AECOM Imagine it. Delivered.

AECOM Per- and Poly-Fluoroalkyl Substances (PFAS)

Capabilities and Experience

photo credit: www.af.mil

AECOM has PFAS experience at over 400 sites globally

photo credit: www.af.mil

Providing PFAS and Other Environmental Services to the DOD

Why Choose AECOM?

Our fundamental approach to PFAS program management includes:

- **STRATEGIC PROGRAMMING.** Use of our programmatic experience supported by over a decade of working at commercial and DoD sites including program management of the Australian DoD PFAS program. We bring a cadre of technical and program professionals to the Armed Forces' drivers, challenges, and stressors with up-front, well-developed tools, meaning overall greater efficiency, less reactivity and award-winning environmental stewardship.
- **INNOVATIVE STUDIES.** A regulatory and scientifically defensible investigative approach that is optimized into detailed Conceptual Site Models (CSMs) through our Predictive Integrated Stratigraphic Modeling (PRISM™) practice. We streamline the investigative process, minimizing rework and maximizing the results per dollar spent.
- **REGULATORY EXPERTISE.** Decades of regulatory experience with USEPA and in every state that is built on partnering and trust. We bring instant credibility with all state regulatory agencies to find the best solutions in the least amount of time.
- **FOCUSED TECHNOLOGICAL SOLUTIONS.** A thorough understanding of the remedial technologies available including their applications by media, limitations, effectiveness, and cost. We begin with the end in mind by leveraging our insight and unmatched knowledge of remedial technologies and provide the best, most cost-effective options available.

Overall, AECOM provides an approach that minimizes expenditures, maximizes schedule efficiencies, and diminishes the risk to the Armed Forces mission.

Specialized Experience and Technical Competence

AECOM provides direct experience successfully executing environmental contamination investigation projects spanning multiple installations across the US and internationally. AECOM initiated its first Per- and Poly-Fluoroalkyl Substances (PFAS) project in 2001, and has since become a recognized PFAS industry leader. Our teams have presented and authored dozens of PFAS-related conference presentations and publications, and have worked at PFAS sites for the Air Force, Air and Army National Guard, and Navy in support of the Department of Defense (DoD). We are currently working on nearly 100 PFAS projects throughout the world.

As the *Engineering News Record* (ENR) #1 Environmental Firm, our team qualifications, size, and diversity is unmatched. We bring veteran professionals with over 15 years of experience conducting all aspects of PFAS site characterization, risk assessment, remediation, and response/mitigation measures. AECOM's PFAS Technical Practice Group (TPG) allows technical staff to share knowledge, lessons learned, and best practices from projects executed worldwide. AECOM is also a leader in treatment of PFAS-impacted drinking water, wastewater, and groundwater, partnering with academic and industry experts to develop and deliver cost-effective technologies that generate less waste.

Past Performance

With nearly 25 years executing environmental restoration work, AECOM presents DoD with a reliable, low-risk partner that consistently delivers up to and beyond expectations. We have executed over $2B in work for AFCEC in the last 10 years alone. We have helped the DoD solve their most challenging environmental issues, performing the full array of restoration activities at all phases from investigation to complete remediation.

As a fully integrated environmental team, we are able to provide unparalleled resources and expertise to Federal clients. For our DoD contracts, 78% of our final Contractor Performance Assessment Reports System (CPARS) ratings received during the past 5 years have been either Exceptional or Very Good. These ratings are a testament to our Project Managers' ability to deliver top-quality results while serving as responsible stewards of client funds and adhering to established performance schedules.

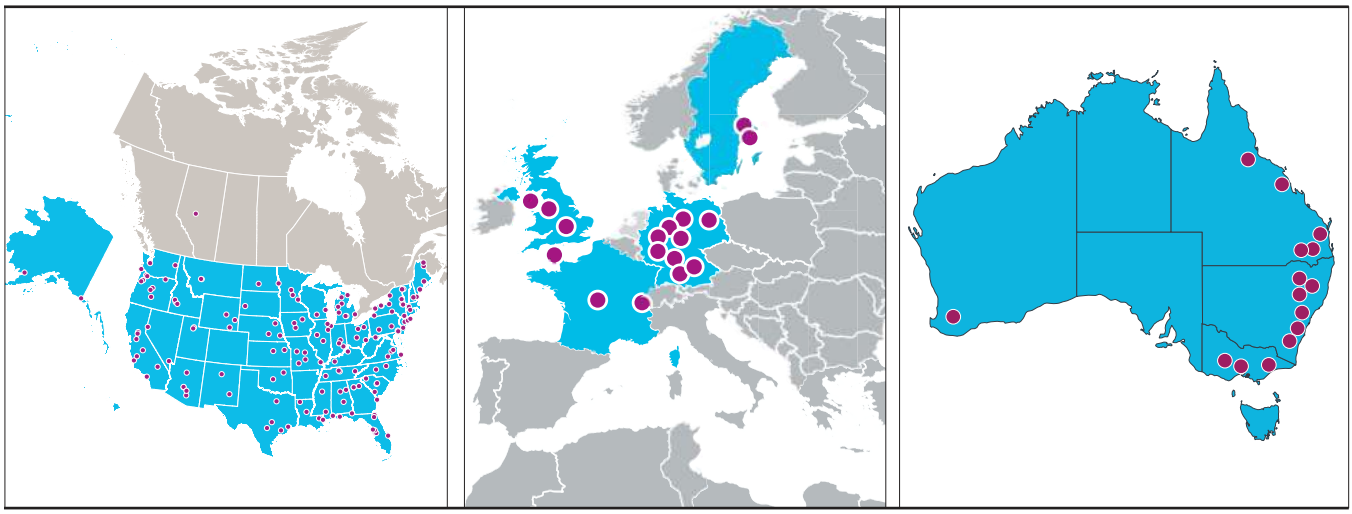
Capacity

AECOM is the largest environmental restoration company in the US with thousands of environmental professionals in close proximity to DoD installations. We employ more than 1,900 project managers, including hundreds who have managed projects for US military clients. Our project managers include architects, engineers, scientists and planners. AECOM has executed several thousand Task Orders (TOs) for DoD in the last 10 years through contracts with AFCEC, USACE, Navy, and National Guard. With access to 85,000 employees worldwide including over 7,000 in our environmental services organization, AECOM can respond rapidly with staff at any site.

Location

AECOM has executed A-E services at more than 75 active and all BRAC installations in the US plus at 23 OCONUS locations. To sustain the Federal Government's mission, AECOM can draw resources from over 500 offices worldwide (including 190 OCONUS offices), combining experienced project managers with local technical expertise in the general geographical area of the project and knowledge of the locality of the project.

AECOM Global PFAS Project Sites



CONTRACTS HELD BY AECOM

- ARMY Omaha District UNR MEGA ERS MATOC – W912DY-16-D-0026
- ARMY Omaha District H&H IDIQ – W9128F-14-D-0032
- ARMY Baltimore District HTRW IDIQ –W912DR-18-D-0005
- ARMY Baltimore District MAES - W912DR-19-D-0001
- ARMY Alaska District HTRW IDIQ – W911KB-19-D-0005
- ARMY New England District HTRW – W912WJ-16-D-0005
- AFCEC AE13 ES, URS Group Inc. (an AECOM company), FA8903-16-D-0029
- NAVY CLEAN Northeast, Southeast, Midwest, Northwest – N62470-11-D-8013
- NAVY CLEAN Hawaii, Guam, Pacific Ocean and the NAVFAC-PAC AOR - N62742-17-D-1800
- NAVY A-E Services for Multimedia Environmental Compliance Engineering Support at Navy and Other DOD Installations, Worldwide - N62470-14-D-9016

AECOM

Technical Capabilities

AECOM Capability Overview — PFAS Management



Areas of Expertise

- PFAS Sampling
- Toxicity/Risk Assessment
- Feasibility Studies/Remediation/ Development of Treatment Technologies
- Regulatory Navigation/Negotiation
- Off-Site Release Mitigation
- PFAS Waste Management

More Information

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AECOM has been conducting PFAS investigations since 2001, has worked on many of the world's most significant PFAS problems, and is currently working on over 165 PFAS sites around the globe including >50 DoD and 15 R&D projects.

What Are PFAS?

Per- and Poly-fluoroalkyl Substances (PFAS) comprise a diverse group of synthetic chemicals used for over 50 years in various military and industrial applications and consumer products. PFAS are key components of aqueous film forming foams (AFFF) used for Class B fire fighting and fire suppression starting in the 1960s. Sources of PFAS at military and commercial airports can include: fire training areas, nozzle test areas, hangars and other buildings equipped with fire suppression equipment, fire stations, AFFF loading, handling and storage areas, aircraft and vehicle crash response areas, and AFFF ponds, sumps, and tanks. The U.S. Air Force estimates PFAS-containing AFFF may have been used at approximately 200 active and former Air Force bases, including Air National Guard and Air Force Reserve facilities.

Properties of PFAS

- Limited sorption to soil and sediments
- Highly water soluble, non-volatile and extremely mobile in water
- Exceptional stability
- Persistent with very little attenuation
- Widely present in the environment, bioaccumulative and detected in plants, many animals, and humans

Potential Health Effects

Toxicological data are generally limited for most PFAS with the exception of a few more highly studied compounds. The C8 Science Panel identified the following probable links to Perfluorooctanoic Acid (PFOA) exposures:

- Ulcerative colitis
- Thyroid disease
- Testicular and kidney cancer
- Pregnancy-induced hypertension
- Diagnosed high cholesterol

Increased Regulatory Attention

Concerns associated with PFAS prompted the USEPA to include six PFAS compounds on its Unregulated Contaminant Monitoring Rule – 3 List (UCMR-3) that required sampling/analyzing the compounds in large public water systems. This sampling resulted in the discovery of impacted drinking water supplies, several linked to DoD and commercial airport sites. The USEPA promulgated Lifetime Health Advisory Levels (HALs) for perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) in drinking water at 0.070 µg/l (70 parts per trillion) with a recommendation for combined PFOS/PFOA concentrations <70 ppt. While USEPA considers a broader regulation, state environmental and health agencies are setting standards for drinking water, often lower than the HALs, and often for additional compounds to PFOS and PFOA.

Areas of Expertise

PFAS Sampling. PFAS sampling requires careful consideration of field sampling materials to obtain samples free of ambient contamination and high quality analytical data. AECOM developed internal training for PFAS sampling, and all field teams are required to complete this training before conducting PFAS sampling. AECOM worked closely with analytical laboratories certified to conduct PFAS analysis, audited them, and influenced their procedures.

