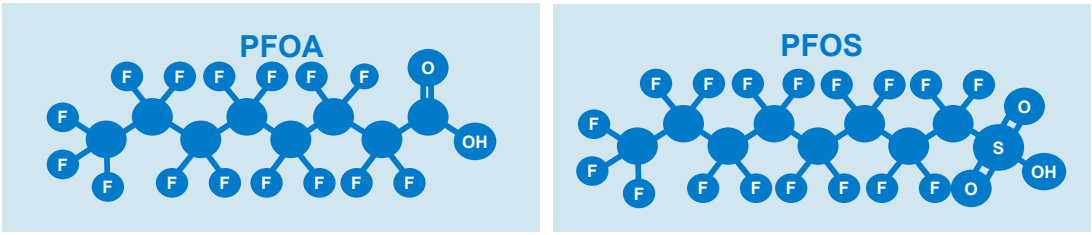
Contents

Introduction

Per- and polyfluoroalkyl substances (PFAS) are a family of more than 10,000 man-made compounds that are sometimes referred to as "*forever chemicals*" because they do not easily break down naturally in the environment. As a result, these chemicals have spread across the world and have built up over time in our water sources, our soil, and even within our bodies. Because PFAS have been linked to negative health outcomes, the response to this issue has been a steadily intensifying stream of public activism, media scrutiny, corporate litigation, government regulation, and investments in remediation and destruction solutions. It is becoming more commonplace to find local newspapers profiling PFAS contamination through front-page articles. Environmental activists have turned up the volume on the PFAS issue, forcing regulatory bodies and industry groups alike to act. In 2019, media focus on the issue even included the release of a box office movie starring Mark Ruffalo entitled *Dark Waters*.

PFAS resistance to degradation in the natural environment is due to the strong carbon-fluorine bonds found in every PFAS compound, which also imbues these chemicals with special properties that make them repellant to water and oil. Following their creation in the 1940s, PFAS quickly found a broad range of commercial use-cases, including: food packaging, rain gear, household items (makeup, paints, floss), stain resistant products (furniture, carpets, rugs), nonstick cooking products, fire-fighting foams, and fire-retardant clothing. The chemical structures for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), two of the most well-studied and prevalent PFAS compounds, are depicted in exhibit 1.

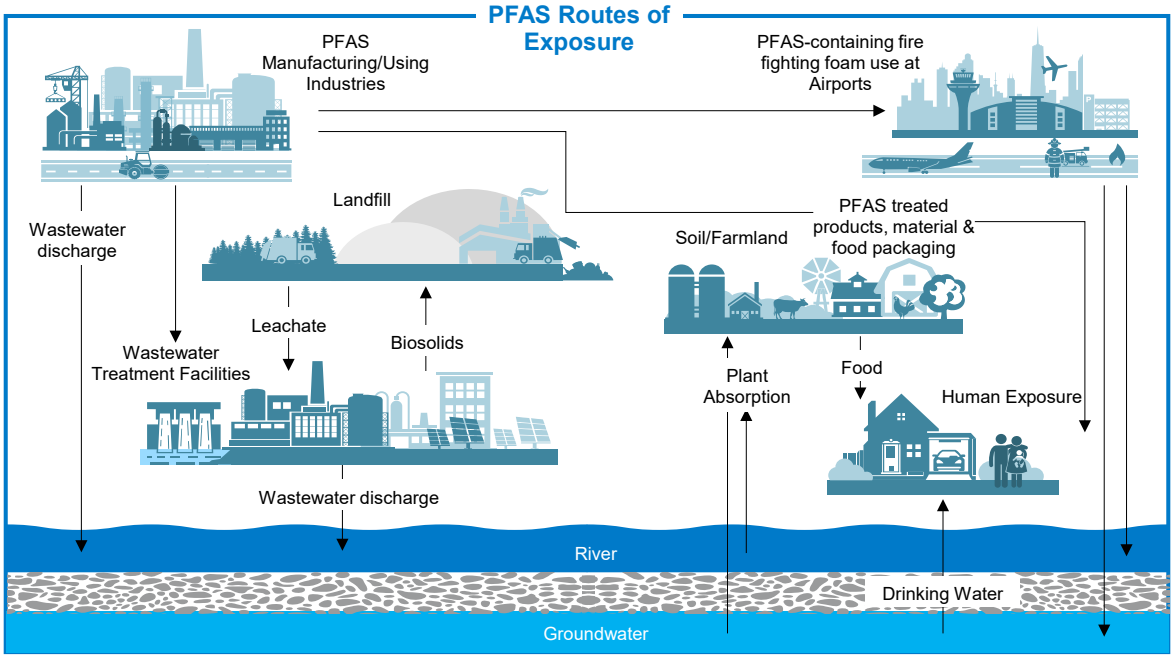
Exhibit 1
PFAS Report
PFOA/PFOS Chemical Structure



Note: F = Fluorine, O = Oxygen, OH = Hydroxide, S = Sulfur
Sources: William Blair Equity Research and American Water Works Association

Common pathways by which PFAS enter the natural environment include industrial and manufacturing effluent, run-off from usage of firefighting foams, and landfill leachate. Humans are exposed to these chemicals in a variety of ways, including (but not limited to) through drinking water, the consumption of contaminated fish and/or plants grown in PFAS-contaminated soil, and eating food wrapped in PFAS-containing packaging. Due to the fact that most water treatment facilities lack the sophistication to adequately extract PFAS from wastewater and groundwater, consumption of PFAS through contaminated drinking water is the most prevalent form of human exposure. In fact, the *Environmental Business Journal (EBJ)* estimates that over 14,000 publicly owned treatment works and water utilities have been contaminated by PFAS compounds.

Exhibit 2
PFAS Report
PFAS Routes of Exposure



Sources: William Blair Equity Research and McAlister GeoScience

Scientists continue to study the impacts that PFAS may have on human health. The research is ongoing because individual studies vary by groups of people, nature of exposure, and types of PFAS compounds. The Centers for Disease Control (CDC) has concluded that exposure may lead to a variety of negative health outcomes, including a greater risk for high cholesterol, kidney cancer, testicular cancer, liver damage, low birth weights, and damage to the immune system.

This report provides an overview of PFAS, the evolving regulatory environment and its implications on the PFAS market, the various technologies being used to remediate and eventually destroy PFAS compounds, and the emerging competitive environment in these nascent markets. The purpose of this report is to help investors understand how this market will unfold over the next several years, and to identify the key technologies and players that are best positioned to address this issue of growing importance.

As an executive summary, we expect the PFAS solutions market to grow exponentially over the next decade as growing bodies of research confirm the negative health effects associated with these chemicals. Through the patchwork of various state and federal regulations, we see two major near-term catalysts that would stimulate a step-function increase in demand for PFAS services and solutions (i.e., enforcing maximum contaminant levels and hazardous substance designations). This would affect activities associated with consulting, testing, remediation, and destruction of PFAS compounds. Although TAM estimates differ by source, we see some convergence around 57,000 locations with potential PFAS contamination. There are several types of remediation technologies at commercial scale today, each with its own set of pros and cons. We believe each will have a role to play depending on the use-case and customer preference, with some better suited for certain types of applications. The differing remediation and destruction technologies are highlighted in

this report, along with many of the current market leaders, which investors can use as a roadmap to better understand the competitive environment and various opportunities in this nascent growth market.

PFAS Contamination: Size and Scope

Background

Following their development in the 1940s, companies began using PFAS in a variety of manufacturing processes and commercial and consumer products. Voluntary corporate phaseout of certain PFAS compounds did not begin until the early 2000s. While these phaseout programs (primarily coordinated by the Environmental Protection Agency [EPA] domestically) have helped to curb further releases of PFOA and PFOS from upstream point sources, much damage has already been done, with varying degrees of regional contamination both domestically and globally. In fact, samples obtained from more than 2,000 participants in the National Health and Nutrition Examination Survey conducted in 2003 showed PFOA and PFOS (two of the most well-studied and prevalent PFAS compounds) in 99.7% and 99.9% of serum samples, respectively.

Testing over the last 20 years has shown a decline in the presence of PFOA and PFOS in human blood levels, as these compounds are no longer manufactured domestically. Nevertheless, complete phaseout of all PFAS compounds from manufacturing processes is still in progress, and while regulated, there is no current ban on the importation of PFAS compounds from foreign countries. Perhaps even more troubling is the fact that many corporations are increasingly replacing long-chain compounds (PFOA and PFOS) for new shorter-chain PFAS chemicals (e.g., PFHxA, PFHpA, PFBS, PFOSA, PFBA, GenX)—many of which have been minimally (if at all) regulated but share similar traits to legacy PFAS compounds, including a resistance to degradation in the natural environment.

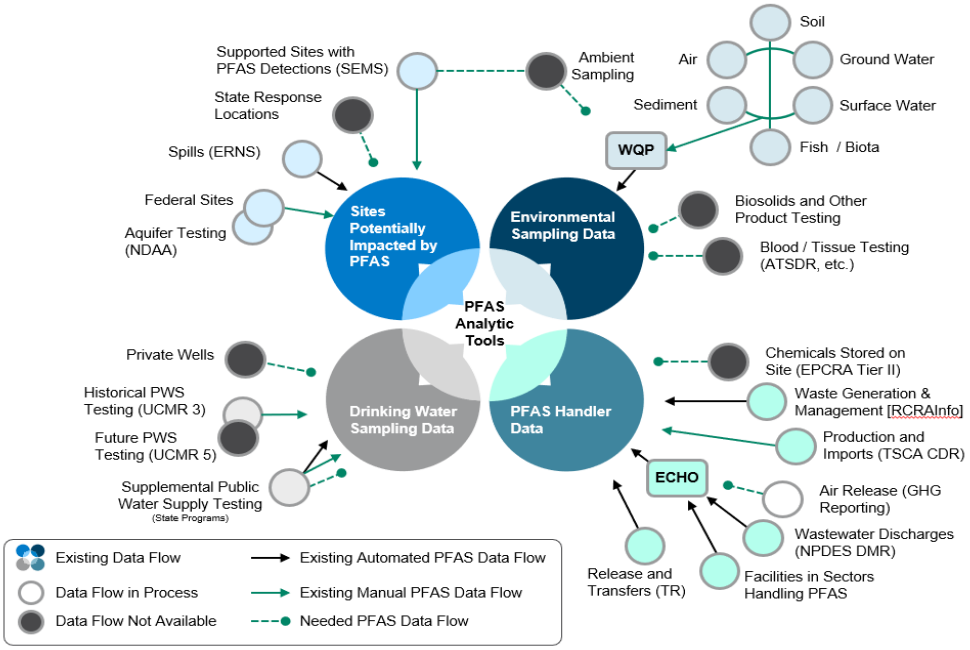
As will be discussed in depth in the sections to follow, the regulatory environment pertaining to PFAS (at both the federal and state level) is still very much in flux. While certain states have been more proactive in establishing and enforcing PFAS regulations, federal agencies have largely limited their actions to the establishment of non-enforceable guidelines and recommendations. More enforceable federal regulatory actions are likely to pass in the near to medium term, but the lack of overarching regulation at the federal level has led to inconsistent PFAS contamination reporting practices.

EPA Analysis

Given this incongruency in data reporting, determining the size and scope of the PFAS contamination issue is a challenging and ongoing discovery process. Nevertheless, in an effort to provide communities with the most accurate and up-to-date information related to PFAS reporting, testing, and occurrences across the country, the EPA has compiled the national PFAS data sets by integrating the most recent PFAS data collected at the national, state, tribal, and local level. On January 5, 2023, the EPA officially launched its PFAS Analytic Tools, which compiles and integrates the agency's PFAS data sets on a single platform.

PFAS are identified through the EPA's Computational Toxicology (CompTox) Chemicals Dashboard, which provides chemistry, toxicity, and exposure information for more than 1 million chemicals including data and models to assist in chemical identification. Exhibit 3 provides a depiction of the current sources of data being used to compile the EPA's national PFAS data sets and analytic tools. We provide a comprehensive review of these data sets in appendix C.

Exhibit 3
PFAS Report
Sources of National PFAS Data Sets

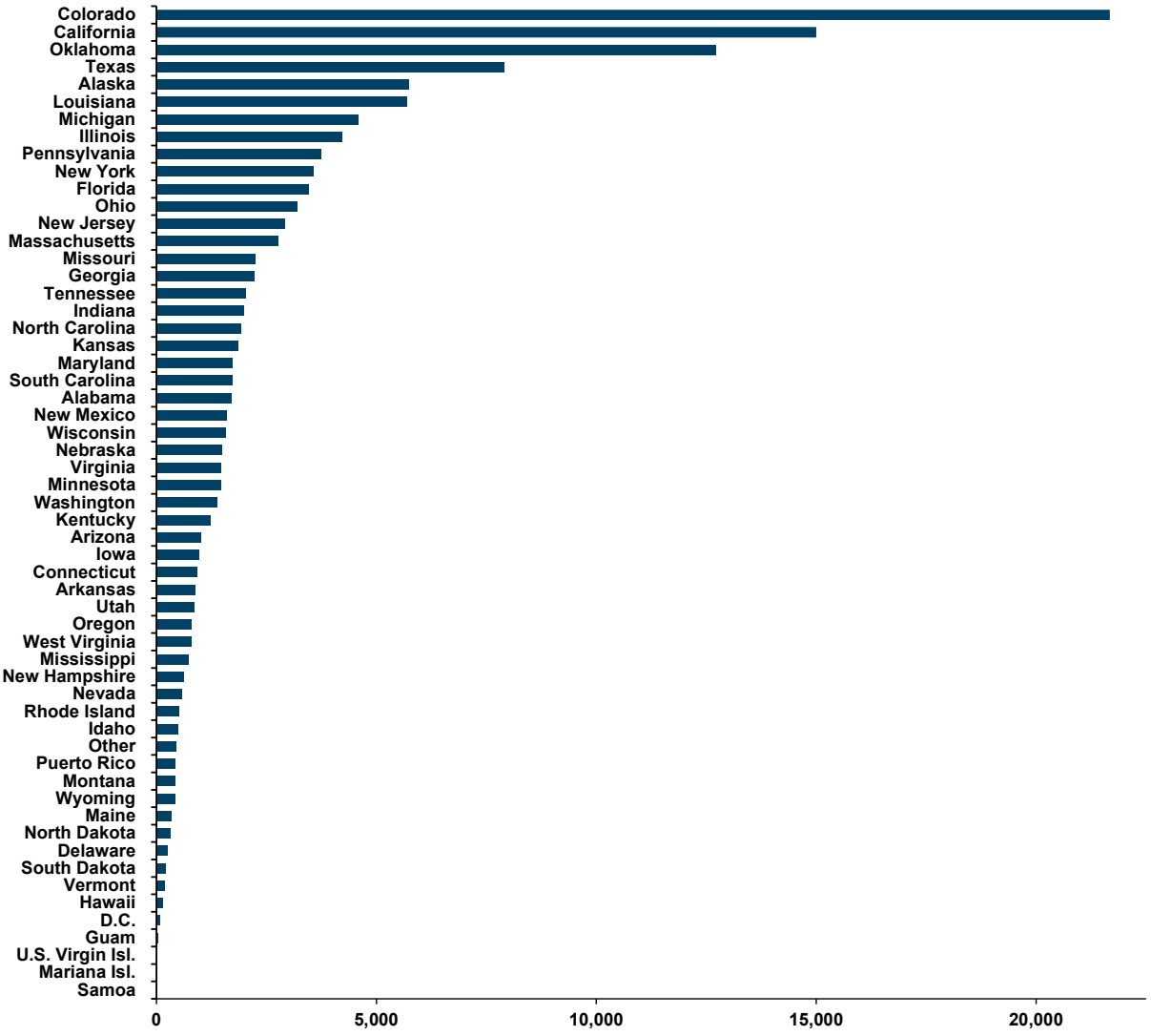


Sources: Environmental Protection Agency, Enforcement and Compliance History Online, and William Blair Equity Research

According to the EPA's latest PFAS data sets, there are *over 137,000 facilities across the United States* and its associated territories that may be handling, using, and/or releasing PFAS into the environment. This is well above prior numbers released by the Environmental Working Group (EWG), an activist nonprofit group focused on research and advocacy in several areas, including toxic chemicals and drinking water pollutants. EWG estimated contamination at 42,000 industrial and municipal locations as recently as October 2021, up from the 2,500 potential industrial discharge sites estimated in April 2020. It is important to note that the EPA has not confirmed the presence of PFAS contamination at these 137,000 locations but rather used various data sources, including Enforcement Compliance History Online (ECHO) and the Federal Aviation Administration's Airport Data and Information Portal, to identify facilities that *might* have handled, used, and/or released PFAS.

Based on EPA data, the state with the most facilities potentially handling, using, or releasing PFAS is Colorado with 21,676 sites, followed by California (15,000 sites) and Oklahoma (12,726 sites). In total, nearly 36% of all facilities that may be handling, using, or releasing PFAS are located in Colorado, California, or Oklahoma, according to the EPA.

Exhibit 4
PFAS Report
Facilities That "May Be Handling PFAS" by State/Territory

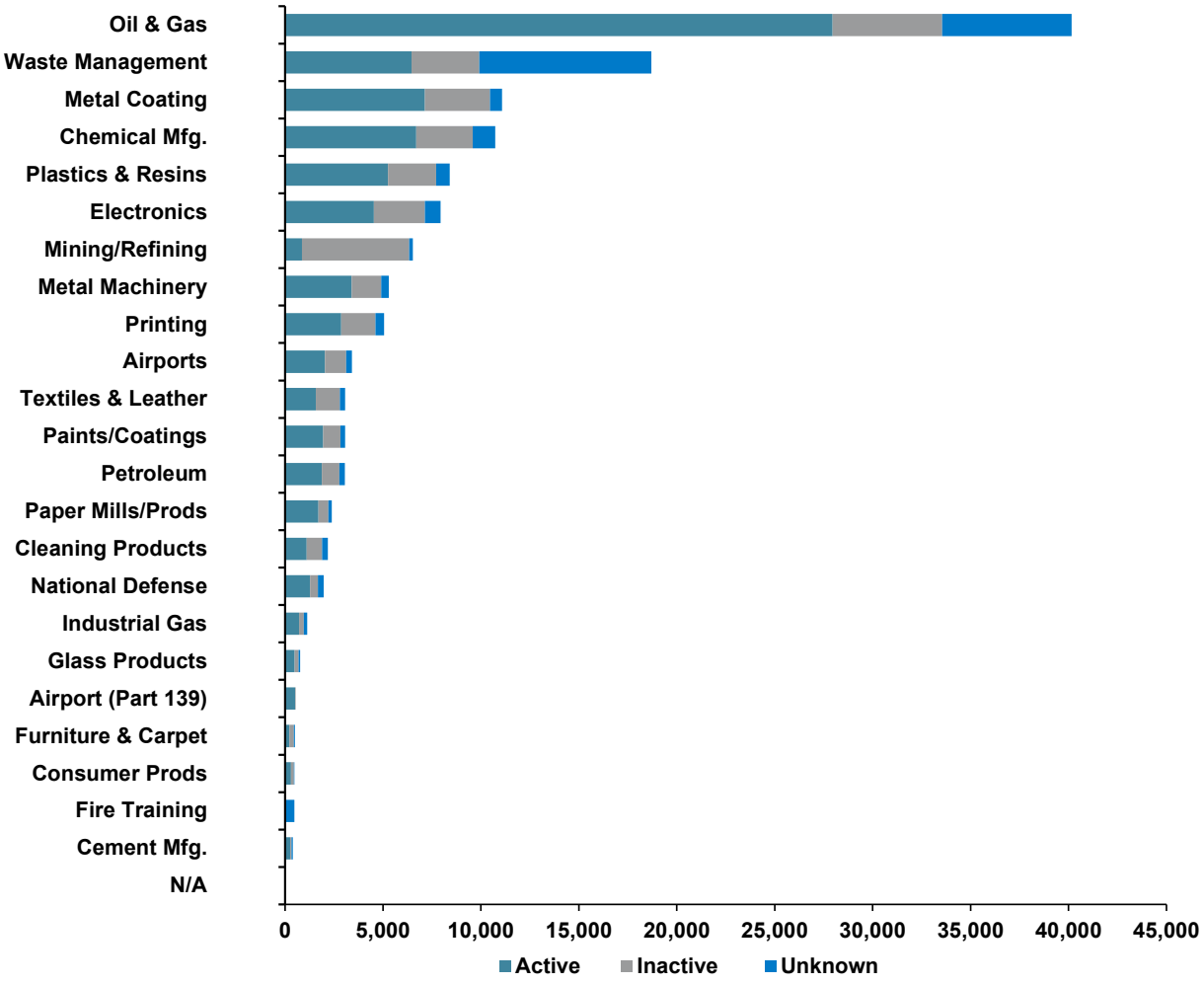


Notes:
1) This list includes facilities that "potentially" handle, use and/or release PFAS based on their respective industrial profile. EPA has not confirmed whether each individual facility on the list actually handles, uses, and/or releases PFAS.
2) Data current as of 1/8/2023.

Source: Environmental Protection Agency, Enforcement and Compliance History Online

The industry with the most facilities suspected of potentially handling, using, and/or releasing PFAS is oil and gas, with over 40,000 locations, followed by waste management (18,699 locations) and metal coating (11,070 locations).

Exhibit 5
PFAS Report
Facilities That "May Be Handling" PFAS by Industry



Notes:

1) This list includes facilities that "potentially" handle, use and/or release PFAS based on their respective industrial profile. EPA has not confirmed whether each individual facility on the list actually handles, uses, and/or releases PFAS.

2) Facilities can be counted in more than one industry.

3) Data current as of 1/8/2023.

Source: Environmental Protection Agency, Enforcement and Compliance History Online

Until the 21st century, commercial airports, military bases, and fire training facilities regularly used aqueous film-forming foams (or AFFFs) during operations on a day-to-day basis. AFFFs represent a significant source of PFAS pollution, and high concentrations of PFAS continue to be found in the soil, groundwater, and bodies of water surrounding these locations. The Department of Defense (DoD) is investigating over 700 military sites for suspected PFAS contamination. We explore the size and scope of military site contamination as well as ongoing remediation efforts and funding in the next section of this report.

Third-Party Analysis

Given the inherent uncertainty associated with the EPA's estimate for sites with PFAS contamination, other industry experts have attempted to size the extent of PFAS contamination in the United States. By compiling site count estimates sourced from various regulatory bodies (U.S. Census Bureau, EPA, ITRC, FAA, U.S. DOT), survey results, and feedback from remediation experts, the *EBJ's* "Working Model of Sites with PFAS Contamination" indicates that there are *over 57,000 sites with PFAS contamination.* Almost 25% of these estimated sites are public operating wastewater treatment works or water utilities. Greater than 15% of the locations are related to sites where PFAS are currently manufactured, that use PFAS in manufacturing processes, or likely have PFAS contamination through some other manufacturing-related activity.

Given the challenges associated with sizing the issue of PFAS contamination in the United States, it is worth noting that other groups have reached similar conclusions to the *EBJ* in terms of site count as it relates to PFAS contamination. In October 2022, the PFAS Project Lab at Northeastern University published a paper through the *Environmental Science & Technology Letters* scientific journal identifying *57,412 sites* with presumed PFAS contamination (49,145 industrial sites, 3,493 military sites, 4,255 wastewater treatment plants, and 519 large airports). The PFAS Project Lab continues to update its latest findings pertaining to known and presumptive PFAS contamination through an online interactive map. To date, the PFAS Project Lab has identified over 1,700 sites with known PFAS contamination. While providing concrete numbers around PFAS site contamination will remain a challenge until stricter measurement and testing regulations are implemented, we see general consensus for PFAS site contamination settling around 57,00 locations domestically.

Exhibit 6
PFAS Report
Summary of Estimated Sites With PFAS Contamination

Source	Site Estimate
EPA's PFAS Analytic Tools	As of January 8, 2023, the EPA estimates that there are ***137,282*** sites that "potentially" handle, use and/or release PFAS based on their respective industrial profile
EBJ's Working Model of Sites With PFAS Contamination	The EBJ working model (published in fall 2022) estimates that there are ***57,378*** sites with PFAS contamination
PFAS Project Lab's PFAS Contamination Site Database	The PFAS Project Lab has estimated that there are ***1,750*** sites with known PFAS contamination and ***57,412*** sites with suspected PFAS contamination

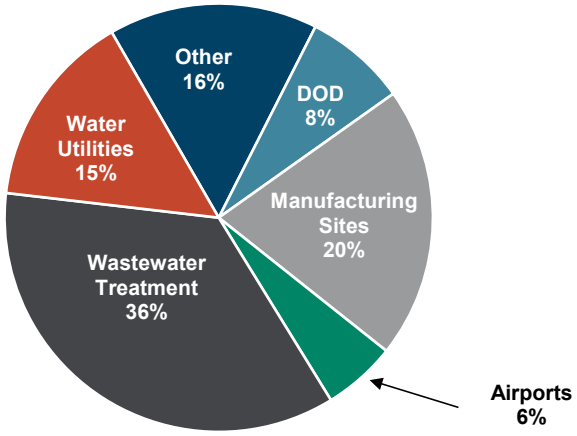
Sources: Environmental Protection Agency, *Environmental Business Journal,* PFAS Project Lab, *Environmental Science & Technology Letters*

Through a number of expert interviews with remediation professionals, the *EBJ* was also able to come to an estimate for average costs associated with remediation and necessary site upgrades based on site contamination. The model estimates that remediation costs and system upgrade costs will *each* total over $100 billion over the next 20 years.

According to the *EBJ's* working model, more than 50% of the $200 billion-plus costs associated with PFAS will be needed for system upgrades for wastewater treatment facilities as well as both rural and urban water utilities. Nearly 8% of all remediation costs will go toward DoD sites, including military bases that have historically and/or currently use AFFF. Other notable site categories that will require significant remediation costs include manufacturing sites (21%) and airports

(6%). Applying these percentages to the *EBJ's* $200 billion TAM estimate implies PFAS remediation expenditures of roughly $16 billion for DoD, $43 billion for private industry, and $12 billion for airports over the next 20 years.

Exhibit 7
PFAS Report
EBJ Working Model PFAS Cost Breakdown by Site Category



Source: *Environmental Business Journal*

Federal Regulation

While U.S. government institutions have been aware of the health risks associated with PFAS since before the turn of the 21st century, federal agencies have been slow to establish recommendations and regulations aimed at properly addressing PFAS contamination. These agencies have certainly lagged behind their counterparts on the state level regarding efforts to identify, regulate, and remediate PFAS in and around their respective communities. Nevertheless, the establishment of enforceable guidelines at the national level is a critical next step toward achieving national PFAS reduction goals.

Environmental Protection Agency

Recent efforts around PFAS regulation have taken more of a whole-government approach (FDA, DoD, CDC, etc.); however, most regulations related to PFAS at the federal level have historically been (and continue to be) promulgated by the EPA. In exhibit 8, we provide an overview of the most high-profile programs currently used by the EPA to regulate PFAS at the federal level.

Exhibit 8
PFAS Report
Federal Program Descriptions

Toxic Substances Control Act (TSCA)	The TSCA authorizes the EPA to require reporting, record keeping, testing, and restrictions of chemicals and chemical mixtures that may pose a risk to human health or the environment.
Safe Drinking Water Act (SDWA)	The SDWA is the federal law that protects public drinking water supplies throughout the nation. Under the SDWA, the EPA has authority to set enforceable maximum contaminant levels (MCLs) for specific chemicals and to require testing of public water supplies.
National Defense Authorization Act (NDAA)	Through the NDAA (which is enacted yearly), Congress mandates a number of actions that the DoD must comply with, some of them concerning PFAS. At the same time, separate PFAS-related requirements for the EPA or other federal entities are also made. These activities are not regulations or guidelines but are important for advancement of the government's PFAS-related initiatives.
PFAS Action Plan	The EPA's PFAS Action Plan describes the agency's approach to identifying and understanding PFAS and its approaches to addressing current PFAS contamination, preventing future contamination, and effectively communicating with the public about PFAS.
PFAS Strategic Roadmap	The EPA's strategic roadmap sets out a whole-agency approach to addressing PFAS including a timeline by which the agency plans to take specific policy actions to safeguard public health, protect the environment, and hold polluters accountable.
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)	Informally known as **Superfund**, CERCLA allows the EPA to clean up contaminated sites while forcing responsible contaminating parties to either perform cleanups or reimburse the government for EPA-led cleanup work.
Resources Conservation and Recovery Act (RCRA)	The RCRA is the public law that creates the framework for the proper management of hazardous and nonhazardous solid waste.
Clean Water Act (CWA)	The CWA gives the EPA authority to control water pollution by regulating discharges into the nation's surface water by setting wastewater standards for industry and requiring discharge monitoring, primarily through its NPDES permit program.
Toxics Release Inventory (TRI)	The TRI requires the annual reporting of environmental releases of approximately 800 chemicals that the EPA has concluded cause: 1) cancer or other chronic human health effects; 2) significant adverse acute human health effects; and/or 3) significant adverse environmental effects. For chemicals regulated under the TRI, facilities that manufacture, process, or use these chemicals in amounts above established levels must submit annual reporting forms for each chemical.
U.S. Food and Drug Administration (FDA)	The FDA is responsible for protecting the public health by ensuring the safety, efficacy, and security of human and veterinary drugs, biological products, and medical devices; and by ensuring the safety of the nation's food supply cosmetics, and products that emit radiation. The FDA currently regulates certain PFAS used in grease-proofing agents for food packaging via a Food Contact Notification Program.

Note: This list is not meant to be comprehensive but rather a compilation of the most noteworthy programs under which PFAS are regulated by the U.S. government at the federal level.
Sources: Environmental Protection Agency, Interstate Technology and Regulatory Council

The timeline in exhibit 9 outlines PFAS-related regulatory actions taken by the EPA and other federal agencies over the last two decades. The primary takeaway from this timeline is that a significant number of actions have been taken over the last two years. We believe that these actions are laying the groundwork for enforceable regulation, which would stimulate an increased need for PFAS testing and remediation in the coming years.