Toxicity/Risk Assessment. AECOM has performed critical reviews of research on PFAS toxicity, maintains a current collection of human health/ecotoxicological information, and tracks this literature to allow us to select toxicity values that are appropriate for the receptors for different types of habitats and exposure pathways. This allows risk assessments to be targeted to the site and to reduce unnecessary remediation needs and costs by avoiding the use of default values. Our risk assessors globally have performed precedent-setting human health and ecological PFAS-specific risk assessments which assist our clients in managing PFAS impacts using state-of-the science information.

Feasibility Studies/Remediation/Development of Treatment Technologies. PFAS remediation is challenging, with a limited number of commercially available effective technologies. Demonstrated options for soil include: Excavation and off-site disposal or incineration; and isolation in place. Demonstrated options for groundwater include: Pump and treat with granular activated carbon or thermal oxidation. Testing of stabilization (soil/groundwater) and ion exchange resins are showing promise. AECOM is currently conducting PFAS treatment R&D on behalf of the U.S. Air Force, Australian Defence, and Canadian Government.

Regulatory Navigation/Negotiation. AECOM has been actively involved in negotiating with regulators to ensure that pragmatic management measures are put in place. As the regulations continue to evolve, AECOM has the capabilities to address Applicable or Relevant and Appropriate Requirements (ARARs) for sites and contaminants regulated by USEPA and State/Local regulators. AECOM brings its regulatory expertise in solving complex waste management thereby minimizing environmental liabilities. AECOM also tracks regulatory developments for PFAS closely.

Off-Site Release Mitigation. Numerous AECOM personnel with PFAS experience can respond quickly to off-site releases and potential human exposures. In addition to residential or private drinking water sampling, AECOM performs community relations activities including development of communications plans, hosting community engagement meetings, and establishing call centers.

Waste Management. AECOM provides a wide range of capabilities to manage PFAS-contaminated wastes. Our teams utilize off-the-shelf technologies ranging from incineration for solid wastes to granular activated carbon systems for water wastes. We are also looking to newer, innovative ways to manage wastes with the goal of destroying PFAS molecules, focusing on sustainable and affordable technologies that emphasize total destruction through electrochemical oxidation, ultrasonic or enzymatic oxidative destruction. We have also evaluated the feasibility of stabilizing and reducing PFAS in soil and solid waste using commercial products such as RemBind® and innovative enzymatic oxidation destruction. Our waste management experience includes support to clients for compliance with permitted waste requirements when other chemicals of concern are also contained in the impacted media.

Our Approach

AECOM was awarded our first PFAS project in 2001, and has since become a recognized industry leader on PFAS around the globe. We've established global and regional leaders that support PFAS projects and understand how to work closely with local teams. AECOM's PFAS Technical Practice Group (TPG) tracks regulatory and treatment technology developments and meets monthly to exchange recommendations. AECOM participates in research forums and works with leading academics globally. For example, AECOM and University of Georgia currently have an Air Force Broad Agency Announcement (BAA) grant for conducting a pilot study to evaluate treatment technologies at Wurtsmith AFB.

Key AECOM Attributes

- Conducted PFAS activities at ~200 U.S. DoD facilities and is currently conducting PFAS preliminary assessments/site investigations, remedial investigations/feasibility studies, Conceptual Site Models (CSMs), and R&D for DoD.
- Worldwide, multi-country experience in all aspects of PFAS investigation, risk assessment and remediation in consulting, research, and regulatory developments.
- Conducting the largest PFAS investigation ever performed; collecting >15,000 samples, investigating several entire counties, and collecting samples along an 80 mile segment of a large river.
- Designed, installed, operated, monitored and maintained dozens of full scale PFAS groundwater remediation systems, hundreds of residential and 10 commercial supply well PFAS treatment systems.
- Conducting innovative on-site soil and groundwater remediation bench and pilot scale testing on behalf of the Australian and U.S. DoD.

Risk Assessment Services for Per- and Poly-Fluoroalkyl Substances (PFAS)

Areas of Expertise

- **Design of sampling and analysis plans** for PFAS in multiple environmental media (water, soil, sediment, tissues), and data collection for ultimate use in risk assessment
- **Human health risk assessment** for PFAS in accordance with guidelines from USEPA, US Navy, Australia and individual states
- **Critical reviews** of human health-based toxicity studies and regulatory thresholds
- **Ecological risk assessment** for PFAS in accordance with guidelines from agencies in USA, Canada, United Kingdom, European Union and Australia
- **Development of ecological screening benchmarks** for water, sediment and soils and toxicity reference values for invertebrates, fish, birds and mammals
- **Tracking continuing research and development** in the ecotoxicity of PFAS
- **Innovative evaluations of ecological impacts** related to accidental and chronic releases of PFAS into aquatic and terrestrial environments using field data collection, toxicity testing and other methods
- **Regulatory tracking and client alerts** on PFAS
- **Comparative evaluations of toxicity** of long-chain and short-chain PFAS

More Information

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Overview

Per- and Poly-Fluoroalkyl Substances (PFAS) are perfluorinated compounds that are widely used by a number of industries. Some of the most commonly used PFAS, including perfluorooctane sulfonate (PFOS) and perfluorooctanoic acids (PFOA) are now known to be persistent, toxic at relatively low concentrations and bioaccumulative. The behavior of PFAS in the environment provides unique challenges when assessing contaminated soil, groundwater and surface water.

Our Approach

AECOM is well-placed to guide clients through the identification, evaluation, management and, if warranted, remediation of PFAS. We have worked with multinational oil clients and the Department of Defense, and are providing informed advice to a wide range of clients around the impact of state, federal and international legislation associated with the use, storage and disposal of these products.

Examples of PFAS sources include:

- Aqueous Film Forming Foams (AFFFs), which are used on flammable liquid (Class B) fires
- Industrial surfactants, including hydraulic fluids and photolithographic coatings
    - In Scotch-Guard, Gore-Tex and a number of textile products
    - In Teflon 'non-stick' products

Some of these chemicals are now listed as 'persistent organic pollutants' under the Stockholm Convention of Persistent Organic Pollutants.

The regulatory landscape around the storage, use and remediation of PFAS is changing rapidly. Environmental regulators may require an overly conservative approach to investigations and PFAS management on-site, despite evidence that in some instances, fluorinated products

are the most 'fit-for-purpose' currently available. Some jurisdictions have also indicated that in the future, PFAS should completely be removed from use on industrial sites. In some instances, this is not practical and the use of replacement compounds may introduce other potential human health or environmental issues. AECOM has been actively involved in negotiating with regulators to ensure that pragmatic management measures are put in place that do not compromise human health or the environment.

Key AECOM Attributes

- **Interpretation of Multi-media sampling and PFAS data.** Because PFAS chemicals have unique properties and are distributed throughout the world, data collection for risk assessment use requires particular attention to avoid cross-contamination and selection of the correct tissues for analysis. AECOM is practiced in designing and executing large-scale multi-media sampling, including many types of tissue (vegetation, invertebrates, fish, blood, milk, etc), working directly with analytical laboratories to generate data of the risk assessment quality and educating regulators and clients who may be unfamiliar with PFAS. This assists with project efficiency and success.
- **PFAS Ecotoxicity database.** AECOM maintains a current collection of ecotoxicological information for PFAS. There is a vast amount of emerging literature on ecotoxicity of PFAS with respect to numerous biological groups. AECOM tracks this literature and is able to select toxicity values that are appropriate for the receptors for different types of habitats. This allows ecological risk assessments to be targeted to the site and avoids default values, and minimizes the potential for overestimation of risks, reducing unnecessary remediation needs and costs.
- **Major Clients and Projects.** Human health and ecological risk assessments on multiple large scale projects for US Navy, US Army Corps of Engineers, Oil and Gas clients, Chemical industry, Australian Air Force and other clients, involving PFAS in soil, sediment, groundwater, surface water, vegetation, fish and other biological tissues.

Key Reference Material

- Groundwater and PFAS: State of Knowledge and Practice (NGWA). https://my.ngwa.org/nc__store?search=pfas
- Per-and Polyfluoroalkyl Substances (PFAS) Fact Sheets (ITRC). https://pfas-1.itrcweb.org/fact-sheets/

World-wide, multi-country experience in all aspects of PFAS investigation, risk assessment and remediation in consulting, research, and regulatory developments

Per- and Poly-Fluoroalkyl Substances (PFAS), including Perfluorooctanonic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS), comprise a diverse group of synthetic chemicals used for over 50 years in various military and industrial applications and consumer products. In May 2016, USEPA established the life-time health advisory levels of 70 parts per trillion (ppt) for PFOA and PFOS. However, several states have recently established standards and guidance values in the 10 to 20 ppt range for these two chemicals. As these standards and guidance values are lowered, public scrutiny rapidly raised concerns about the extent of PFAS in environmental media. Since 2001, AECOM has been contracted by a confidential manufacturing client to manage a PFOA site-related environmental assessment program that included multi-media sampling for PFOA on and around their fluoropolymer manufacturing facility located in West Virginia. AECOM has also been contracted by the Australian and U.S. Departments of Defense to sample and assess PFAS impact to the many types of environmental media due to Aqueous Film Forming Foam releases at their most challenging sites.

FOR MORE INFORMATION about our PFAS sampling expertise

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AECOM PFAS Sampling Education and Training Program

AECOM has conducted PFAS sampling of over 12 different media types at over 400 sites in 6 countries. We've collected over 3,000 high quality samples of commonly tested media such as drinking water, groundwater and soil, and less common media such as animal tissue, produce, manufacturing and waste water treatment sludge, concrete infrastructure, and aqueous film forming foam. With the downward race of standards and guidelines for PFAS, analytical reporting limits in the 2 to 20 parts per trillion (ppt) range, and the significant potential for cross-contamination, sampling integrity is paramount for generating reliable data that are usable for risk reduction decision-making.

With nearly 20 years of PFAS sampling experience, as well as interactions with regulatory agencies, **AECOM in 2016 took an important step in developing an internal PFAS Sampling Education and Training Program to ensure each and every Project Manager and field personnel involved in projects that include PFAS sampling of any media type, use standardized procedures on PFAS project sites and collect high-quality data.** Concurrently, AECOM works closely with analytical laboratories and academic communities to update the program as new scientific data become available, to continuously improve the quality of PFAS data.

AECOM's PFAS Sampling Education and Training Program is designed to:

- Educate staff in PFAS background information including:
  - Complexities of PFAS chemistry and unique behavior when released into the environment
  - The potential presence of PFAS in specialty products, but also in 100s of common articles of commerce, including some sampling equipment and items commonly found in the sampling environment
  - Falling regulatory standards/guidance values that are driving down analytical reporting limits
- Train all staff in the specifics of which items/materials of construction are:
  - Shown to be PFAS cross contamination sources that cannot be used in the immediate sampling environment
  - Potential cross contamination sources that need to be evaluated prior to use via pre-investigation blanks, or may be used with caution
  - Known to be acceptable for use for multi-media sampling

Our sampling guidance also features an awareness identification system that differentiates the field sampling materials that:

- Cannot be used in the immediate sampling environment
- Use with caution
- Are safe and can be used

AECOM's PFAS Sampling Education and Training Program also covers the following topics:

- Safety
- Training requirement
- General PFAS sampling
- Media-specific sampling
- Proper collection and interpretation of all types of blanks
- Managing PFAS Investigation Derived Wastes (IDW)
- Guidance for subsurface investigation activities at PFAS sites, such as well installation, hydraulic testing and well abandonment

We advise our project teams that the AECOM PFAS Sampling Education and Training Program supplements AECOM-required training, but does NOT replace PFAS sampling Standard Operative Procedures (SOPs) fulfilling regulatory or client specific needs.

AECOM's PFAS practice is committed to investing in efforts that build trust and bring quality that our clients expect, such as AECOM's PFAS Sampling Education and Training Program.

AECOM's PFAS Education and Training Program Sampling was developed to:

- ☑ Educate all AECOM staff
- ☑ Include 12+ environmental media
- ☑ Cover best practices for all field activities encountered during PFAS investigation
- ☑ Include site investigation and remediation system monitoring, globally
- ☑ Include a sampling equipment/material awareness identification system
- ☑ Improve data quality and reduce cross contamination

AECOM Treatability Studies Laboratory

Areas of Expertise

- Bioremediation (aerobic and anaerobic)
- *In situ* chemical oxidation
- Chemical reduction
- Solidification/stabilization
- Surfactants treatment
- Metals fixation
- Batch and column tests
- Flocculation and settling tests
- Cell culture of beneficial microbial strains

The contaminants of concern that can be evaluated with these tests include:

- Chlorinated ethanes/ethenes: PCE, TCE, 1,1,1-TCA, cis-DCE, etc.
- Benzene, toluene, ethylbenzene, and xylene (BTEX)
- Chloroform
- Nitrosodimethylamine (NDMA)
- 1,4-Dioxane
- Toxic metals: mercury, arsenic, hexavalent chromium
- PFAS

More Information

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Overview

The AECOM Treatability Study Laboratory provides a cost-competitive option for performing batch and column treatability studies to evaluate chemical, biological, and physical treatment approaches for a wide range of chemicals in various environmental media, at projects across the US. Bench-scale treatability studies can be used to compare treatment alternatives, evaluate reagent types, dosages and application methods, shed light on site biogeochemical conditions, and provide proof-of-concept evidence that a selected remedial technology will attain performance objectives. The treatability study results can be used to support all aspects of remedy selection, design, and implementation.

Our Approach

Analytical Capabilities

On-site analytical capability is critical to measure the real-time contaminant degradation kinetic data and determine the time points for off-site quantitative analyses, if needed.

Our facility offers the following analytical capabilities:

- Ion chromatography: Nitrate, sulfate, chloride, organic acids
- Gas chromatography (FID and TCD detection): VOCs and gases
- Atomic absorption (metals)
- Mercury analysis
- UV-VIS spectrophotometry: reduced iron, reduced anthraquinone disulfonic acid (AQDS), protein, hexavalent chromium
- Soil oxidant demand test
- Total organic carbon (TOC)
- pH, ORP, DO, specific conductivity, temperature, and turbidity

Community/Stakeholder Relations

Areas of Expertise

- Communications Strategy Plan
- Printed Information Materials
- Preparation of News Releases, Media Briefs, and Presentation Materials
- Website Development and Management
- Q&As
- "Behind the Scenes" Briefings
- Risk Communications
- Public Information Forums
- Mailing Lists
- Information Repositories

More Information

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Overview

Regulatory agencies, stakeholders and the public are often concerned about the potential threats and impact of environmental projects — actual and perceived — to public health and the environment. When a project is complicated by political, environmental, or site conditions, these complications are difficult to understand. No matter how sound the proposal or technical solution is, the project can be delayed, if the community distrusts the source of the technical analyses. This will impact the schedule and, usually, the cost of an otherwise successful project.

AECOM's experience and literature confirm that the best approach to community relations is to keep stakeholders and the public informed throughout project planning process, so that no one feels the need to take dramatic action to be heard or considered. Research has shown that regular communications lead to familiarity; familiarity can lead to understanding, which can increase one's comfort and decrease one's perception of risk.

AECOM's community relations experts have implemented successful, cost-effective public involvement programs to support complex environmental projects for many private and public sector clients, including:

- Major government agencies
- Multinational manufacturers
- Global oil and gas firms
- Integrated power companies

Our Approach

Our approach to community relations projects is to work as a team with our clients' environmental and communications professionals to develop effective strategies and implement successful programs. AECOM's Community Relations Specialists work side-by-side with our project and site managers, technical staff, and scientific risk assessors to help identify key community issues, and articulate a realistic and understandable view of the work being done and the potential risks or exposures involved. Aware of important issues potentially affecting a site, we communicate the facts in a non-threatening manner to enhance understanding and trust.

Our experience has shown that focused planning facilitates effective community relations – and successful projects. AECOM focuses on:

- Minimizing project costs and delays
- Identifying, anticipating, and addressing public concerns
- Establishing and improving our clients' credibility
- Improving the quality of decisions through consensus-building

Areas of Expertise

AECOM has extensive experience in developing strategies, and sharing information through community communications, public education, and outreach programs. Nearly all of our projects involve communicating technical information in a manner easily understood by both technical and non-technical audiences. Our work has included communications tools for a wide range of environmental projects, including:

- **COMMUNICATIONS STRATEGY PLAN**. A Communications Strategy Plan is a key element in creating and maintaining effective communications with stakeholders and the community. An effective Plan should outline the essential components of a Community Relations Program, including rationale for conducting the program; events that will require communications; messages to convey; potential audience for communications; vehicles to convey message(s); participants in communications process and their roles; and timing of events/schedule.
- **PRINTED INFORMATION MATERIALS.** Printed information materials include Fact Sheets, Newsletters, Brochures, and Issue Papers, which are useful tools for providing information to the community about a project. We are adept at dispelling public fears of misunderstood projects, which often boil down to fear of the unknown or fear of unforeseen consequences.
- **PREPARATION OF NEWS RELEASES, MEDIA BRIEFS, AND PRESENTATION MATERIALS.** We assist our client in distributing accurate, scientifically-sound information to media outlets and other information providers.
- **WEBSITE DEVELOPMENT AND MANAGEMENT.** AECOM's project websites for its clients are an integral tool for providing accurate information to the community on multiple issues surrounding a project.
- **Q&AS.** Developed for internal project team use, Q&As "brainstorm" questions or concerns the public may have regarding the site, and develop answers to these questions. By having the questions and answers formalized, all project team members can provide consistent responses to public or media inquiries.
- **INTERNAL TEAM BRIEFINGS.** Often, our clients' public relations professionals or media contact person(s) are the focus of inquiries from the public or press. We work "behind the scenes" with these persons to ensure they are adequately briefed on the site, the issues, and the action plan. Often, AECOM develops answers to the "tough questions" the public or media may ask, documents these answers in an internal briefing document, and distributes this to all team members.
- **RISK COMMUNICATIONS.** AECOM specializes in preparing and implementing effective risk communications programs by working with the scientific risk assessors to articulate a realistic view of the risk for the public.
- **PUBLIC MEETINGS AND INFORMATION FORUMS.** These forums, which include stakeholder/community advisory groups, restoration advisory boards, and open houses, are managed, developed and coordinated by AECOM to ensure maximum participation, and rational, science-based communication among all parties.
- **MAILING LISTS.** An essential element of each Community Relations Program, a mailing list is typically generated by reviewing potential stakeholders in the cleanup of the site (e.g., local, county, state officials) and potential impacted citizens (e.g., residents or businesses in a certain radius of the site).
- **DOCUMENT REPOSITORIES.** Typically housed in public libraries or town offices, a document repository provides a central location for the community to access important site information.

PFAS Management at Landfills

Areas of Expertise

- PFAS Sampling
- Toxicity/Risk Assessment
- Feasibility Studies/Remediation/Development of Treatment Technologies
- Regulatory Navigation/Negotiation
- Off-Site Release Mitigation

More Information

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AECOM has been conducting PFAS investigations since 2001, and is currently working on hundreds of PFAS sites around the globe. Our DE-FLUORO™ Treatment System is a promising new treatment technology that has shown complete destruction of PFAS in pilot studies.

What Are PFAS?

Landfills are the final stage in the life cycle of many commercial products that contain Poly- and Perfluoroalkyl Substances (PFAS) and PFAS is frequently reported present in landfill leachate. PFAS comprise a diverse group of synthetic chemicals used for over 50 years in various military and industrial applications as well as consumer products. Some of the most commonly used PFAS, including perfluorooctane sulfonate (PFOS) and perflurooctanoic acids (PFOA) are now known to be persistent, toxic at relatively low concentrations and bioaccumulative. In addition, 5:3 FTCA is one of the largest contributors to overall PFAS releases in leachate. The behavior of PFAS in the environment provides a unique challenge when assessing contaminated soil, groundwater and surface water. PFAS is introduced into landfills and leachate from industrial waste, discarded consumer products (carpet, waterproofed clothing, etc.), and biosolids.