Exhibit 9
PFAS Report
PFAS Federal Regulatory Timeline

Date	Description	Program
Mar-02	EPA publishes a significant new use rule (SNUR) requiring notification before any future manufacture (or import) of 13 PFAS chemicals. Limited use of PFAS still allowed where no alternatives are readily available.	Toxic Substances Control Act
Jan-06	EPA invites 8 major PFAS industry companies to join the EPA's 2010/2015 PFOA Stewardship Program promoting the phaseout of PFOA.	Toxic Substances Control Act
Oct-07	Updated SNUR with 183 PFAS chemicals believed to no longer be manufactured (including imported) or used in the U.S.	Toxic Substances Control Act
May-12	UCMR 3 (2013-2015) is published allowing EPA to collect data on 6 PFAS compounds (PFOA, PFOS, PFBS, PFNA, PFHxS, and PFHpA).	Safe Drinking Water Act
Jan-15	Updated SNUR to require manufacturers (including importers) of PFOA and PFOA-related chemicals to notify EPA at least 90 days before starting or resuming new uses of these chemicals in any products.	Toxic Substances Control Act
Jan-16	FDA bans 3 perfluorinated compounds (PFCs) from use in food packaging material.	U.S. FDA
May-16	EPA establishes a combined, non-enforceable, health-based drinking water advisory of 70 parts per trillion (ppt) for PFOA and PFOS.	Safe Drinking Water Act
Nov-16	FDA amends food additive regulation no longer allowing the use of two remaining long-chain PFCs.	U.S. FDA
Jan-18	NDAA for fiscal 2018 mandating CDC and ATSDR study PFAS exposure and health implications in communities near current/former military bases with PFAS-contaminated water.	National Defense Authorization Act
May-18	PFAS listed as a topic for future investigation under Final 2016 Effluent Guidelines Program Plan.	Clean Water Act
Jan-19	NDAA for fiscal 2019 requiring DoD to: 1) assess contamination at DoD installations and identify remediation actions within 180 days after establishment of drinking water MCL advisory by EPA; and 2) conduct an assessment of health implications of PFAS exposure for armed forces representatives and veterans.	National Defense Authorization Act
Feb-19	EPA issues PFAS Action Plan, which (among other things) outlined a path to establish MCLs for PFOA and PFOS in drinking water.	PFAS Action Plan
Jan-20	NDAA for fiscal 2020 (among other items) required DoD to share PFAS monitoring and detection with municipalities and drinking water utilities adjacent to installations, provide blood testing for PFAS for all DoD firefighters during their annual physical exam, and ensure no water contaminated with PFOA or PFOS above EPA's 2016 MCL advisory is used for agricultural purposes.	National Defense Authorization Act
Feb-20	EPA provides update to PFAS Action Plan.	PFAS Action Plan
Feb-20	EPA adds 172 PFAS to the list of chemicals that must be reported under TRI program in accordance with NDAA 2020.	Toxic Release Inventory
Jan-21	NDAA for fiscal 2021 (among other items) mandates a survey of technologies to replace AFFF, establishes an interagency working group to coordinate federal PFAS R&D, and prohibits DoD purchase of certain PFOA or PFOS-containing items.	National Defense Authorization Act
Feb-21	EPA reproposes UCMR 5 for collection of new data on PFAS in drinking water and reissues final regulatory determinations for PFOA and PFOS.	Safe Drinking Water Act
Apr-21	EPA disqualifies PFAS chemicals for low volume exemptions (LVEs).	Toxic Substances Control Act
Apr-21	EPA issues final toxicity value for PFBS.	CERCLA (Superfund)
Aug-21	EPA publishes first draft of Method 1633—a CWA analytical method for testing PFAS compounds in wastewater and other environmental media. The latest version of this draft can detect up to 40 different PFAS compounds in wastewater, surface water, groundwater, soil, biosolids, sediment, landfill leachate, and fish tissue. While recommended, use of Method 1633 is not yet final but, once formally adopted, could drive material action from industrial manufacturers related to PFAS cleanup. The final version of Method 1633 is expected to be published in 2023.	Clean Water Act

Notes:

1) This timeline is not meant to be a comprehensive list but rather a compilation of the most noteworthy PFAS-related regulatory actions taken by the federal government over the last two decades.
2) Additional agencies who have played a role in PFAS-related research and policy initiatives include the CDC's National Health and Nutrition Examination Survey program, the Department of Health and Human Services' Agency for Toxic Substances and Disease Registry, the U.S. Geological Survey, the Strategic Environmental Research and Development Program, and the DoD's environmental, resilience, and installation energy and water technology demonstration and validation program.
3) Embedded links direct to source materials/press releases.

Sources: Environmental Protection Agency, Interstate Technology and Regulatory Council, Federal Register, U.S. Department of Defense, Congress.gov, Regulations.gov

Exhibit 9 (Cont.)
PFAS Report
PFAS Federal Regulatory Timeline

Date	Description	Program
Sep-21	EPA publishes Preliminary Effluent Guidelines Program Plan 15 noting plans to begin a rule-making process to set wastewater discharge limits for PFAS manufacturers, PFAS feedstock businesses that use PFAS to formulate other products, and metal finishing companies. Further research will be conducted to determine if rulemaking is warranted for other industry categories including commercial airports, textile and carpet manufacturers, pulp/paper/cardboard facilities, and landfills.	Clean Water Act
Oct-21	EPA publishes PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024 with a focus on addressing PFAS through research, restriction, and remediation.	PFAS Strategic Roadmap
Oct-21	EPA issues final toxicity assessment for GenX chemicals—a member of the PFAS family of compounds.	CERCLA (Superfund)
Oct-21	In response to a petition from the New Mexico governor, EPA initiates the process to add 4 PFAS (PFOA, PFOS, PFBS, and GenX) as RCRA hazardous constituents and commits to a rule-making effort to clarify that RCRA has authority to require cleanup of wastes that meet the definition of hazardous waste.	Resources Conservation and Recovery Act
Dec-21	EPA publishes UCMR 5, which requires sample collection for 30 chemical contaminants between 2023 and 2025, including new data on frequency and degree to which 29 PFAS are found in the nation's drinking water systems.	Safe Drinking Water Act
Jan-22	NDAA for fiscal 2022 (among other items) included a temporary moratorium on incineration of AFFF generated by DoD.	National Defense Authorization Act
Apr-22	EPA publishes Final Strategic Plan for fiscal 2022-2026 addressing PFAS through 4 strategic goals including: 1) enforce environmental laws and ensure compliance; 2) ensure clean and healthy air for all communities; 3) ensure clean and safe water for all communities; and 4) safeguard and revitalize communities.	PFAS Strategic Roadmap
Apr-22	EPA proposes to regulate PFAS under the CWA's aquatic life criteria, allowing regulators to reduce PFAS at the source and measure for absorbable organic chlorine in water samples.	Clean Water Act
Jun-22	Through the bipartisan Infrastructure Investment and Jobs Act (IIJA), EPA announces $1 billion in grant funding for disadvantaged communities for the purpose of removing PFAS and other emerging contaminants from drinking water. This grant represents only a portion of the $10 billion earmarked for water remediation under IIJA.	PFAS Strategic Roadmap
Jun-22	EPA reissues interim health advisories for PFOA and PFOS at 0.004 ppt and 0.02 ppt, respectively (replacing the 2016 advisory of 70 ppt), and establishes final health advisories for PFBS (2000 ppt) and GenX (10 ppt) chemicals.	Safe Drinking Water Act
Jul-22	House passes NDAA for fiscal 2023, which includes several amendments aimed at limiting PFAS contamination (e.g., testing for PFAS in school drinking water, publishing EPA's water quality criteria).	National Defense Authorization Act
Aug-22	EPA proposes designating PFOA and PFOS as hazardous substances under CERCLA.	CERCLA (Superfund)
Nov-22	EPA releases prepublication version of CCL5 containing 66 chemicals, 12 microbes, and 3 chemical groups (including PFAS). The revised CCL significantly expands the definition of PFAS and potentially implicates thousands of individual PFAS chemicals for future regulation under SDWA.	Safe Drinking Water Act
Dec-22	EPA proposes to close elimination of "de minimus" exemption for PFAS by adding them to the list of "chemicals of special concern."	Toxics Release Inventory
Dec-22	The Biden administration passes NDAA for fiscal 2023 following its approval by the Senate, which includes $1.2 billion in funding to support contaminated site cleanup efforts and $11 million for research related to PFAS.	National Defense Authorization Act
Jan-23	EPA proposes to establish a National Enforcement and Compliance Initiative (NECI) to address PFAS contamination.	CERCLA (Superfund)
Jan-23	9 additional PFAS compounds are automatically added to the TRI for reporting year 2023 under the framework of NDAA 2020	National Defense Authorization Act
Jan-23	EPA releases Effluent Guidelines Program Plan 15 (Plan 15), further restricting PFAS discharges from industrial sources through a multifaceted Effluent Limitations Guidelines (ELG) program.	Clean Water Act
Jan-23	EPA proposes a SNUR for "inactive" PFAS, or PFAS that have not been manufactured, imported, or processed since June 21, 2006. Industry required to notify EPA at least 90 days prior to beginning manufacture, import, and/or process of inactive PFAS.	Toxic Substances Control Act

Notes:
1) This timeline is not meant to be a comprehensive list but rather a compilation of the most noteworthy PFAS-related regulatory actions taken by the federal government over the last two decades.
2) Additional agencies who have played a role in PFAS-related research and policy initiatives include the CDC's National Health and Nutrition Examination Survey program, the Department of Health and Human Services' Agency for Toxic Substances and Disease Registry, the U.S. Geological Survey, the Strategic Environmental Research and Development Program, and the DoD's environmental, resilience, and installation energy and water technology demonstration and validation program.
3) Embedded links direct to source materials/press releases.
Sources: Environmental Protection Agency, Interstate Technology and Regulatory Council, Federal Register, U.S. Department of Defense, Congress.gov, Regulations.gov

With the emergence of PFAS as a contaminant of concern in the early 2000s, initial response from the EPA largely focused on limiting further contamination by helping upstream PFAS manufacturers to phase out their use of legacy PFAS compounds (e.g., PFOA). From 2010 to 2019, the agency's focus shifted toward establishing guidelines and policies related to PFAS monitoring and testing and the establishment of non-enforceable, health-based drinking water advisory levels.

In February 2019, the EPA released its PFAS Action Plan, laying out the agency's primary short- and long-term goals related to addressing PFAS contamination across the United States. With the transition of executive responsibilities from the Trump administration to the Biden administration in 2021 came a reinvigorated wave of PFAS-related action taken by the EPA. Building on its PFAS Action Plan, the EPA published a PFAS Strategic Roadmap, providing a more detailed and comprehensive outline of the agency's approach, goals, and objectives, and key actions as it aims to address the ubiquitous presence of PFAS contamination across the United States.

Exhibit 10
PFAS Report
PFAS Strategic Roadmap: Goals and Objectives

Research	
Goal	**Objectives**
Invest in research, development, and innovation to increase understanding of PFAS exposures and toxicities, human health and ecological effects, and effective interventions that incorporate the best available science.	• Build evidence based on individual PFAS and define PFAS categories to establish toxicity values and methods • Increase scientific understanding of the PFAS universe, sources of environmental contamination, exposure pathways, and human health & ecological effects • Expand research on current and emerging PFAS treatment, remediation, destruction, disposal, and control technologies • Conduct research to understand how PFAS contribute to the cumulative burden of pollution in communities with environmental justice concerns
Restrict	
Goal	**Objectives**
Pursue a comprehensive approach to proactively prevent PFAS from entering air, land, and water levels that can adversely impact human health and the environment.	• Use and harmonize actions under all available statutory authorities to control and prevent PFAS contamination and minimize exposure to PFAS during consumer and industrial uses • Place responsibility for limiting exposures and addressing hazards of PFAS on manufacturers, processors, distributors, importers, industrial and other significant users, dischargers, and treatment and disposal facilities • Establish voluntary programs to reduce PFAS use and release • Prevent or minimize PFAS discharges and emissions in all communities, regardless of income, race, or language barriers
Remediate	
Goal	**Objectives**
Broaden and accelerate the cleanup of PFAS contamination to protect human health and ecological systems.	• Harmonize actions under all available statutory authorities to address PFAS contamination to protect people, communities, and the environment • Maximize responsible party performance and funding for investigations and cleanup of PFAS contamination • Help ensure that communities impacted by PFAS receive resources and assistance to address contamination, regardless of income, race, or language barriers • Accelerate the deployment of treatment, remediation, destruction, disposal, and mitigation technologies for PFAS, and ensure that disposal and destruction activities do not create new pollution problems in communities with environmental justice concerns

Source: Environmental Protection Agency

The EPA has been steadily executing against this roadmap in recent months. While a number of key actions outlined by the EPA in its Strategic Roadmap will take several years to execute, we highlight that the agency is currently pursuing two PFAS-related initiatives that would have a significant impact on the market for PFAS services (e.g., consulting, testing, remediation, and destruction).

Following the release of interim health advisories for both PFOA and PFOS in June 2022, the EPA is now developing *a proposed rule to establish a national primary drinking water regulation for PFOA and PFOS*. We believe this proposal is imminent as it was originally expected to be released by the end of 2022, with the final rule expected by the end of 2023. Once finalized, this regulation would allow the EPA to set enforceable maximum contaminant levels (MCLs) for the nation's drinking water supply.

Second, the EPA expects to *publish a final rule designating PFOA and PFOS as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (aka CERCLA or Superfund)* by the summer of 2023. With these chemicals designated as hazardous substances under Superfund, reporting requirements would significantly increase for industry participants who have been involved with PFOA and PFOS over their operating history. In addition, those parties responsible for PFAS contamination would be required to compensate affected parties and bear proportional remediation costs.

While most industry experts recognize the significance of these proposals and the massive implications their adoption would bring for industry participants and PFAS service providers alike, it is difficult to find strong conviction in the timing of regulatory action. Nevertheless, we believe designation of PFAS as a hazardous substance under CERCLA and the establishment of MCLs for PFOA and PFOS remain on track for completion before the end of 2023. We note that the likelihood of a hazardous substance designation under CERCLA for PFAS is further strengthened following the EPA's recent action on January 12, 2023, proposing to establish a National Enforcement and Compliance Initiative (NECI) related to PFAS. Developed every four years, NECIs are enacted to address serious and widespread environmental issues by holding responsible parties accountable for their pollution.

Department of Defense

Many legacy manufacturers and consumer-product companies that have used PFAS compounds in their industrial processes have hesitated to take significant steps toward PFAS remediation until more regulatory clarity at the federal level emerges. Conversely, the DoD has taken proactive steps to investigate hundreds of military bases suspected or confirmed of having PFAS contamination related to AFFF usage and to implement remediation measures as needed. Since the 1960s, the DoD has used AFFF in various firefighting actions and training exercises.

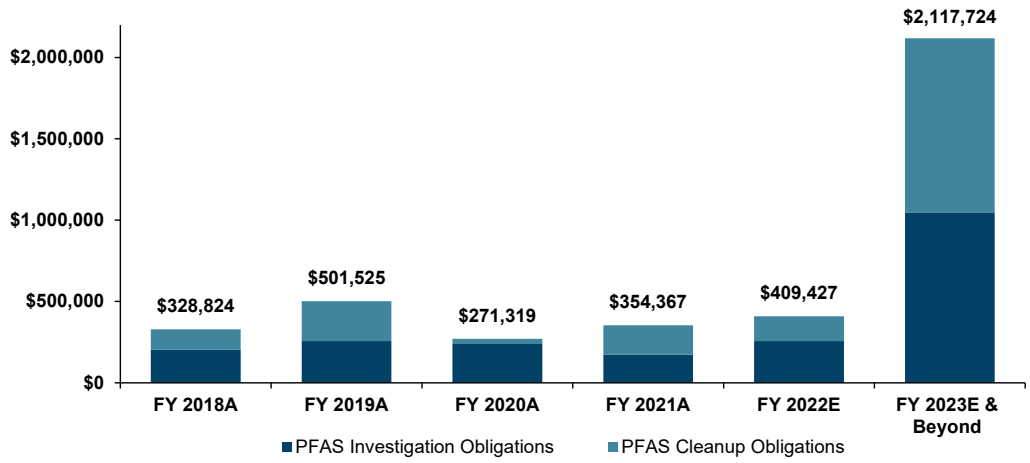
While phaseout of AFFF is well underway, the DoD has estimated that there are over 700 military sites that are known to have (or are suspected of having) released PFAS chemicals into the environment. Through water sampling and lab tests, the EWG has identified levels of PFOA and PFOS contamination in the groundwater surrounding 266 of these locations that are above those of current EPA health advisories.

Protecting active military members and their families living on (or near) military bases with PFAS contamination has been identified as a critical issue for the DoD. As a result, the department is increasingly taking steps to fund PFAS testing, research, and remediation efforts through its annual budget, the National Defense Authorization Act (NDAA). In the DoD's fiscal year 2022 NDAA, $560 million in funding was allocated toward PFAS remediation, research, and training to prevent toxic AFFF contamination. In addition, the 2022 NDAA: 1) created a PFAS Task Force assigned with finding a firefighting solution that does not risk PFAS contamination, 2) extended funding to health-based research as it pertains to PFAS in drinking water, and 3) established stricter regulations around PFAS removal and destruction.

In compliance with requests by both the House and Senate Committees on Appropriations, the Defense Department submits intermittent updates to Congress outlining costs pertaining to the investigation and cleanup of DoD sites, including those contaminated with PFAS. As of the DoD's most

recent report submitted in July 2022, the Defense Department dedicated $1.46 billion to PFAS releases through fiscal 2021. The DoD also estimated its PFAS obligation would total $409.4 million in fiscal 2022 and $2.12 billion thereafter. However, the DoD expects these estimates to increase over time as more information is gathered around the magnitude of cleanup needed.

Exhibit 11
PFAS Report
DoD Investigation and Cleanup Costs Related to PFAS-Contaminated Active Sites



Notes:
1) $ in thousands.
2) Investigation costs include but are not limited to site investigation work (e.g., preliminary assessments, site inspections, remedial investigations) and monitoring.
3) Cleanup costs include but are not limited to site restoration; remedial action (e.g., supplying bottled water, installing granular activated carbon filters).
4) William Blair estimate for investigation obligations vs. cleanup obligations in FY 2022 and FY 2023 & Beyond.
Source: Department of Defense

In December 2022, Congress passed the fiscal year 2023 NDAA. This NDAA includes a number of PFAS-related provisions, including $1.2 billion in funding to support contaminated site clean-up efforts and $11 million for research related to PFAS. Several additional 2023 NDAA PFAS-related provisions are outlined in exhibit 12.

Exhibit 12
PFAS Report
2023 NDAA PFAS-Related Provisions

Phase out purchase of PFAS-containing personal protective firefighting equipment
Instruct DoD to bestow prizes for the development of PFAS-free protective gear
Require DoD to publish regular updates about PFAS-related research
Provide $20 million for an ongoing study on the impact of PFAS on defense communities' health conducted by ATSDR
Require DoD to identify critical uses of PFAS and report on purchases of products without PFOA/PFOS

Source: Environmental Working Group

State Regulation

Given the uneven distribution of PFAS contamination across the United States, a significant amount of PFAS-related policy has emerged from the state level to protect local communities. We believe this growing body of work will drive increased awareness and additional funding at the national level as states look to federal agencies for guidance on this environmental issue.

As discussed previously, the federal government continues to ramp up its PFAS-related policy initiatives. Nevertheless, most states have already begun the process of establishing and implementing legislation that will work to reduce the amount of upstream and downstream PFAS contamination in their respective communities. In fact, Safer States, an organization comprising environmental health groups from across the United States that closely monitors PFAS-related state regulation, has identified over 150 PFAS-related policies (adopted or current) in 27 states that have taken or are in the process of taking regulatory action against PFAS. Over 100 of those bills have already been adopted across 23 states.

In exhibit 13, we provide a list of respective states that have taken or are in the process of taking action against PFAS contamination as it relates to water, food packaging, textiles, firefighting foam, cosmetics, and litigation. In appendix B of this report, we profile multiple states that have taken both legislative and nonlegislative PFAS-related action.

Exhibit 13
PFAS Report
State-Level PFAS Action

State	Action Items					
	Water	Food Packaging	Textiles	Firefighting Foam	Cosmetics	Litigation
Alaska	✓					✓
California	✓	✓	✓*	✓	✓	
Colorado	✓	✓	✓*	✓	✓	✓
Connecticut	✓	✓		✓		
Delaware	✓					✓*
Florida	✓					
Hawaii		✓		✓		
Illinois	✓			✓*		
Maine	✓*	✓	✓	✓		✓
Maryland	✓	✓	✓*	✓	✓	
Massachusetts	✓*					✓
Michigan	✓*					✓*
Minnesota	✓	✓				✓*
New Hampshire	✓*			✓		✓
New Jersey	✓*					✓
New Mexico	✓					✓
New York	✓*	✓	✓*	✓*		✓
North Carolina	✓					✓
Ohio	✓					✓
Oregon	✓					
Pennsylvania	✓*					
Rhode Island	✓*	✓				
Vermont	✓*	✓	✓*	✓		✓
Virginia	✓					
Washington	✓	✓	✓*	✓		
Wisconsin						✓

Key

✓ = regulating PFAS chemicals in drinking water and/or taking action to expand PFAS monitoring

✓* = adopted enforceable standards or a MCL for PFAS chemicals in drinking water

✓ = taking action to eliminate PFAS in food packaging

✓ = taking action to eliminate PFAS in carpets, rugs, textile furnishings, upholstered furniture, fabric treatments and/or other textiles

✓* = taking action to eliminate PFAS from and/or require disclosure of PFAS in firefighting personal clothing and equipment

✓ = taking action through legislation and regulation to ban the use of PFAS based firefighting foam, and/or creating take back programs for already purchased foam

✓* = banning incineration of AFFF

✓ = taking action to eliminate PFAS chemicals in cosmetics

✓ = suing PFAS manufacturers, firefighting foam producers, polluting companies, and the Department of Defense over contamination

✓* = settled lawsuit

Source: Safer States

Corporate Litigation and Liability Update

PFAS compounds were first synthesized in the 1940s by scientists at the Minnesota Mining and Manufacturing Company—better known as 3M. The newfound method of bonding carbon to fluorine atoms resulted in the creation of PFOA and (shortly thereafter) PFOS. Not long after patenting its methodology for manufacturing fluorine-based compounds, 3M entered a multidecade contract to sell PFOA to E.I. du Pont de Nemours and Co. (known today as DuPont de Nemours), which subsequently used the compounds to create Teflon™-containing products including cookware, paint, and apparel. 3M also used PFOS in the manufacturing of its own products, such as Scotchgard™ fabric protector and aqueous film-forming foam (AFFF), which 3M provided to the U.S. military for decades.

The release of internal documents associated with lawsuits filed against these two companies provided evidence that 3M and DuPont were potentially aware of the possible health concerns associated with PFAS prior to the EPA being alerted of their risks in 1998. By 1962, DuPont had conducted in-house research showing PFOA exposure was linked to the enlargement of certain organs in rodents. According to an internally released timeline, it appears that 3M was aware of the presence of fluorochemicals in blood samples of certain employees by 1976. By 2001, 3M had discovered a positive association between levels of PFOA in employee serum samples and cholesterol and triglycerides levels, two compounds that are known to increase the risk of heart disease.

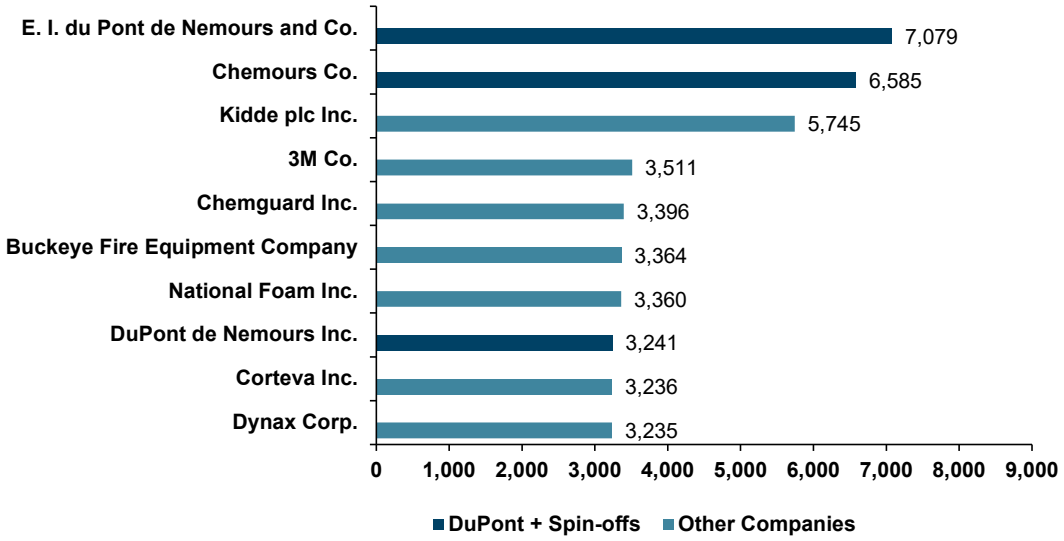
Throughout the late 1990s and early 2000s, additional information on the potential hazards of PFAS exposure continued to surface. In response, plaintiffs (many of whom lived close to plants that manufactured and/or handled PFAS) filed suit against large corporations like DuPont and 3M demanding reparations related to PFAS contamination.

While only 41 PFAS-related cases were filed between 2005 and 2011, case count increased drastically through the 2010s. The vast majority of PFAS-related claims were initially brought against DuPont, primarily stemming from a multidistrict litigation (MDL) in connection with the company's Washington Works manufacturing plant in Parkersburg, West Virginia—made infamous in the critically acclaimed films *Dark Waters* (2019) and *The Devil We Know* (2018). Coined the "Parkersburg Litigation," this class action lawsuit was viewed as a landmark case setting the scene for future PFAS litigation.

Based on an analysis by Bloomberg Law conducted in the spring of 2022, E.I. du Pont de Nemours was listed as a defendant in more than 6,100 of 6,400-plus PFAS-related lawsuits filed between July 2005 and March 2022. It was not until the late 2010s when litigation related to PFAS-containing AFFF began to ramp up that several other large chemical manufacturers found themselves as defendants in PFAS-related claims. As of the time of its review in the spring of 2022, Bloomberg Law noted that several other companies, including 3M, National Foam, Dynax Corporation, Kidde-Fenwal, and Chemguard, were being sued at close to the same rate as DuPont.

While difficult to quantify exactly how much has been paid out in PFAS-related litigation and liability (given the number of settled cases subject to nondisclosure agreements), we estimate that more than $3.0 billion has been paid out toward PFAS-related lawsuits, settlements, and clean-up efforts since 2004. Below, we outline the top 10 corporate defendants by PFAS-related case count according to Bloomberg Law's analysis of federal court dockets, dating from July 2005 to December 2022. There are many other companies that have faced litigious claims due to their historical involvement in manufacturing and/or using PFAS compounds. That list includes Honeywell, Linde, Tyco, Solvay, Arkema, Asahi, BASF, Clariant, and Daikin.

Exhibit 14
PFAS Report
Top 10 Corporate Defendants by Cumulative Case Count (July 2005-December 2022)



Note: Individuals and unnamed defendants are excluded in this visual
Source: Bloomberg Law

Despite massive payouts and a growing number of active cases, certain legacy manufacturers and industry groups have questioned the danger of toxicity levels for PFAS contamination. On 3M's PFAS*facts* webpage, the company claims that "… the weight of scientific evidence does not show that PFOS or PFOA cause harm to the environment or people at current or historical levels." To date, most experimental findings related to PFAS exposure have relied on animal testing, which presents unique challenges when attempting to make cross-species conclusions with humans. Furthermore, the Agency for Toxic Substances and Disease Registry (ATSDR) has determined that more work is needed to prove the causal relationship between PFAS exposure and harmful human health outcomes. Nevertheless, most companies continue to work toward complete phaseout of PFAS. This includes 3M, which in December 2022 announced its plan to spend $1.3 billion to $2.3 billion to cease global production of all PFAS compounds by the end of 2025.

Ringfencing future PFAS litigation and liability can be a challenging task given the extent to which future claims will largely depend on federal regulation, which is still in development. DuPont and its spinoffs—Chemours and Corteva—recently agreed to a cost-sharing program that binds the companies to share the burden for up to $4 billion in expenses related to PFAS over the next 20 years. Similarly, 3M has set aside $644 million in environmental liability reserves primarily to be used for environmental restoration costs associated with PFAS contamination. Importantly, these funds are intended for 3M manufacturing site remediation and do not include potential future costs associated with remediating surrounding communities impacted by PFAS contamination.

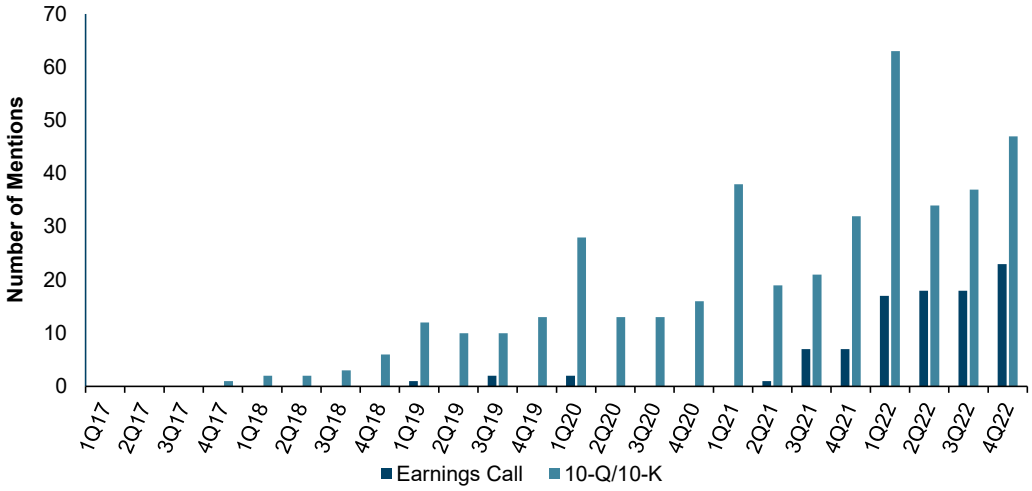
Given that the list of companies who use PFAS compounds in their own products is much longer than the list of companies who were and are responsible for initially manufacturing these chemicals, the number of parties who might ultimately shoulder the weight of both litigation and clean-up costs related to PFAS could grow over time. More recently, plaintiffs have increasingly begun to name companies who use PFAS in product manufacturing as plaintiffs in suits. The manner in

which the EPA designates PFOA and PFOS as hazardous substances under CERCLA (likely to be finalized in the coming months) will have important implications for how remediation and liability costs related to PFAS will be assigned.

We expect increased clarity around PFAS regulation over the next few years, along with additional PFAS-related toxicology research to drive more PFAS-related litigation in the years to come. We also anticipate that, beyond those lawsuits aimed at source manufacturers, legal claims may increasingly fall on downstream PFAS polluters, including consumer product companies, airports, and potentially even effluent sources such as wastewater treatment facilities.

Exhibit 15 displays the number of companies that have mentioned PFAS in an earnings call or 10-Q/10-K filing over the last six years. The number of unique mentions has risen significantly over the last few years, reflecting the growing awareness of health and litigation risk posed to manufacturers and users of PFAS compounds. What was once an obscure topic has quickly become a frequent and recurring issue that many managers and investors are contending with. We believe we are still on the cusp of wider investor awareness around this topic and expect significantly higher unique mentions to occur in the future as the impacts of PFAS exposure on businesses and customers permeate throughout the market.

Exhibit 15
PFAS Report
Unique PFAS Mentions

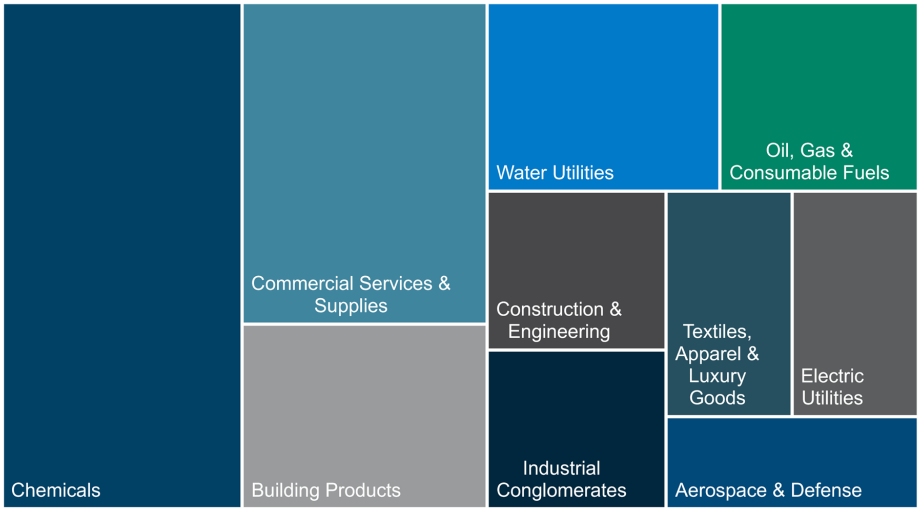


Notes:
1) Unique PFAS mentions include public earnings calls and 10-Q/10-K filings where "PFAS" or "polyfluoroalkyl" was mentioned one or more times.
2) Filings and earnings calls may occur in the quarter proceeding the financial period they cover. For instance, fourth-quarter earnings calls and associated filings would be captured in first-quarter analysis.

Source: Alpha Sense

Exhibit 16 displays the sector breakout weighted by the number of unique PFAS mentions. Notably, the largest grouping is for chemical companies and includes many of the large chemical producers previously discussed. It is understandable that chemical producers would be among the first and most frequent commentators of PFAS, given these companies have the financial and legal resources to recognize both the material and probable nature of their liability risk. We believe these companies are “canaries in the coal mine” for a broader recognition of PFAS liability risk across other sectors that have not yet had to address the implications of PFAS usage (such as the uniform rental or semiconductor industries).