Properties of PFAS

- Limited sorption to soil and sediments
- Highly water soluble, non-volatile and extremely mobile in water
- Exceptional stability
- Persistent with very little attenuation
- Widely present in the environment, bioaccumulative and detected in plants, many animals, and humans

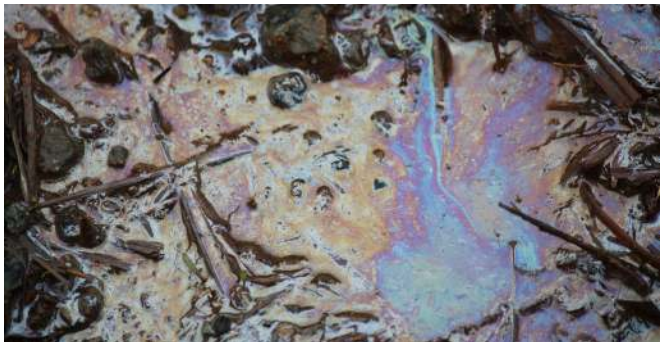
Potential Health Effects

Toxicological data is generally limited for most PFAS with the exception of a few more highly studied compounds. The C8 Science Panel identified the following probable links to PFOA exposures:

- Ulcerative colitis
- Thyroid disease
- Testicular and kidney cancer
- Pregnancy-induced hypertension
- Diagnosed high cholesterol

Increased Regulatory Attention

Concerns associated with PFAS prompted the US EPA to include six PFAS compounds on its Unregulated Contaminant Monitoring Rule – 3 List (UCMR-3) that required sampling/analyzing the compounds in large public water systems. This sampling resulted in the discovery of impacted drinking water supplies, several linked to



joint DoD, commercial airports, and landfill sites. The US EPA also recently finalized its Lifetime Health Advisory Levels (HALs) for perfluorooctanesulfonic acid (PFOS) and PFOA in drinking water at 0.070 µg/l (70 parts per trillion) with a recommendation for combined PFOS/PFOA concentrations < 0.070 µg/l. Given EPA's and states' continued assessments on the effects of PFAS and their impacts to drinking water sources, we expect the regulations will become more stringent as the HALs are further reduced.

Areas of Expertise

PFAS Sampling. PFAS sampling requires unique procedures and materials to obtain high-quality data because of the high potential for introducing contaminants during sampling. AECOM has also developed an internal PFAS sampling training program that staff are required to take before working on PFAS sites where sampling is required. We have also worked closely with analytical laboratories certified to conduct PFAS analysis, perform regular audits on them, and have given input on standard laboratory procedures.

Toxicity/Risk Assessment. AECOM has conducted over 15 years of research on PFAS toxicity, maintains a current collection of human health/ecotoxicological information, and tracks this literature to allow us to select toxicity values that are appropriate for the receptors for different types of habitats. This allows risk assessments to be targeted to the site and to reduce unnecessary remediation needs and costs by avoiding the use of default values.

Feasibility Studies/Remediation/Development of Treatment Technologies. PFAS remediation is challenging with a limited number of commercially available, effective technologies. Demonstrated options for soil include: excavation and off-site disposal or incineration; isolation in place. Demonstrated options for groundwater include: Pump and treat with granular activated carbon or thermal oxidation. Testing of stabilization (soil/groundwater) and ion exchange resins are showing promise. AECOM's PFAS team is currently conducting PFAS treatment R&D on behalf of the U.S. Air Force, Australian Defence, and Canadian Government. Our DE-FLUORO™ Treatment System is a promising new treatment technology that has shown complete destruction of PFAS in pilot studies.

Regulatory Navigation/Negotiation. AECOM has been actively involved in negotiating with regulators to ensure that pragmatic management measures are put in place. AECOM's PFAS Technical Practice Group tracks regulatory and treatment technology developments and meets monthly to exchange best practices/train and solve challenging project problems.

Off-Site Release Mitigation. Numerous AECOM personnel with PFAS experience can respond quickly to off-site releases and potential human exposures. In addition to residential or private drinking water sampling, AECOM performs community relations activities including development of communications plans, hosting community engagement meetings, and establishing call centers.

We have implemented active solutions to mitigate human exposure including design, installation, operation, and maintenance of hundreds of off-site residential point of entry treatment water systems and 10 public water supply treatment systems treating over 13 billion gallons of water to date.

Our Approach

AECOM was awarded our first PFAS project in 2001, and has since become a recognized industry leader on PFAS around the globe. We've established global and regional leaders that support PFAS projects and understand how to work closely with local teams. Our staff participate in research forums and work with leading academics globally. For example, AECOM and University of Georgia currently have an Air Force Broad Agency Announcement (BAA) grant for conducting a pilot study to evaluate treatment technologies at Wurtsmith AFB.

Key AECOM Attributes

- Conducted PFAS activities at >50 U.S. DOD facilities and is currently conducting PFAS PA/SIs, RI/FSs, and R&D for DOD.
- World-wide, multi-country experience in all aspects of PFAS investigation, risk assessment and remediation in consulting, research, and regulatory developments.
- Conducting the largest PFAS investigation ever performed; collecting >15,000 samples, investigating several entire counties, and collecting samples along an 85 mile segment of a large river.
- Designed, installed, operated, monitored and maintained dozens of full scale PFAS groundwater remediation systems and 100s of residential and 10 commercial supply well PFAS treatment systems.
- Is conducting innovative *in situ* soil and groundwater remediation bench and pilot scale testing on behalf of the Australian and U.S. DOD.
- Assisting clients in responding to state agency-required PFAS sampling initiatives at landfills.

AECOM's PFAS Treatment Technology DE-FLUORO™ Destroys PFAS

Photo courtesy of Magneli

Dissolved PFAS can now be destroyed on site

- **DE-FLUORO™ technology destroys PFAS.**
- **DE-FLUORO™ can be integrated easily with existing primary separation technology.**
- **AECOM's Global PFAS Team has driven this innovation from research and bench-scale studies to field demonstrations and commercialization.**

Challenges of PFAS Treatment

Per- and Polyfluoroalkyl Substances (PFAS) have been widely used and released into the environment. PFAS have chemical structures involving one of the the strongest bonds in nature, the carbon-fluorine (C-F) covalent bond, representing a class of chemicals that are extremely challenging to remediate. Mass transfer technologies (e.g., granular activated carbon, ion exchange (IX) resin, reverse osmosis) do not destroy PFAS but concentrate PFAS on adsorption media and in reject/waste water. Once exhausted, the spent media and wastewater require on-site management or off-site disposal, thermal treatment or regeneration. Regenerable media also produce PFAS laden regenerant waste that require PFAS management and treatment.

DE-FLUORO™ Technology

Our team has successfully used a proprietary electrode to mineralize PFAS with evidence of complete defluorination and desulfurization. PFAS are destroyed via direct electron transfer and free radical reactions under room temperature and atmospheric pressure with relatively low energy consumption. Our project team has successfully used this proprietary electrode to treat PFAS in ion-exchange regenerant waste, soil washing wastewater and other PFAS-impacted natural waters and wastewaters and Aqueous Film Forming Foam (AFFF) concentrate.

MORE INFORMATION

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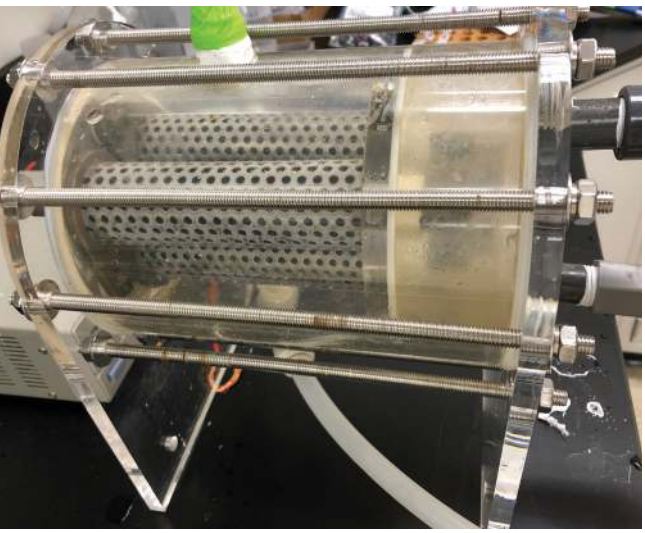
Imagine it. Delivered.

DE-FLUORO™ technology destroys PFAS



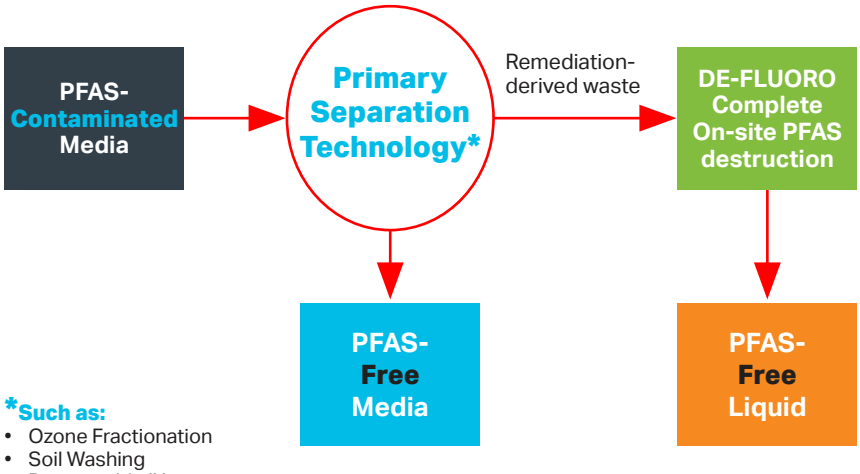
Demonstrated Results and Commercialization

- DE-FLUORO™ is a compact, highly efficient cost-effective mobile treatment system that destroys PFAS in solution on site, eliminating the need for off-site disposal of PFAS-laden wastes and their associated liability.
- DE-FLUORO™ is able to destroy PFAS in multiple types of media with varying water chemistry. Media that have been tested include source area groundwater, untreated wastewater, AFFF concentrate, and remediation-derived wastes (e.g. still bottom from regenerable IX, soil washing wastewater, and ozone fractionation waste). Further testing is planned in the near future for additional PFAS wastes.
- We are confirming the commercial viability and scalability of the technology, and planning to commission two field models. The first model will use plate electrodes and is currently more appropriate for small-scale applications. The second model uses tubular electrodes and can be used for small to large-scale applications. Optimization of both models is ongoing.