Exhibit 16
PFAS Report
Top 10 Industries for Unique PFAS Mentions



Source: Alpha Sense

PFAS Remediation

As discussed previously, PFAS are highly resistant to degradation in the natural environment given the unique strength of the carbon-fluorine chemical bond structure. Biodegradability timescales range from dozens to hundreds to even thousands of years. Furthermore, once released, these compounds can be highly mobile, traveling hundreds of miles from the point of release or use. PFAS have been detected in various types of contaminated media around the world—even in locations as remote as Antarctica and the Tibetan plateau, where concentrations of PFOA are well above the most stringent regulations as a result of exposure to PFAS-contaminated rainwater, according to a study published in the Environmental Science & Technology journal in August 2022.

Below, we list several media sources that have been found to have PFAS contamination:

- Groundwater
- Surface water
- Rainwater
- Wastewater (industrial and municipal)
- Drinking water
- Landfill leachate
- Construction dewatering
- Biosolids
- Investigation-derived waste (IDW)
- Septage
- Soil
- Air

This list is by no means all-encompassing but provides a sense of the breadth of media in need of remedial action as it pertains to PFAS contamination. In many cases, the contamination of one media can be directly attributable to contamination of a different media. For instance, the contamination of drinking water is often a consequence of upstream PFAS contamination of groundwater from a point source. In cases like these, the most impactful and cost-effective remediation strategy likely involves some form of source control and remediation upstream as well as monitoring and treatment activity downstream at impacted drinking water wells. Efficient and effective remediation of the abovementioned (and various other) contaminated environmental media is a critical step in an ongoing effort to reduce the number of PFAS exposure pathways currently facing animals and humans.

In this section, we discuss various forms of PFAS remediation technologies. As outlined above, the spectrum of environmental media in need of PFAS remediation is extensive. While we recognize the importance of remedial technology that targets non-water-based vectors (e.g., soil washing), we believe the greatest near-term addressable market opportunity involves remediation of contaminated water. This section of the report focuses on remediation technologies that target water as the contaminated environmental media. This list is not meant to be comprehensive but rather to focus on some of the most prominent technologies and solutions.

Single-Use Ion-Exchange (IEX) Resins
Often used in the treatment of drinking water or groundwater, ion-exchange (IEX) resin technology capitalizes on the electrical charge of ions to remediate PFAS. IEX technology works by filtering PFAS-contaminated water through a matrix of polymer-based resin beads. As the contaminated water passes through the tank (or bed) of resins, PFAS ions show attraction to particular functional groups (or fixed ions) existing throughout the IEX resin matrix. Depending on polarity, the PFAS molecule will bind to either positively or negatively charged functional groups on the resin beads, resulting in a remediated water stream. Advantages of using IEX resins include effective remediation of various types of PFAS chemicals (including both short- and long-chain structures) and a relatively smaller environmental footprint versus other remediation technologies including granular activated carbon (discussed below). Drawbacks to single-use IEX resins include a higher relative upfront cost, reduced remediation efficiency at elevated chloride concentrations (e.g., PFBA, PFPeA, PFHxA), and the fact that resins cannot be regenerated for future use.

Regenerable IEX Resins
SORBIX™ RePURE regenerable IEX resins were patented in May 2019 by ECT2, a global environmental solutions provider focused on the removal of air and water contaminants. Following its acquisition of ECT2 in September 2019, Montrose Environmental became the owner of ECT2's patented regenerable resin technology.

Mechanically similar to the single-use IEX technology discussed above, this form of remediation technology benefits from two qualities that differentiate it from traditional IEX treatment. As the name suggests, these beads can be regenerated. Once the resins are used to extract PFAS from the contaminated water, they are cleaned on-site with a solvent-brine regenerant solution. While not chemically complex, this regeneration process is one proprietary element of the overall solution. Following regeneration of the resin beads, Montrose further distills the PFAS-laden waste stream to recover and reuse the vast majority of regenerant solution. Another proprietary process known as SuperLoading® is then used to further concentrate the PFAS into a solid waste. During the overall process, the PFAS waste stream is concentrated in SuperLoading tanks at a rate of up to 20 million to 1 (depending on PFAS concentration level) allowing for easy removal off-site.

These two traits of on-site regeneration and super loading allow ECT2's RePURE IEX resins to deliver effective PFAS-remediation in a more sustainable (reduction in overall waste volume) and cost-effective way (as measured by total costs, rather than just the upfront cost) when compared to other solutions. In addition, RePURE IEX resins can be paired with on-site destruction technology

to further reduce costs and mitigate the risk of future PFAS release and liability. Regenerable IEX resins have been shown to be most effective (i.e., superior breakthrough curves) in situations where there are: 1) high concentrations of PFAS, 2) multiple PFAS streams, and/or 3) short-chain PFAS compounds (e.g., GenX, PFBA, PFBS) that require removal.

Disadvantages associated with regenerable IEX resin technology include its higher upfront cost, power requirements associated with distillation, and limited practical applicability in situations where there are low levels of PFAS concentration across large bodies of water (e.g., drinking water treatment plants). Taking all of these advantages and limitations into account, we believe Montrose's regenerable IEX solution is best suited for customers with acute levels of PFAS concentration (e.g., military bases, airports, landfills, industrial sites), sites with a high degree of short-chain pollution, locations with multiple streams of contamination, and projects where sustainability and/or total systems cost are a focus.

Granular Activated Carbon

Granular activated carbon (GAC) is one of the most commonly used PFAS-remediation solutions and is frequently deployed to remediate drinking water that has been contaminated by other types of organic compounds. By introducing high surface area, low-volume, heated carbon to PFAS-contaminated water, GAC technology is able to adsorb the PFAS molecules, separating them from the contaminated water stream. GAC technology typically requires lower upfront costs (relative to many resin-based technologies) and can be effective in removing long-chain PFAS compounds (e.g., PFOA, PFOS) in lower concentrations. GAC is a long-standing technology that has proved to be an effective way to remove a variety of co-contaminants, including volatile and semi-volatile organic compounds and total petroleum hydrocarbons. When thinking about GAC technology, we offer investors the oversimplified example of a Brita water filter.

There are some limitations associated with GAC remediation. In certain applications where there are high concentrations of PFAS or multiple short-chain compounds, GAC technology has shown lower efficacy rates and/or breakthrough curves. In addition, GAC technology has a larger environmental footprint, given that the byproduct of GAC is a significant amount of "dirty" carbon that requires proper disposal. Furthermore, GAC technology requires longer contact times (relative to resin-based technologies), which requires larger vessels and a larger overall footprint. While it is possible for some forms of GAC to be regenerated, regenerated carbon is not typically used in drinking water applications and regeneration normally occurs off-site. While GAC technology has an important role to play in PFAS remediation, we believe it is better suited for situations where the volume of treatable water is greater but PFAS concentration is lower (e.g., municipal drinking water facilities) and where removal of short-chain PFAS is not required. In these cases, the carbon is not saturated as quickly, which reduces the disposal and media replacement costs. We believe GAC will be an important solution for PFAS removal over the next decade, given its status as a reliable and proven technology, and the large number of potentially applicable municipal wastewater treatment sites.

High-Pressure Membranes

While not as commonly used in the remediation of PFAS contaminants as some of the solutions mentioned above, high-pressure membranes can be an effective way by which to filter out PFAS from a contaminated water source. When contaminated water is forced through a high-pressure membrane (such as nanofiltration or reverse osmosis), the membrane will reject particles or contaminants at various degrees depending on membrane permeability.

According to the EPA, nanofiltration and reverse osmosis membranes can be more than 90% effective in removing various forms of PFAS as well as various co-contaminants. However, the technology produces a reject stream made up of high-strength waste equal to approximately 20% of the feedwater flow, which can present challenges. As a result, high-pressure membranes are commonly used in residential applications where the overall volume of water being treated is smaller.

Exhibit 17
PFAS Report
PFAS Remediation Technologies

Technology	Image	Description	Advantages	Disadvantages
Single-Use Ion-Exchange Resins (IEX)		Single-use ion-exchange resin technology is an effective treatment solution for water-based PFAS contamination. When PFAS-contaminated water is run through a matrix of resin beads, the negatively and/or positively charged PFAS molecules attach to oppositely charged functional groups throughout the resin matrix, leaving behind a clean effluent water stream.	Effective remediation of both short- and long-chain PFAS Relatively small environmental footprint	High upfront costs Reduced remediation efficacy at elevated chloride concentrations (e.g., PFBA, PFPeA, PFHxA) Resins are nonregenerable
Regenerable Ion-Exchange Resins (IEX)		Patented in May 2019 by ECT2 (a subsidiary of Montrose Environmental Group), SORBIX™ RePURE regenerable IEX resins use the same resin-based technology as traditional IEX with the additional benefit of allowing resin beads to be regenerated on-site, providing a more sustainable and cost-efficient PFAS-remediation solution. The system can also reduce the overall volume of concentrated PFAS waste through a proprietary process known as SuperLoading™.	Regenerable and SuperLoading nature allowing for lower relative lifetime operating costs and improved sustainability versus alternative technologies (e.g., GAC, single-use IEX resins) Improved success with short-chain PFAS compounds (GenX, PFBA, PFBS, etc.) Superior breakthrough curves in cases with multiple PFAS streams and where PFAS is highly concentrated	High upfront costs Elevated distillation energy requirements Less practical for scenarios with lower PFAS concentrations
Granular Activated Carbon (GAC)		Using high surface area, low volume, heated carbon, GAC technology acts as a filter for PFAS-contaminated water streams. When contaminated water is channeled through a GAC system, the activated carbon adsorbs the PFAS compounds, resulting in a PFAS-free effluent outcome.	Minimal upfront cost Particularly effective against long-chain compounds (e.g., PFOA, PFOS) Effective removal of co-contaminants (VOCs, SVOCs, TPH)	Relatively large environmental footprint Lower efficacy rates and/or breakthrough curves against high-concentrate PFAS and/or short-chain compounds
High Pressure Membranes		High pressure membrane systems (including nanofiltration and reverse osmosis) use various degrees of membrane permeability to capture PFAS particles as pressurized contaminated water is filtered through the system.	More than 90% effective in removing various types of PFAS Effective removal of short-chain PFAS	Generates a high volume waste stream equal to 20% of feedwater flow Less practical in remediating high volumes of water Potentially energy intensive

Note: This exhibit is not meant to represent a comprehensive list of all available PFAS-remediation technologies. Furthermore, the technologies mentioned above primarily highlight the most mature and notable solutions for PFAS remediation in water.
Sources: EPA, ECT2, Evoqua, 374Water

PFAS Destruction

PFAS isolation and environmental remediation are crucial steps toward mitigating the adverse effects of PFAS contamination. However, as advancements in remediation technology help deliver higher volumes of concentrated PFAS waste, there is a growing need for sustainable and cost-effective ways by which to destroy PFAS waste streams. Eventually, we expect the addressable market for services associated with PFAS destruction to grow in tandem with demand for PFAS remediation.

The EPA's most recent interim guidance (released in December 2020) highlights three technologies that "may control releases of PFAS waste" either through PFAS destruction or migration control based on research available at time of publishing. The first two options, permitted landfilling and underground injection, represent PFAS disposal solutions, with the third solution being PFAS destruction through thermal treatment. While recognizing certain value offered across each of these technologies when it comes to PFAS destruction or disposal, each has its own limitations. Neither landfill disposal nor deep well injection offer a permanent solution, and PFAS can be reintroduced back into the environment through landfill leachate if not managed appropriately. In regard to thermal treatment, the EPA has noted that PFAS destruction through incineration is still not well understood, but that incomplete thermal destruction can result in the creation of products of incomplete combustion, which find their way back into the natural environment. In fact, several state and regulatory bodies have begun to ban the practice of PFAS incineration. Given the inherent limitations associated with these incumbent forms of PFAS disposal and destruction as well as increasingly stringent federal and state PFAS-related regulations, PFAS destruction remains a key area of focus and investment across academic and government institutions, as well as commercial end-markets.

Standard chemical advanced oxidation processes that have been used to destroy other contaminants are ineffective at mineralizing PFAS, particularly the most recalcitrant perfluoroalkyl sulfonates. Similarly, while bioremediation, which relies on microbial bacteria for the breakdown of contaminants, has had success historically in the treatment of polychlorinated biphenyls (PCBs) and energy-rich hydrocarbon compounds, very little success has been observed to date in the bioremediation of PFAS, and never outside a laboratory.

Electrochemical oxidation has shown success in the breakdown of many regulated PFAS, but not in achieving complete mineralization. Reductive processes initiated via ultraviolet adsorption of chemical reagents have shown more promise in destroying a wide range of PFAS, but often still require coupling with an oxidation step to achieve complete mineralization. One promising technology known as hydrothermal alkaline treatment (HALT), which uses heated, compressed water and a reagent to break the carbon-fluorine bond in PFAS molecules, has been gaining traction in scientific circles recently. Nevertheless, many of these systems can be challenging to implement at scale given the cost implications and volume limitations associated with their operation.

To date, the most effective PFAS destruction solutions are inherently more costly given their energy intensive nature and higher capital costs. Going forward, we anticipate that PFAS destruction technologies that are able to offer superior destruction capabilities at scale and at the lowest energy and total system costs will have the most success in the market for PFAS destruction. The decision between on-site versus off-site destruction is equally likely to impact the selection process for destruction technology. Industries and federal agencies (e.g., DoD) might be more inclined to select those solutions that destroy PFAS on-site to mitigate any potential future liability associated with off-site transfer and destruction. Given that existing destruction technologies are better suited for highly concentrated PFAS waste streams, we believe on-site destruction methodologies will pair well with remediation solutions that can reduce the overall volume of PFAS waste (e.g., regenerable resins, foam fractionation). In exhibit 18, we outline several emerging PFAS destruction technologies along with their associated advantages and limitations. Destruction technologies outlined in the exhibit include solutions designed for both liquid and solid PFAS waste streams.

Exhibit 18
PFAS Report
PFAS Destruction Technologies

Technology	Description	Advantages	Disadvantages
Hydrothermal Alkaline Treatment (HALT)	• Developed and patented by Colorado School of Mines (and licensed by Aquagga), HALT uses hot, compressed water and a reagent to break the strong carbon-fluorine bonds found in PFAS compounds. • The outcome of HALT is complete mineralization of PFAS with no toxic byproducts. • HALT has been shown to destroy greater than 99.7% of PFAS from fire training pit water samples as well as co-treatment of about 80% of hydrocarbon co-contaminants. • Phase II projects are underway involving pilot-scale programs, which will set a path toward contracted commercial deployment of the HALT system at active PFAS remediation sites.	Complete PFAS mineralization High destruction efficacy Short residence times Treatment of high salinity wastewater Low energy requirements with heat recovery No toxic byproducts	Limited proof at scale Oustanding questions around operational costs
Supercritical Water Oxidation (SCWO)	• SCWO works to break down insoluble, organic compounds by exposing them to supercritical water (water above 374 °C and 221 bar) and an oxidizing agent (e.g., oxygen). • Historically, SCWO has been used to destroy halogenated compounds, PCBs, and chemical warfare agents. • SCWO has shown an ability to break down the strong carbon-fluorine bonds found in PFAS compounds, reducing the contaminant to a nontoxic waste stream of water, minerals, gases, and heat.	High destruction efficacy Short residence times Ability to recover energy (e.g., heat)	High energy requirements Creation of fluoride salt byproduct reducing system performance Buildup of corrosive gases during oxidation reaction Significant site infrastructure requirements
Electron Beam (E-Beam)	• E-Beam accelerators have shown success in the treatment of PFAS-contaminated water by exposing the compound to a beam of hydrated electrons sourced from a high energy electron beam. • Since the 1960s, E-Beam technology has been used in a variety of end scientific and industrial applications (e.g., environmental waste remediation, water treatment, materials processing). • The interactions of electrons with water leads to a water radiolysis reaction, which, in turn, creates various reactive species (e.g., hydrated electrons, hydroxyl radicals) that work to degrade PFAS compounds.	Promising option for PFAS breakdown under favorable conditions Successful degradation of other various contaminants along with PFAS Proven breakdown of PFAS in landfill leachates (excl. PFBS)	High energy requirements Limited ability to treat large flow rates Large footprint System cost and complexity Potential for incomplete defluorination during treatment Success dependent on conditions (water quality, additive concentrations, etc.)
Electrochemical Oxidation (EO)	• EO oxidizes pollutants in contaminated water through the use of electrical currents. The technology has shown to be an effective treatment tool for the destruction of persistent organic pollutants and certain PFAS compounds. • By exposing PFAS-contaminated water to an array of electrodes (both a negatively charged cathode and positively charged anode), EO oxidizes the carbon-fluorine bonds found in PFAS, eventually resulting in their separation into carbon dioxide and fluorine molecules.	Effective destruction of long-chain PFAS Low energy costs Operation at ambient conditions Mobile solution No chemical additive oxidants required	High upfront infrastructure costs Potential generation of toxic byproducts Risk of incomplete destruction of PFAS Efficiency losses with mineral build-up on anode High electrode lifecycle costs Potential volatization of contaminants
Non-Thermal Plasma	• Non-thermal (i.e., cold) plasma is a form of highly energized gas that is created when an electromagnetic field excites a gas's electrons without raising the gas's temperature. • When the plasma's excited electrons are introduced to PFAS-contaminated water, they latch onto existing PFAS compounds resulting in a severance of its carbon-fluorine bonds.	Effective destruction of long-chain PFAS No additional system chemicals and/or additives required Low temperature requirements	Potential production of short-chain PFAS Energy intensive Long residence times Scalability challenges

Note: This exhibit is not meant to represent a comprehensive list of all available PFAS-destruction technologies.
Sources: Aquagga, Environmental Protection Agency (Research BRIEF), ACS ES&T Engineering, Science Direct, Michigan State University (Center for PFAS Research), Air Force, University of Michigan (Michigan Engineering), Drexel University, WSP, *Journal of the Air & Waste Management Association,* NBC News, *Nature, Ultrasonic Sonochemistry,* ChemEng Evolution, American Society of Civil Engineers, *Environmental Science & Technology,* WaterWorld, *Chemical & Engineering News,* ScienceDaily, 374Water

Exhibit 18 (cont.)
PFAS Report
PFAS Destruction Technologies

Technology	Description	Advantages	Disadvantages
Mechanochemical Degradation (MCD)	• MCD uses a ball-milling device to create a high energy environment where persistent organic pollutants can be destroyed. • By crushing added co-milling reagents (silica, potassium hydroxide, etc.) with stainless-steel milling balls, MCD produces radicals, electrons, heat, and plasma, which degrade PFAS into fluoride and carbon compounds. • MCD is most often used in destruction of PFAS found in soil.	Relatively low energy requirements Viable option for on-site soil remediation and destruction Potential use as a unit operation in series with other technologies for treatment of ash or biosolids Potentially scalable solution	System efficiency dependent on soil type (reduced efficacy with clay-like soil) Potential release of gaseous PFAS emissions (i.e., products of incomplete destruction) Limited proof of concept from laboratory and pilot-scale testing
Pyrolysis & Gasification	• The process of pyrolysis and gasification result in the decomposition of organic material at elevated temperatures in solid waste streams. • Unlike incineration, these processes are carried out in an oxygen-free environment (in the case of pyrolysis) and a low oxygen environment (in the case of gasification). • A byproduct of pyrolysis (and certain types of gasification) is biochar and synthetic gas (syngas), both of which are useful as a soil amendment and during the process of biosolid drying. • Research has shown that pyrolysis and gasification could represent a more sustainable PFAS destruction solution when compared with incineration.	More sustainable relative to incineration/landfilling Potentially useful byproducts in biochar and syngas Scalable solution	Relatively limited research on destruction efficacy Significant financial costs Potential release of products of incomplete destruction
Dimethyl Sulfoxide (DMSO)	• DMSO allows for the breakdown of PFAS compounds into fluorine ions and other environmentally safe byproducts through exposing the PFAS molecules to sodium hydroxide and dimethyl sulfoxide. • Importantly, DMSO requires much lower heat requirements for destruction versus traditional incineration.	Effective destruction of PFOA Lower energy requirements	Ineffective in destruction of PFOS Creation of ultra-short-chain PFAS Scalability concerns High cost of DMSO acquisition and disposal Management of co-solvents (e.g., organic solvents, high-pH water)
Sonolysis	• Sonolysis facilitates the removal of contaminants from water through the use of ultrasonic waves. • When exposed to ultrasound waves, high pressure, heated cavitating bubbles are generated and, subsequently, collapse, which generates radical species and plasma. These species work together to degrade contaminants like PFAS. • Sonolysis effectiveness can depend on a variety of factors including power density, solution temperature, solution pH, water quality, ultrasonic frequency, and sparging gas.	Complete mineralization (no generation of short chains or toxic by-products) Well-suited for low volume/high concentration waste streams	High energy costs Potential issues around scalability
UV-Sulfite + Iodide System	• UV-Sulfite treats PFAS-contaminated water with UV radiation and sulfite to facilitate the breakdown of PFAS compounds. • Recent research has shown that when iodide is added to the process, reaction times are up to four times as fast, which can significantly reduce energy and chemical system costs.	Success against short-chain perfluoroalkyl carboxylates (e.g., PFBA, PFHxA) Reduced energy and chemical costs	Reduced efficacy against short-chain perfluoroalkyl sulfonates (e.g., PFBS, PFHxS)
Bioremediation	• Bioremediation involves the use of microbial bacteria to facilitate the breakdown of contaminants. • There are relatively few examples of successful PFAS destruction through bioremediation. • However, biological breakdown of PFAS through bioremediation remains an important area of research and funding.	Sustainable Low relative cost Less disruptive to soil/water	Questionable efficacy as isolated treatment solution Effectiveness mitigated in the presence of additional microorganisms Defluorination performance limited by microbe growth rates

Note: This exhibit is not meant to represent a comprehensive list of all available PFAS-destruction technologies.
Sources: Aquagga, Environmental Protection Agency (Research BRIEF), ACS ES&T Engineering, Science Direct, Michigan State University (Center for PFAS Research), Air Force, University of Michigan (Michigan Engineering), Drexel University, WSP, *Journal of the Air & Waste Management Association,* NBC News, *Nature, Ultrasonic Sonochemistry,* ChemEng Evolution, American Society of Civil Engineers, *Environmental Science & Technology,* WaterWorld, *Chemical & Engineering News,* ScienceDaily, 374Water

Competitive Landscape

Given the size and scope of PFAS contamination today as well as a growing public and private awareness toward the potentially harmful health effects associated with this family of chemicals, we believe the addressable market for PFAS services is still in its nascency and will expand rapidly over the next decade. As a result, it is unlikely that any single PFAS services provider or remediation technology will be the sole winner. Rather, we anticipate customer decisions about which PFAS solutions providers to use will be driven by a combination of factors including cost, sustainability, volume and type of PFAS contamination, and nature of contamination (water, soil, air, etc.).

In exhibit 19, we provide an overview of key commercial players in the market for PFAS services and solutions. In appendix A of this report, we provide additional detail about the PFAS-related services offered by these and other PFAS solution providers.

Exhibit 19
PFAS Report
PFAS-Services Competitive Matrix

MONTROSE ENVIRONMENTAL

Integrated environmental solutions provider with patented regenerable ion-exchange resin technology for PFAS remediation.

Example Project
PFAS Remediation at Pease Air National Guard Base (Portsmouth, New Hampshire)

TETRA TECH

Consulting and engineering services provider servicing commercial and government clients. Water-based PFAS-related services include R&D, water quality characterization, and design, demonstration, remediation, and municipal-scale treatment solutions.

Example Project
OCWD PFAS Treatment System Development Project (Orange County, California)

EVOQUA WATER TECHNOLOGIES

Water and wastewater treatment solutions provider servicing industrial, municipal, and recreational customers. The company takes a solutions-based, technology-agnostic approach to PFAS remediation helping customers deal with contamination in a cost-effective and efficient manner.

Example Project
Kennebunkport Wells Water District PFAS Remediation Project (Kennebunkport, Maine)

CleanHarbors

A leading provider of environmental, energy, and industrial services and the largest hazardous waste disposal company in North America. Along with capabilities in testing, treatment, and remediation, Clean Harbors is particularly well positioned to handle a variety of PFAS waste streams with ownership of 70% of North America's incineration capacity.

Example Project
PFAS Incineration and Thermal Destruction Capabilities (Facility in Lambton, Ontario)

PARSONS

IT and smart city solutions provider for government customers with multi-industry expertise in managing, mitigating, and remediating PFAS.

Example Project
US Army National Guard Task Order for PFAS Remediation & Feasibility Studies (Multiple Locations)

Jacobs

Engineering and technical solutions provider primarily serving government customers. PFAS-related services include assessment, measurement, and testing as well as both conventional and developmental water (GAC, AEX, RO) and soil (incineration, capping, etc.) remediation technologies.

Example Project
Low Temperature Desorption of PFAS in Soils (Undisclosed US Navy Installation)

AECOM

Infrastructure consulting firm offering an end-to-end portfolio of PFAS-related solutions including consulting and assessment, remediation (water, concrete, soil, foam), and destruction (DE-FLUORO™ Technology).

Example Project
Regional Groundwater Quality Assessment (Melbourne, Australia)

ARCADIS

Provider of sustainable design, engineering, and consultancy solutions for natural and built assets. Arcadis offers a range of PFAS-based solutions including assessment and consulting support, site evaluation, and material-specific remediation capabilities (water, AFFF, concrete, soil).

Example Project
PFAS Remediation for Guernsey Airport (United Kingdom)

374water
Invent the Future with Us

A cleantech company focused on providing clients with sustainable waste management solutions. Through its patented supercritical water oxidation treatment technology (AirSCWO™), 374Water is capable of completely eliminating PFAS waste from water treatment, wastewater, and other industrial sources.

Example Project
Elimination of PFAS in Lime Stabilized Sludge (Small-Scale Municipality, Maine)

VEOLIA ENVIRONNEMENT

Water, waste, and energy management solutions provider for communities and industries. Veolia takes a 6-step approach to PFAS that includes sampling and testing, treatability studies, pilot studies, design, construction and operation, and waste treatment.

Example Project
Development of Mobile PFAS Treatment Solution for AFFF-Impacted Stormwater and Large Contaminated Dam (Mornington Peninsula - Victoria, Australia)

EPOC ENVIRO

An environmental engineering firm focused on helping clients permanently remove PFAS and other emerging contaminants. EPOC offers fractionation-based remediation solutions for water (SAFF™), soil (PFAST), and infrastructure (PFAIT).

Example Project
AACO Oakey SAFF™ PFAS Remediation Water Treatment Plant (Oakey, Australia)

Crystal Clean

National provider of environmental services and the sole distributor and operator of 4never™ - a closed-loop PFAS remediation and destruction solution for the industrial and landfill markets.

Example Project
Partnership With Revive Environmental, Allonia, and EPOC Enviro to Bring Full-Scale, Closed-Loop PFAS Solution to Market Using SAFF™ and PFAS Annihilator™ Technology (Multiple Locations)

RAMBOLL

Multidisciplinary engineering, architecture, and consultancy company; Ramboll offers a number of PFAS services including site investigation and remediation, health and risk assessment, forensic analysis, due diligence and compliance, air emissions, transport and transformation, product safety and stewardship, water and wastewater treatment, and expert services and litigation support.

Example Project
Water Treatment Plant Upgrade to Remove PFAS With 100% Cost Recovery (City of Martinsburg, West Virginia)

REGENESIS

A remediation professional services company specializing in *in situ* colloidal activated carbon solutions designed for the treatment of soil and groundwater. REGENESIS is able to target contamination at both the release site (SourceStop™) and within groundwater (PlumeStop®).

Example Project
Camp Grayling Joint Maneuver Training Center *In Situ* Treatment of PFAS (Grayling, Michigan)

Revive environmental

Founded in 2023, Revive Environmental markets its technology to customers and communities for the treatment of complex environmental contaminants. The company offers both PFAS destruction and media renewal technology through its patented solutions: PFAS Annihilator™ and GAC Renew™.

Example Project
Partnership With Crystal Clean, Allonia, and EPOC Enviro to Bring Full-Scale, Closed-Loop PFAS Solution to Market Using SAFF™ and PFAS Annihilator™ Technology (Multiple Locations)

WSP

A professional services firm providing technical expertise and strategic advice to clients in a variety of end-markets. WSP offers various PFAS-related services including portfolio screening, investigation and assessment, site characterization, and risk assessment.

Example Project
AFFF-Related PFAS Remediation for International North American Airport Client (Undisclosed North American Airport)

Note: This exhibit is not meant to be a comprehensive list of all PFAS-service providers. Appendix A offers a broader (but still not all-encompassing) list of PFAS-service providers.
Sources: Montrose Environmental Group, Tetra Tech, Evoqua, Clean Harbors, Parsons , Jacobs, AECOM, Arcadis, 374Water, Duke.edu, Clear Creek Systems, EPOC Enviro, OPEC Systems, Heritage-Crystal Clean, Ramboll, REGENESIS, Revive Environmental, WSP Global

Summary and Conclusion

Over the last 50 years, PFAS compounds have permeated the soil, water, and air, as well as the bodies of many different animals (including humans) across the globe. As research builds up that confirms the negative health effects associated with these chemicals, we expect the PFAS solutions market to grow exponentially over the next decade. This includes activities associated with consulting, testing, remediation, and destruction of PFAS compounds. Although this report was primarily dedicated to PFAS remediation and destruction, we believe the markets for both consulting and laboratory-based measurement and analysis will experience similar growth trajectories. Companies, organizations, institutions, and governments around the world will need help understanding what their PFAS exposure level is (i.e., testing) and how to navigate the regulations, reporting requirements, liabilities, and options to remove and destroy these substances (i.e., consulting).

Because this is a new market, the patchwork of various federal and state regulations can be overwhelming, particularly for companies that operate in more than one region. Appendices B and C provide a glimpse into the growing mosaic of regulations, data collection, and reporting requirements. However, we believe there are two major near-term catalysts that would stimulate a step-function increase in demand for PFAS services and solutions. First is the EPA establishing a national primary drinking water regulation for PFOA and PFAS, enabling the enforcement of MCLs. Second is designating PFOA and PFAS as hazardous substances under CERCLA Superfund. Although timing is uncertain, we currently expect both of these events to occur in 2023.

Given the large number of potentially contaminated sites, we expect the addressable market for PFAS removal solutions to expand significantly over the next several years. Historically, the variance of TAM estimates has varied too widely to be considered reliable by investment-grade standards. More recently, however, the growing body of scientific data and research has enabled the convergence of TAM estimates by several high-quality and trusted sources. Because the pricing of PFAS removal can vary by solution, and timeline of expenditures is unclear, we believe it is more useful to think about the TAM in terms of number of contaminated sites, rather than dollars. The EPA's estimate of 137,000 potentially contaminated sites is at the high end, while the *Environmental Business Journal* and the PFAS Project Lab at Northeastern University have converged around an estimate of 57,000 locations with presumed PFAS contamination. The *EBJ* has taken one step further, estimating removal expenditures of $200 billion (up from $160 billion in 2019) over the next 20 years. Although these TAM estimates are surely subject to change, the magnitude of the problem implies a large and growing addressable market for requisite solutions over the next decade.

There are several different types of technologies to address PFAS remediation, the most prominent of which include GAC, ion-exchange resins, and high-pressure membranes. Each of these technologies have pros and cons, and we believe each will have a role to play depending on the use-case and customer preference (which will be driven by a combination of different factors). We do not believe PFAS remediation is a winner-take-all situation and would not be surprised to see other promising technologies emerge in the coming years. Over the near term, however, there are a handful of companies with profitable, commercial-scale solutions that exist in the market (and the field) today. Many of these companies are privately held, and some are publicly traded, such as Montrose Environmental, Tetra Tech, Evoqua, Jacobs, AECOM, and Veolia, to name a few. There are many other publicly traded companies along the PFAS value chain (Ecolab, Danaher, Agilent, Exponent) or in the early stages of developing removal solutions.

One company currently under our coverage is Montrose Environmental. Taking a holistic approach to many different environmental issues, Montrose focuses on three primary PFAS solutions:

- ***Consulting.*** The company offers investigation and assessment services through its team of scientists and environmental professionals. Once contracted, Montrose creates a conceptual model of the contaminated site providing a framework by which to decide on short- and long-term remedial and treatment solutions. Using in-house protocols for investigation and sampling, Montrose is able to develop an understanding of the pollution source and evaluate the fate and transport of PFAS contamination. Importantly, understanding of PFAS toxicology is still relatively premature and toxicology can vary by compound type. Montrose's environmental and disaster response business (CTEH) is well positioned to address the evolving toxicological needs related to PFAS.

- ***Testing.*** Taking into consideration a client's individual testing and reporting requirements, Montrose offers one of the largest PFAS testing lab networks in the United States through Enthalpy Ultratrace Lab, which has experienced a significant uptick in PFAS orders over the last several quarters. Montrose offers the equipment and sophistication to detect both legacy (PFOS/PFOA) and new PFAS compounds (e.g., GenX) at low detection levels. The company can also provide air sampling and analysis through Montrose Air Quality Services (MAQS). By better understanding site toxicity through lab-based analysis, Montrose can offer clients insight into the extent of PFAS contamination in surrounding soil and bioaccumulation in nearby wildlife (e.g., plants, fish).

- ***Remediation.*** Montrose offers a suite of remediation solutions, primarily focused on treatment of PFAS-contaminated water. This includes the company's proprietary remediation technology, known as SORBIX™ RePURE regenerable resins. This patented technology is both "regenerable" and enables "super-loading," making it well suited to address certain situations where there is a high concentration of PFAS, multiple contaminated streams, and/or short-chain compounds. The company can offer remediation solutions at various scales (e.g., pilot, bench, full) and in a range of configurations (modular, mobile, custom, etc.).

Montrose's PFAS-related revenue has increased from approximately $40 million in 2021 to $100 million in 2022, and management expects PFAS-related revenue to be three to four times as large over the next several years. As public outcry and regulatory mandates around PFAS contamination rise, we expect public and private demand for Montrose's integrated PFAS solutions offering to grow in the years to come. Furthermore, we see the need for Montrose's proprietary PFAS remediation technology to grow over time driven by the number of highly contaminated sites and industry focus on lifecycle costs and sustainability initiatives.

Appendix A: PFAS Services Competitive Analysis

ACV Enviro | Republic Services

ACV Enviro is a fully integrated environmental services and waste management organization with expertise across various service-oriented end-markets including industrial, disposal, field, lab pack, on-site, remediation, and emergency response. Following the completed acquisition of ACV Enviro by Republic Services on May 2, 2022, ACV Enviro began the process of rebranding its business to Republic Services.

General Overview
ACV Enviro can help clients identify, collect, and process PFAS chemicals in a compliant manner by providing cost-effective, turnkey PFAS management solutions. ACV Enviro accepts the following PFAS waste streams: AFFF, firefighting foam, and fire-related debris; contaminated or impacted soil, sludge, or bio solids; and wastewater, leachate, and filter cake.

PFAS Services

Testing & Analysis: Sample collection and certified lab analysis, and analytical review.

Collection: Develop means and methods for impacted material collection; provide necessary equipment for media storage, and assist with media change out for fire suppression systems.

Disposal: Transportation and proper disposal of contaminated materials using permitted fleet of vacuum trucks, tankers, roll offs, dump trucks, etc.

AECOM (ACM)

AECOM is a premier infrastructure firm, delivering professional services throughout the project lifecycle. The company operates through four segments: design and consulting, construction services, AECOM Capital, and management services.

General Overview
Since 2001, AECOM has partnered with companies and organizations across the world to *identify* and *resolve* the challenges of PFAS:

- *Identify:* The company has evaluated hundreds of sites around the world, guiding companies and organizations of all sizes to investigate and understand the scale of their PFAS problem.
- *Resolve:* AECOM is recognized as an industry leader in helping clients navigate through regulatory requirements and budget constraints to develop tailored and appropriate solutions for projects of any size.

The company offers a comprehensive understanding of remediation technologies including their applications by media, limitations, effectiveness, and cost.

PFAS Services

Consulting: Investigation of nature and extent of site contamination, human health and ecological risk analysis, survey and testing capabilities, and PRedictive Integrated Stratigraphic Modeling (PRISM®) enabling state-of-the-art subsurface investigation of groundwater flow to provide insight into potential PFAS migration.

Remediation

- ***Soil:*** Significant global experience in evaluating, selecting, designing, and implementing a range of remediation technologies for PFAS impacted soil, and capabilities in sustainable and affordable destruction technologies including electrochemical oxidation, ultrasonic, or enzymatic oxidative destruction.

- ***Water:*** More than 10 years of experience designing, installing, operating, monitoring, and maintaining full-scale PFAS groundwater remediation systems and hundreds of residential and commercial supply well PFAS treatment systems. The company offers design-build capabilities across various technologies (e.g., ion exchange resins, GAC), providing assistance from pilot testing through start-up and O&M.

- ***Concrete:*** Characterization of concrete pads and infrastructure at various facilities to identify factors that influence PFAS adsorption, impregnation, and remobilization; and design and implementation of solutions that mitigate/eliminate the risk of concrete acting as a secondary source of PFAS to the environment.

- ***Foam:*** Assist industry with identification, management, excavation, and remediation of PFAS resulting from AFFF; and comprehensive assessment of disposal options, costs associated with PFAS-containing waste streams, fluorine-free versus fluorinated foam performance, and method development for foam releases.

Destruction: DE-FLUORO™ destruction technology is an economically and environmentally sustainable electrochemical oxidation solution that destroys PFAS from contaminated liquids without the generation of hazardous waste.

PFAS Business Commentary

"... PFAS investment is accelerating and our leadership in assessment and destruction are leading to substantial growth opportunities. In fact, the U.S. pilot, our groundbreaking PFAS destruction technology, DE-FLUORO is now well underway and we are advancing our plans to commercialize this proprietary technology at scale to meet a multibillion-dollar demand opportunity."

With respect to PFAS market and AECOM's technology: "*... think that with the funding (IIJA) and some long-term regulatory changes that we expect in the US from the EPA, that also provides a significant long-term benefit to the business."*

– Troy Rudd, CEO (Second Quarter 2022 Earnings Call)

Project Descriptions

- ***Regional Groundwater Quality Assessment (Melbourne, Australia):*** Regional groundwater quality and PFAS assessment on behalf of EPA Victoria to characterize groundwater conditions and streamline the redevelopment of Australia's largest urban renewal precinct.

- ***Storm Water Evaluation and Mitigation for PFAS Contamination (Confidential Military Base, Michigan):*** AECOM's comprehensive evaluation of elevated PFAS focused on the hydraulic connection between groundwater and storm water, advancing the remedial design for effective treatment.

Arcadis (ARCAY)

Arcadis is the world's leading company in delivering sustainable design, engineering, and consultancy solutions for natural and built assets.

General Overview
Arcadis works with leading universities and technology providers to offer innovate remediation solutions in four core materials: AFFFs, concrete, water, and soil. In addition to its remediation services, the company offers assessment and consulting support, site evaluation, and hydrogeological services related to PFAS. Arcadis has over 75 projects across 300 individual sites in its PFAS portfolio.

PFAS Services

Consulting: Assessment of potential ecological and human health risk; consultation on compliance, M&A, capital investment, and performance and sustainability issues; and development of response programs and community outreach strategies.

Site Evaluation & Restoration: Investigation and evaluation of contaminated sites, development of cost-effective site management strategies, and design and implementation of optimized remediation treatments.

Material-Specific Solutions:

- ***Water:*** Emerging adsorbent development (superfine activated carbon and modified-silica based), foam fractionation for the removal of PFAS and other co-contaminants, and destruction technology development (e.g., electron beam and sonolysis).
- ***AFFFs:*** Expertise in firefighting foam chemistry and regulations, and firefighting foam replacement/transition programs to fluorine-free foams (F3).
- ***Concrete:*** Concrete surface sealants to prevent contamination or manage PFAS leaching.
- ***Soil:*** Soil stabilization through the use of fixing agents (organoclays, activated carbon, etc.); soil washing through the transfer of PFAS to its liquid phase, which can then be treated; on-site management/containment options (caps, containment cells, etc.); and on-site thermal treatment.

Hydrogeological Services: Dewatering studies, pumping tests and analysis, groundwater supply and water resource evaluation, groundwater impact assessments, and groundwater fate and transport modeling.

PFAS Business Commentary

"… tightening regulation around PFAS has seen us supporting more clients as they are obviously required to adhere to strict environmental obligations."

– Peter Oosterveer, CEO (Second Quarter 2022 Earnings Call)

Project Descriptions

- ***Protecting Guernsey's Water from PFAS (Guernsey Airport, U.K.):*** After PFAS contamination was discovered in surface water, Arcadis assessed soil, groundwater, and surface waters; implemented interim emergency response measures; and designed and developed a bespoke GAC water treatment system (Groundwater Improvement System) that can treat up to 20 liters of water per second, ensuring PFAS concentration levels remain below current U.K. drinking water criteria.
- ***PFAS Remediation for Australian Aviation Client:*** When 22,000 liters of AFFF escaped from a failed deluge system in an Australian airport, Arcadis (in conjunction with Evocra) developed a proprietary method to clean up PFAS contamination that is fast and meets stringent discharge standards. Using this purpose-built method, 15 million liters of contaminated water were treated and 3.5 kilometers of total area was decontaminated.

Battelle

Battelle is the largest independent nonprofit applied science and technology organization in the world. The company supports various businesses and government agencies across multiple markets including health, industry, national security, infrastructure, and environment.

General Overview
Battelle offers a full suite of technologies and services to assist companies and governments alike in every stage of their PFAS efforts—from analysis to action. The company markets customizable and scalable PFAS solutions that meet the needs of specific clients. Battelle can optimize customers' existing remediation plans where needed to meet evolving regulatory and stakeholder needs.

Battelle's trademarked PFAS destruction solution, ANNIHILATOR™, uses supercritical water oxidation (SCWO) to effectively destroy PFAS in contaminated wastewater, landfill leachate, and AFFF to non-detectable levels in seconds with inert salts and PFAS-free water remaining.

In partnership with Viking Global Investors, Battelle launched Revive Environmental in January 2023, which markets its PFAS Annihilator and GAC RENEW™ technology.

PFAS Services

Analytical Tools: Source tracking for PFAS (PFAS Signature®), rapid tests to determine PFAS presence, analytical methods for new and emerging compounds, and optimized total oxidizable precursor assay.

Site Assessment: Groundwater PFAS transport simulator (Battelle Predict™), passive sampling in aquatic systems, and ambient air monitoring for PFAS.

Health: Review of state and federal public health policies, investigations of pathways and biomarkers for exposure measurements, in vivo and in vitro studies to investigate the impact of different compounds and concentrations, and long-range, geographically focused and demographical studies on populations.

Treatment/Destruction: Removing PFAS from GAC (RENEW™ GAC Regeneration Technology), eliminating PFAS in AFFF, and closed-loop, on-site destruction of PFAS through SCWO technology (PFAS Annihilator).

PFAS Air Insight™ Technology: Modified version of EPA's Compendium Method TO-13A to measure PFAS contamination in ambient air delivering critical data to help clients make informed, science-based decisions. Benefits include low solvent volumes, short extraction times, optimized extraction techniques, maximized recoveries, and quality data delivered.

Project Descriptions

- ***4never™ Launched as First Full-Scale, Closed-Loop PFAS Solution in Market (2023):*** Revive Environmental (in partnership with Heritage-Crystal Clean, Allonnia, and EPOC Enviro) brings an end-to-end solution to separate, concentrate, transport, and annihilate PFAS contamination from landfill and industrial waste management sites.

- ***GreenFire Commercial Contract (2022):*** PFAS Annihilator used to destroy AFFF at stockpile location in Charlotte, North Carolina.

Calgon Carbon Corporation | Kuraray Co.

Calgon Carbon is an acknowledged leader in the activated carbon and reactivation industry for many liquid and vapor phase applications. The company offers cutting-edge purification systems for drinking water, wastewater, odor control, pollution abatement, and various industrial and commercial manufacturing processes. Since 2018, Calgon Carbon has operated as a wholly owned subsidiary of Kuraray Co., Ltd.

General Overview
Servicing both municipal water treatment and industrial professionals, Calgon Carbon offers proven treatment solutions for PFAS removal in drinking water and remediation settings including equipment, on-site installation and exchange services, activated carbon, financing, and reactivation. As the world's largest manufacturer of activated carbon, Calgon Carbon specializes in GAC remediation technology as well as reactivation services. As of 2019, the company operated more than 45 PFAS treatment locations across the United States.

PFAS Services

Analysis & Testing: Lab and field tests as needed to determine appropriate treatment plan (e.g., GAC, IEX), and pilot testing.

GAC Remediation:

- FILTRASORB® products: Signature line of re-agglomerated and durable GAC solutions, offering the ability to remove typical PFOA and PFOS to non-detect levels, and re-agglomerated, coal-based GAC for removal of short- and long-chain PFAS.
- Full range of GAC adsorption equipment and products for PFAS treatment.

Ion-Exchange Remediation: Fixed bed modular ion-exchange systems for removal of ionic compounds from water. A proven technology with installation at a global scale, and piping network that uses two ion-exchange vessels in tandem allowing continuous remediation along with resin exchange or backwash operations.

Reactivation/Destruction: Globally stationed carbon reactivation sites with the ability to thermally destroy more than 99.99% of PFAS while retaining reactivated carbon for future use, Custom Municipal Reactivation (CMR) can reduce GAC-related operating costs by as much as 20% compared to virgin GAC, and management of the disposal and regeneration of resins during ion-exchange operations.

Project Descriptions

- ***Upstate New York Municipal Drinking Water PFOA Remediation:*** In conjunction with C.T. Male Associates, Calgon Carbon implemented a Model 10 two-vessel pressurized carbon system safely reducing PFOA contamination so that municipal drinking water was safe for public consumption.
- ***GAC Removal of PFAS from Eielson AFB (Alaska):*** Calgon Carbon installed temporary (2016) and (eventually) permanent (2018) FILTRASORB 400 GAC systems reducing PFOS levels to undetectable levels on all vessels.

Claros Technologies, Inc.

Claros Technologies is an advanced materials company that designs and develops sustainable materials and solutions with zero toxic waste.

General Overview
Through ClaroSafe™, Claros Technologies offers a highly customized, full-suite of PFAS-related services including testing and analysis, capture, concentration, destruction, and ongoing monitoring.

PFAS Services

Testing & Management:

- Testing – provide quantitative results (parts per trillion) for all 40 regulated PFAS compounds (as of March 2022)
- Analyzing – interpretation of technical reports, allowing for understanding of facility implications
- Regulatory briefings – provide real-time updates of federal and state PFAS-related actions and regulations
- Consulting – Develop and provide analytical methodology and help in determination of next steps

Capture: Customized solutions to target PFAS using a filter that is smaller and more efficient than traditional activated carbon.

Concentrate: Concentration of PFAS waste by more than 100,000 times, allowing for easier management and destruction.

Destruction: Permanent solution for PFAS waste through a proprietary PFAS destruction system called The Elemental™ that breaks PFAS down into its naturally occurring elements. Features of The Elemental include: 1) 97%-100% destruction of all PFAS compounds including ultrashort chains within 1 to 3 hours; 2) operation at room temperature and within a small footprint, allowing for low operating and maintenance costs; and 3) demonstration of success in wastewater, media concentrates (GAC, IEX, etc.), and AFFFs.

Project Descriptions

- ***Case Study of Elemental System used at Military Site:*** Elemental system treatment for 2 hours resulted in a 97%-100% destruction in all PFAS compounds in AFFF wastewater, including shorth chains, in a single pass.

Clean Harbors Inc. (CLH)

Clean Harbors is a leading provider of environmental, energy, and industrial services and the largest hazardous waste disposal company in North America, servicing a diverse customer base, including the majority of *Fortune* 500 companies, small private companies, and federal, state, provincial, and local governmental agencies.

General Overview
As a full-service environmental remediation resource provider, Clean Harbors is uniquely positioned to guide customers through the process of testing, treatment, and final deposition and destruction of their materials and media. The company can provide a variety of solutions and services including remediation equipment, remediation rentals, operations and maintenance, remediation and environmental construction, waste disposal, and transportation for air, soil, and water applications. With no media restrictions, Clean Harbors is able to use the best remediation solution (or a combination of treatments where necessary) to reach customer goals.

PFAS Services

Analysis: Sample collection, sample analysis through certified partner labs, analytical data review, and treatment approach development.

Remediation: Piloting trailers for on-site and real-time media treatment comparison; full-scale, temporary, and permanent systems including media, operation and maintenance of systems, and change-out services.

PFAS Destruction: With ownership of 70% of North America's incineration capacity, Clean Harbors is particularly well positioned to handle PFAS waste streams (including AFFFs, treated soils and water, and investigation derived waste). The company also offers PFAS destruction through thermal treatment using its Thermal Destruction Unit and on-site disposal.

PFAS Business Commentary

"Our incinerators, in particular the rotary kiln incineration, can safely and effectively destroy PFAS, even though it's a forever chemical, they talk about 99.9999% destruction, which is basically fully destructed, vaporizing the hazardous waste. And so I'm of the view that, that's a great secular tailwind over the next three to five years, as regulation continues to get formed, the EPA comes out with more and more regulation."

"… if you think about a long-term investment in Clean Harbors, I think PFAS is going to be part of the story, like CFCs were back in the 1970s, frankly."

– Michael Battles, CFO (CJS Securities New Ideas for the New Year Conference; January 2023)

"Our strategy continues to be around predominantly taking advantage of high-temperature … incineration at our units. As we mentioned a quarter ago, we have undertaken compliance testing and have proven well that our

incinerators have the technology to properly destroy PFAS-contaminated material. That being said, we also have other opportunities to manage those contaminated wastes into our landfills as well as treatment systems that we can treat water on our customer sites and perform remedial activities, and we continue to build out our portfolio to take advantage of that."

"We are seeing a continued growth in our pipeline. Hard at this point really to define what that contribution might be into 2024, but needless to be said that opportunities and how we work with our customers, contaminated soils in particular, and water treatment pipeline continues to grow here for us."

– Eric Gerstenberg, COO (Third Quarter 2022 Earnings Call)

"We don't have any (PFAS revenue) assumed in our guidance. We'll probably do a few tens of millions in PFAS related revenue this year. So, it's really kind of a rounding error. But there is a lot of inbound customer requests at this point because they sort of see … what's coming."

– Jim Buckley SVP, IR (UBS Global Industrial and Transportation Conference; June 2022)

Project Descriptions

- ***PFAS Incineration and Thermal Destruction Capabilities at Lambton Facility (Ontario, Canada):*** Lambton facility offers various solutions for PFAS disposal including hazardous waste landfilling, thermal destruction unit (thermal treatment), and liquid injection incinerator.

Clear Creek Systems

Clear Creek specializes in the filtration and treatment of stormwater, contaminated groundwater and industrial process water.

General Overview
Clear Creek is a pioneer in the PFAS remediation space developing treatment solutions to remove PFAS/PFOS chemicals from water. The company is agnostic when it comes to the development of its treatment systems and can design, build, install, and operate any system regardless of size. The company has designed and implemented PFAS treatment solutions across various industries including municipal drinking water, airports, port facilities and marine terminals, and landfills.

PFAS Services

Remediation: Solutions are tech-agnostic but the company primarily designs GAC, resin, or combined (i.e., GAC and resins) systems. A combined (or paired) system allows for lengthened life cycle of both activated carbon and resins.

Project Descriptions

- ***Design/Installment of PFAS Treatment System (Massachusetts):*** Clear Creek designed and installed a permanent resin system operating at 500 GPM managing PFAS to non-detect levels.

- ***Design and Mobilization of PFAS Temporary Treatment System (Sturgeon Bay, Wisconsin):*** Clear Creek designed and mobilized a 200 GPM PFAS temporary treatment system for a project at a Wisconsin shipyard. The system included solids settling, sand filtration, and carbon media for PFAS removal.

Envirogen Technologies

Envirogen is a leading international provider of industrial water treatment solutions and process filtration. The company works across sectors to solve process and manufacturing challenges, designing, installing, servicing and maintaining high-quality solutions for a low total cost of ownership.

General Overview
Envirogen's solution for PFAS water treatment includes individual site assessment, water evaluation, selection of optimum treatment technology, and robust system design. The company focuses on overall efficacy of treatment system as well as long-term cost to provide the lowest lifecycle cost for the project. The company offers ongoing support to projects through operations and maintenance and compliance monitoring.

PFAS Services

Assessment and Testing: Site assessment, sampling and data collection, and treatment technology ranking and selection.

Products, Systems, and Services:

- Filtration: Reverse osmosis and nanofiltration
- Adsorption: Activated carbon
- Ion Exchange: Product offerings (SimPACK™, FlexSorb™, MinX™, HyperSorb™, MinFlex™) and services (Resin Regeneration, Tank Services, Softening)
- O&M Services: Groundwater treatment/remediation, and industrial wastewater treatment

Project Descriptions

- ***PFAS and VOC Removal from Groundwater at Undisclosed Site:*** Envirogen was tasked with the installment and start-up of a combined GAC and IX treatment system, enabling the highest removal efficiency for PFAS from a contaminated site's groundwater.

Environmental Resource Management

Environmental Resource Management (aka ERM) is an environmental consultancy firm focused on creating solutions to sustainability challenges for some of the world's leading organizations. The company operates a comprehensive service model allowing ERM to develop strategic and technical solutions that advance objectives on the ground or at the executive level.

General Overview
ERM focuses on bringing a comprehensive "boots to boardroom" consulting solution to clients who are dealing with PFAS-related liabilities. PFAS consulting services include environmental, health and safety management, compliance, permitting, site investigation, remediation, decommissioning, and retirement processes.

PFAS Services

Management & Compliance: Integration of EHS social, legal and other requirements into core business; development and streamlining of compliance management systems and their implementation; ensuring compliance with complex air, water, and waste regulations/permits; use of robust audit programs that focus on areas where risks remain; simplifying data management and making data-driven decisions; and safeguarding business continuity and future operations.

Liability Portfolio Management & Remediation: Options analysis and exit strategy, digital portfolio dashboarding, liability assessment, asset recycling, regulatory adaptation strategies, and portfolio risk heat mapping for PFAS.

EPOC Enviro | OPEC Systems

EPOC Enviro is an environmental engineering firm dedicated to developing and implementing clever and practical engineering solutions on a global scale to permanently remove PFAS and other emerging contaminants from the environment. EPOC Enviro is known as OPEC Systems in Australia, which represents a large market for the company.

General Overview
EPOC Enviro focuses on applying sound engineering and science-based principles to create robust remediation solutions related to PFAS. The company offers customized PFAS remediation solutions to bring real results for clients, communities, and the environment. EPOC's flagship solution, Surface Active Foam Fractionation (or SAFF®), is a sustainably engineered, multistage remediation treatment that uses aeration (i.e., foam fractionation) to rapidly remove target PFAS contaminants. Manufactured by EPOC Enviro, SAFF is exclusively distributed by Allonnia in North America.

PFAS Services

SAFF Water Remediation

- Superior Performance: A physical separation process using semi-continuous batch foam fractionation for PFAS remediation, with removal levels exceeding 99.99% for greater than or equal to C6 and above and >99% for most short-chain PFAS chemistries
- Minimum Waste: Rapidly achieves PFAS concentration factors of up to 3.5 million times, enabling effective pairing with portable destruction technologies for on-site closed loop remediation
- Plug and Play: Modular, containerized PFAS remediation solution for rapid on-site deployment and commissioning
- Heavy Lifter: Robust technology that is unaffected by the presence of co-contaminants, even at high concentrations
- Applications: Landfill leachate, groundwater, and reverse osmosis reject water
- Models: SAFF 20 (lower flow sites) and SAFF 40 (high flow-through capabilities)

PFAS Fractionation Assisted Soil Treatment (PFAST): Developed to treat and clean impacted soils and hardstand at highly contaminated sites. PFAST is a sustainable, high-volume technique applicable to a wide range of soil types with processing capabilities of up to 50 tonnes per day of PFAS impacted soil. The system can treat and recover 90%-99% of contaminated soils for beneficial on-site reuse.

PFAS Fractionation Assisted Infrastructure Treatment (PFAIT): Uses powerful PFAS scrubbing chemistries combined with foam fractionation to strip residual PFAS compounds bound to infrastructure (e.g., fire-fighting appliances, storage tanks, sprinkler systems).

Project Descriptions

- ***4never™ Launched as First Full-Scale, Closed-Loop PFAS Solution in Market (2023):*** EPOC Enviro (in partnership with Heritage-Crystal Clean, Allonnia, and Revive Environmental) brings an end-to-end

solution to separate, concentrate, transport, and annihilate PFAS contamination from landfill and industrial waste management sites.

- ***SAFF Oakey Project (DoD):*** Design, build, test, and commission a SAFF PFAS remediation water treatment plant capable of processing a minimum of 250,000 L/day of PFAS contaminated water to below the health-based guidance values in the contract.

- ***SAFF Sweden Project (Envytech Solutions AB):*** Design, build, test, commission, and deliver a containerized PFAS remediation system capable of processing 240 m^3/day of PFAS contaminated water.

Evoqua Water Technologies (AQUA)

Evoqua is a leading provider of water and wastewater treatment solutions, offering a broad portfolio of products, services, and expertise to support industrial, municipal, and recreational customers. On January 23, 2023, Evoqua entered a definitive agreement to be acquired by Xylem Inc.

General Overview
Evoqua provides effective solutions for remediating emerging contaminants including PFAS from municipal and industrial water sources. The company is a single-source provider of remediation services, meaning it can provide customers with pilot testing as well as follow-up services. Evoqua is solutions-based and technology-agnostic with regard to its PFAS remediation services, allowing the company to provide the most effective solutions based on the water and treatment goals of its customers. Evoqua's remediation solutions include emergency, permanent, rental, and mobile options with flexible financing options.

PFAS Services

Assessment: Bench- and pilot-scale capabilities to provide insight into optimal treatment options.

Remediation:

- ***Summary:*** Water remediation solutions include pilot testing, installation and commissioning, media options, emergency response, and follow-up services (e.g., carbon reactivation and ion exchange). The company is technology-agnostic and can offer carbon, resin, or reverse osmosis solutions for PFAS remediation.

- ***End-Markets:*** Municipal drinking water (rural/low flow, large providers), construction site water treatment, EPA/superfund sites, military bases, and airports.

- ***Adsorption Systems:*** Aqua-Scrub® Carbon, PG Polyglass Liquide Phase, PV® High Pressure Liquide Phase Carbon, LS-275SS Vapor Adsorption Liquid Scrubber, WHISPER® Biofilter, LP Carbon Adsorbers, and HP® Liquid Phase Carbon Adsorption Systems.

- ***Carbon Media:*** NoRise pH Stabilized Activated, AquaCarb® GAC (reactivated/coal-based/coconut shell based), AquaPAC Powdered Activated, AquaPAC S Series Powdered Reactivated, BevCarb® 1240 Coal-Based GAC, GFH® DRY Granular Ferric Hydroxide Media, and Spent Carbon Reactivation and Recycling.

- ***Ion Exchange Resin:*** Epicor™ Powdered Ion Exchange Resin.

- ***MitiGATOR™:*** A mobile remediation solution that combines both carbon and resin to either provide stand-alone treatment for contaminated water or act as a treatment step within a multistep treatment system.

Destruction: Ongoing investments and research into destruction technology (e.g., plasma technology, foam fractionation, supercritical water) and application.

PFAS Business Commentary

Update on PFAS environment: *"It continues to proceed. We expect by the end of the year the MCLs will be defined. Then, there'll be a year of debate. And then after that, they'll be the CERCLA designation, hopefully. So, it's going to be several years before it really ramps up in that regards. But it continues to progress at a slightly accelerated pace."*

– Benedict Joseph Stas, CFO (Credit Suisse Industrials Conference; December 2022)

"… we expect PFAS remediation to provide long-term growth for many years to come."

– Ronald Keating, CEO (Fourth Quarter 2022 Earnings Call)

PFAS pipeline is *"stable at $100 million."*

– Walt Kozlowski, Director–Strategic Marketing, Sustainability (Goldman Sachs Water Symposium; September 2022)

"(PFAS) awareness level has continued to rise, not just within the sector and the utility sector, but within the community where PFAS is being found…."

With respect to PFAS pipeline progression: *"… pipeline has been pretty steady. We're winning roughly 30% of those deals that are out there…."*

With respect to PFAS opportunity: *"… probably a three- to five-year horizon before we start to see something material. But that doesn't mean that we're not working on it; we absolutely are. And we're in the mix both with current customers that understand our solution set as well as our … rentals and temporary systems and things like that are actually quite needed."*

Evoqua has *"80-plus (PFAS) installations … and they range anywhere from as small as $50,000 systems up to $10 million systems…."*

– Snehal Desai, Chief Growth & Sustainability Officer (Oppenheimer ESG Summit; September 2022)

Project Descriptions

- ***Kennebunkport PFAS Remediation Project (Kennebunkport & Wells Water District [KWWD]):*** Evoqua helped identify and provide the most cost-effective solution (i.e., GAC) for PFAS remediation with a KWWD supply well.

- ***Southern California Water District Removal of PFOA/PFOS from 30 Systems:*** Evoqua provided 30 liquid phase media adsorption vessel systems to the Southern California water district for removal of PFAS, allowing the district to deliver clean drinking water to more than 2.5 million district customers.

Geosyntec Consultants

Geosyntec consultants

Geosyntec is a consulting and engineering firm that works with private and public sector clients to address new ventures and complex problems involving the environment, natural resources, and civil infrastructure.

General Overview
Geosyntec practitioners have decades of experience addressing emerging contaminants, including PFAS, in natural and treatment environments. The company's consultants use various tools in appropriate and defensible ways for client advocacy in regulatory negotiations, property transactions, claim disputes, and strategic site management. PFAS-related expertise includes years of experience in PFAS investigation and remediation, hands-on project experience, a peer-reviewed publication record, investment in PFAS research, and an owner-based focus on the issue.

PFAS Services

Measurement & Testing: Expertise in using diagnostics and forensic tools to distinguish PFAS sources.

Project Implementation: Experience in implementing strategic site investigation and remediation programs for routine or complex sites. Committed to offering cost-effective, defensible solutions for clients.

AFFF Release Mitigation: Proficiency in mitigating PFAS impacts following incident response activities using AFFF.

Legal: Testifying and consulting capabilities, and direct involvement in many of the largest and most complex legal disputes related to emerging contaminants.

Research & Development: Actively leading applied research and demonstration efforts to develop new technologies for sampling and treating PFAS. Authors of guidance documents, technical articles, books, and journal publications to communicate key PFAS advances.

Project Descriptions

- Focused remedial investigation at Plattsburgh AFB (USAF, Ahtna)
- Large-scale multimedia PFAS assessment (confidential client, Florida)
- PFAS source assessment, forensics, and compliance (confidential client, New England)
- PFAS investigation related to California statewide orders (multiple landfills and airports, California)
- Fire training area assessments (confidential client, Florida)
- Groundwater modeling to evaluate PFAS fate and transport (Eielson AFB, Alaska)
- Smoldering combustion treatment of PFAS-impacted materials (SERDP, Savron)
- PFAS stormwater best management practices (SERDP, Texas Tech, Stanford University, SPAWAR/NIWC Pacific, University of Alabama)
- Stormwater drywell guidance (California State Water Resources Control Board)
- In-situ treatment to enhance PFAS removal/destruction (ESTCP, Navy, University of California, Berkeley)
- Development of real-time PFAS analytical methods (Geosyntec, Eurofins)
- Human health risk, fate, and chemical liability assessment (Minneapolis-St. Paul, Minnesota)
- Community outreach/regulatory policy adherence (Issaquah Valley aquifer, King County, Washington)
- Expert panel regarding PFAS regulation (RAAF Base Williamtown, Australia)
- Catalyzing knowledge transfer among key stakeholders (SERDP, ESTCP, Ohio State University)
- Guidance for assessing the ecological risks of PFAS to threatened and endangered species at AFFF-impacted sites (SERDP, Colorado School of Mines)
- Litigation support for solid waste industry (confidential client, U.S.)
- Developing a lines-of-evidence approach to assessing PFAS treatment technologies (SERDP, Oregon State University, Colorado School of Mines, University of California, Berkley)

Ground/Water Treatment & Technology

Ground/Water Treatment & Technology (GWTT) is a vertically integrated total water management solutions company that self-performs system design; civil, electrical, and mechanical site work; equipment fabrication and customization; dewatering; and licensed operation and maintenance for groundwater treatment systems.