PFAS concentration reductions after DE-FLUORO™ treatment of various waste streams

Sample Description	Initial PFAS Concentration (ppb)	Reduction (%) Post-DE-FLUORO™ Treatment		
		PFOA	PFOS	Total PFAS (31 compounds)
Untreated wastewater	400	100	100	100
Source zone groundwater	500	100	99.9	98.6
Fractionation wastewater	1,800	99.7	99.6	99.4
Soil washing wastewater	14,000	100	99.9	99.2
Ion exchange resin regenerant	400,000	98.5	98.5	92.9

Path to Total Destruction



***Such as:**
- Ozone Fractionation
- Soil Washing
- Regenerable IX
- Foam Fractionation
- Reverse Osmosis

AECOM

Department of Defense Experience

PFAS Projects for the Air National Guard

Fiscal Year (FY) 16 Phase 2 Regional Site Inspections (SIs) for PFAS at Multiple Air National Guard (ANG) Installations

AECOM is under contract to complete PFAS SI activities for 78 areas of concern (AOC) at seven ANG installations in five different states, with an optional 125 AOCs at 12 ANG installations in seven additional different states. Our team is delivering defensible, regulatory approved No Further Action (NFA) decision documents. AECOM is also providing data quality objectives specific to AOCs not meeting NFA criteria to provide clear direction for follow-on Remedial Investigations. To ensure a consistent approach across all ANG installations, AECOM's project management office developed a consistent and repeatable field sampling process that is used by all AECOM local offices to supplement the SI Work Plan. This process includes standardized field sampling forms, chain-of-custody, database-generated pre-printed sample labels, etc., in order for the local office to complete the field work and provide high-quality, consistent project documentation. We are analyzing for the six Third Unregulated Contaminant Monitoring Rule (UCMR-3) PFAS (PFOS, PFOA, PFBS, PFNA, PFHXS and PFHPA) and providing minimum reporting limits of 4 nanograms per liter (ng/L) for groundwater and surface water and 3 nanograms per gram (ng/g) for soil and sediment, which are well below any current applicable Federal, State, or local action and notification levels. Additionally, to help ANG respond consistently to public concerns, AECOM is providing community relations planning, consisting of first level planning involving a Decision Tree and Communication Plan. When sampling results confirm off-base migration, AECOM is providing pre-established protocols for each of a number of scenarios outlined in the Decision Tree and Communication Plan. Each scenario can result in a different set of responses that range from simply communicating no impact/detections, to immediately implementing mitigation measures.

PFOS/PFOA SI, Delaware ANG Base, New Castle, Delaware, Contract: W9133L-14-D-0001

AECOM has been advising the ANG on management of PFOS/PFOA at the Delaware ANG facility since 2014 and began conducting groundwater monitoring for PFOS/PFOA at the base in 2016. AECOM's involvement has consisted of:

- Briefing ANG personnel on the current state of the industry with regard to PFOS/PFOA investigation and regulation.
- Providing technical support to the ANG in their discussions of PFOS/PFOA at the Delaware ANG facility with the Delaware Department of Natural Resources and Environmental Control and EPA. During these meetings, AECOM has been a strong advocate for the ANG, identifying potential sources of PFAS contamination outside the base boundary.
- Completed a basewide groundwater monitoring event for PFOS/PFOA in April 2016 and October 2016.

PFAS Projects for the Navy

PFOS/PFOA RI, Findings of Suitability to Transfer (FOST)/Findings of Suitability to Lease (FOSL) Support, Naval Air Station (NAS) Joint Reserve Base (JRB) Willow Grove, NJ, and Naval Air Warfare Center (NAWC) Warminster, PA, NAVFAC Atlantic Contract N62470-11-D-8013, Task Order (TO) WE28.

AECOM performed an RI of groundwater, soil, surface water and sediments; source study; Community Environmental Response Facilitation Act investigations, and is managing FOST preparation. Our team responded rapidly to the discovery of PFOS/PFOA in nearby municipal supply wells by developing a work plan sampling over 30 base-wide monitoring and potable supply wells and surface water pathways. We conducted a study to identify potential on- and off-base sources of PFOS/PFOA contamination in groundwater and initiated a private potable well search within 1.5-miles of the base to identify potential drinking water receptors. AECOM prepared and implemented a RI Sampling and Analysis Plan to delineate the nature and extent of PFOS/PFOA contamination at the base. Field work included the installation of over 90 nested monitoring wells up to 400 feet (ft) deep. Downhole geophysics were performed on each borehole and meetings held with the Navy, EPA, Pennsylvania Department of Environmental Protection, and U.S. Geological Survey (USGS) to determine well construction specifications. The RI also included the sampling of approximately 200 monitoring wells, surface and subsurface soil sampling, and surface water and sediment sampling in multiple waterways. The RI included calculation of human health project-specific screening levels for soil, groundwater sediment, and surface water. Project-specific ecological screening values were developed for surface soil, sediment, and surface water based on review of available literature. Surface water mass loading calculations were used to show the Navy was not the only PFAS contributor.

PFAS Preliminary Assessments, SIs, RIs, and Long Term Monitoring, Naval Facilities Engineering Command (NAVFAC) Atlantic Comprehensive Long-term Environmental Action Navy (CLEAN) Contract Number N62470-11-D-8013, Multiple TOs.

AECOM, in a joint venture with EnSafe, is performing Preliminary Assessments, SIs, RIs, and Long Term Monitoring of PFAS at 15 US Navy installations. We have been able to respond rapidly to these multi-site emerging requirements due to our worldwide presence, use of multiple offices to provide a consistent approach, experience with local regulatory requirements, and high-quality service. Recent projects include:

- **Naval Station Great Lakes/Site 4 Former Firefighting Training Area (FFTA), Lake County, IL.** AECOM is performing long-term groundwater monitoring for PFAS and other contaminants of concern.
- **Former Naval Air Station South Weymouth, Weymouth, MA.** AECOM is monitoring and assessing the extent of PFOS/PFOA contamination in a groundwater plume at a Former FTA, Operable Unit (OU) 04. Our team is performing an on-site groundwater and soil RI for the six UCMR-3 PFAS, including development of a Human Health Risk Assessment (HHRA) at Hangar 1, OU25. We are also performing a preliminary assessment of groundwater, surface water, and sediment at multiple basewide sites for the six UCMR-3 PFAS.
- **Former BHRA, Annapolis, MD.** AECOM is providing SI, RI, Feasibility Study, Proposed Plan, and Record of Decision support for potential PFOS/PFOA groundwater contamination at this Base Realignment and Closure (BRAC) site.

- **Naval Computer and Telecommunications Area Master Station Atlantic - Site 1, Fire Training Area, Cutler, ME.** AECOM is performing a SI to determine if PFOS/PFOA are migrating to a drinking water well one mile away.
- **Portsmouth Naval Shipyard, Basewide, OU3, Kittery, ME.** AECOM performed a basewide assessment to identify potential sources for PFOS/PFOA to groundwater based on historic and current installation activities. Groundwater sampling is being completed as part of a Five Year Review process to determine presence/absence of PFOS/PFOA at a former landfill.
- **Former Naval Air Station Brunswick, Brunswick, ME.** AECOM is conducting a basewide investigation to assess absence/presence of PFOS/PFOA primarily in groundwater. However, surface water and sediment have been added in limited locations. The surface water and sediment study encompasses a storm water retention pond system that received the majority of the base's runoff/discharge. The groundwater investigation includes impacts to private drinking water wells. Additionally, AECOM is assessing the treatability of two different granulated activated carbon systems in an existing treatment plant for the treatment of 16 PFAS.
- **Naval Station Newport, Newport, RI.** AECOM prepared a Basewide Preliminary Assessment to identify potential sources of PFOS/PFOA in groundwater. Groundwater sampling has been conducted in two areas to expedite a solar array proposal and a property transfer.
- **Former Naval Construction Battalion Center Davisville, North Kingstown, RI.** AECOM is preparing a preliminary site assessment for potential PFOS/PFOA impacts to groundwater from historical base operations.

PFAS Projects for the Air Force

The AECOM Team is currently supporting Air Force efforts to address PFAS at many of their installations. It is estimated that PFAS-containing Aqueous Film Forming Foams (AFFF) may have been used at approximately 200 active and former Air Force bases, including Air National Guard and Air Force Reserve facilities.

FY14 Spangdahlem Air Base (SAB), Germany, PFAS Site Investigation, Contract/Task Order (TO) Number: W912GB-09-D-0029/0006

AECOM was contracted to assess the presence, extent, and degree of PFAS in soil at a number of potential PFAS source areas throughout the SAB, Germany. Investigations by the communities neighboring the SAB found that the effluent water from the SAB contributes to PFAS contamination of surface water and groundwater. In addition, PFAS impacts cause a cost increase for sewage treatment. A work group was established between the US and the German stakeholders to investigate the PFAS sources and transport pathways. AECOM was contracted to perform a first set of on-base soil investigations. The SAB pre-defined six AOCs where PFAS-containing AFFF was released in the past. Under this TO, AECOM provided:

- Drilling services;
- Soil and water sampling services;
- Laboratory analysis; and
- A comprehensive investigation report, including the assessment of the transport mechanism for PFASs that apply at the site, recommendations for further investigations, and a German translation of the investigation report for the German authorities.

The investigation found that soil impacted with PFAS led to an adverse alteration of storm water, seepage water, and/or perched groundwater. The investigation also showed that the storm water discharge system plays a relevant role for the distribution of PFAS from the original source areas. The storm water discharge system is able to transport PFAS dissolved in water as well as "solid" substance in the form of foam. At locations where PFAS foam could have accumulated in the past, secondary sources of PFAS may potentially have formed.

Calumet Air Force Station (AFS), PFAS Preliminary Assessment

AECOM is conducting a preliminary assessment for PFAS to identify any potential AOCs at the former Calumet AFS, Michigan. The preliminary assessment will be performed to locate, evaluate, and assess the potential for environmental risk associated with past use and storage of AFFF at Calumet AFS. The preliminary assessment will include a history of ownership of the parcels that made up Calumet AFS, and a description of uses and operations of the AFS during its history.

Chanute AFB, IL, PFOS/PFOA Leachate Treatment System O&M

AECOM is providing operations and maintenance support to a landfill leachate treatment system designed and implemented to remove PFAS before discharge to a publicly-owned treatment works (POTW). O&M activities include monitoring of system parameters including flow, pressure, temperature, etc. to ensure the proper treatment of leachate water before discharge to a POTW that is not equipped to remove PFAS. Influent and effluent will be monitored to measure the performance of the carbon treatment vessels and anticipate when replacement will be required. Reports are prepared periodically to demonstrate system performance and absence of PFAS in effluent.