General Overview
Leveraging its systems engineers and chemistry expertise, GWTT provides bespoke water treatment system builds and operational services that use a combination of technologies to meet clients' specific contaminant profile and effluent requirements. The company determines its choice of treatment technology based on the unique contaminant profile of each project.

PFAS Services

Testing & Analysis: Water and soil testing prior to system build to understand contamination profile.

Remediation: Technology selection based on project's unique contaminant profile. Treatment technology options offered include GAC, nonregenerating synthetic resins, and regenerating synthetic resins.

O&M: Full suite of day-to-day O&M services to clients focused on increased efficiency and cost savings.

Project Descriptions

- ***PFOA/PFOS Treatment System at U.S. AFB (Portsmouth, NH):*** Project management for construction of 200 GPM capacity groundwater extraction and PFOS Treatment System at U.S. AFB.

Heritage-Crystal Clean, Inc. (HCCI)

Heritage-Crystal Clean is a national leader in the environmental services market, providing full-service parts cleaning, containerized waste management, used oil collection, wastewater vacuum services, antifreeze recycling, and field services. The company also owns and operates a used-oil refinery.

General Overview
Through various joint ventures, Crystal Clean provides turnkey PFAS remediation and destruction solutions.

PFAS Services

4never™ Closed-Loop PFAS Solution: In January 2023, Crystal Clean entered a partnership with Allonnia, Revive Environmental, and EPOC Enviro to launch 4never, a closed-loop PFAS solution for landfill and industrial waste management companies. The technology uses EPOC Enviro's SAFF foam fractionation technology as well as Revive's PFAS Annihilator solution to completely destroy PFAS. Crystal Clean will operate as the exclusive distributor and operator of 4never.

PFAS Business Commentary

Regarding size of PFAS market opportunity: *"I can't even tell you the TAM. It's going to be huge. This is a nine-figure opportunity for us, we believe … we think this is probably $25 million for next year for us in revenue…."*

– Mark DeVita, CFO (Needham Growth Conference; January 2023)

"… even though regulations aren't driving it, companies are concerned about how they manage wastewater that has PFAS contamination. I do think we're at the leading edge of it, and probably ahead of a lot of our competitors with our total turnkey package."

"...haven't forecasted any meaningful revenue for next year, but ... currently managing two landfills today, managing their leachate stream and PFAS contaminated with the equipment that we have under a JV agreement. We're excited about it. It's working well."

– Brian Recatto, CEO (Third Quarter 2022 Earnings Call)

"We are taking calls all the time asking if we can help to get rid of PFAS...."

– Brian Recatto, CEO (Press Release; March 2022)

Project Descriptions

- ***4never™ Launched as First Full-Scale, Closed-Loop PFAS Solution in Market (2023):*** Crystal Clean (in partnership with Revive Environmental, Allonnia, and EPOC Enviro) brings an end-to-end solution to separate, concentrate, transport, and annihilate PFAS contamination from landfill and industrial waste management sites.

Jacobs Solutions Inc. (J)

Jacobs is a leading provider of engineering and technical solutions for government customers. Its engineering solutions span several major end-markets including water, transportation, high-tech, nuclear energy, and pharmaceuticals.

General Overview
Jacobs offers planning and development services for PFAS management strategies that are both cost effective and compliant with the current regulatory environment. The company's PFAS-related services include characterization and risk assessment, master planning, remediation and infrastructure solutions, and communication strategies.

PFAS Services

Assessment: Human health risk assessment, ecological risk assessment, site investigation, characterization and hydrogeology, and personnel interviews and historical records searches.

Measurement & Testing: Water source monitoring and evaluations, bench- and pilot-scale testing, hydraulic distribution modeling, and technology alternatives evaluations.

Water Remediation:

- ***Conventional Technologies:*** GAC, ion-exchange sorption, membrane filtration (e.g., reverse osmosis), and alternative absorbents (e.g., surface modified clay, cyclodextrin)

- ***Development Technologies:*** Advanced oxidation-reduction, in situ sequestration (e.g., colloidal activated carbon), and biotreatment.

Soil Remediation:

- ***Conventional Technologies:*** Capping, stabilization, disposal (e.g., offsite transfer to landfill), and incineration.

- ***Development Technologies:*** Thermal desorption, size segregation/soil washing, and natural solutions (e.g., enhanced natural in situ processes).

PFAS Business Commentary

"… our innovation investments in PFAS solutions have resulted in an award for its first of its kind program to study nature-based remediation options at more than 35 airports across Australia."

– Robert Pragada, COO (Second Quarter 2022 Earnings Call)

With respect to timing around PFAS opportunity: *"… you're talking about a few-year window here. The next two to five years are a very interesting time that we'll see acceleration on many fronts in this country, but also realize that other countries around the globe, actually their regulatory environment actually is a bit different than ours. And so, in some parts of the world, Australia as an example, they are a bit further ahead in terms of their regulatory way of thinking about this."*

"… with the Biden Administration and the EPA taking their interest and working their way through, especially from an environmental justice perspective and the focus around this class of compounds, we're seeing increased activity and more collaboration between the feds and the states."

– Jan Walstrom, Senior Vice President, Solutions & Global Environmental Market Director (Bank of America PFAS Water Summit; June 2021)

Project Descriptions

- ***Low Temperature Desorption of PFAS in Soils (U.S. Navy Installation):*** In conjunction with U.S. Navy LANTDIV, Battelle, and SGS AYXS Analytical Services, Ltd., Jacobs was able to show effective removal of PFAS from soil using thermal treatment through various bench-scale tests.

- ***PFAS Clean-up at North Bay Jack Garland Airport (Ontario, Canada):*** Jacobs was selected for environmental assessment activities, development of remedial design, and engineering consulting services related to PFAS cleanup.

Montrose Environmental Group (MEG)

Montrose Environmental is a leading integrated environmental solutions provider, with a broad portfolio of technologies that are used to evaluate, analyze, and remediate environmental issues for corporate and government clients.

General Overview
Montrose offers various PFAS services including risk assessment and remediation, sample collection and analysis, validation, treatment and reporting. The company's PFAS experts include scientists, geologists, engineers, chemists, risk assessors, and field technicians who are uniquely positioned to construct turnkey solutions for clients when it comes to management of PFAS-related challenges.

The company's PFAS treatment capabilities include: 1) modular for fast installation, turnkey, and quick start-up projects; 2) mobile for short-term water treatment activities; and 3) custom design to meet specific customer needs (e.g., GAC system upgrade/replacement, supplemental PFAS treatment, bespoke site-specific needs). Montrose offers PFAS treatment solutions for surface water, wastewater, drinking water, groundwater, construction dewatering, and investigation derived waste. Along with being 13 times more effective in remediation when compared with other forms of treatment, Montrose's PFAS solutions can reduce waste by up to 99%, lifecycle costs by 50%, and treatment system size by 67% (when compared with incumbent carbon treatment systems).

PFAS Services

Investigation: Multidisciplinary team of investigators, scientists, and environmental professionals who can 1) characterize the PFAS-contaminated site (e.g., understanding of source area, points of exposure, extent of

migration, and fate and transport); and 2) develop conceptual site models to help in the establishment of interim and long-term treatment solutions.

Lab Services: Scaled PFAS analysis platform (Enthalpy Ultratrace Lab) capable of precise detection of both legacy (PFOS/PFOA) and new PFAS compounds (e.g., GenX). Ultratrace offers a dedicated laboratory to minimize background- and cross-contamination, an extensive compound list, large sample capacity, senior project scientists for test-plan development and sampling support, standard 10 business-day turnaround, and NELAP accreditation.

Air: Comprehensive air sampling capabilities through Montrose Air Quality Services (MAQS) to assist in determining off-site sources and deposition of PFAS from air-borne emissions.

Water Treatment:

- ***Overview:*** Capable of providing detailed system designs, disinfection services, change-out frequency estimation, accelerated column testing, in situ liquid-activated carbon injection, and bench-scale and pilot-scale treatment studies for removal of individually targeted PFAS.
- ***Treatment Configuration Options:***
  - Modular for fast installation, turnkey, and quick start-up projects.
  - Mobile for short-term water treatment activities.
  - Custom design to meet specific customer needs (e.g., GAC system upgrade/replacement, supplemental PFAS treatment, bespoke site-specific needs).
- ***Technology:***
  - *PILOT PS Series:* Used in pilot programs for ready-to-run demonstration of remediation technology.
  - *SORBIX PURE and RePURE™ Ion Exchange (IEX) Resin System:* Patented single-use (PURE) and regenerable (RePURE) resin solution offering 13 times greater remediation effectiveness versus other approaches (e.g., GAC, reverse osmosis). Regenerable RePURE solution reduces waste by 99%, lifecycle costs by 50%, and treatment system size by 67%.
  - *FOAM-X:* Proprietary foam fractionation system that offers a cost-effective solution for PFAS removal from highly contaminated water.

Best Practice Usage: Offering consulting services to various organizations as it relates to PFAS management and best practices (e.g., transition from AFFF to fluorine free foams, characterization and testing of PFAS waste for wastewater treatment plant acceptance).

PFAS Business Commentary

"… we think that (PFAS) could be a third or more of (our) business over time."

"If you have water with lots of PFAS in it, so high concentrations. And you're worried about lifecycle costs which tends to be more prominent with the private sector. And then this concept of sustainability…. Those themes pull demand to us and we've demonstrated now over and over again that our solution works really well."

– Vijay Manthripragada, CEO (Needham Growth Conference; January 2023)

"… in our remediation and reuse segment, revenues increased 32% year-over-year … reflecting a significant increase in demand for our PFAS water treatment services…."

"As we think about PFAS in aggregate representing Montrose's percentage of revenue … this year, we think it will be closer to 20%. As we look across the next three to five years, we think that has the possibility of increasing well beyond the 20% of full revenue mix."

Commentary on recent federal and state PFAS regulatory action as it relates to demand for Montrose's services: *"We expect all these developments will continue to create tailwinds across our three segments."*

– Vijay Manthripragada, CEO (Third Quarter 2022 Earnings Call)

Regarding relative advantage of Montrose's technology: "*have relative advantages … when you have more complex water and you have more contamination."*

– Vijay Manthripragada, CEO (Second Quarter 2022 Earnings Call)

Project Descriptions

- ***Pease Air National Guard Base (Portsmouth, New Hampshire):*** Installment of Montrose's regenerable IEX solution at the former base fire training area has allowed for reduction in PFAS contamination from "more than 100ppb" to "below 30ppb."

- ***Drinking Water System Evaluation, Remediation and Water Supply Protection (New York):*** Following the installment of a GAC system for removal of PFAS contamination near a local airport and military base, Montrose was tasked to evaluate the effectiveness of the GAC system, critically review investigation data on the crisis, and provide immediate recommendations for remedial action.

- ***Design, Permitting and Installation of Treatment System for Public Water Supply System (New Jersey):*** Montrose designed and permitted a GAC system to address detected PFOS/PFOA for a small potable water supply system, ultimately helping reduce contamination from 88 ppt to non-detect levels.

- ***Airport Investigation (New Jersey):*** Montrose conducted assessment for potential groundwater contamination, which included testing of existing monitoring wells and direct-push sampling.

- ***Alternative Treatment Methods Testing (Pennsylvania):*** Montrose performed bench-scale testing of alternative treatment methods for a municipal public supply where groundwater had been contaminated with PFAS.

- ***Assessment and Remediation of Drinking Water Supply at an Army Installation (California):*** Montrose was contracted to assess and remediate drinking-water supply fed by three wells. Scope of work included assessment of remedial options, a bench-scale study, and a pilot study.

Pall Corporation | Danaher

Pall Corporation is a global leader in high-tech filtration, separation, and purification, serving the diverse needs of customers across a wide range of applications including power generation, industrial manufacturing, microelectronics, chemicals and polymers, biotech, food and beverage, laboratory, medical, aerospace, and oil and gas. Since 2015, Pall Corporation has operated as a wholly owned subsidiary of Danaher.

General Overview
Pall Water, a division of Pall Corporation, can offer effective removal of PFAS from wastewater and drinking water through its portfolio of temporary and permanent water treatment solutions. The company's PFAS remediation technology uses microfiltration (MF), ultrafiltration (UF), and reverse osmosis (RO)/closed-circuit reverse osmosis (CCRO). The company's solutions are designed for municipal and industrial waste treatment applications.

PFAS Services

Remediation:

- ***MU/UF:*** Robust and durable membrane for long service life. Removal of particulates, oxidized inorganics, and total organic carbon.
- ***RO:*** Effective removal of wide spectrum of PFAS. Treatment results in creation of waste stream treated with GAC. Removed compounds destroyed through thermal regeneration of carbon.
- ***CCRO:*** Standard RO components in a patented process design. Removed compounds destroyed by thermal regeneration of carbon. Allows for improved recovery and reduction of waste volume, energy costs, and carbon volume requirements.
- ***System Options:*** Adaptable options including mobile, trailer, or containerized (e.g., Aria™ FAST MF, Aria FAST UF, Aria IMPRO™ CCRO) or permanent/packaged equipment (e.g., Aria FIT MF/UF Packaged Systems, Aria FLEX MF/UF Large Volume Systems, IMPRO CCRO systems of all sizes).

Parsons Corporation (PSN)

Parsons is a leading provider of IT and smart city solutions for federal, state, and local government customers.

General Overview
Through practical innovation, insight, advocacy, and technology, Parsons offers PFAS management, mitigation, and remediation assistance to clients. Parsons' PFAS team offers various expertise in a variety of fields including ecological risk assessment, human health, water and wastewater treatment, hydrogeology, remediation, and modeling. The company takes a full lifecycle approach to PFAS management by identifying PFAS, breaking it down, remediating the problem, and providing follow-on monitor and support solutions. Parsons has conducted PFAS investigations at over 1,000 sites and has designed, constructed, and operated a number of industrial wastewater plants across the United States focused on treatment of PFAS.

Given the company's role as a government consulting agency, Parsons has worked with the DoD for over 50 years offering environmental engineering services, including those related to PFAS investigation, mitigation, and remediation.

PFAS Services

Disciplines: Hydrogeology, human health, ecological risk assessment, water and wastewater treatment, remediation, and modeling.

Innovation: Conducting self-funded, internal research and development for improved management and remediation of PFAS; collaborating with other research organizations on PFAS destruction technology, testing methods, and analytical tools; optimizing filtration technologies for various PFAS (e.g., PFOA, PFOS) and replacement products (e.g., GenX).

Industry Expertise: Water supply treatment, manufacturing, firefighting, metal plating facilities, landfills, petroleum facilities, industrial coating, and aviation facilities.

PFAS Business Commentary

"Our Parsons emerging contaminant team has been aggressively pursuing opportunities and building market share with a total of over $40 million in PFAS contract wins in both our Federal Solutions and Critical Infrastructure segments over the last nine months."

– Carey Smith, CEO (Third Quarter 2022 Earnings Call)

Project Descriptions

- ***U.S. Army National Guard Task Order for PFAS Remediation & Feasibility Studies (National):*** On November 7, 2022, Parsons announced that it had won an 8-year, $28 million contract to conduct remedial investigations and feasibility studies at 16 Army National Guard Facilities across 12 states where AFFF or other PFAS releases have occurred.

Ramboll

Ramboll is a global, multidisciplinary engineering, architecture and consultancy company operating across the following markets: buildings, transport, water, environment and health, energy, and towers and telecom services.

General Overview
Ramboll has been providing expert solutions to PFAS challenges for more than 20 years. The company offers 1) a global network of experts with local knowledge of the rapidly evolving PFAS scientific, regulatory, and treatment landscape; 2) extensive practical experience, along with insight into evolving PFAS regulations and emerging technical topics; 3) innovative, industry-leading forensic approaches to characterizing PFAS sources; and 4) a unique combination of expertise in PFAS chemistry, health effects, and engineering.

PFAS Services

Site Investigation & Remediation: Site investigations for PFAS in soil, groundwater, surface water, sediment, air, produce and livestock; human health and ecological risk assessments; feasibility studies, cost estimation and remedy selection; remedial design and remedial action implementation; and risk communication among many stakeholders, including the public.

Health Science & Risk Assessment: Assistance in assessing potential human health and environmental risks associated with exposure to PFAS, and evaluation of toxicology, epidemiology, and pharmacokinetic aspects of PFAS.

Forensic Analysis: Experience using forensic analysis to assist clients in identifying the relative contributions of various potential sources of PFAS detected in the environment.

Due Diligence and Compliance: Business risk management and/or property transactions; assistance navigating PFAS-related issues during mergers and acquisitions, property transactions, divestitures, and ongoing operations.

Air Emissions, Transport, & Transformation: Assist clients in characterizing and controlling PFAS emissions to air and in evaluating PFAS transport and transformation in the environment.

Product Safety and Stewardship: Development, implementation, and monitoring of PFAS product safety and stewardship programs.

Water & Wastewater Treatment: Holistic approach to understanding and reducing PFAS discharges; planning, permitting, and treatability evaluations; and engineering and treatment plant construction and O&M.

Expert Services & Litigation Support: Expert representation for clients involved in PFAS-related litigation.

Project Descriptions

- ***Multimedia PFAS source investigation, risk assessment, and remediation at an industrial manufacturing facility (confidential client, United States):*** Helped client save over $20 million and minimize liabilities, resulting in clean community drinking water.

- ***Site investigation and remediation at a former fire training ground (confidential client, Australia):*** Demolishing a former aluminum smelter and remediating PFAS-contaminated land for future commercial or industrial use.

- ***Water treatment plant upgrades to remove PFAS (City of Martinsburg, West Virginia):*** Provided services to upgrade one of the largest water treatment plants in the United States that removes PFAS to meet potable water quality requirements and helped secure 100% cost recovery from the U.S. federal government.

- ***Support for client during PFAS litigation (confidential client, Italy):*** Supporting a client during criminal proceedings related to the charge of PFAS contamination.

- ***PFAS guidance for Danish EPA and regions (Danish EPA and Regions, Denmark):*** Prepared guidelines for investigating and remediating PFAS contamination on behalf of the Danish EPA and regions.

- ***Exposure and risk assessment of PFAS in consumer products (confidential client, Global):*** Assessed potential human health risks associated with exposures to residual PFAS in consumer products.

REGENESIS

REGENESIS offers remediation professionals a suite of innovative technologies and services to treat a wide range of contaminants, including petroleum hydrocarbons, chlorinated solvents, PFAS and metals, via enhanced bioremediation, bioaugmentation, in situ chemical oxidation, reduction (ZVI), sorption, desorption, immobilization, and vapor intrusion mitigation.

General Overview
REGENESIS is a leader in research, development, and commercialization of technology-based solutions for the environment, including PFAS remediation. The company exclusively works for environmental engineering consulting firms who engage the company for any of the following:

- Achieve site closure efficiently and cost-effectively
- Evaluate a range of sites impacted with subsurface contamination
- Develop tech-based solutions for groundwater and soil remediation
- Minimize risk and increase the certainty of remediation with turnkey services
- Make remediation solutions recommendations and provide product/technology applicability assessment and application designs
- Help navigate regulatory frameworks and provide end-user information
- Review site remediation performance and results

PFAS Services

SourceStop™ Colloidal Activated Carbon (CAC):

- ***Overview:*** Applicable to the vadose zone, capillary fringe, and groundwater of PFAS source areas to rapidly remove high levels of PFAS from the dissolved phase. SourceStop eliminates or drastically reduces the movement of mass from the source area.

- ***Benefits:*** Rapid risk reduction, cost effective (avoidance of excavation and disposal or pump and treat), safe to use, highly flexible to match site needs, and sustainable approach (no disposal or energy use).

- ***Source Applications:*** Soil and groundwater.
- ***Site Applications:*** Airports, fire training areas, industrial sites, and fire-response locations.

PlumeStop® Liquid Activated Carbon™:

- ***Overview:*** Unique groundwater remediation technology designed to rapidly remove and permanently degrade groundwater contaminants. PlumeStop absorbs PFAS in groundwater, preventing further migration and providing enhanced attenuation of the residual plume.
- ***Key Points:*** Targets dissolved-phase plumes, achieves very low remedial targets, provides long-term treatment, and addresses further influx and back diffusion.
- ***Site Applications:*** Brownfield, dry cleaning, government/defense, industrial sites/manufacturing, and rail.

Project Descriptions

- ***Camp Grayling Joint Maneuver Training Center In Situ Treatment of PFAS (Michigan):*** REGENESIS Remediation Services (RRS) completed the first and longest-run successful in situ treatment of PFAS in United States using PlumeStop CAC.
- ***New York Brownfield Site Treated for PFAS Achieves Closure (New York):*** REGENESIS provides PlumeStop in situ remediation solution for 25-acre former refinery in a mixed-use industrial/commercial area that was contaminated with PFAS.
- ***Camp Grayling Military Training Center In Situ CAC Pilot Testing (Michigan Army National Guard):*** Economical and effective pilot testing using PlumeStop at Camp Grayling results in reduction in PFAS and PCE to non-detect levels 3.5 years post-application.
- ***Solvents Recovery Service of Soil/Groundwater Remediation using PlumeStop (New England):*** PlumeStop quickly reduced PFOS/PFOA levels and estimated savings of $400,000 annually as a result of halting pump and treat operations.

Revive Environmental

Founded in 2023 through a partnership between Battelle and Viking Global Investors, Revive Environmental offers advanced technologies to assist customers and communities in eliminating complex environmental contaminants.

General Overview
Revive Environmental offers deployable technology to treat and destroy environmental contaminants including PFAS. The company's PFAS solutions offer mitigation of both diluted and concentrated PFAS in various media including drinking water/wastewater, landfill leachate, and AFFF. Examples of patented PFAS technology include PFAS Annihilator™ and GAC Renew™.

PFAS Services

PFAS Annihilator

- ***Overview:*** Designed by Battelle, PFAS Annihilator uses high temperature and pressure in a process known as supercritical water oxidation (SCWO) to break the carbon-fluorine bonds within PFAS, effectively destroying the compound.

- ***Benefits:***

  - Complete destruction of PFAS (both short and long chain)
  - Treatment of any PFAS concentration or matrices
  - No harmful byproducts
  - On-site or mobile

GAC RENEW™

- ***Overview:*** GAC RENEW enables on-site regeneration of granular activated carbon, allowing for extended lifespan, minimal downtime, and reduced total ownership costs. The technology operates as a dual tank system, allowing for continued treatment even as one tank undergoes regeneration. PFAS Annihilator is employed to destroy concentrated extract following application of regenerant solution.

Project Descriptions

- ***4never™ Launched as First Full-Scale, Closed-Loop PFAS Solution in Market (2023):*** Revive Environmental (in partnership with Heritage-Crystal Clean, Allonnia, and EPOC Enviro) brings an end-to-end solution to separate, concentrate, transport, and annihilate PFAS contamination from landfill and industrial waste management sites.

Tetra Tech, Inc. (TTEK)

Tetra Tech is a leading global provider of consulting and engineering services supporting global commercial and government clients focused on water, environment, sustainable infrastructure, renewable energy, and international development.

General Overview
Tetra Tech has expertise in helping clients address emerging contaminants that can be found in groundwater and surface waters including PFAS. Services include research and development, water quality characterization, and design of demonstration, remediation, and municipal-scale treatment solutions.

PFAS Services

Research & Development: Regulatory compliance support, toxicity studies, and risk assessment.

Water Quality Characterization: Monitoring, sampling, lab analysis, predictive modeling, and communication and outreach.

Demonstration, Remediation, and Full-Scale Treatment: Feasibility studies, demonstration studies, and detailed design.

PFAS Business Commentary

Regarding new programs to investigate and treat emerging contaminants: *"... we have $50 million worth of orders to investigate emerging contaminants. And to be specific, that's primarily PFAS ... to look back a year, that number was probably around $20 million. So it's up by about 150%. So it's growing."*

Regarding PFAS market opportunity for Tetra Tech: *"Adding treatment technologies to treat PFAS at every single water supply utility in the U.S."*

"... stringent government regulations are driving additional spending for our scientists and our engineers to investigate, assess, and evaluate innovative treatment technologies to address emerging contaminants such as PFAS."

– Dan Batrack, CEO (First Quarter 2022 Earnings Call)

Project Descriptions

- ***PFAS Treatment System Development Project (Orange County Water District):*** The company completed the development of the largest ion-exchange PFAS treatment plant in the United States for three Orange County Water District agencies including 11 ion-exchange systems, a 25 million gallon-per-day booster pump station, and an on-site chlorine generation system.

TIGG | Newterra

TIGG is a leading manufacturer of activated carbon equipment and filters used in environmental remediation activities including water and air treatment. The company operates across a number of market sectors including PFOA/PFOS, municipal water, groundwater treatment, manufactured gas plants, water filtration, PCB removal, soil vapor extraction, vapor emission, and odor removal.

General Overview
The company develops, designs, manufactures, and installs environmental remediation equipment for the removal of trace contaminants from the air, water, process liquids, and gases. TIGG offers complete filtration tank systems along with GAC media, which can remove PFOA and PFOS to nondetectable levels.

PFAS Services

CP20K PFAS Treatment Systems: Deep bed, back washable, dual vessel skid adsorption systems using TIGG's 5DC virgin coconut GAC media to remove PFAS to nondetectable levels in potable water. The dual-vessel system comes in a variety of sizes and can be installed in 8 hours or less.

Groundwater Remediation:

- CANSORB P: Liquid phase activated carbon adsorption vessel
- ECONO L Drum: Polyethylene-built activated carbon groundwater adsorption drum with a closed head offering a dependable solution for small scale remediation projects.

US Ecology | Republic Services

US Ecology is a leading provider of environmental services to commercial and government entities. The company offers treatment, disposal, and recycling capabilities for hazardous, nonhazardous, and radioactive waste; leading emergency response and standby services; and a wide range of complementary field and industrial services. Following the completed acquisition of US Ecology by Republic Services on May 2, 2022, US Ecology began the process of rebranding its business to Republic Services.

General Overview
US Ecology has 70-plus years of experience within the environmental solutions industry and is a market leader in PFAS waste management for government and industry clients. The company offers comprehensive PFAS solutions including both turnkey remediation and transportation capabilities and disposal options through regulatory-compliant disposal sites. Working alongside environmental engineering and consulting businesses, US Ecology uses a partnership approach to mitigate PFAS risk and manage projects. US Ecology accepts the following PFAS waste streams:

- Industrial by-products (plating, finishing, manufacturing, and other)
- Landfill leachate
- Filter cake and water treatment media
- Liquid phase
- Solid or liquid remediation waste and debris

- AFFF concentrates and firefighting foam
- Contaminated soils, rinsates, sludges, and groundwater

PFAS Services

Remediation: Thermal, carbon filtration, ion-exchange, or resin filtration systems designed to meet water quality standards set by publicly owned treatment works.

Landfill Disposal:

- ***Overview:*** Secure disposal in arid climate Subtitle C landfills with zero leachate discharge ending the mobility cycle of PFAS. Disposal sites are strategically located in Grand View, Idaho, and Beatty, Nevada.

- ***Design Criteria:*** Double or triple synthetic liners, multiple leachate collection and removal systems, leak detection systems, run-on, runoff, and wind dispersal controls, and construction quality assurance program.

Deep-Well Injection:

- ***Overview:*** Accepting large volume, high-concentration PFAS liquid waste at secure underground deep-well injection disposal facility in Winnie, Texas. Injection facility is strictly regulated and well-positioned to accept PFAS from across the United States.

Project Descriptions

- ***Michigan EGLE Program for Safe Disposal of Class B AFFF:*** US Ecology contributed to the safe disposal of more than 30,000 gallons of Class B AFFF by collecting AFFF liquid from Michigan-based fire departments and transporting it to a licensed hazardous waste facility in Idaho for solidification and disposal.

- ***Partnership with City of Ionia, Michigan, to Dispose of PFAS-Contaminated Waste Solids:*** US Ecology partnered with the City of Ionia to remove, transport, and dispose of over 1,700 tons of PFAS-contaminated waste solids.

- ***Wurtsmith AFB Project (Iosco County, Michigan):*** Successful removal, transportation, and disposal of over 24,000 tons of PFAS-contaminated soil resulting from use of AFFF.

Veolia (VIE-FR)

Veolia is a global leader in optimized resource management, designing and providing water, waste and energy management solutions that contribute to the sustainable development of communities and industries.

General Overview
Veolia provides treatment for PFOA and PFOS to both municipal and industrial customers including municipal drinking manufacturers, refineries, airports, military sites, drinking water facilities, and more. The company's PFAS solutions to municipal drinking water customers include funding security, management of PFAS in contaminated water, and waste treatment through incineration or other forms of destruction. Veolia offers a six-step approach to PFAS remediation allowing for maximum efficiency and single-point management.

PFAS Services

Sampling & Testing: Administer sample plan development, training, sampling, and testing for ground/surface water.

Treatability Study: Evaluate water characteristics and potential treatment challenges within state/local policy, and deliver temporary/emergency solutions or full-scale treatment with available technologies.

Pilot Study: Conduct lab trials or pilot testing in the field to evaluate pretreatment needs and best fit technologies (e.g., activated carbon, ion exchange, reverse osmosis, foam fractionation).

Design: Select the most adapted process technology and sizing for chemical destruction in a safe, environmentally friendly manner while minimizing life cycle cost (including operations and maintenance expenses, such as media change-out optimization and disposal costs).

Construction & Operation: Capital program management (CPM) services with a turnkey solution that includes construction and O&M pricing.

Treatment of Waste: Offer an environmentally responsible disposal option for the spent material resulting from the water treatment through incineration at facility in Port Arthur, Texas.

Project Descriptions

- ***Mobile PFAS Treatment of AFFF Contaminated Site (Victoria, Australia):*** Veolia was contracted to develop a mobile remediation solution to treat and manage a large body of contaminated water near a former fire-fighting training site that had previously used AFFF. Veolia's solution included technical resources and project management, environmental and quality plans, pipeworks, tanks, pumps and instruments, and commissioning and ongoing sampling and real time data reporting.

WSP Global Inc. (WSP-CA)

WSP is a globally recognized professional services firm, providing technical expertise and strategic advice to clients in the transportation and infrastructure, property and buildings, environment, industry, resources and energy sectors, as well as offering project and program delivery and advisory services.

General Overview
WSP addresses PFAS concerns by combining practical solutions with innovative ideas and ground-breaking technologies, aligned with clients' goals and risk tolerance levels. The company has completed hundreds of PFAS-related projects including portfolio screening, investigation and assessment, site characterization, and risk assessment. WSP's PFAS Practice Area network comprises more than 100 specialists and 155-plus office locations around the globe. Through academic and industrial partnerships, WSP has several applied research and development activities currently underway including:

- Electro-oxidation (EO) destruction of PFAS in groundwater, industrial, and other PFAS-containing aqueous waste streams
- Ball milling destruction of PFAS in soil
- Modified clay mineral mediated in situ and ex situ treatment in all environmental media

PFAS Services

Consulting & Assessment: Desktop site portfolio screening, corporate and employee training, due diligence, PFAS-specific evaluation in Phase 1 Environmental Site Assessments, standards/guidelines development or regulatory peer review, permitting and compliance, site investigation (chemical forensics, transport modelling and Groundwater Plume Analytics®), risk assessment/toxicology, air modeling, technical support for hearings/litigation, and environmental health and safety/industrial hygiene.

Transition: Product stewardship, operation/supply chain assessment, development of PFAS-free or low impact practices, PFAS/AFFF phaseout, equipment cleaning and treatment.

Remediation: Site remediation, water, wastewater, and leachate treatment.

Destruction: Efficient, sustainable, and scalable Electro-oxidation PFAS destruction solution using long-lasting electrodes.

Project Descriptions

- ***PFAS Remediation at Multiple Locations at a North American Airport:*** WSP was contracted by an international North American Airport for the characterization and remediation of PFAS impacts associated with the historical and current firefighting training facilities.

- ***Helping Protect the Public and Environment from PFAS Impacts on a Military Base:*** Case study in WSP's success factors associated with PFAS analysis and mitigation—particularly the value of having a 3D conceptual site model to determine the pathways and receptors, and to provide information for choosing mitigation methods.

374Water (SCWO)

374Water is a global cleantech, social impact company whose mission is to preserve a clean and healthy environment that sustains life. The company is focused on pioneering a new era of sustainable waste management that supports a circular economy and enables organizations to achieve their environmental, social, and governance (ESG) and sustainability goals.

General Overview

374Water offers a simple, proven PFAS treatment option known as AirSCWO™. AirSCWO relies on the unique reactivity and transport properties of water above its critical point of 374 °C and 218 atmosphere. At these conditions, organics are fully soluble in supercritical water, and with the addition of oxygen, all organics rapidly and completely oxidize to form carbon dioxide, clean water, and inorganic salts. 374Water is the first company to develop a SCWO sanitation treatment system with patented self-sustaining reactor technology.

PFAS Services

AirSCWO:

- ***Overview:*** AirSCWO™ is a physical-thermal process that uses water above its critical point and air to yield a highly effective oxidation reaction that completely eliminates organic compounds. This supercritical water oxidation treatment technique results in energy generation and safe products that can be recovered and reused. The system harnesses an efficient decentralized solution for treating a broad range of waste feedstocks rapidly, continuously, cost-effectively and with unprecedented reliability. Treating PFAS concentrate like GAC, IEX resin, PFAS laden sludge, or any PFAS slurry through an AirSCWO system results in greater than 99.9% elimination of PFAS and their derivatives.

- ***Features:*** Continuously operating (24x7 flow-through system), compact/modular, containerized, small footprint, fully automated (digital with SCADA and process historian), energy efficient (self-sustaining power generation), omniprocessor (processes a wide variety of wastes).

- ***Sizing & Performance:***

  - AirSCWO Nix6

    - Daily Capacity: 6 wet tonne/day
    - Energy: -240 kWh/day
    - Container Size: 40 feet

- AirSCWO Nix30
  - Daily Capacity: 30 wet tonne/day
  - Energy: +300 kWh/day
  - Container Size: 3x40 feet
- AirSCWO Nix30
  - Daily Capacity: 200 wet tonne/day
  - Energy: +4,000 kWh/day
  - Container Size: Bespoke sizing

Project Descriptions

- ***Small Scale Municipality—Elimination of PFAS in Lime Stabilized Sludge (Maine):*** 374Water's SCWO system effectively treated contaminated sludge and destroyed PFAS below the regulatory limits. Treatment was stable, reliable, and effective and there were no signs of enhanced corrosion.

Appendix A Notes and Sources

This list is not meant to be comprehensive given the highly fragmented nature of the environmental remediation industry and market for PFAS-related services.

Sources: FactSet, William Blair Equity Research, ACV Enviro, AECOM, Arcadis, Battelle, Calgon Carbon Corporation, Claros Technologies, Clean Harbors, Clear Creek Systems, Envirogen, Environmental Resource Management, EPOC Enviro, Evoqua, Geosyntec Consultants, GWTT, Heritage-Crystal Clean, Jacobs, Montrose Environmental Group, Pall Corporation, Parsons, Ramboll, REGENESIS, Revive Environmental, Tetra Tech, TIGG, US Ecology, Veolia, WSP Global, 374Water

Appendix B: State Profiling

Alabama

Background

- The primary agency overseeing Alabama's PFAS-related initiatives is the Alabama Department of Environmental Management (ADEM).
- As part of UCMR 3, 124 public water systems across the state began monitoring for 6 PFAS in 2012. Eight systems had results at or over the 70 ppt EPA health advisory level for combined PFOA/PFOS. Various responses (e.g., installment of water treatment systems, re-sourcing of water) were taken at each of these locations in response to PFAS contamination.

Alaska

Background

- The primary agency overseeing Alaska's PFAS-related initiatives is the Alaska Department of Environmental Conservation (DEC).
- Legacy PFAS contamination is primarily a function of the use of AFFFs in training exercises and firefighting.
- In conjunction with the EPA's issuance of lifetime health advisory levels in 2016, the DEC release cleanup levels for PFOS and PFOA.
- In 2018, the DEC issued its PFAS Action Plan as well as action levels for 6 PFAS compounds (PFOS, PFOA, PFNA, PFHxS, PFHpA, PFBS), which are used to establish levels at which polluting parties are responsible for remediation of impacted water supplies.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFOS and PFOA combined

- Concentration Level: 70ppt
- Type of Regulation: Adopt EPA Standard
- Adoption Status: Action Level

Arizona

Background

- The primary agency overseeing Arizona's PFAS-related initiatives is the Arizona Department of Environmental Equity (ADEQ).
- In 2018, the ADEQ began conducting PFAS screening focusing on public water systems near potential PFAS contamination sites (military bases, airports, industrial & manufacturing facilities, and firefighting training locations).
- Based on work by the ADEQ, there are no known cases of PFAS being manufactured in Arizona.
- The state's most significant PFAS contamination has been a result of AFFF use at military sites during training exercises and jet fires. According to the DoD, there are 12 military bases in Arizona with drinking water above the EPA's health advisory level.

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

SB 1526: Prohibits the use of PFAS-containing firefighting foam for training purposes. (2019)

Arkansas

Data was not readily available

California

Background

- The primary agency overseeing California's PFAS-related initiatives is the State Water Resources Control Board - a division of the California Environmental Protection Agency (CEPA).
- Over 16 million Californians are supplied by PFAS-contaminated water systems.
- Since 2012, the California Environmental Protection Agency has been working with the US EPA and other agencies to address PFAS contamination in the state.
- The state has been at the forefront in regulating PFAS in firefighting foam, carpets and rugs, food packaging, and juvenile products.
- Companies are also subject to "right-to-know" legislation which requires manufacturers of various products to notify consumers of the presence of hazardous chemicals.
- In a recently announced piece of legislature, California will prohibit the sale of apparel, accessories, cosmetics, and handbags which contain PFAS beginning in 2025.

BCLP[1] March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFOA:

- Concentration Level: 5.1 ppt
- Type of Regulation: Notification
- Adoption Status: Regulation

PFOS:

- Concentration Level: 6.5 ppt
- Type of Regulation: Notification
- Adoption Status: Regulation

PFBS:

- Concentration Level: 400,000 ppt
- Type of Regulation: Notification
- Adoption Status: Regulation

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **AB 1817:** Beginning January 1, 2025, prohibits PFAS in apparel (both indoor and outdoor), accessories, and handbags. PFAS in outdoor apparel for severe wet conditions will be eliminated as of 2028 and manufacturers will be required to disclose the presence of PFAS in the products as of 2025. Directs manufacturers to use the least toxic alternative. (2022)
- **AB 2771:** Beginning January 1, 2025, prohibits a person or entity from manufacturing, selling, delivering, holding, or offering for sale in commerce any cosmetic product that contains intentionally added PFAS. (2022)
- **SB 154:** Includes allocating $50 million for technical and financial assistance to drinking water systems to address PFAS. (2022)
- **SB 178:** Includes $50 million to address PFAS in drinking water systems. (2022)
- **AB 180:** Includes $30 million to address PFAS in drinking water systems. (2022)
- **AB 1201:** Reforms labeling for compostable products, ensuring that an item that claims to be compostable actually is so. The law will also cut chemical contamination of compost by banning PFAS from any products labeled as compostable. (2021)
- **AB 1200:** Prohibits the sale of plant-based food packaging in the state that contains PFAS, and requires manufacturers of cookware sold in the state to disclose on the product label and on the company's internet website if the cookware contains certain hazardous chemicals. (2021)
- **AB 652:** Bans the entire class of PFAS from a wide array of "juvenile" products. Requires a manufacturer to use the least toxic alternative when replacing PFAS chemicals in a juvenile product. (2021)
- **SB 343:** Reforms labeling for compostable products, ensuring that an item that claims to be compostable actually is so. The law will also cut chemical contamination of compost by banning PFAS from any products labeled as compostable. (2021)
- **SB 1044:** Prohibits the manufacture and sale of firefighting foam containing PFAS, prohibits the use of PFAS foam for training purposes, requires manufacturers of firefighting protective equipment to disclose the inclusion of PFAS in their products. (2020)
- **SB 1371:** Allows state Water Board to require monitoring for and reporting of PFAS by water utilities. (2020)
- **SB 312:** Requires cosmetics manufacturers to disclose lists of chemicals, flavors, and fragrances included in their products to the state along with associated health hazards. Requires the state to maintain a public website displaying the information, (2020)

- **AB 841:** Requires the state to develop a work plan to determine select PFAS to test for risks to human health. (2020)
- **AB 756:** Requires public water systems to monitor for PFAS. (2019)
- **AB 1879:** Establishes a process to identify, prioritize and evaluate chemicals of concern in consumer products, determine how best to limit exposure or reduce the level of hazard, and establishes green chemistry challenge grants and a Green Ribbon Science Panel. (2008)

Current Policy

SB 72 / AB 221: Provides $120 million for technical and financial assistance to drinking water systems to address PFAS

Colorado

Background

- The primary agency overseeing Colorado's PFAS-related initiatives is the Colorado Department of Public Health and Environment (CDPHE).
- Results from state testing conducted in 2020 indicated PFAS contamination at over 100 public drinking water sources.
- Counties with elevated PFAS concentrations in drinking water include Englewood, Frisco, Aurora, Brighton, Thornton, Arapahoe County, Crowley County, Lafayette and Sterling.
- Firefighting foams are of particular concern in Colorado with PFAS being found at a number of industrial locations, airports, and military sites.
- Elevated groundwater contamination is also the result of the fracking industry which uses PFAS to break up shale rock.
- The State's PFAS Fund focuses on water testing and a take-back and replace initiative around firefighting foams.
- In 2022, the State's legislative body began work on a policy that would ban PFAS use in consumer products and end avoidable use of PFAS by 2030.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

3 PFAS substances combined

- Concentration Level: 70 ppt
- Type of Regulation: Guidance
- Adoption Status: Translation Level

PFBS

- Concentration Level: 400,000 ppt
- Type of Regulation: Guidance
- Adoption Status: Translation Level

PFHxS

- Concentration Level: 700 ppt
- Type of Regulation: Notification
- Adoption Status: Regulation

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **HB 1348:** Establishes a regulatory scheme that requires disclosure of certain chemical information for products used in downhole oil and gas operations. The discloser most also provide the commission with a declaration that the chemical product contains no intentionally added PFAS chemicals. (2022)
- **HB 22-1345:** Restricts the sale and distribution of consumer products containing PFAS chemicals. Consumer products include oil and gas products; carpets and rugs; cosmetics; fabric treatments; food packaging; juvenile products; textile furnishings; and upholstered furniture. (2022)
- **HB 20-1119:** Addresses the authority of the state government to regulate PFAS. Prohibits the use of class B firefighting foam that contains intentionally added PFAS in certain aircraft hangars beginning January 1, 2023. (2020)
- **SB 20-218:** Creates fund PFAS cash fund, used to fund the PFAS grant program, the PFAS takeback program, and provide technical assistance in locating and studying PFAS to communities, stakeholders, and relevant regulatory bodies. (2020)
- **HB 19-1279:** Prohibits the sale of PFAS-containing firefighting foam in certain circumstances, prohibits the use of PFAS foam for training, requires manufacturers to disclose if protective equipment they produce includes PFAS, and requires the Department of Health to conduct a survey to determine the amount of PFAS foam currently held, used, and disposed by fire departments. (2019)

Connecticut

Background

- The primary agencies overseeing Connecticut's PFAS-related initiatives are the Department of Energy and Environmental Protection (DEEP), Department of Public Health (DPH), and the Department of Emergency Services and Public Protection (DESPP).
- In 2018, the DPH first identified elevated levels of PFAS in a private well in Greenwich.
- In 2019, drinking water action levels were established for five PFAS chemicals (PFOA, PFOS, PFNA, PFHpA, and PFHXs) by the DPH.
- In 2019, the state releases a comprehensive PFAS Action Plan.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

5 PFAS substances combined

- Concentration Level: 70 ppt
- Type of Regulation: Notification
- Adoption Status: Health Advisory

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **SB 837:** Prohibits the use of firefighting foam containing PFAS in training purposes and establishes a take-back program for such products. Prohibits the sale of food packaging containing PFAS. (2021)
- **HB 6666:** Requires employees of a bottler to test for perfluoroalkyl substances and other unregulated contaminants. (2021)
- **HB 6690:** Provides grants-in-aid to municipalities for the purpose of providing potable water and for assessment and remedial action to address pollution from PFAS. (2021)
- **HB 5518:** Appropriates $2 million for PFAS cleanup and remediation. (2020)

Current Policy

- **SB 101:** Requires the testing of a home's water for the presence of PFAS during a home inspection conducted pursuant to the potential sale of a home.
- **SB 100:** Establishes an account in the general fund to provide grants to towns that need PFAS testing and remediation.
- **HB 5250:** Establishes a grant program to reimburse municipalities for costs related to the removal of PFAS from fire apparatus.

Delaware

Background

- The primary agencies overseeing Delaware's PFAS-related initiatives are the Department of Natural Resources and Environmental Control (DNREC) and Delaware Heath and Social Services (DHSS) Division of Public Health.
- The DNREC maintains a list of sites being investigated for PFAS in groundwater, drinking water, or surface water. The list contains 15 sites spread across Sussex, Kent, and New Castle counties.
- The DHSS is leading a plan to implement MCLs for PFOA and PFOS of 21 ppt and 14 ppt respectively.
- The DNREC and its partners are currently conducting statewide PFAS sampling through public potable wells.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFOS and PFOA combined

- Concentration Level: 70 ppt
- Type of Regulation: Adopt EPA Standard
- Adoption Status: Guidance Policy

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **HB 8:** Directs the Department of Natural Resources and Environmental Control and the Division of Public Health to establish MCLs for PFOA and PFOS. (2021)

Florida

Background

- The primary agencies overseeing Florida's PFAS-related initiatives are the Department of Environmental Protection (DEP) and the Division of Waste Management (DWM).
- The DEP regularly conducts site investigations that are known or suspected of having soil or groundwater PFAS contamination.
- The DWM is conducting investigations to understand possible sources and environmental impacts from PFAS.
- In March 2022, the DEP published its PFAS Dynamic Plan to provide a coordinated approach to the complex issues related to PFAS.
- Use of PFAS throughout the state has led to groundwater contamination and contamination of state funded cleanup sites, dry-cleaning solvent cleanup program sites, and fire training facilities.

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **HB 1475:** Requires the Department of Environmental Protection to adopt statewide rules for cleanup target levels for PFAS in soil and groundwater by a specific date. (2022)
- **HB 5001:** Appropriates $29.6 million for the testing and remediation of any pollutant that is a PFAS. (2022)
- **SB 2500:** Provides $1 million for the University of Florida PFAS Contaminated Material Treatment Pilot project. (2021)
- **HB 5001:** Appropriates $1 million to assist homeowners with private well water contaminated with PFOA and/or PFOS. (2020)

Georgia

Background

- The primary agency overseeing Georgia's PFAS-related initiatives is the Environmental Protection Division (EPD).
- In the winter of 2021, EPD initiated a targeted PFAS monitoring project to assess the level of PFAS in drinking water across the state. Public water systems received sample kits from the EPD Laboratory to collect finished drinking water.
- Results of this testing showed PFOA and PFOS presence at detectable levels in 10 public water systems, PFBS in 13 public water systems, and no detectable GenX in finished drinking water.
- EPD is currently sampling large public water systems that serve populations of 100,000 or more.

Hawaii

Background

- The primary agency overseeing Hawaii's PFAS-related initiatives is the Department of Health (DOH).
- On January 6, 2023, PFHxA were detected in water samples at the Waipahu Wells II GAC Treatment facility. The levels of PFHxA ranged from 0.0020 ug/L to 0.0023 ug/L which is below the Hawaii DOH's environmental action level of 1.0 ug/L.

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **HB 1644:** Beginning December 31, 2024, prohibits the manufacture, sale, distribution, and use of food packaging that contains PFAS. Beginning July 1, 2024, prohibits the

manufacture, sale, distribution, and use of class B firefighting foam that contains intentionally added PFAS for training and testing purposes. (2022)

Idaho

Background

- The primary agency overseeing Idaho's PFAS-related initiatives is the Idaho Department of Environmental Quality (DEQ).
- According the DEQ, Idaho has not seen widespread detections of PFAS chemicals.
- Since there are currently no final national primary drinking water standards for PFAS, PFAS is not currently regulated in Idaho, and public water systems are not required to monitor for the contaminant.
- While PFAS monitoring is not required on a regular basis, PFAS monitoring has occurred. Sampling efforts to-date include EPA-required sampling (under UCMR), DoD sampling (e.g., Mountain Home AFB), voluntary public water system sampling, and DEQ sampling through federal grant funds.

Illinois

Background

- The primary agency overseeing Illinois' PFAS-related initiatives is the Illinois Environmental Protection Agency (IEPA).
- Notable PFAS-related actions taken by the Illinois EPA include a statewide community water supply sampling program, groundwater standard development, and regulation of class-B firefighting foams.
- A Chicago Tribune investigation (published in July 2022) identified 1,654 facilities across the state that are considered to have contributed to PFAS pollution.
- The Tribune's investigation also found that 6 out of every 10 state residents receive drinking water from a site that has been shown to have PFAS contamination.
- Communities along Lake Michigan (including Chicago, Evanston, Glencoe, Lake Forest, Waukegan, Wilmette and Winnetka) have been shown to have particularly elevated levels of PFAS.

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **HB 4818:** Prohibits the disposal by incineration of any PFAS substance, including, but not limited to, aqueous film-forming foam. (2022)
- **SB 0561:** Creates the PFAS Reduction Act. Prohibits the use, manufacture, and sale of Class B firefighting foam containing PFAS chemicals. (2021)

Indiana

Background

- The primary agency overseeing Indiana's PFAS-related initiatives is the Indiana Department of Environmental Management (IDEM).
- The IDEM began sampling community public water systems in February 2021 throughout the state. None of the PFAS samples from Phase 1 were above the EPA HALs for finished/treated drinking water. Phase 2 and Phase 3 results have not been released at this time.
- IDEM is partnering with the Indiana Department of Homeland Security and the State Fire Marshal's Office to collect PFAS-containing firefighting foam from fire departments around the state.
- Additional IDEM activities include development of screening levels for three PFAS compounds and partnership with stakeholders (e.g., state military bases, Ohio River Sanitation Commission).

PFAS-related Adopted/Current Policy according to Safer States

Current Policy

- **HB 1219:** Establishes a PFAS biomonitoring pilot program under the development of homeland security to collect and analyze blood samples of individuals who were previously, or are currently, firefighters.

Iowa

Background

- The primary agency overseeing Iowa's PFAS-related initiatives is the Iowa Department of Natural Resources.
- According to the Iowa DNR, the scope of PFAS contamination in Iowa "appears to be lower at this point".
- Nevertheless, the DNR published a PFAS Action Plan in January 2020 to protect the health of Iowa resident and the environment from PFAS.
- The first focus area of the action plan is a precautionary approach to identify and minimize exposure of Iowans to PFAS through drinking water
- The DNR is taking measures to undertake statewide sampling of PFAS in public water supplies to determine the prevalence of PFAS in Iowa.

PFAS-related Adopted/Current Policy according to Safer States

Current Policy

- **HF 18:** Requires an inspection of a private well that serves a building upon the transfer of ownership of the building. The inspection shall examine the level of nitrate, nitrite, arsenic, coliform bacteria, and PFAS.

Kansas

Background

- The primary agency overseeing Kansas' PFAS-related initiatives is the Kansas Department of Health and Environment (KDHE).
- The KDHE is taking steps to address PFAS in drinking water through a joint investigation conducted by the Bureau of Environmental Remediation and the Bureau of Water.
- This investigation includes development of a state-wide inventory and prioritization of potential PFAS sources.
- This inventory report was subsequently used to create a PWS PFAS Monitoring Plan published in June 2019.

Kentucky

Background

- The primary agency overseeing Kentucky's PFAS-related initiatives is the Kentucky Energy and Environment Cabinet which oversees the Kentucky Department for Environmental Protection (DEP).
- In 2019, PFAS were detected in 41 of 81 WTPs who were selected to sample finished drinking water for PFAS. Summed results for PFOA and PFOS were below the US EPA's recommended health advisory threshold of 70 ng/L.
- In 2020, PFAS was detected at 36 of 40 surface water monitoring stations sampled by the state. The most frequently detected PFAS was PFOS (found at 34 monitoring stations)
- In 2021 and 2022, the DEP measured PFAS concentrations in fish from 7 streams. PFAS were detected in all 98 samples. The average concentration of PFAS in fish from the stream study was 13 ppb.

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **SB 104:** Prohibits the use of PFAS-containing firefighting foam for training purposes or testing purposes. (2019)

Louisiana

Data was not readily available

Maine

Background

- The primary agency overseeing Maine's PFAS-related initiatives is the Maine Department of Environmental Protection (MDEP).
- PFAS has been found in a number of places in Maine including landfills, wastewater, sludge and septage spreading sites, surface waters, drinking water supplies, agricultural sites, and remediation and clean-up sites.
- In January 2020, the Maine PFAS task force released its final report and recommendations, Managing PFAS in Maine, Final Report from the Maine PFAS Task Force. This report influenced Maine's 130th Legislature to establish new legislative initiatives related to PFAS.
- Maine was the second state to ban PFAS chemicals in food packaging.
- In 2021, Maine became the first state to adopt a law that will eliminate all non-essential PFAS use in products. This measure is on pace to be adopted in 2030.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

6 PFAS substances combined

- Concentration Level: 20 ppt
- Type of Regulation: Notification
- Adoption Status: Interim Drinking Water Standard

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **LD 2019:** Requires the registration of adjuvants in the State and regulates the distribution of pesticides with PFAS. (2022)
- **LD 1875:** Requires state department to study methods of treating leachate from state-owned landfills to reduce the concentration of PFAS in leachate. (2022)
- **LD 1911:** Prohibits the spreading of PFAS-laden sludge and sludge-derived compost as fertilizer. (2022)
- **LD 1503/HP 1113:** Requires manufacturers to report products containing intentionally added PFAS. Prohibits the sale of products containing intentionally added PFAS. Establishes a "currently unavoidable" framework in the long term. (2021)
- **LD 129/SP 64:** Requires PFAS monitoring in drinking water and establishes MCLs for PFAS. (2021)
- **LD 264:** to prohibit aerial application of pesticides containing PFAS. (2021)
- **LD 363/HP 261:** Provides that an action arising out of any harm or injury caused by PFAS must be commenced within 6 years after the plaintiff discovers or should have discovered such harm or injury. (2021)
- **LD 558:** Directs the Dept. of Agriculture, Conservation, and Forestry to study alternative cropping systems for farmers affected by PFAS contamination. (2021)
- **LD 1505/HP 1115:** Restricts the use of PFAS in firefighting foam. (2021)
- **LD 1600/HP 1189:** Investigates PFAS contamination of land and groundwater. (2021)
- **LD 780/HP 585:** Gives the Maine DEP authority to order the clean-up of PFAS contaminated sites or seek compensation from responsible parties to pay for that clean up. (2021)
- **LD 221/HP 156:** Provides funding to abate, clean up and mitigate threats or hazards posed by PFAS. Establishes one limited-period Agricultural Compliance Officer position in the Bureau of Agriculture program and provides funding for the Office of the Commissioner program to work directly with affected farmers on PFAS mitigation efforts. Provides funding to support the treatment of drinking water and environmental testing and management of contaminated waste caused by PFAS. (2021)
- **LD 1733:** Provides funding to expand efforts to address imminent risk to public health through investment in public water system improvements, including mitigation of lead in drinking water at schools/day-cares and PFAS substances effects. (2021)
- **LD 1433:** Prohibits the sale of food packaging with intentionally added toxic heavy metals, PFAS, or phthalates. (2019)
- **LD 1129:** Selects up to 70 chemicals as Chemicals of High Concern based upon likely exposure to children or fetuses, and uses this list to designate Priority Chemicals which will require reporting and disclosure when used in children's products. (2011)
- **LD 2048:** Identifies chemicals of high concern, and requires reporting on usage and replacement with safer alternatives. (2008)

Current Policy

- **LD 73:** Requires persons that extract water in this State to be sold as bottled water to conduct monitoring for PFAS in the bottled water.
- **LD 75:** Authorizes the adoption of state drinking water rules by the Commissioner of Health and Human Services to require that those rules establish a MCL equivalent to zero nanograms per liter for certain PFAS.
- **LD 132:** Beginning January 1, 2024, requires carriers offering health plans to provide coverage for blood testing for PFAS.

Maryland

Background

- The primary agency overseeing Maryland's PFAS-related initiatives is the Maryland Department of the Environment (MDE).
- MDE has conducted and/or reviewed investigations into PFAS contamination related to drinking water, military bases, the PAX River, Webster Field, the Naval Research Lab in Chesapeake Beach, fish tissue sampling, and effluent from wastewater treatment plants.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFHxS

- Concentration Level: 140 ppt
- Type of Regulation: Guidance
- Adoption Status: Health Advisory

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **HB 0275 / SB 0273:** Restricts the use of PFAS chemicals in food packaging, rugs and carpets, and replaces PFAS-laden firefighting foam with safter alternatives. Requires notification for firefighter turnout gear that contains PFAS and stops the landfilling and incineration of PFAS foam. (2022)
- **HB 0643:** Prohibits PFAS, mercury, and other chemicals in cosmetics. (2021)

Current Policy

- **HB 0031:** Establishes labelling, marketing, and advertising requirements for recycling products and packaging. Products and packaging that contain PFAS chemicals can't be labelled as recyclable.

Massachusetts

Background

- The primary agencies overseeing Massachusetts' PFAS-related initiatives are the Massachusetts Department of Environmental Protection (MassDEP) and the PFAS Interagency Task Force.
- In 2020, Massachusetts legislature appointed the PFAS Interagency Task Force to investigate water and ground contamination of PFAS across the Commonwealth. The agency adopted their final report on PFAS in April 2022.
- On October 2, 2020, MassDEP published its PFAS public drinking water standard for 6 PFAS (see survey below).
- Massachusetts is home to some of the strictest PFAS standards in the country, strengthened by the Baker-Polito administration promulgation and implementation of nation-leading rules for drinking water systems and clean-ups of contaminated sites, and investment of substantial funding to assist communities as they address PFAS contamination in drinking water systems.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

6 PFAS Substances combined

- Concentration Level: 20 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

Michigan

Background

- The primary agencies overseeing Michigan's PFAS-related initiative are the Michigan PFAS Action Response Team (MPART) and the Michigan Department of Environment, Great Lakes, and Energy (EGLE).
- According to the EGLE, over 1.5 million residents have been drinking PFAS-contaminated water and PFAS might have been used at as many as 11,300 locations across the state
- Based on the latest data from MPART's PFAS Geographic Information System, the EGLE has identified 234 sites with PFAS contamination and collected 2,047 and 596 PFAS-contaminated surface water and public drinking water supply samples, respectively.
- Contamination is especially prevalent in (1) Oscoda after PFAS runoff from Wurtsmith AFB polluted the surrounding ground and surface water and (2) west Michigan where runoff from leather manufacturing and treatment has polluted over 1,500 wells.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFNA
- Concentration Level: 6 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFOS
- Concentration Level: 16 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

Gen X or HFPO-DA
- Concentration Level: 370 ppt
- Type of Regulation: Guidance
- Adoption Status: Regulation

PFHxA
- Concentration Level: 400,000 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFOA
- Concentration Level: 8 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFHxS
- Concentration Level: 51 ppt
- Type of Regulation: MCL

Adoption Status: Regulation

PFBS
- Concentration Level: 420 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **HB 5783:** Includes $500 thousand for disposal of firefighting foam containing PFAS, $20 million for PFAS and environmental contamination response, and $3 million for PFAS remediation. (2022)
- **SB 0565:** Appropriates funding for PFAS remediation projects. (2022)
- **SB 0082:** Appropriations for fiscal year 2021-2022, Provides a one-time appropriation of $14.45 million for PFAS remediation. Provides $20.276 million for PFAS and environmental contamination response. (2021)
- **HB 4390:** Prohibits the use of PFAS firefighting foam for training purposes. (2020)
- **HB 4389:** Requires discharges of PFAS-containing firefighting foam to be reported to the state. Establishes a take-back program for PFAS foams. (2019)

Minnesota

Background

- The primary agency overseeing Minnesota's PFAS-related initiatives is the Minnesota Pollution Control Agency (MPCA).
- In the early 2000s, the MPCA discovered the first perfluorinated chemicals at 4 locations in Washington County that were being used as waste dumping sites by 3M.
- In 2018, the state of Minnesota settled a lawsuit with 3M for $850 million related to PFAS contamination.

- Ongoing MPCA efforts related to PFAS contamination include partnering with landfill owners to establish water quality standards.
- The Minnesota Department of Health has also been active around the issue of PFAS by establishing fish consumption advisories related to PFOS contamination.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFOS
- Concentration Level: 15 ppt
- Type of Regulation: Guidance
- Adoption Status: Health Advisory

PFOA
- Concentration Level: 35 ppt
- Type of Regulation: Guidance
- Adoption Status: Health Advisory

PFHxS
- Concentration Level: 47 ppt
- Type of Regulation: Guidance
- Adoption Status: Health Advisory

PFBS
- Concentration Level: 2,000 ppt
- Type of Regulation: Guidance
- Adoption Status: Health Advisory

PFBA
- Concentration Level: 7,000 ppt
- Type of Regulation: Guidance
- Adoption Status: Health Advisory

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy
- **HF 3765:** Appropriates funds to research and address PFAS contamination. (2022)
- **SF 20:** Provides funding to develop and implement an initiative to reduce sources of PFAS upstream of wastewater treatment facilities. Provides funding to develop strategies to manage PFAS in land-applied biosolids. Includes a prohibition of PFAS in food packaging with an implementation date of Jan 1, 2024. (2021)
- **HF 359:** Bans manufacture and sale of halogenated, phosphorus-based, nitrogen-based, and nanoscale flame retardants in residential upholstered furniture, children's products, and residential and business textiles. Prohibits the manufacture and sale of PFAS-containing firefighting foam. (2019)
- **HF 2123:** Generates a list of chemicals of high concern and priority chemicals, along with participation in Interstate Chemicals Clearinghouse. (2009)

Current Policy
- **SF 73:** Packaging for cannabis flower, cannabinoid products, and hemp-derived consumer products must not contain or be coated with any perfluoroalkyl substance.
- **HF 172:** Provides $478 thousand to the Board of Regents of the University of Minnesota to develop novel methods for the detection, sequestration, and degradation of PFAS in Minnesota's lakes and rivers.

Mississippi

Background
- The primary agency overseeing Mississippi's PFAS-related initiatives is the Mississippi Department of Environmental Quality (MDEQ).
- According to the MDEQ, Mississippi has not been a major producer of PFAS and currently does not have any PFAS manufacturers operating.
- However, the state does have a wide range of industry that uses PFAS.
- MDEQ is currently evaluating industrial and commercial usage of PFAS in the State and reviewing common areas of concern (e.g., landfills, fire training facilities, wastewater treatment plants) that may need additional future evaluation.
- The state also has multiple military and federal facilities that are being assessed for PFAS due to historical uses and activities on-site.
- MDEQ will continue to monitor actions at the federal level related to PFAS and prepare to take any actions that may be warranted once federal regulations on PFAS are finalized.

Missouri

Background

- The primary agency overseeing Missouri's PFAS-related initiatives is the Missouri Department of Natural Resources (MoDNR).
- The PFAS Workgroup (organized by the MoDNR) is a stakeholder workgroup made up of department team members and Missouri experts in the fields of wastewater, stormwater, drinking water, chemistry, analytical methods and environmental advocacy. The workgroup is mainly dedicated to developing policies and tools regarding PFAS.
- Since 2013, the MoDNR has performed PFAS occurrence monitoring projects for public drinking water supplies through federal and voluntary sampling programs.
- Beginning in 2022, the MoDNR began a voluntary PFAS sampling program for facilities renewing existing wastewater or stormwater permits.
- Missouri will be allotted approximately $237 million to distribute for Clean Water State Revolving Fund and Drinking Water Revolving Fund projects, including funds for specific projects like treating emerging contaminants such as PFAS.