Peterson AFB, CSM

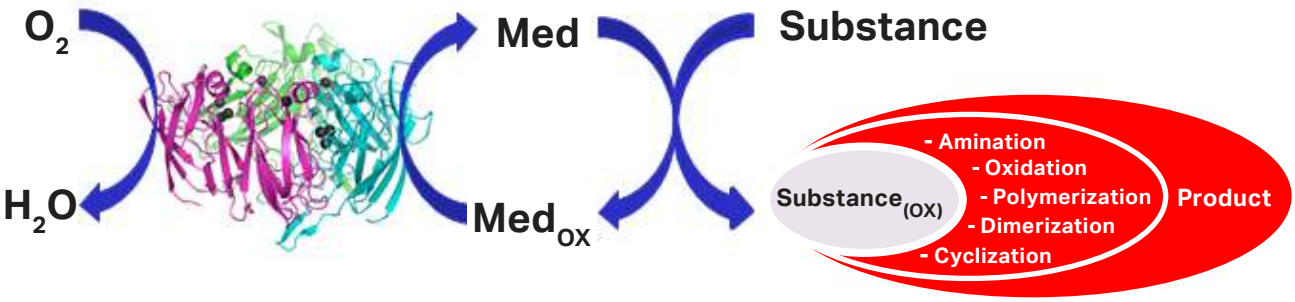
AECOM is using Environmental Sequence Stratigraphy at Peterson AFB to develop geologic cross-sections and water table maps in support of the PFAS assessment efforts at Peterson AFB. Initial regional geologic cross-sections were developed by our team prior to the SI kickoff meeting, and AECOM attended the kickoff meeting and provided geologic and hydrogeologic expertise in support of decisions regarding placement of PFAS SI wells. Subsequent to the SI, we further refined the geologic cross-sections utilizing boring logs from the SI, conducted a synoptic gauging event of all existing wells on Peterson AFB and Colorado Springs Airport, generated a groundwater water table map to predict groundwater flow and potential PFAS migration in the area of Peterson AFB, and briefed the results of the CSM to Peterson AFB and the Air Force. The CSM will allow the Air Force to streamline RI activities by accurately predicting PFAS contaminant migration pathways and will define potential liability.

PFAS Projects for Australian Ministry of Defense

The AECOM PFAS team collaborates globally to apply innovative approaches and practices needed to address this emerging contaminant. AECOM has undertaken PFAS related environmental work at a number of Australian Ministry of Defense (MoD) facilities since late 2013, in particular the Army Aviation Centre Oakey (AACO) and the Royal Australian Air Force (RAAF) Base Williamtown. The original scopes had to be modified rapidly to innovatively and cost effectively assess two of the largest PFAS groundwater contamination plumes in Australia. AECOM has been undertaking the projects simultaneously and in a severely compressed schedule to meet client reporting obligations. AECOM also rapidly responded to client requests for 'adhoc' technical information required for senate inquiry meetings. Our team developed an expanding risk-based response to assess water contamination and risks, engage with community and stakeholders, and address potential health risks. Projects undertaken did not impact DoD's operational capacity. AECOM subsequently developed the precedent-setting impact and risk-based approach to the Strategic Management Plan (to cost-effectively guide future work for a 10+ year period. This plan presented a strategic road map prioritizing actions, not only related to contamination but also provided consistent messaging internally and externally on community, legal matters, socioeconomic issues, regulatory compliance, etc. AECOM provided advice to the DoD regarding the requirement to implement risk mitigation measures (e.g., 'Do Not Drink Water' advice). In addition, AECOM has achieved effective community and stakeholder engagement, produced high quality deliverables that have been accepted by the Technical Advisor and Auditor and regulating agencies, and have provided technical and strategic leadership that has leveraged off international expertise. For these projects AECOM provided the following broad ranging services:

- Residential water sampling (households and water tanks)
- Groundwater sampling program (private and public wells)
- Soil, groundwater, surface water, sediment, porewater, concrete sampling program
- Management of alternative water supply for affected community
- Sampling and cleaning of water tanks and swimming pools
- Chemical characterization of AFFF concentrate
- Stakeholder communications and management (project website, email address, 1800 telephone, mailing address, community engagement meetings, letterdrops, stakeholder briefings, minister inquiries)
- Development of protocols and advice documents (water use surveys, qualification assessment decision trees, feasibility study for alternate water supplies)
- Ecological assessment
- Human health and ecological risk assessment
- Hydrogeological modelling (including solute fate and transport)
- Horse and livestock watering advice
- Remedial/Treatment research
- Soil stabilisation trials
- Fate and transport research (transformation of PFAS precursors)
- Plant uptake research
- Chicken/egg translocation study
- Seafood study
- Management of a Sharepoint and Geographic Information System (GIS) database

Enzymatic Oxidative Treatment Technology for Perfluorinated Compounds



AECOM collaborating with University of Georgia in developing novel technologies for treatment of persistent perfluorinated compounds commonly found in aqueous film-forming foam (AFFF) of air force fire training areas.

Client

AFCEC

Location

Multiple Locations, USA

Contract Value

USD 632K

Years

2012—2016

More Information

1.978.905.2100
AskEnvironment@aecom.com

Project Overview

Per- and Poly-Fluoroalkyl Substances (PFAS) make up a group of compounds that have extreme thermal and chemical stability. Due to their unusual characteristics, PFAS are found in hundreds of articles used in nearly every aspect of daily lives. Although the excellent chemical inertness is a huge advantage in the use of PFAS, it also causes considerable environmental concerns because of the ubiquitous presence in the environment and toxicity to animals and potentially humans. Contaminated water treated with granular activated carbon (GAC) has been the most common treatment to remove PFAS, although several studies reported using electrochemical, photolytic, or sonochemical oxidation and catalyzed hydrogen peroxide propagation to break down PFAS. These approaches require large energy inputs, and special devices, thus limit their full-scale applications. This project identified an approach that can decompose PFAS under naturally relevant conditions.

Client Benefits

A novel PFAS treatment technology was developed to replace or combine with the existing pump and treatment that commonly uses GAC as the PFAS treatment system. The novel enzymatic treatment system uses bulk enzyme to sustainably treat PFAS and can be used for both *in situ* and *ex situ* applications.

Work Performed

Enzymatic oxidative treatment refers to an important class of reactions that are facilitated by fungal extracellular enzymes to mediate the polymerization of small molecule humic precursors into humic substances in the environment. These enzymes oxidize phenolic or anilinic substrates into radical and quinone intermediates that are further covalently bound with each other via coupling. The active intermediates formed during reactions can also attack other persistent organic compounds such as polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs), thus incorporating them into humification and leading to their decomposition and detoxification. AECOM collaborated with UGA to investigate the possibility and mechanisms of PFAS (with use of PFOA to model PFAS) degradation by enzymatic oxidation.

AECOM's scope includes this technology development project management, selects air force sites for bench-scale study, two *in situ* pilot studies and one *ex situ* treatment systemfor comparison with the GAC treatment systems. AECOM will conduct engineering design, treatment system installation, operation and monitoring of treatment performance. The performance results will be used as guidance for future scale-up full treatment systems. Currently, AECOM and UGA had published this enzymatic treatment technology on the Environmental Science and Technology Letter in 2015 to document the success of bench-sale treatment success.

AECOM

Private Sector Experience

PFAS Projects for the Private Sector

PFOS/PFOA SI (Confidential Client)
AECOM performed extensive site assessments in Decatur, Alabama where biosolids from a Waste Water Treatment Plant that contained PFAS were used as fertilizer over a multi-county area. The resulting impacts to soil, groundwater, surface water, sediments, agricultural crops, and cattle caused concerns from the community and stakeholders. Our team worked closely with the stakeholders, including the Centers for Disease Control and Prevention, to reach consensus on the scope of investigations and data quality objectives. The multi-disciplinary project team worked extensively with the client, regulatory community, and other key stakeholders to successfully scope the SI, including the overall sampling strategy, to reach consensus on the DQOs and desired outcomes of the project. The project team successfully satisfied all stakeholder concerns and the site was ultimately closed without any remediation.

Enhanced Groundwater Remediation System Design for PFOA

URS successfully removed PFOA to a level below regulatory standards at this complex site.

Client

Manufacturing Company

Location

New Jersey, USA

Contract Value

USD 2.6MM

Years

2008—2012

More Information

1.978.905.2100
AskEnvironment@aecom.com

This project was completed by URS, which became a part of the AECOM family of companies in October 2014.

Project Overview

At this former manufacturing facility, URS assisted in assessing the remediation needs necessary to extract and treat volatile organic compounds (VOCs) and perfluorooctanoic acid (PFOA) that were identified in the groundwater below the site.

Client Benefits

- URS provided a multi-disciplined team of water treatment and remediation technical resources to complete this project with complex treatment and regulatory issues.
- The team worked with the regulatory agency to obtain a permit by rule for treatment and discharge systems.
- The URS treatment system design met industry and stricter client standards
- The treatment system successfully removed contaminants below regulatory levels.
- Reinjection of groundwater is returning valuable resources and minimized the impact to water allocation permit application.

Work Performed

URS' complete remediation system for VOCs and PFOA included the design, permitting, and construction of the following components:

- Six groundwater extraction wells with an expected pumping capacity of 405 gpm
- Four extraction well houses and well transmission mains totaling 10,000 ft
- Iron removal by pH adjustment, oxidation, flocculation/ settling to prevent fouling of the GAC filters

- Continuous backwash sand filters for polishing removal of manganese, arsenic, and aluminum.
- Low profile coarse bubble air stripping and granular activated carbon (GAC) filters to treat extracted groundwater
- 69,000 gallon equalization reservoir to accommodate all recycle flows
- Residuals solids management including 100,000 gallon dual compartment residuals holding tank and nine separate covered sand drying beds totaling 14,700 ft2
- A Rapid Infiltration Basin (RIB) system of 1.2 acres to recharge treated groundwater back into the source aquifer

Six extraction wells captured potentially impacted groundwater throughout the site and pumped water via four separate transmission water mains to the new Groundwater Treatment Plant (GWTP) building. Additionally, the existing pump and treat wells were re-routed to the new GWTP and can be operated for additional capture if necessary.

The transmission mains join to form a common header pipe at the GWTP. The combined water will be pH adjusted with sodium hydroxide before flowing through a cascade aerator. The cascade aerator at the elevated groundwater pH facilitates oxidation of the reduced iron in the groundwater. The groundwater then flows by gravity into a rapid mix, coagulation, flocculation, and settling unit. Plate settlers are used to minimize the required footprint necessary for settling. Sodium hypochlorite and polymer is then added to the groundwater prior to entry into the plate settlers. The unit process clarifies the groundwater of the precipitated iron and other metal hydroxide species. This unit process, because of the groundwater quality, generates a significant volume of residuals, which will settle out of solution.

The clarified water in the plate settlers then flows to the continuous backwash filters. Potassium permanganate may be added prior to the backwash filters, if necessary, for manganese removal. The continuous backwash filters also removes other colloidal precipitates not removed upstream in the plate settlers.

Water then flows into a low profile coarse bubble air stripper for removal of VOCs. The air is then discharged to the atmosphere through a stack located on top of the GWTP building roof. The treated water from this unit operation then flows into a 16,800-gallon equalization tank. This tank serves as a hydraulic “break” for the treatment system. High service pumps then convey water through the GAC vessels for further organic polishing and PFOA removal. Following GAC treatment, the groundwater is then discharged into the RIBs for final disposal by aquifer recharge.

The residuals from the plate settlers are periodically drained into one of two 50,000 gal settling tanks to thicken under quiescent conditions. The residuals in the settling tanks are dosed with polymer and mixed for further thickening during an additional settling and supernatant decant phase before ultimate application on the sand drying beds. Upon further solids concentration on the sand drying beds, the dried solid “cake” is then physically removed and hauled off-site for ultimate disposal. The filtrate water that passes through the sand is then pumped at a continuous rate back to the headworks of the GWTP.

Design/Installation of Granular Activated Carbon Systems/O&M for Seven Public Water Treatment Facilities

All systems achieved (and continue to achieve) the remedial objective for reducing PFOA in drinking water.

Client

Confidential Manufacturing Company

Location

Ohio, West Virginia, USA

Contract Value

USD 3.3MM

Years

2005—present

More Information

1.978.905.2100
AskEnvironment@aecom.com

This project was completed by URS, which became a part of the AECOM family of companies in October 2014.

Project Overview

As part of a legal settlement, the client was required to initiate a program to upgrade existing potable water works in the region around the company's manufacturing facility to remove perfluorooctanoic acid (PFOA) from the raw water. URS provided planning, design, permitting, health and safety and construction management, and operation and maintenance (O&M) phase services for the installation of eight granular activated carbon (GAC) units for seven public water treatment facilities. The team assisted through all phases of the project from pilot testing through start-up and O&M.

Client Benefits

- URS was able to implement the systems to meet a very tight regulatory deadline. Client had requested the most rapid implementation possible to meet legal agreements and water utility project objectives. The first 3 systems were completed within 16 months of initiating design and permitting activities. The remaining 4 facilities were completed within 48 months of design initiation.
- URS provided a consistent, dedicated team of experts throughout all phases of the project. A unique blend of water treatment and remedial design resources were used to meet complex regulatory and end user issues. Dedicated staff continues to be used during the monitoring and O&M phases of work. URS was very responsive to the client's and agency's needs during this fluid and challenging project.
- URS accommodated the client's need to provide them with monthly cost updates and forecasts that were used for setting account reserves for project execution.
- URS expertly provided construction management for all client vendors and subcontractors ($12 million vendor and subcontract value). Project was completed on time and under budget. Total change orders approved were less than 5 percent of contract bid price.

- URS achieved design and construction of this technically challenging remedial project. Consistent removal of PFOA from low ppb to non-detect levels had only been demonstrated at the pilot level. Development and execution of responsive monitoring programs were key to successful implementation.

Work Performed

The client had initiated a program to upgrade existing potable water works in the region around its manufacturing facility in West Virginia. The program included the installation of state-of-art treatment systems for seven facilities operated by local water utilities to remove PFOA from the raw water as part of a legal settlement.

Following URS' detailed evaluation and pilot testing of treatment technologies, GAC was selected as the preferred technology. The particular carbon media selected for this application excels at trace level contaminant removal found in the groundwater at these locations. The systems consistently and reliably reduce the PFOA content to low part-per-trillion (ppt) levels.

All seven facilities are presently operating with the new equipment, and each offered unique challenges for the incorporation of the additional treatment into their overall process. At one location, an intricate pump and control strategy was required to boost the water through the pressure filters while not overloading the geologic formation at any individual supply well. A finished water equalization tank was provided at another site to ease operations of the facility by "decoupling" the wells and distribution pumps. Other sites containing iron/manganese removal and softening systems required detailed analysis to optimize the retrofit. Nearly every facility required additional and/or relocation of chemical application points for chlorine, fluorosilicic acid, potassium permanganate, caustic soda, and corrosion inhibitors as chemical dosing was altered with the addition of GAC treatment. The most extensive project included the construction of an entirely new treatment system since construction of the carbon filtration unit could not occur in the existing well field located in the Ohio River floodplain.

Each installation also presented a unique set of permitting and regulatory requirements that were addressed by working closely with the utilities, state, and local authorities to obtain the necessary health and operating permits.

The GAC layout allows for series operation so a polishing bed of carbon follows the first bed to add redundancy and avoid release of PFOA into the system. In some locations, multiple trains of vessels are run in parallel to increase hydraulic capacity. Design considerations also included carbon backwash handling, carbon change-out access, pressure relief, high pressure installations, and flow balancing between vessels.

The treatment concept was also implemented for leachate treatment at two landfills containing the compound to protect receiving waters.

The project goals for expedient installation were achieved by accelerating the design/construction schedules while meeting safety and cost expectations. Five separate facilities were designed, permitted, and constructed within 32 months. The remaining two sites were constructed the following year.

Dry Run Landfill Pond/Leachate Treatment System for PFOA-Contaminated Industrial Landfill

URS provided a rapid response and expedited design, permitting and construction, successfully removing the contaminant to bring the site into compliance.

Client

Industrial Landfill

Location

West Virginia, USA

Contract Value

USD 250K

Years

2005-2007 (Design & Construction)
2007-present (Operations & Maintenance)

More Information

1.978.905.2100
AskEnvironment@aecom.com

This project was completed by URS, which became a part of the AECOM family of companies in October 2014.

Project Overview

At this 26 acre industrial landfill site, URS designed a remediation system to treat NPDES outfall discharge that failed to meet metal parameters for a 25-year storm event.

Client Benefits

- URS provided a rapid response to the emerging contaminant issue in the landfill leachate. The team expedited design, permitting and construction to meet regulatory permit requirements.
- The team successfully removed the contaminant below regulatory levels. We are also currently evaluating BMPS for stormwater control and contaminant reduction at other outfall locations.
- URS provided a full range of services for this project – including regulatory assistance, permitting, conceptual and final design, bid preparation and contractor selection, construction oversight, start-up, and long-term monitoring and O&M.
- Provided a consistent, dedicated team of experts throughout all phases of the project. Dedicated staff continues to be used during the monitoring and O&M phases of work. URS was very responsive to the client's and agency's needs during this project.

Work Performed

Surface water and some seeps from a 26 acre industrial landfill are collected in a surface pond that discharges to a receiving stream. Discharge from the pond exceeded metal parameters for the NPDES outfall and there was also a need to remove perfluorooctanoic acid (PFOA). A design was needed to treat water up to a 25-yr storm event from the landfill. Design and construction of the leachate treatment system is complete. AECOM continues to perform monitoring, reporting, and O&M activities.

The existing lined pond acts as an equalization basin for the treatment system and provides primary treatment (aeration and settlement). URS designed and constructed a leachate pump station adjacent to the existing pond discharge pipe to collect water and pump it at 150 gpm to the treatment building. A ductile iron pipe connected to the existing pond discharge pipe directs flow into the precast concrete pump station. Following treatment, the effluent is discharged back into the same stream channel at the same location of the present Outfall 001.

Using the URS treatment system, leachate is initially filtered for iron and manganese removal. The first cartridge filter (5 micron) reduces discharge of metals/solids into the environment and reduces the clogging potential in the subsequent organic removal Granular Activated Carbon (GAC) treatment unit.

The URS GAC system consists of two units in series to maintain a lead and polishing bed. The primary adsorption of PFOA occurs in the first carbon bed (lead bed) in a series operation. The second bed provides a polishing step (polishing bed) so that any breakthrough of PFOA from the lead bed adsorbs prior to discharge. When breakthrough is measured after the lead bed, the carbon will be replaced with a fresh bed. Effluent from the GAC unit flows into a mixed open neutralization tank to adjust the pH for further treatment. Hydrochloric acid is added to lower the pH to 6.5 and optimize the insolubility of aluminum. Multiple pH probes measure the pH of the water to adjust the chemical feed rates to maintain the target operating point. A slowly mixed flocculation tank following the neutralization tank provides the residence time for aluminum floc development. A feed pump delivers the flocculated leachate to a 1 micron cartridge filter for aluminum removal.

A 4,500 gallon effluent holding tank receives the filter effluent and discharges by gravity to the existing Outfall 001. The effluent holding tank also provides a volume of treated water that can be used for back flushing activities for the GAC units. Backwash water overflow is discharged to a recycle manhole that drains into the holding pond.

Sample taps are provided at the inlet and outlet of each treatment unit in the system for monitoring purposes.

URS conducts operations, maintenance and monitoring of the treatment system on an ongoing basis.

Investigation and Remediation of PFOA in Environmental Media and Drinking Water at Former Manufacturing Site

URS's assessment gave the client a clear idea of the extent of PFOA contamination, transport and migration pathways and exposure risks.

Client

Confidential Manufacturing Company

Location

Ohio and West Virginia, USA

Contract Value

USD 3.7MM

Years

2001—present

More Information

1.978.905.2100
AskEnvironment@aecom.com

This project was completed by URS, which became a part of the AECOM family of companies in October 2014.

Project Overview

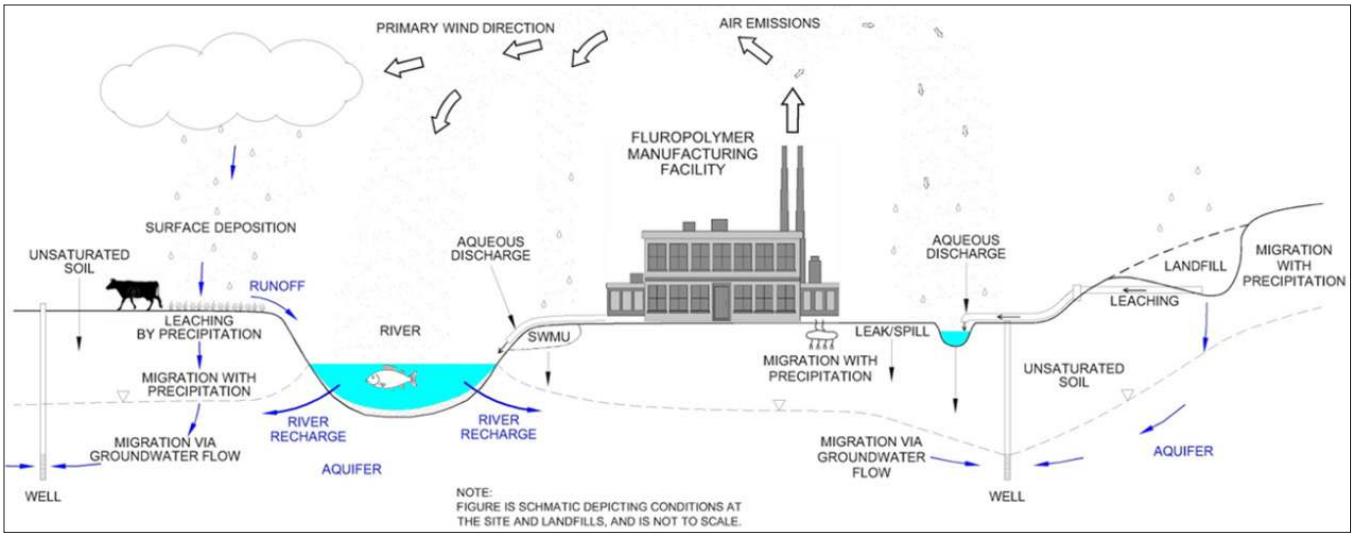
In 2001, URS was contracted to manage a screening level Perfluorooctanoic Acid (PFOA) site-related environmental assessment program that included multi-media monitoring of PFOA on and around a fluoropolymer manufacturing facility in West Virginia. The objectives of this investigation were to develop a Site Conceptual Model (SCM) that described the PFOA sources, pathways of migration and the presence of PFOA in environmental media on and around the site and to assess exposure on a screening level basis. The client committed to three phases of investigation (Phase I through III) to meet the objectives of this investigation, in addition to a previous commitment to conduct a Resource Conservation Recovery Act Facility Investigation at the facility.