Montana

Background

- The primary agency overseeing Montana's PFAS-related initiatives is the Montana Department of Environmental Quality (DEQ).
- To date, PFAS have been detected in soil, groundwater, and surface water (storm water outfalls) above screening levels at two active military installations in Montana (Montana Air National Guard and Malmstrom AFB in Great Falls). In addition, PFAS have also been detected above groundwater screening levels at Fort Harrison in Helena at the former Glasgow AFB in Saint Marie. Further investigation is ongoing.
- PFAS-related actions taken by the DEQ include:
  - Ongoing regulatory oversight for the identified PFAS sites in Montana
  - Development of a PFAS working group
  - Development of a potential PFAS site list
  - Evaluation of potential funding sources to conduct soil and groundwater sampling at or near identified or potential PFAS sites and to expand sampling of public and private drinking water systems at or near identified or potential PFAS sites.

Nebraska

Background

- The primary agency overseeing Nebraska's PFAS-related initiatives is the Nebraska Department of Environment and Energy (NDEQ).
- NDEQ has formed a multi-program team to track issues associated with PFAS.
- Initial sampling for PFAS compounds was conducted at 25 public water systems between 2013-2015 by the DHHS Drinking Water Program. None of those samples had detections of PFAS.
- In 2017, NDEQ completed a state-wide PFAS inventory identifying 990 sites that potentially used or produced PFAS compounds. Based on the inventory, NDEQ conducted initial PFAS sampling of nearby private wells. While levels of concern have not been detected, NDEQ is early in the investigation.

Nevada

Background

- The primary agency overseeing Nevada's PFAS-related initiatives is the Nevada Division of Environmental Protection (NDEP).
- In response to the passing of Assembly Bill 97 in 2021, the NDEP developed a working group composed of representatives of interested state and local public agencies, labor organizations, community organizations and trade associations to support the development of the PFAS Action Plan for the State of Nevada.

- Along with other items, the PFAS Working Group is tasked with evaluating potential for contamination, determining the location and extent of releases, compiling existing information (state, federal, and local), and determine sources of exposure for state residents.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFOA and PFOS
- Concentration Level: 667,000 (.667 ug/L)
- Type of Regulation: Guidance
- Adoption Status: Basic Comparison Levels

PFBS
- Concentration Level: 667,000,000 (667 ug/L)
- Type of Regulation: Guidance
- Adoption Status: Basic Comparison Levels

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy
- **AB 97:** Prohibits the use of firefighting foam containing PFAS for testing and training purposes; establishes a work group to study issues related to PFAS and develop recommendations for state action; prohibits flame retardants in the manufacture, sale, and distribution of children's products, upholstered residential furniture, residential textiles, business textiles, or mattresses (includes exemptions). (2021)

New Hampshire

Background
- The primary agency overseeing New Hampshire's PFAS-related initiatives is the New Hampshire Department of Environmental Services (NHDES).
- The NHDES has responded to the threat of PFAS contamination through testing, sampling and monitoring of groundwater, drinking water, surface water and fish, soil, wastewater and biosolids, and waste sites and landfills.
- The NHDES continues to conduct several ongoing site investigations at various contamination origination sites
- Contaminated sites of particular concern include Pease AFB (Portsmouth) and contamination stemming from industrial facilities in southern New Hampshire.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFNA
- Concentration Level: 11 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFOA
- Concentration Level: 12 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFOS
- Concentration Level: 15 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFHxS
- Concentration Level: 18 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy
- **HB 1547:** Requires the commissioner of the department of environmental services to adopt rules relative to perfluorinated chemical remediation in the soil. (2022)
- **HB 1546:** Allows the commissioner of the department of environmental services to adopt rules about airborne PFAS in certain circumstances. (2022)
- **HB 1185:** Enables wastewater treatment plants to require providers of discharge to test such discharge for PFAS. (2022)
- **HB 271:** Directs the department of environmental services to set maximum contaminant limits for PFAS. (2021)
- **HB 236:** Creates a statute of limitation (6 years) on civil actions relative to damage caused by PFAS. (2021)
- **HB 256:** Adds members from Londonderry to the commission to investigate and analyze the environmental and public health impacts relating to releases of perfluorinated chemicals into the air, soil, and groundwater in Merrimack, Bedford, and Litchfield. (2021)
- **HB 1264:** Sets MCLs for PFOA, PFOS, PFHxS, and PFNA in drinking water; establishes PFAS fund. (2020)

- **HB 737:** Establishes a commission to investigate and analyze the environmental and public health impacts relating to releases of perfluorinated chemicals in the air, soil, and groundwater in Merrimack, Bedford and Litchfield. (2019)
- **HB 257:** Prohibits the manufacture, sale, use, and purchase of firefighting foams containing PFAS. (2019)
- **SB 309:** Requires the commissioner of the department of environmental services to adopt a state drinking water standard, and ambient and surface groundwater standards for perflurochemicals. (2018)

Current Policy
- **HB 398:** Requires certain notice of PFAS and other groundwater contamination prior to the sale of real property.
- **HB 414:** Requires insurance coverage for preventative PFAS care.
- **HB 242:** Prohibits the sale and distribution of food packaging that contains PFAS beginning January 1, 2024.
- **HB 465:** Restricts the use of PFAS in rugs, carpets, and aftermarket stain and water-resistant treatments.

New Jersey

Background
- The primary agency overseeing New Jersey's PFAS-related initiatives is the New Jersey Department of Environmental Protection (DEP).
- PFAS was first discovered in the water supply surrounding Dupont's Chambers Works plant in Salem County.
- In 2018, New Jersey set an MCL for PFNA becoming the first state to ever pass an MCL for any PFAS chemical.
- In 2019, New Jersey became the first state to require companies responsible for PFAS contamination to address the issue.
- The DEP is in the process of developing surface water quality standards for PFOA, PFOS, and PFNA as well as establishing soil remediation standards for these chemicals.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFNA/PFOS
- Concentration Level: 13 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFOA
- Concentration Level: 14 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFAS-related Adopted/Current Policy according to Safer States

Current Policy
- **AB 1554 / S 2145:** Prohibits sale, distribution, and import of certain products marketed as recyclable, unless DEP determines that products are widely recycled. The bill would also explicitly exclude certain products - such as those that contain hazardous chemicals or PFAS - from being deemed recyclable by the DEP.
- **A 4125 / S 2712:** Prohibits sale, manufacture, distribution, and use of firefighting foam containing intentionally added PFAS.
- **A 4760 / S 3176:** Requires DEP and Drinking Water Quality Institute to perform a study concerning the regulation and treatment of PFAS.
- **A 4759 / S 3179:** Requires public water systems and landlords to provide certain notice of elevated PFAS levels in drinking water; requires DEP to establish an educational program.
- **A 4761 / S 3178:** Requires DEP to perform certain assessments concerning the regulation of PFAS
- **A 4762 / S 3180:** Requires certain water purveyors to identify, and use, alternative water supply sources when PFAS exceed MCLs.
- **A 4758 / S 3177:** Enacts the "Protecting Against Forever Chemicals Act". Establishes requirements, prohibitions, and programs for regulation of PFAS.

New Mexico

Background

- The primary agency overseeing New Mexico's PFAS-related initiatives is the New Mexico Environment Department (NMED).
- In an effort to better understand the scope of potential and existing PFAS contamination around the state, the NMED has worked with state and federal partners to conduct sampling for PFAS in water around the state.
- The state has conducted sampling investigations at the following locations across the state: Cannon AFB (Curry County), Holloman AFB (Otero County), well testing in Curry and Roosevelt Counties, statewide PFAS study (partnership between NMED Drinking Water Bureau and US Geological Survey [USGS]), PFAS sampling in Los Alamos National Laboratory, and monitoring under the US EPA's UCMR 3.
- In 2018, the state was notified of PFAS discovery in groundwater at and around Cannon AFB and Holloman AFB. The United States and New Mexico are currently engaged in a lawsuit over the definition of "hazardous waste" as it pertains to Connon AFB's RCRA permit.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFOS and PFOA combined

- Concentration Level: 70 ppt
- Type of Regulation: Adopt EPA Standard
- Adoption Status: Toxic Pollutant Standard

New York

Background

- The primary agencies overseeing New York's PFAS-related initiatives are the Department of Environmental Conservation (DEC), the Department of Health (DOH), and the Water Quality Rapid Response Team (WQRRT).
- The Clean Water Infrastructure Act of 2017 has directed DEC, in consultation with DOH, to build a comprehensive database, evaluate and prioritize over 1,750 inactive solid waste sites statewide to determine any potential impacts from PFAS and/or other contaminants of concern on drinking water sources. The Departments are conducting drinking water sampling in areas where groundwater may have been impacted to verify drinking water quality and to identify appropriate next steps.
- In January 2016, New York became the first state to regulate PFOA as a hazardous substance followed by the regulation of PFOS in April 2016.
- Through funding prioritized by New York State in the Environmental Protection Fund, DEC has worked with municipal fire and emergency response departments across the state to collect, remove, and dispose of PFAS-containing firefighting foam. As of summer 2018, more than 25 thousand gallons of contaminated foam has been collected and properly disposed; collections are ongoing.
- The state has taken remedial action related to PFAS to ensure clean water is being provided in the Hoosick area.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFOA/PFOS

- Concentration Level: 10 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **A 07063:** Prohibits the use of PFAS in apparel as an intentionally added chemical. (2022)
- **A 09279:** Establishes a carpet collection program. Beginning December 31, 2024 prohibits the sale of carpets containing PFAS. (2022)
- **S 7167:** Prohibits the manufacture and sale of firefighting foam containing PFAS, requires manufacturers of firefighter protective equipment to disclose the inclusion of PFAS in their products. (2020)
- **S 8817:** Prohibits the use of food packaging containing PFAS chemicals. (2020)
- **S 439:** Prohibits the manufacture, sale, and distribution for use of firefighting foam containing PFAS. (2019)

- **A 6296:** Requires manufacturers of children's products containing dangerous chemicals to notify the state and retailers; bans the sale of children's products containing dangerous chemicals. (2019)

Current Policy
- **S 227:** Enacts the "PFAS surface water discharge disclosure act". Requires publicly owned treatment works and people who discharge industrial waste to such treatment works to disclose the measurement of PFAS found in any discharge into the state waterways.
- **S 773:** Requires disclosure of information on various toxic chemicals in pet products.
- **S 992:** Prohibits the sale and distribution of anti-fogging sprays and wipes containing PFAS.
- **A 994:** Prohibits the use of PFAS in apparel and outdoor apparel for severe wet conditions.
- **S 1322:** Prohibits the use of PFAS in apparel and outdoor apparel for severe wet conditions.
- **A 952:** Provides for a partial real property tax exemption for the PFAS water filtration plant for the City of Newburgh, Orange County, New York.
- **S 1340:** Provides that no person shall sell or offer for sale any cosmetic product or personal care product containing mercury.

North Carolina

Background
- The primary agencies overseeing North Carolina's PFAS-related initiatives are the North Carolina Department of Health and Human Services (NCDHHS) and the North Carolina Department of Environmental Quality (NCDEQ).
- NCDHHS is aware of several communities where high levels of PFAS are a known or suspected issue.
- In June 2017, GenX was found in the Lower Cape Fear River Basin, downstream of the Chemours Fayetteville Works facility. GenX and other PFAS have also been found in other private drinking water wells near the Chemours facility. NCDHHS response has included setting provisional drinking water health advisory for GenX, leading targeted biomonitoring, and conducting a community survey of residents living near the Chemours facility
- Legacy PFAS have also been measured in the Pittsboro drinking water source and finished drinking water (i.e., Upper Cape Fear River Basin).
- Additional actions taken by the NCDHHS against PFAS include a PFAS community survey, review of new data, engagement with researchers, health education, guidance for physicians, and public health assessments and health consultations.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

GenX or HFPO-DA
- Concentration Level: 140 ppt
- Type of Regulation: Guidance
- Adoption Status: Health Advisory

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy
- **S 99:** State budget included funding for university research to monitor for PFAS in rivers, provisions for alternative water supplies for residents near a factory that has contaminated nearby wells, and funding for studies of downstream impacts. (2018)

North Dakota

Background
- The primary agencies overseeing North Dakota's PFAS-related initiatives are the North Dakota Department of Environmental Quality (NDDEQ) and the North Dakota Department of Health (NDDoH).
- In April 2018, the Environmental Health Section of the NDDoH created a work group tasked with conducting an initial baseline survey to determine the presence/absence of PFAS in North Dakota.
- As of this survey's most recent update (2021), samples were taken from a variety of sites where PFAS would potentially be present including drinking water treatment plants, wastewater treatment plants, biosolids, landfills and ambient groundwater samples from industrial areas. Primary sample summary results were as follows:
  - **Drinking Water Treatment Plant:** 65 samples were collected for 65 plants. 14 plants had detections. All detections were below 3 ppt.

- **Wastewater Treatment Plant:** 8 samples were collected from 2 plants including influent, effluent, landfill leachate, and biosolids. All samples had detections for PFAS analytes, but only leachate and biosolid samples exceeded EPA's PFOA/PFOs HAL.
- **Landfill/Industrial:** 6 samples were collected from 3 oilfield special waste landfills, one sample from industrial predischarge wastewater and 10 groundwater samples from a firefighting training area located on an industrial site. Industrial sites, landfill groundwater wells, and leachate samples had detections for PFAS with some exceeding EPA's PFOA/PFOS HAL.
- **Ambient Groundwater:** 13 samples were collected from 4 aquifers. PFAS were detected in 10 samples with PFBA being the most common analyte. No samples exceeded the EPA's PFOA/PFOS HAL

Ohio

Background

- The primary agencies overseeing Ohio's PFAS-related initiatives are the Ohio Department of Health (ODH) and the Ohio Environmental Protection Agency (EPA).
- In September 2019, Ohio Governor Mike DeWine directed Ohio EPA and ODH to analyze the prevalence of PFAS in Ohio's drinking water.
- As of December 2021, the Ohio EPA collected over 20,000 raw samples that showed PFAS in finished drinking water. 20 of these samples were above their respective detection limit.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFNA
- Concentration Level: 21 ppt
- Type of Regulation: Guidance
- Adoption Status: Health Advisory

PFHxS
- Concentration Level: 140 ppt
- Type of Regulation: Guidance
- Adoption Status: Health Advisory

PFBS
- Concentration Level: 140,000 ppt
- Type of Regulation: Guidance
- Adoption Status: Statewide PFAS Action Plan

PFOS and PFOA combined
- Concentration Level: 70 ppt
- Type of Regulation: Adopt EPA Standard
- Adoption Status: Statewide PFAS Action Plan

Gen X or HFPO-DA
- Concentration Level: 700 ppt
- Type of Regulation: Guidance
- Adoption Status: Statewide PFAS Action Plan

PFAS-related Adopted/Current Policy according to Safer States

Current Policy
- **HB 365:** Requires the Director of Environmental Protection to adopt rules establishing maximum allowable contaminant levels in drinking water quality standards for certain contaminants.

Oklahoma

Background

- The primary agency overseeing Oklahoma's PFAS-related initiatives is the Oklahoma Department of Environmental Quality (DEQ).
- The DEQ does not currently regulate PFAS in environmental media.
- The DEQ has published general PFAS sampling guidance in order to establish general PFAS sampling guidance protocols and prevent sample cross-contamination with PFAS-containing materials.
- The DEQ has also published specific PFAS sampling guidance for air, drinking water, fish, groundwater, soil and sediment and surface water.

PFAS-related Adopted/Current Policy according to Safer States

Current Policy
- **SB 622:** Oklahoma PFAS Waste Act - requires promulgation of rules and regulations by Department of Environmental Quality on PFAS waste.

Oregon

Background
- The primary agencies overseeing Oregon's PFAS-related initiatives are the Oregon Health Authority (OHA) and the Oregon Department of Environmental Quality (DEQ).
- Between 2013-2015, all larger public drinking water systems and several smaller systems overseen by OHA monitored for 6 PFAS under the EPA's UCMR. None of the systems had detectable levels of chemicals using the best testing methods available at the time.
- The DEQ is working with landowners of several sites where PFAS have been found. Contamination appears to be related to AFFF.
- DEQ's Toxic Reduction and Safer Alternatives programs are working to identify alternatives for PFAS in food packaging, coordinating with the state on PFAS-release efforts, collaborating with Interstate Chemicals Clearinghouse and other states to assess firefighting foam alternatives, promoting awareness for PFAS-free consumer products, and promoting PFAS-free materials in state purchasing contracts.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

4 PFAS substances combined
- Concentration Level: 30 ppt
- Type of Regulation: Guidance
- Adoption Status: Health Advisory

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy
- **HB 3473 / SB 478:** Requires reporting of high-priority chemicals in children's products and phaseouts of these products in children's cosmetics, mouthable products, and products made for kids under the age of 3. (2015)
- **SB 737:** Requires DEQ to test wastewater treatment plants for persistent, bioaccumulative, and toxic chemicals, including PFAS. (2007)

Current Policy
- **SB 546:** Requires Oregon Health Authority to adopt and maintain list of designated high priority chemicals of concern used in cosmetic products and to periodically review and revise list. Requires manufacturers of cosmetic products sold in state to include on manufacturer's website notice of certain chemicals used in products, beginning on January 1, 2025. Bans manufacture, sale and distribution of cosmetic products containing certain chemicals and classes of chemicals in state, beginning on January 1, 2025.
- **SB 543:** Prohibits food vendors from using polystyrene foam containers in sales of prepared food. Prohibits a person from selling and distributing foodware containers containing PFAS.

Pennsylvania

Background
- The primary agency overseeing Pennsylvania's PFAS-related initiatives is the Pennsylvania Department of Environmental Protection (PDEP).
- Authorities were first made aware of PFAS contamination in public water supplies in 2013 following the addition of PFOS and PFOA to the federal government's UCMR 3 for drinking water.
- With the EPA's health advisory level of 70 ppt for PFOA and PFOS in 2016, the state began partnering with both federal and local groups to locate wells and water systems with significant PFAS contamination, particularly in the southeastern region of the state which is home to several DoD facilities (Horsham, Warrington, Warminster).
- With the signing of an Executive Order in September of 2018, Governor Tom Wolf established the PFAS Action Team to manage community PFAS exposure, ensure drinking water safety, and partner with stakeholders to address PFAS contamination.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water[2]

PFOA
- Concentration Level: 18 ppt
- Type of Regulation: MCL
- Adoption Status: Final-form Rulemaking

PFOS
- Concentration Level: 14 ppt
- Type of Regulation: MCL
- Adoption Status: Final-form Rulemaking

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy
- **B 1410:** Creates remediation fund for customers of water utilities financially impacted by PFAS contamination related to military installations. (2019)

Rhode Island

Background
- The primary agency overseeing Rhode Island's PFAS-related initiatives is the Rhode Island Department of Health (RIDOH).

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water[2]

6 PFAS substances combined
- Concentration Level: 20 ppt
- Type of Regulation: MCL
- Adoption Status: Interim Drinking Water Standard

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy
- **HB 7438 / SB 2044:** Prohibits the sale or promotional distribution of any food package in Rhode Island which contains PFAS, effective January 1, 2024. (2022)
- **HB 7233 / SB 2298:** Authorizes and requires the department of health to take action to establish MCLs for PFAS in drinking water and set interim standards. The act would also provide that the department of environmental management set standards for PFAS in ground and surface waters, and adopt standards for PFAS monitoring at landfills. (2022)

South Carolina

Background
- The primary agency overseeing South Carolina's PFAS-related initiatives is the South Carolina Department of Health and Environmental Control (DHEC).
- DHEC has developed and is implementing several strategies for assessing PFAS in the state's surface water, groundwater and land applied material. When concentrations indicate, further investigation is conducted to identify potential sources of reduce impacts.
- In June 2022, the South Carolina House Ways and Means Committee added a budget provision establishing the "PFOS, PFOA and Emerging Pollutants Remediation Fund" for the mitigation of emerging contaminants in drinking water above the HAs, with an emphasis on private wells and small drinking water systems.

PFAS-related Adopted/Current Policy according to Safer States

Current Policy
- **HB 3499:** Requires the Department of Health and Environmental Control to establish statewide MCLs for PFOS, PFOA, chromium-6, 1-4 dioxane, and any other public water system pollutants for which at least two other states have established MCLs or issued public health guidance.

South Dakota

Background

- The primary agency overseeing South Dakota's PFAS-related initiatives is the South Dakota Department of Agriculture and Natural Resources.
- PFAS-related initiatives at the state-level are limited at this time.
- The City of Sioux Falls has taken an initiative to protect the public from PFOA and PFOS by implementing a monitoring program that includes monthly tests of water treated by the Sioux Falls Water Division.
- The City of Sioux Falls has proactively and temporarily discontinued the use of any well where PFAS have been detected. The city is working with the State Department of Environment and Natural Resources' Drinking Water Program to further understand the new health advisory.

Tennessee

Background

- The primary agency overseeing Tennessee's PFAS-related initiatives is the Tennessee Department of Environment & Conservation (TDEC).
- TDEC is conducting a statewide sampling initiative to test all public drinking water sources for 29 PFAS compounds in order to understand the presence of and concentration of PFAS compounds in source waters throughout the state. The results of this sampling will help both TDEC and the regulated community understand how to reduce human exposure to PFAS via drinking water.
- TDEC formed an interdisciplinary group to identify potential activities likely to contribute to PFAS contamination and determine the agency's best course of action for protecting Tennesseans from adverse health effects resulting from PFAS contamination. The working group consists of representatives from state and federal government, non-profits, private industry, and academia.

Texas

Background

- The primary agency overseeing Texas' PFAS-related initiatives is the Texas Commission on Environmental Quality (TCEQ).
- PFAS-related initiatives at the state-level are limited at this time.
- A report from the Lubbock Avalanche-Journal from June 2019 noted that 222 private wells and 3 public wells surrounding Reese AFB had PFOS and PFOA levels above the EPA's 70 ppt HAL.

Utah

Background

- The primary agency overseeing Utah's PFAS-related initiatives is the Utah Department of Environmental Quality (DEQ).
- While PFAS compounds have never been produced in Utah, many industries in the state likely use PFAS in their manufacturing processes.
- Historically, military installations and airports in the states are known to have used firefighting foam that contains PFAS.
- In Spring 2019, DEQ assembled a PFAS Workgroup to evaluate the potential for environmental contamination in Utah and develop a reconnaissance plan for PFAS.
- The workgroup developed an ongoing monitoring and reporting strategy to determine if PFAS contaminants can be found in Utah’s groundwater, drinking water, tissue, surface water, or soils.
- Although current information doesn't indicate that widespread PFAS contamination is likely in the state, DEQ intends to be proactive in assessing the possibility of PFAS contamination and taking appropriate actions if necessary.

Vermont

Background

- The primary agencies overseeing Vermont's PFAS-related initiatives are the Department of Environmental Conservation (DEC) and the Vermont Agency of Natural Resources.
- The state is proactively taking steps to safeguard the public from PFAS contamination. These steps include ensuring drinking water is safe, investigating and managing PFAS contamination, reducing the risks to drinking water from firefighting foam, and ensuring rivers, lakes, ponds and wetlands, fish and wildlife are safe from PFAS contamination.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

5 PFAS substances combined

- Concentration Level: 20 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **H 740:** Includes allocating $420,000 for the purchase of laboratory equipment to test for PFAS in drinking water to support public health testing requirements. (2022)
- **H 446:** Requires state department to conduct a study on microplastics and PFAS in food packaging and food waste. (2022)
- **S 113:** Establishes a cause of action for medical monitoring expenses. (2022)
- **S 20:** An act relating to restrictions of PFAS and other chemicals of concern in consumer products. (2021)
- **H 955:** Appropriates $550,000 to improve public water systems contaminated with PFAS, and $50,000 to reimburse schools with contaminated water who must utilize alternate water supplies. (2020)
- **S 49:** Sets MCLs for 5 PFAS chemicals in water of 20ppt each and cumulatively, requires testing for PFAS chemicals, and requires landfills to relate leachate to remove PFAS chemicals. (2019)
- **S 10:** Creates liability and penalties for contaminating water supplies with perfluorinated chemicals. (2017)
- **S 239:** Establishes a process for identifying chemicals of high concern; prohibits sale or distribution of consumer products containing priority chemicals. (2014)

Current Policy

- **H 50:** Prohibits the labeling of consumer products that contain PFAS as compostable.

Virginia

Background

- The primary agency overseeing Virginia's PFAS-related initiatives is the Department of Environmental Quality (DEQ).
- In collaboration with the Virginia Department of Health (VDH), the DEQ is developing strategies to identify potential hot spots, working with the public and local governments when PFAS is found in the environment.
- DEQ is also creating a "PFAS 101" training for DEQ and VDH and other Virginia agencies to raise awareness.
- Virginia PFAS sites: Fentress Air Base, Oceana Naval Air Station, Northwest Annex, NASA Wallops Island, DuPont Spruance

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **HB 919:** Requires the Board of Health to adopt MCLs in all water supplies and waterworks in the Commonwealth for PFOA, PFOS, and for such other PFAS. (2022)
- **HB 1257:** Requires Department of Health to set MCLs for PFAS and other chemicals in drinking water. (2020)
- **HB 586:** Tasks Commissioner of Health to convene work group to study occurrence of PFAS in state drinking water and develop recommendations for MCLs. (2020)

Current Policy

- **HB 1011:** Directs the Commissioner of Health to convene a workgroup to study the occurrence of PFAS in drinking water in the Commonwealth.
- **HB 1400 / SB 800:** Provides $320,000 for the Virginia Department of Environmental Quality to conduct ambient surface water and groundwater surveillance for PFAS.
- **HB 1855:** Prohibits the sale, offering for sale, or manufacturing for sale of children's products that contain PFAS.
- **SB 1013:** Requires a waterworks owner to notify customers when a water quality analysis reveals that PFAS are present in the water supply or when a contaminant in the water supply exceeds MCLs established in state or federal regulations, whichever is more stringent.
- **HB 2189:** Requires industrial users of publicly owned treatment works that receive and clean, repair, refurbish, or process items that contain PFAS to test waste streams for PFAS prior to and after cleaning, repairing, refurbishing, or processing such items.

Washington

Background

- The primary agencies overseeing Washington's PFAS-related initiatives are the Department of Health (DOH) and the Department of Ecology.
- The Departments of Ecology and Health developed a statewide Chemical Action Plan for PFAS in November 2021 to address human exposure and environmental contamination.
- In 2018, state legislature restricted the use of PFAS in firefighting foam and banned fire training with PFAS firefighting foams. The law also requires reporting of PFAS in firefighter's personal protective equipment.
- In 2018, the state restricted the use of PFAS in food contact papers and paperboard, once safer alternatives are identified.
- In 2019, the state authorized the Department of Ecology to further restrict PFAS and other harmful chemical classes in consumer products.
- In October 2021, the State Board of Health adopted standards for PFAS in Group A public drinking water systems (see survey results below). Along with these standards, the rule also requires monitoring, recordkeeping and reporting, follow-up actions, and other associated requirements for PFAS.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water

PFNA

- Concentration Level: 9 ppt
- Type of Regulation: Notification
- Adoption Status: Rules

PFOA

- Concentration Level: 10 ppt
- Type of Regulation: Notification
- Adoption Status: Rules

PFOS

- Concentration Level: 15 ppt
- Type of Regulation: Notification
- Adoption Status: Rules

PFHxS

- Concentration Level: 65 ppt
- Type of Regulation: Notification
- Adoption Status: Rules

PFBS

- Concentration Level: 345 ppt
- Type of Regulation: Notification
- Adoption Status: Rules

PFAS-related Adopted/Current Policy according to Safer States

Adopted Policy

- **HB 1694:** Improves logistical processes for the regulation of priority chemicals in consumer products. (2022)
- **HB 1080:** Appropriates funding for PFAS treatment, cleanup, and pilot project. (2021)
- **HB 2265:** Eliminates exemptions from restrictions on use of PFAS-containing firefighting foam. (2020)
- **SB 5135:** Directs the Department of Ecology to identify and take regulatory action on consumer products that are a concern for sensitive populations and species. Prioritizes PCBs, PFAS, organohalogen flame retardants, phthalates, and phenolic compounds (BPA, APEs) for initial consideration. (2019)
- **HB 2658:** Prohibits the manufacture and sale of food packaging containing PFAS chemicals and requires the Department of Ecology to conduct an assessment on safer alternatives (2018)

- **SB 6413:** Prohibits the manufacture and sale of class B firefighting foam containing PFAS chemicals. (2018)

Current Policy

- **HB 1047:** beginning January 1, 2025, no person may manufacture, knowingly sell, offer for sale, distribute for sale, or distribute for use in this state any cosmetic product that contains any of the following intentionally added chemicals or chemical classes: ortho-phthalates, PFAS, formaldehyde, mercury, triclosan, and more.
- **SB 5245:** Requires the state department to establish pollutant limits for PFAS chemicals in biosolids by July 1, 2025. Prohibits land application of biosolids that do not comply with a PFAS chemical pollutant limit.

West Virginia

Background

- The primary agencies overseeing West Virginia's PFAS-related initiatives are the Department of Environmental Protection (WVDEP) and the West Virginia Department of Health and Human Resources (WVDHHR).
- A West Virginia PFAS Work Group was convened in 2019, with the goal of determining the best path forward for studying PFAS. This group meets quarterly to share developing news on PFAS, discuss PFAS investigation activities in the State, evaluate any recently produced data, determine State needs and action plans based on these updates (including implementation of federal regulations).
- The WVDEP and the WVDHHR contracted with the United States Geological Survey (USGS) to conduct sampling of pre-treated drinking water for 26 PFAS compounds in all public water systems and 27 schools/daycares. Sampling began in June 2020 and concluded in May 2021.
- Latest results (as of 2022) from this sampling showed at least 1 PFAS detected at 24% of the sites sampled, 47 of which were groundwater sources and 20 were surface-water sources. 5 sites exceeded the EPA's HAL of 70 ppt. These sites were located in highly susceptible karst and alluvial groundwater aquifers on the east and west sides of the State.
- While more recent studies have aimed to determine the presence of PFAS compounds in raw water, the WVDEP is now coordinating with DHHR and the USGS to test for these compounds in finished (drinking) water at all sites identified as having PFOA or PFOS detections in the raw water above the new HALs.

Wisconsin

Background

- The primary agencies overseeing Wisconsin's PFAS-related initiatives are the Wisconsin Department of Natural Resources (WDNR) and the Wisconsin PFAS Action Council (WisPAC).
- PFAS has been found across the state with some of the most severe contamination in Marinette County as a result of firefighting foam pollution from the Tyco Fire Products Testing facility.
- Other areas with significant PFAS contamination include Milwaukee, Eau Claire, and Wausau.
- In December 2020, the WisPAC published a PFAS Action Plan which serves as a roadmap for how state agencies will address PFAS. The action plans guiding principles include Environmental Justice, Health Equity, Innovation, and Pollution Prevention.
- In August 2022, the WisPAC provided an update to the State governor outlining progress against key initiatives related to the PFAS Action Plan including standard setting, sampling, pollution prevention, engagement, education, and communication, research and knowledge, phase out, future investments, and identifying and addressing historic discharges.
- Under the Biden administration's Infrastructure Law, Wisconsin will receive $12.8 million over each of the next 5 years to be used for PFAS remediation in drinking water.

BCLP March 2022 Survey Results: State Regulation of PFAS in Drinking Water[2]

PFOA/PFOS

- Concentration Level: 70 ppt
- Type of Regulation: MCL
- Adoption Status: Regulation

Wyoming

Background

- The primary agency overseeing Wyoming's PFAS-related initiatives is the Wyoming Department of Environmental Quality (WDEQ).
- According to the WDEQ, no known PFAS production has occurred in Wyoming and only a few industries that commonly use PFAS occur in Wyoming.
- Nevertheless, PFAS chemicals have accumulated in biosolids, wastewater, landfills, and industrial sites in the State and may be found near military facilities and airports that used AFFF.
- In 2018, the WDEQ funded a study to conduct an initial inventory and prioritization of potential sources of PFAS, primarily based on proximity to priority drinking water aquifers. Based on this prioritization system, aquifers in proximity to sites with AFFF were most likely to have PFAS.
- The WDEQ will conduct an additional study to assess the potential source areas identified during the 2018 study and investigate additional potential PFAS sources in Wyoming, and any potential impacts to groundwater.