Client Benefits

- URS's thorough environmental assessment of the site left the client well informed of the transport and migration pathways of PFOA in environmental media and potential exposure pathways.
- URS's drinking water remediation systems have operated successfully for the past 11 years, significantly reducing human exposure to PFOA.

Work Performed

Conceptual Site Model. URS generated a CSM that identified releases from solid waste management units and historical air emissions as the primary PFOA sources at the site. The primary transport mechanism to environmental media both on and off site is leaching of air deposits via precipitation into soil and groundwater, which is utilized as a drinking water source. In support of the CSM, URS also developed a groundwater flow model (1999) focused on the site and later developed a revised groundwater flow model (2003) that included a much larger area surrounding the site.



Multi-Media Sampling. URS developed multi-media sampling plans designed to understand the sources of PFOA at the site and the pathways of migration from those sources to on- and off-site environmental media, as required by the West Virginia Department of Environmental protection. URS also provided support for multi-media PFOA sample analysis method development and validation, and maintained a database of all results associated with the project. The aerial extent of the investigation included within six Public Water Supply (PWS) districts around the facility and as far as 26 miles upstream and 80 miles downstream. Environmental media sampled by URS on site and nearby included:

- Surface and subsurface soil (on and off site)
- Groundwater (on and off site)
- Local surface water (on and off site)
- Hay, beef fodder, grass and roots (on and off site)
- Air sampling (on and off site)
- Residential drinking wells (within the six PWS districts)
- Public Service District (PSD) well fields (off site)
- River water (off site)
- Fish, small mammals and beef tissue (off site)
- Home-grown produce (off site)

Drinking Water Remediation. Because groundwater is utilized as a drinking water source, URS designed and installed, and continues to perform operation and maintenance on granular activated carbon (GAC) treatment systems at the site, at 10 well fields at eight public water supplies upstream and downstream of the site, and at over 100 private residences.

Reporting Requirements and Other Activities. URS also generated numerous project-required reporting deliverables including two Quality Assurance Project Plans, monthly, quarterly and annual public water supply reports to PWSs, quarterly residential result letters to residents, quarterly update reports to EPA, Ohio Environmental Protection Agency and West Virginia Department of Environmental Protection, and two Data Assessment Reports, which summarized all activities performed related to the project from 2001 through 2008 and from 2008 through 2012. In 2007, URS and the client collaborated on a joint peer-reviewed publication titled "Transport of Ammonium Perfluorooctanoate in Environmental Media near a Fluoropolymer Manufacturing Facility".

Project Outcomes. Transport and migration pathways from the site to on- and off-site environmental media and the presence of PFOA in environmental media are well understood and exposure to PFOA associated with the facility was adequately characterized and assessed on a screening level basis. Drinking water remediation has operated successfully for the past 11 years, significantly reducing human exposure to PFOA. Now AECOM, our team continues to provide O&M for the GAC treatment systems, conducts additional sampling and generates reporting documents as required by other commitments made by the client. In addition, AECOM is providing similar services for the client at several other sites where PFOA is found in environmental media.

Bench and Pilot Scale Testing for Foaming Agent Removal from Wastewater

AECOM was able to identify methods to reduce foaming of wastewater prior to discharge to the municipal sewer system.

Client

Confidential Firefighting Equipment Manufacturer

Location

Confidential, USA

Contract Value

USD 190K

Years

2014—present

More Information

1.978.905.2100
AskEnvironment@aecom.com

Challenges

Many wastewater treatment technologies can induce foaming during use. Minimizing foaming during treatment, while removing chemicals that cause foam, was especially challenging.

Project Overview

At this firefighting equipment manufacturing site, AECOM was contracted to help the client identify potential treatment technologies to remove foaming materials from wastewater prior to discharge to the city's sewer system. AECOM is also under contract to provide design services for the full-scale wastewater pretreatment facility.

Client Benefits

AECOM identified several technologies and combinations of technologies that are effective in removing high concentrations of foam-causing chemicals from wastewater. Very little data exists for this unique treatment application. Therefore, the effectiveness of these technologies was demonstrated through bench and pilot scale testing.

Work Performed

A confidential manufacturer of fire-fighting equipment and chemicals operates a test facility to evaluate the effectiveness of their products, and discharges the resulting wastewater to a sanitary sewer. The sewer authority limited the volume of the manufacturer's discharge due to the foaming properties of the wastewater, which limited the test activities that could be conducted. The manufacturer needed a method to pretreat the wastewater to significantly reduce foaming prior to discharge.

AECOM identified potential treatment technologies and coordinated bench and pilot studies for pretreatment of the manufacturer's wastewater, with the objective to remove foaming materials from the wastewater prior to discharge to the municipal sewer system. Technologies included air-sparged hydrocyclone, electrocoagulation, membranes (ultrafiltration, nanofiltration and reverse osmosis), anaerobic biological treatment and evaporation technologies using bench-scale treatability testing, and upflow anaerobic sludge blanket and evaporation technologies through on-site pilot testing. Anaerobic biological treatment, membranes, and evaporation technologies proved effective to varying degrees in reducing the foaming properties of the wastewater, and in removing the specific chemicals which contribute to foaming.

PFAS Remediation at a Former Fire Extinguisher Factory

Impacted soils have been successfully removed from the site and properly disposed of off site. This process prevented direct contact between contaminated soil/surface water and humans and eliminated the possibility of future re-contamination with potentially impacted groundwater. In addition, the ongoing groundwater monitoring show significantly decreased PFAS results in local groundwater and in the site's discharge water.

Client

Fire Extinguisher Manufacturer

Location

Northern Germany

Contract Value

~ 800,000 EUR

Years

1995—present

More Information

1.978.905.2100
AskEnvironment@aecom.com

Project Overview

At this former fire extinguisher manufacturing facility, AECOM was contracted to provide site assessment and prepare a remedial concept to clean up Per- and Poly-Fluoroalkyl Substances (PFAS). Upon regulator's approval, the site has been remediated by soil excavation and surface restoration. Groundwater Monitoring is ongoing.

Client Benefits

- Former sources of contamination, including the onsite Fire Training Area and a downgradient surface water body were successfully removed
- Remediation measures also eliminated the possibility of future re-contamination
- Mitigation of client's liability issues and cost savings for long term clean up at the site
- AECOM provided a full range of services for the site – from authority management to assessment, design, permitting, cleanup, and reconstruction
- Good planning and transparent communication with all involved project stakeholders provided sustainable and long lasting excellent relationships with the relevant regulators, the site owners, and the site neighbors
- Maintenance of cooperative relationship with all involved parties facilitated project execution during its entire duration

Work Performed

The site was used as agricultural land until 1945, and in 1953, was developed into a fire extinguisher factory, which operated until 2007, producing and testing fire extinguishers on site.

In 2008, PFAS was detected in the sewage sludge. Extensive site investigations found elevated PFAS concentrations in soil, groundwater, surface water, and discharge water on site and on two neighboring properties.

AECOM prepared a remedial concept in 2012 in response to the PFAS detections. The team planned excavation and the remedial target values, and also defined the two main remediation zones:

- The former on-site Fire Training Area (FTA)
- A pond on a downgradient neighboring property

The former on-site FTA acted as the main source area for PFAS in soil. Discharge occurred via shallow groundwater influenced by a very shallow drainage system present in the neighboring grassland, leading to PFAS accumulation in the downgradient pond located on the neighboring property. In addition, PFAS was discharged via the on-site sewer lines into the public sewer system.

FTA Remediation. Following the removal of all above ground structures and surface sealing, the impacted soil was excavated. This process included confirmation sampling, analyses, and further excavation as needed. The base of the excavation was sealed with a geomembrane, then backfilled with clean soil and a drainage system was installed and connected to the separator present on site. Finally, the surface sealing was re-established to include storm water drainage into the on-site sewer line.

Pond Remediation. Following the property clearance and the preparation of the access road, loading area, etc., the pond sediments were excavated and separated based on pre-investigation results and organic residuals. The pit base was then backfilled with clean soil above the groundwater fluctuation and also sealed with a geomembrane. After the installation of a circumferential drainage and the connection to the existing water treatment plant for the drainage water from the meadow, the landscaping was installed. This process prevented direct contact between contaminated soil and humans and eliminated the possibility of future re-contamination with potentially impacted groundwater.

Sewer Line Remediation. The on-site sewer line section between the former FTA and the transfer point to the public sewer system was flushed with high pressure water. The flushing water was collected, sampled, analyzed, and properly disposed of. Using these remedial measures, the PFAS-concentrations in the discharge water of the site were significantly reduced.

Groundwater Remediation. AECOM has been conducting groundwater remediation by pump & treat at the site since 1995 due to elevated chlorinated hydrocarbon concentrations in the groundwater. Since 2008, groundwater samples have also been collected and analyzed for PFAS during a semi-annual routine groundwater monitoring of more than 30 wells located on-site and on downgradient private properties. A general decrease of the PFAS in groundwater can be observed over time. Since the main PFAS source (former on-site FTA) has been remediated by soil exchange, there is presently no known PFAS input and a future decrease of PFAS concentrations in groundwater is anticipated.

AECOM

Key Staff

PFAS Contacts

AECOM PFAS Team	Contact Information	Region/Role	Regional Market Sector Lead	Environmental Business Lead	Federal Business Lead for Emerging Contaminants
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