Notes and Sources:

1) Bryan Cave Leighton Paisner Survey - results current as of March 1, 2022
2) Data updated by William Blair. Drinking water regulations updated after March 1, 2022
3) Information regarding adopted and/or current PFAS-related policy for each state is not exhaustive and may exclude current or proposed PFAS-related policy within each respective state legislature.

Sources: Safer States, Alabama Department of Environmental Management, Alaska Department of Environmental Conservation, Arizona Department of Environmental Quality, California Water Boards, Colorado Department of Public Health and Environment, Denver Post, NRDC, Connecticut Department of Energy & Environmental Protection, Delaware Department of Natural Resources and Environmental Control, Delaware Health and Social Services, Florida Department of Environmental Protection, Georgia Environmental Protection Division, Hawaii.gov, Idaho Department of Environmental Quality, Illinois Environmental Protection Agency, Chicago Tribune, Indiana Department of Environmental Management, Iowa Department of Natural Resources, Kansas Department of Health and Environment, Kentucky Department for Environmental Protection, Maine Department of Environmental Protection, Maryland Department of the Environment, Mass.gov, Detroit Free Press, Michigan Environmental Council, Michigan.gov, Minnesota Pollution Control Agency, Minnesota 3M PFAS Settlement, Mississippi Department of Environmental Quality, Missouri Department of Natural Resources, Montana Department of Environmental Quality, Nebraska Department of Environment and Energy, Nevada Division of Environmental Protection, New Hampshire Department of Environmental Services, New Jersey Department of Environmental Protection, New Mexico Environment Department, New York Department of Environmental Conservation, North Carolina Department of Health and Human Services, North Dakota Department of Environmental Quality, Ohio Environmental Protection Department, Oklahoma Department of Environmental Quality, Oregon.gov, Pennsylvania Department of Environmental Protection, Rhode Island Department of Health, South Carolina Department of Health and Environmental Control, City of Sioux Falls, Tennessee Department of Environment & Conservation, Texas Commission of Environmental Quality, Lubbock Avalanche-Journal, Utah Department of Environmental Quality, Vermont Department of Environmental Conservation, Virginia Department of Environmental Quality, Washington Department of Health, West Virginia Department of Environmental Protection, USGS, The Badger Herald, Wisconsin Department of Natural Resources, Wyoming Department of Environmental Quality

Appendix C: National PFAS Data Sets

There are several considerations to keep in mind when using the EPA's national PFAS data sets:

1. much of the data collected is voluntarily submitted, which makes state, county, or city comparisons difficult given the variation in testing and reporting between different areas;

2. many data sets include locations where PFAS have not been found to provide the analyst with a comprehensive sense of where testing and sampling has occurred;

3. the data used in assembling the national PFAS data sets provide results as of a particular date and time. Depending on the duration of time since the last data refresh, the data may inaccurately depict the current state of PFAS occurrence.

With these constraints in mind, we believe the national PFAS data sets and the EPA's PFAS Analytic Tools portray the most accurate and comprehensive picture of the size and scope of potential PFAS contamination across the United States. In the following subsections, we will examine each of the individual data sets that make up the EPA's national PFAS data sets in more detail through the lens of four data flow categories: PFAS handler data, sites potentially impacted by PFAS, environmental sampling data, and drinking water sampling data. Each subsection within these data flow categories includes an exhibit that summarizes the general description, sources, data release cadence, and caveats and limitations of these data sets, as well as a link to the EPA's Analytic Tools website. Refer to the EPA's published metadata for additional information on each of these data sets.

PFAS Handler Data
Currently included in the existing data flow from PFAS handlers are the following: Facilities in Sectors Handling PFAS, Wastewater Discharges, Releases and Transfers, Production and Imports, and Waste Generation and Management. In addition, the EPA is in the process of collecting air release data through greenhouse gas reporting and hopes to eventually add "chemicals stored on site" data to the handler data set through the Emergency Planning and Community Right-to-Know Act (EPCRA) Tier II.

Facilities in Sectors Handling PFAS. In response to a growing number of requests from regulatory bodies and the general public, the EPA (as part of its PFAS Action Plan released in 2019) is committed to collecting and publishing data related to industry sites that may be handling or releasing PFAS into the environment. Using the North American Industry Classification System (NAICS) Codes and the Standard Industrial Classification Codes (related to CWA, RCRA, and CAA records) available in ECHO, as well as additional data from the Federal Aviation Administration's Airport Data and Information Portal and ECHO fire training site searches, the EPA compiled the ECHO PFAS Industry Sectors data set, which at its initial publishing in October 2021 listed over 120,000 sites across the United States that might be handling and/or releasing PFAS chemicals. As of January 8, 2023, the data set now lists over 137,000 industry locations.

Exhibit 20
PFAS Report
ECHO PFAS Industry Sectors Data Set

General Description	• Data set compiled from various sources for the purpose of showing which industries may be handling or releasing PFAS into the environment • As of January 8, 2023, there were 137,282 facilities subject to federal environmental programs that have operated or currently operate in industry sectors with processes that may involve handling and/or the release of PFAS
Data Set Source(s)	• A majority of records are identified based on the NAICS Codes and SIC Codes with CWA, RCRA, and CAA records (from ECHO) • Additional facilities were identified through 2 additional data sources: (1) Fire Training Sites (using ECHO) and (2) 14 CFR Part 139 Airports
Type of Data Flow	• Existing automated data flow
Data Refresh Interval	• Weekly
Disclosures	• Inclusion of a facility in this data set does NOT indicate that PFAS are being manufactured, processed, used, or released by the facility; listed facilities *potentially* handle PFAS based on their industrial profile • EPA has not confirmed whether each individual facility on the list actually handles PFAS • Keyword searches in ECHO for Fire Training sites may misidentify some facilities and should not be considered to be an exhaustive list of fire training facilities in the United States
Link to Industry Sectors Data Set Tools[1]	https://awsedap.epa.gov/public/extensions/PFAS_Tools/PFAS_Tools.html

Notes:
1) Industry Sectors Data Set tools can be found on the EPA's PFAS Analytic Tools website under the "Industry Sectors" tab
2) Data current as of 1/8/2023
Sources: Environmental Protection Agency, Enforcement and Compliance History Online

Wastewater Discharges. The Clean Water Act (CWA) requires that those facilities responsible for water pollution from a point source have a National Pollutant Discharge Elimination System (NPDES) permit. The procedure to obtain an NPDES permit involves a comprehensive review of the regulated entity's NPDES permit application by a permitting authority (either a state authority or the EPA) who decides whether or not monitoring of the polluting activity is required. If monitoring is needed, the permittee will be required to report wastewater flow and pollutant concentrations to the appropriate authority through a Discharge Monitoring Report (DMR). In creating the national PFAS data sets, ECHO extracts DMR data from the EPA's Integrated Compliance Information System for the National Pollutant Discharge Elimination System (ICIS-NPDES). Since 2007, the EPA has recorded more than 11,000 notifications of PFAS and/or PFAS-related compounds from 161 total facilities.

Exhibit 21
PFAS Report
NPDES PFAS Discharge Monitoring Data Set

General Description	• Data collected through DMRs of U.S. NPDES permit holders responsible for U.S. water pollution from a point source • This data layer includes PFAS-related DMR data from 2007 to present • Since 2007, 161 facilities have combined to submitted more than 11,000 release notifications of 71 unique PFAS and/or PFAS-related substances
Data Set Source(s)	• Extracted by ECHO from DMR data stored in the ICIS-NPDES
Type of Data Flow	• Existing automated PFAS data flow
Data Refresh Interval	• Weekly
Disclosures	• Less than half of states have required PFAS monitoring for at least one of their permittees and fewer states have established PFAS effluent limits for permittees • In April 2022, EPA issued a memo recommending more comprehensive monitoring information on potential sources of PFAS in CWA programs EPA oversees; EPA plans to issue a subsequent memo that provides guidance to state permitting authorities • New rulemakings have been initiated that may increase the number of facilities monitoring for PFAS in the future • For states that may have required monitoring, there may exist some reporting and data transfer issues on a state-by-state basis
Link to Discharge Monitoring Data Set Tools[1]	https://awsedap.epa.gov/public/extensions/PFAS_Tools/PFAS_Tools.html

Notes:
1) Discharge Monitoring Data Set tools can be found on the EPA's PFAS Analytic Tools website under the "Discharge Monitoring" tab
2) Data current as of 1/8/2023
Sources: Environmental Protection Agency, Enforcement and Compliance History Online

Releases and Transfers. The Toxics Release Inventory (TRI) is responsible for tracking the oversight of chemical release and waste management for over 21,000 facilities in both covered industry sectors and federal facilities. As part of this process, TRI requires these facilities to file reports outlining the quantity of TRI-reportable chemicals released into the environment and/or managed through waste disposal (e.g., treatment, energy recovery, recycling, off-site transfer). The TRI chemical list included 774 individual chemicals and 33 chemical categories as of February 2022. PFAS were added to the EPA's TRI chemical list in 2020 in accordance with the NDAA for fiscal 2020. PFAS-related TRI data is categorized into three separate buckets: 1) TRI on-site releases, 2) TRI off-site releases, and 3) TRI total waste management.

Exhibit 22
PFAS Report
TRI PFAS Releases and Transfers Data Set

General Description	• Data collected from both covered industry sectors and federal facilities that actively release chemicals into the environment and/or manage their removal through various disposal methods **PFAS or PFAS-Related Activity Reported During 2021** • On-site Releases = ~400K on-site releases • Off-site Transfers = 800K-plus lbs. of reported transfers • Total Waste Managed = 6.5m-plus lbs. of waste managed
Data Set Source(s)	• Compliant TRI reporting by covered industry sectors and federal facilities
Type of Data Flow	• Existing automated PFAS data flow
Data Refresh Interval	• Twice a year; refresh occurs in the fall of each calendar year and spring of the following year
Disclosures	• Data file includes releases and waste management data for chemicals identified in EPA's CompTox Chemicals Dashboard list of PFAS without explicit structures and list of PFAS structures in DSSTox • The TRI data gathered and presented in this tool are restricted to the PFAS added to the TRI chemical list per the NDAA and to other TRI-listed organic chemicals that contain fluorine atoms and also found on EPA's CompTox Chemicals Dashboard • Note that some regulations have specific chemical structure requirements that define PFAS differently than the lists in EPA's CompTox Chemicals Dashboard • It is strongly recommended to consult the latest reported TRI data on the program website to review PFAS reporting as considered by the TRI Program
Link to Toxic Releases Data Set Tools[1]	https://awsedap.epa.gov/public/extensions/PFAS_Tools/PFAS_Tools.html

Notes:
1) Toxic Releases Data Set tools can be found on the EPA's PFAS Analytic Tools website under the "Toxic Releases" tab
2) Data current as of 1/8/2023
Sources: Environmental Protection Agency, Enforcement and Compliance History Online

Production and Imports. Every four years, by way of the Chemical Data Reporting (CDR) under the Toxic Substances Control Act (TSCA), manufacturers and importers are required to submit information to the EPA on their domestic production of chemicals as well as those chemicals that they import. This reporting is necessary at production thresholds of 25,000 pounds for most chemicals and 2,500 for certain chemicals. This submission includes information regarding volume of production, site details, parent company, and processing and use data. To inform the national PFAS data sets, the EPA gathered nonconfidential business information CDR records filtered for PFAS chemicals from 1998 to 2016.

Exhibit 23
PFAS Report
CDR PFAS Production and Imports Data Set

General Description	• Data collected from domestic manufacturers and importers of chemicals that includes (but is not limited to) site details, parent company information, volume and production, and processing and use data • Over the course of this data set's reporting history, 108 parent companies representing 132 total facilities have reported the manufacture and/or import of 311 PFAS and/or PFAS-related compounds
Data Set Source(s)	• 2020 CDR, 2016 CDR, 2012 CDR, 2006 IUR, 2002 IUR[1], 1998 IUR • List of defined structure PFAS chemicals and undefined structure PFAS chemicals established by CCTE[3] (Sept 16, 2020) • List of PFAS chemicals and substances whose names are withheld as confidential business information that were released as part of the Freedom of Information Act • Identifiers for CDR reporting sites and locational information for each site (Facility Registry Service) • A link summarizing each site's enforcement and compliance history (ECHO)
Type of Data Flow	• Existing manual PFAS data flow
Data Refresh Interval	• Every four years
Disclosures	• This data file includes production and importation data for chemicals identified in EPA's CompTox Chemicals Dashboard list of PFAS without explicit structures and list of PFAS structures in DSSTox • Note that some regulations have specific chemical structure requirements that define PFAS differently than the lists in EPA's CompTox Chemicals Dashboard • Reporting information on manufactured or imported chemical substance amounts should not be compared between facilities, as some companies claim Chemical Data Reporting Rule data fields for PFAS information as Confidential Business Information
Link to Production Data Set Tools[2]	https://awsedap.epa.gov/public/extensions/PFAS_Tools/PFAS_Tools.html

Notes:
1) Public access to 1998 and 2002 IUR data was not functioning as of February 3, 2020
2) Production Data Set tools can be found on the EPA's PFAS Analytic Tools website under the "Production" tab
3) The Center for Computational Toxicology & Exposure
4) Data current as of 1/8/2023
Sources: Environmental Protection Agency, Enforcement and Compliance History Online

Waste Generation and Management. Whenever hazardous waste is shipped, it must have a shipment manifest, which assists the EPA in tracking waste material from inception to destruction through the Resource Conservation and Recovery Act Information (RCRAInfo) system. A manifest contains important codes that help to identify, categorize, and describe the waste that is being shipped. Waste codes for PFAS do not currently exist, and Vermont is the only state with designated codes for PFAS waste. In compilation of this data set, the EPA screened e-Manifest records for common PFAS-related keywords (e.g., PFAS, PFOA, PFOS, AFFF, PERFL, GenX) as well as for Vermont's two waste codes (VT21 and VT22) against various text fields.

Exhibit 24
PFAS Report
RCRA PFAS Transfers Data Set

General Description	• Data collected from e-Manifest records of U.S.-based shipments of hazardous waste containing PFAS • While PFAS codes do not currently exist at the federal level, the EPA has screened RCRA data for these PFAS keywords (PFAS, PFOA, PFOS, PERFL, AFFF, GENX, and GEN-X) against key text fields (manifest handling instructions, nonhazardous waste description, DOT printed information, waste line handling instructions, waste residue comments) • Vermont is currently the only state with active PFAS waste codes (VT21 and VT22) • From July 2018 to September 2022, 4,298 unique manifest IDs related to PFAS have been collected by the RCRA
Data Set Source(s)	• PFAS-related and state code keyword search against RCRA e-Manifest records
Type of Data Flow	• Existing automated PFAS data flow
Data Refresh Interval	• Transfers
Caveats and Limitations	• Amount or concentration of PFAS being transferred cannot be determined from the manifest information • Keyword searches may misidentify some manifest records that do not contain PFAS • This data set should not be considered to be exhaustive of all PFAS waste transfers
Link to Transfers Data Set Tools[1]	https://awsedap.epa.gov/public/extensions/PFAS_Tools/PFAS_Tools.html

Notes:
1) Transfers Data Set tools can be found on the EPA's PFAS Analytic Tools website under the "Transfers" tab
2) Data current as of 1/8/2023
Sources: Environmental Protection Agency, Enforcement and Compliance History Online

Environmental Sampling Data

The only existing data source currently feeding the EPA's Environmental Sampling Data is collected by the Water Quality Portal (WQP)—a data portal that integrates public water quality data from more than 400 federal, state, tribal, and local agencies, as well as the U.S. Geological Survey (USGS) and the EPA. In the future, the EPA plans to source additional data related to blood/tissue testing (ATSDR, etc.), biosolids and other product testing, and ambient sampling to better inform its environmental sampling data as it pertains to PFAS occurrence.

Water Quality Portal. The WQP data portal provides insight into the nature of the nation's water quality. This includes important information pollutant concentration (e.g., PFAS). WQP data includes a variety of fields including project, site, and sample information. In addition to various government sources, academic institutions, nongovernmental organizations, and individuals are regular contributors to the WQP database. The EPA groups WQP data related to PFAS into one of the following categories: water, air, soil, sediment, tissue, and other. PFAS-related data was compiled through the WQP by searches conducted for PFAS chemical names.

Exhibit 25
PFAS Report
WQP PFAS Multimedia Environmental Sampling Data Set

General Description	• The EPA's environmental sampling data is maintained by the Water Quality Portal (WQP)—a data portal developed by and managed by the EPA, USGS, and the National Water Quality Monitoring Council for the purpose of characterizing water quality (including pollutant concentration details) **PFAS-Containing Samples as of January 8, 2023** • Water = 36,712 • Tissue = 36,409 • Air = 5 • Soil = 216 • Sediment = 2,776 • Other = 139
Data Set Source(s)	• Multimedia data compiled by WQP from USGS National Water Information System, the EPA STOrage and RETrieval Data Warehouse, and the USDA ARS Sustaining The Earth's Watersheds - Agricultural Research Database System
Type of Data Flow	• Existing automated data flow
Data Refresh Interval	• Weekly
Disclosures	• EPA did not carry out the sampling or testing of a majority of the data in the WQP PFAS data set • EPA can only speak to the accuracy and completeness of the data from projects like the National Aquatic Resource Survey for which EPA is the data owner/organization • Data may exist within the file on Quality Assurance Project Plans (QAPPs) and the approving agency of the QAPP, if a QAPP is entered
Link to Environmental Media Data Set Tools[1]	https://awsedap.epa.gov/public/extensions/PFAS_Tools/PFAS_Tools.html

Notes:
1) Environmental Media Data Set tools can be found on the EPA's PFAS Analytic Tools website under the "Environmental Media" tab
2) Data current as of 1/8/2023
Sources: Environmental Protection Agency, Enforcement and Compliance History Online

Sites Potentially Impacted by PFAS

Included in the existing data flow related to sites potentially impacted by PFAS are the following: Superfund sites with PFAS detections, spills, and federal sites. The EPA plans to add state response locations to this data set in the future.

Superfund sites with PFAS detections. The EPA maintains a database of information related to National Priorities List sites (aka Superfund sites) under CERCLA. Published data includes information-related site investigations, contamination, and remediation. In addition, the EPA provides PFAS-related data for any Superfund sites when appropriate. As of January 8, 2023, the states with the highest number of Superfund sites with PFAS detections were Massachusetts (26 sites), Pennsylvania (25 sites), and New Jersey (21 sites).

Exhibit 26
PFAS Report
Superfund Sites with PFAS Detection Data Set

General Description	• Data related to site investigations, contamination (e.g., PFAS), and remediation are regularly maintained by the EPA for Superfund sites under CERCLA • PFAS has been detected at 266 Superfund sites in total; 109 of these sites are federal and the remaining 157 are private • The three states with the greatest number of Superfund sites where PFAS have been detected are Massachusetts (26), Pennsylvania (25), and New Jersey (21)
Data Set Source(s)	• Data periodically updated by EPA programs and regional offices
Type of Data Flow	• Existing manual data flow
Data Refresh Interval	• Intermittent
Disclosures	• Detections of PFAS at National Priority List sites do not mean that people are at risk from PFAS, are being exposed to PFAS, or that the site is the source of the PFAS • The information in the Superfund NPL and SAA PFAS detection site list is several years old and may not be accurate today; site information such as site name, site ID, and location, has been confirmed for accuracy; however, PFAS-related information such as media sampled, drinking water being above the health advisory, or mitigation efforts has not been verified • For federal facilities data, the other federal agencies (OFA) are the lead for oversight of sites under their purview and have provided site identification and PFAS testing data to EPA
Link to Superfund Sites Data Set Tools[1]	https://awsedap.epa.gov/public/extensions/PFAS_Tools/PFAS_Tools.html

Notes:
1) Superfund Sites Data Set tools can be found on the EPA's PFAS Analytic Tools website under the "Superfund Sites" tab
2) Data current as of 1/8/2023
Sources: Environmental Protection Agency, Enforcement and Compliance History Online

Spills. Managed by the U.S. Coast Guard, the National Response Center (NRC) is an emergency call center for all discharge spills (e.g., oil, chemicals, AFFF). In an effort to help coordinate an effective government response at the federal level, the NRC takes down various data points related to the spill, including size and nature of release, responsible parties, and facility/vessel characteristics, and distributes this data to the appropriate federal/state agencies. The EPA's PFAS-related spills data set accounts for incidents associated with PFAS and PFAS-containing material (e.g., AFFF).

Exhibit 27
PFAS Report
Spills Data Set

General Description	• The National Response Center (NRC) serves as an emergency call center that fields initial reports for pollution incidents and forwards this information to the appropriate federal/state agencies • From 1990 to 2022, the NRC has fielded 1,114 calls related to PFAS and/or PFAS-containing spills
Data Set Source(s)	• The NRC maintains the national database of all reported releases and spills • Spill information from 1990 to present is restricted to records associated with PFAS and PFAS-containing materials (e.g., AFFF)
Type of Data Flow	• Existing automated data flow
Data Refresh Interval	• Weekly
Disclosures	• The information from the NRC website contains initial incident data that has not been validated or investigated by a federal/state response agency • Keyword searches may misidentify some incident reports that do not contain PFAS • This data set should not be considered to be exhaustive of all PFAS spills/release incidents
Link to Spills Data Set Tools[1]	https://awsedap.epa.gov/public/extensions/PFAS_Tools/PFAS_Tools.html

Note:
1) Spills Data Set tools can be found on the EPA's PFAS Analytic Tools website under the "Spills" tab
2) Data current as of 1/8/2023
Sources: Environmental Protection Agency, Enforcement and Compliance History Online

Federal sites. The EPA continues to collect information on known and/or suspected detections of PFAS at federal sites. This data is gathered from four primary sources:

1. NPL sites where the EPA has primary oversight (also included in Superfund Sites data set);

2. the DoD PFAS website, which is periodically updated with the latest inventory of DoD sites being assessed for PFAS use, release, and contamination;

3. the DoD's annual report to agricultural locations that reside within one mile of a military/national guard site where PFAS have or are suspected of having been released and are now present in the groundwater; and

4. data collected from the National Aeronautics and Space Administration (NASA), U.S. Department of Transportation (DOT), and the U.S. Department of Energy (DOE), which have confirmed detections or suspected releases of PFOA/PFOS.

Exhibit 28
PFAS Report
Federal Sites With Known or Suspected PFAS Detections Data Set

General Description	• The EPA is gathering information on known and suspected detections at federal facilities from various entities including the DoD, NASA, DoT, DoE, and the federal Superfund program • To date, **710 federal sites** have been identified: 283 of these sites are known to have PFAS presence, 374 are suspected of having PFAS, and 53 are pending or unknown
Data Set Source(s)	• NPL Sites (Superfund) • DoD PFAS website • DoD Annual Report to Agricultural Operations (Section 335 NDAA FY2021) • Other federal agencies: NASA, DoT, DoE, ATSDR
Type of Data Flow	• Existing manual data flow
Data Refresh Interval	• Intermittent
Disclosures	• The sites on this list do not necessarily reflect the source(s) of PFAS contamination and detections do not indicate level of risk or human exposure at the site • The data set on agricultural notifications only includes DoD sites (data are not available for other federal agency sites) • EPA is aware that the list included here is not comprehensive of all federal agencies but is working to continue to develop the database • This data could overlap with other data sets provided in the EPA's Analytic Tools
Link to Federal Sites Data Set Tools[1]	https://awsedap.epa.gov/public/extensions/PFAS_Tools/PFAS_Tools.html

Note:
1) Federal Sites Data Set tools can be found on the EPA's PFAS Analytic Tools website under the "Federal Sites" tab
2) Data current as of 1/8/2023
Sources: Environmental Protection Agency, Enforcement and Compliance History Online

Drinking Water Sampling Data

Drinking water sampling data is sourced from EPA-mandated public water system (PWS) historical testing under UCMR 3 and supplementary public water supply testing stored within the Safe Drinking Water Information System (SDWIS) or published online by tribal public drinking water systems

through the EPA's Tribal PFAS Monitoring Results. The EPA plans to incorporate future PWS testing data upon finalization of UCMR 5 in 2023, which has outlined monitoring requirements for 29 additional PFAS compounds. The EPA also plans to add private wells data to this data layer in the future.

Historical PWS testing. Amendments to the 1966 Safe Drinking Water Act (SDWA) mandate that the EPA submit a new list of up to 30 unregulated contaminants every five years to be monitored by 1) all PWSs serving over 10,000 people and 2) a cohort of small public water systems servicing under 10,000 people. These enforceable monitoring guidelines are published in the Unregulated Contaminant Monitoring Rules (UCMRs). Published in 2012, UCMR 3 (in effect between January 2013 and 2015) established monitoring requirements for six PFAS compounds. The EPA's PFAS Analytic Tools reference the National Contaminant Occurrence Database (NCOD), which holds UCMR 3 contaminant data in an effort to better understand PFAS contamination within the nation's drinking water supply.

Exhibit 29
PFAS Report
UCMR PFAS Public Water Supply Monitoring Data Set

General Description	• Under the SDWA, PWSs are required to adhere to contaminant monitoring requirements as outlined in the UCMR • UCMR 3 required testing for 6 PFAS chemicals from January 2013 into 2015 • EPA's PFAS Analytic Tool references the NCOD for UCMR 3 data related to the presence of PFAS contamination in drinking water from PWSs across the United States **Summary Results** • Total PWSs in Selection = 4,920 • Samples in Selection = 51,113 • PWS Above/Equal to MRL[2] = 89 • Samples Above or Equal to MRL = 187 • PWSs Above a Health Advisory = 71 • Samples Above a Health Advisory = 107
Data Set Source(s)	• UCMR 3 data stored in the NCOD
Type of Data Flow	• Existing manual data flow
Data Refresh Interval	• Data for additional PFAS sampling under the UCMR 5 are expected after sampling begins in 2023
Disclosures	• The monitoring for 6 PFAS in public water systems occurred from January 2013 to December 2015 • Since then, many water providers have taken action to reduce PFAS presence in finished drinking water; the data therefore does not show current drinking water exposures, but rather highlights areas where people might want to look further for the latest information, starting with their local drinking water provider • ZIP-codes-served information in this file does not necessarily correlate to exposure to PFAS, as these ZIP codes are not the definitive service areas (i.e., a PWS may only serve a small portion of a ZIP code it has listed as serving)
Link to Drinking Water (UCMR) Data Set Tools[1]	https://awsedap.epa.gov/public/extensions/PFAS_Tools/PFAS_Tools.html

Note:
1) Drinking Water (UCMR) Data Set tools can be found on the EPA's PFAS Analytic Tools website under the "Drinking Water (UCMR)" tab
2) Minimum Reporting Level
3) Data current as of 1/8/2023
Sources: Environmental Protection Agency, Enforcement and Compliance History Online

Supplemental public water supply testing. While the EPA collects PWS contaminant monitoring data for the six PFAS compounds outlined under UCMR 3, several states and individual PWSs have widened the scope of their testing of both source and finished water to include additional PFAS compounds. This data is not submitted to the EPA, but states are permitted to keep their monitoring results within the Safe Drinking Water Information System (SDWIS). In addition, the EPA semi-annually performs web analysis for available data on PFAS monitoring results from tribal PWSs. The EPA integrates drinking water sampling data from the SDWIS and tribal PFAS monitoring data to inform its PFAS analytic tools.

Exhibit 30
PFAS Report
Supplemental Public Water Supply PFAS Monitoring Data Set

General Description	• Certain states and private PWSs have chosen to test source and finished water for PFAS compounds beyond the scope of those required by the UCMR 3; results of this monitoring are not collected by the EPA but are accessible to the agency through the SDWIS • The EPA also analyzes websites for results from PFAS monitoring in tribal PWSs • The data collected from states and tribes is informative for the EPA's PFAS analytic tools **Summary Results: All Samples at PWS** • PWSs = 8,697 • Samples = 174,487 • PWSs with Detections = 2,426 • Samples with Detections = 12,874 • PWSs with Detections above HAL[2] = 1,924 • Detection above HAL = 4,967
Data Set Source(s)	• State and private PWSs monitoring results stored in SDWIS • Web analysis results from PFAS monitoring for tribal PWSs
Type of Data Flow	• Existing manual/automated data flow
Data Refresh Interval	• Intermittent
Disclosures	• This data file includes aggregations from multiple state sampling initiatives; these initiatives vary in sampling/targeting methods (e.g., non-targeted analysis vs. targeted analysis), scope, (e.g., percentage and type of public water system), detection limits, sample location, reporting limits, quantification methods, what data elements are reported, and what data are reported (e.g., some states choosing only to report detections while other states report all test results) • Because of these significant differences in how states and tribes are collecting data, the information in this file should not be compared across state boundaries • EPA intends to continue adding data from more states that make it available
Link to Drinking Water (State) Data Set Tools[1]	https://awsedap.epa.gov/public/extensions/PFAS_Tools/PFAS_Tools.html

Note:
1) Drinking Water (State) Data Set tools can be found on the EPA's PFAS Analytic Tools website under the "Drinking Water (State)" tab
2) Health Advisory Level
3) Data current as of 1/8/2023
Sources: Environmental Protection Agency, Enforcement and Compliance History Online

The prices of the common stock of other public companies mentioned in this report follow:

3M Company (Market Perform)	$126.60
AECOM	$86.58
Agilent Technologies, Inc.	$156.11
Arcadis	$40.45
Arkema	$100.15
Asahi Kasei Corporation	$14.53
BASF SE	$13.81
The Chemours Company	$33.09
Clariant AG	$17.14
Clean Harbors	$122.50
Corteva Inc	$62.70
Credit Suisse Group AG	$3.44
Daikin Industries, Ltd.	$16.48
Danaher Corporation (Outperform)	$274.92
DuPont de Nemours, Inc.	$74.33
Ecolab Inc. (Outperform)	$152.06
Evoqua Water Technologies Corp	$41.82
Exponent, Inc. (Market Perform)	$101.55
Goldman Sachs Group Inc.	$349.63
Heritage-Crystal Clean, Inc.	$36.11
Honeywell International Inc. (Market Perform)	$212.24
Jacobs Solutions Inc. (Outperform)	$124.45
Kuraray Co. Ltd.	$23.83
Linde plc	$330.00
Montrose Environmental Group (Outperform)	$52.04
Morgan Stanley	$95.62
Oppenheimer Holdings Inc.	$47.71
Parsons Corporation (Market Perform)	$44.05
Republic Services, Inc.	$125.68
Solvay	$11.50
Stifel Financial Corp.	$65.86
Tetra Tech. Inc.	$150.88
UBS Group AG	$19.52
Veolia Environmental S.A.	$29.25
WSP Global Inc.	$122.08
Xylem, Inc.	$104.18

IMPORTANT DISCLOSURES

This report is available in electronic form to registered users via R*Docs™ at https://williamblairlibrary.bluematrix.com or www.williamblair.com.

Please contact us at +1 800 621 0687 or consult https://www.williamblair.com/equity-research/coverage for all disclosures.

Tim Mulrooney attests that 1) all of the views expressed in this research report accurately reflect his/her personal views about any and all of the securities and companies covered by this report, and 2) no part of his/her compensation was, is, or will be related, directly or indirectly, to the specific recommendations or views expressed by him/her in this report. We seek to update our research as appropriate. Other than certain periodical industry reports, the majority of reports are published at irregular intervals as deemed appropriate by the research analyst.

DOW JONES: 33891.00
S&P 500: 4111.08
NASDAQ: 12007.00

Additional information is available upon request.

Current Rating Distribution (as of February 6, 2023):

Coverage Universe	Percent	Inv. Banking Relationships *	Percent
Outperform (Buy)	73	Outperform (Buy)	6
Market Perform (Hold)	27	Market Perform (Hold)	3
Underperform (Sell)	1	Underperform (Sell)	0

*Percentage of companies in each rating category that are investment banking clients, defined as companies for which William Blair has received compensation for investment banking services within the past 12 months.

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