NESDI
PFAS Investments

CASE STUDY:

Investments in Per- and Polyfluoroalkyl Substances

Per- and polyfluoroalkyl substances (PFAS) are a class of over six thousand recalcitrant, anthropogenic chemicals that have been widely used for decades in myriad applications. (See the table below.) The distinct chemical nature of PFAS has made it ideal for use in food packaging, non-stick cookware, stain repellents, water proofing, cosmetics, metal plating operations (mist control) and fire suppression. Such pervasive use of these chemicals has led to environmental impacts on a global scale, and recent concerns associated with perceived toxicity has garnered widespread public attention, subsequently creating interest in determining the nature and extent of PFAS impacts in the environment and developing suitable treatment technologies for this chemical class.

The remarkable molecular stability of PFAS, imparted by carbon-fluorine rich bonds contained within the "tail end" of the molecule, creates a complex set of challenges in terms of using conventional remedies to mitigate its presence in the environment. Further, very little is understood regarding its environmental fate and transport, making PFAS site management largely infeasible today.

Historical use of PFAS-containing materials has impacted roughly 700 Department of Defense (DoD) installations to date, where application of PFAS-containing aqueous film-forming foam (AFFF) and PFAS-containing mist suppressant has contributed to significant PFAS release. Recent estimates for PFAS cleanup activities are in excess of two billion dollars. This figure is expected to grow as site investigations persist and as regulatory standards become increasingly stringent. As PFAS cleanup activities commence, the absence of informed decisions regarding strategies for site remediation may lead to costly and unnecessary expenditures.

VARIOUS CHEMICALS AND CHEMICAL CLASSES UNDER THE PFAS MONIKER

<table>
<tr><th colspan="4">Per- and Polyfluoroalkyl Substances</th></tr>
<tr><th colspan="3">Perfluorinated Compounds</th><th>Polyfluorinated Compounds</th></tr>
<tr><td colspan="2">Perfluoroalkyl Acids (PFAA)</td><td rowspan="2">Perfluoroalkane Sulfonamides (FASA)</td><td rowspan="2">Examples:
Fluorotelomer alcohols (FTOH),
N-alkylated Fluorooctane Sulfonamides (FOSA),
N-Alkylated Fluooctane, Sulfonamideoethanols (FOSE)</td></tr>
<tr><td>Perfluoroalkyl Carboxylic Acids (PFCA)

Examples:
PFNA, PFOA, PFHxA, PFBA</td><td>Perfluoroalkyl Sulfonic Acids (PFSA)

Examples:
PFOS, PFHxS, PFBS</td></tr>
</table>

Therefore, it is imperative that strategic investments are made to promote a more holistic understanding of the nature of PFAS. This will allow for the development of more advanced and efficient treatment and site management approaches to ensure that, to the greatest possible extent, protectiveness of human health is maintained.

Over the past several years, the NESDI program has been aggressive in addressing the Department of the Navy's (DoN) PFAS problem by investing in many novel environmental technologies that provide improved insight as to appropriate methodologies for managing PFAS localized in soils and water. More specifically, these efforts directly address risks associated with PFAS plume control, as well as developing more cost-effective treatment options for Navy sites. For instance, NESDI project nos. 527 and 534 have provided significant information—from both a scientific and site management perspective—regarding the behavior of PFAS in the environment under natural processes and anthropogenic activities. Lessons learned from these efforts directly translate into the development of PFAS plume control strategies, which are being demonstrated under NESDI project nos. 569 and 577. Where PFAS plume control cannot be realized, NESDI project no. 555 addresses efforts to discover more cost-effective approaches for PFAS removal from groundwater. Descriptions of each of these projects are highlighted below in brief.

Structure-Function Relationship and Environmental Behavior of PFAS from Aqueous Film-Forming Foams for Conceptual Site Model Development

PI: John Kornuc, project no. 527

The objective of this study was to determine spatial trends for PFAS associated with AFFF use at Navy sites, including perfluoroalkyl acids and precursors, to gain a better understanding of PFAS composition, transport and transformation. The results of this study provide insight as to the type of information which is needed to produce accurate conceptual site models (CSM) at PFAS-impacted sites to design better site investigations, to determine risk, to mitigate PFAS if necessary, and to make other informed site management decisions.

Investigation of the Effect of Prior Remedial Treatment on the Fate and Transport of PFAS Present at AFFF-Impacted Sites

PI: John Kornuc, project no. 534

This study aimed to evaluate the effects of various remediation technologies on fate and transport, and redistribution of PFAS including their precursors in soils collected at sites impacted by AFFF. The column studies were conducted under both oxidizing and reducing conditions using activated persulfate and hydrogen releasing compound (HRC) treatments, respectively, using AFFF-impacted soils with varying properties.

Demonstrating the Effectiveness of Novel Treatment Technologies for the Removal of Poly- and Perfluoroalkyl Substances from Groundwater

PI: Jovan Popovic, project no. 555

Currently, pump and treat is the only available effective method for PFAS removal from groundwater, especially in large volumes. Therefore, sorbent performance needs to be assessed under site specific conditions, given the consideration that a large number of DoD sites rely on these materials for treatment, and any small improvements in sorption capacity will drastically lower treatment costs. This project evaluated sorbent cost-effectiveness for PFAS in groundwater, validated vendor claims on the performance of sorbents, and assessed various sorbent regeneration options to lower potential lifecycle costs and off-site PFAS disposal.

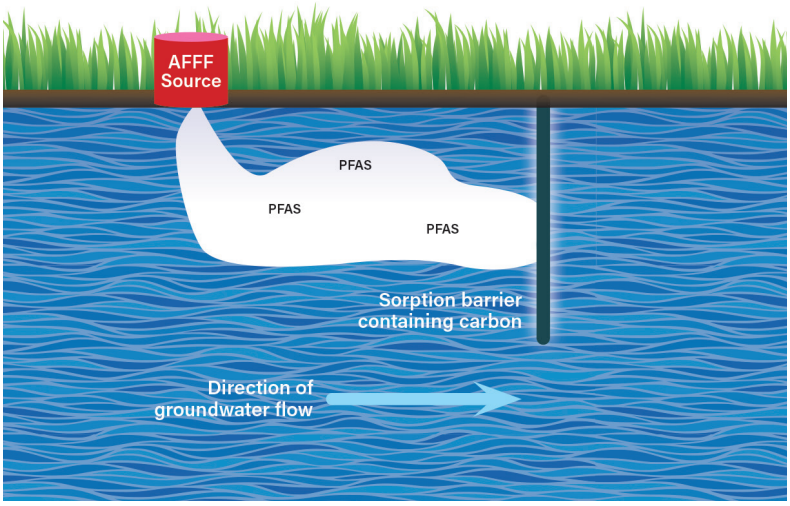
COMPARISON OF PERFLUOROOCTANOIC ACID REMOVAL COSTS

	Estimated Sorbent Mass (kg) Requirement to Remove 1 kg PFOA at DoN Site	Estimated Sorbent Cost to Remove 1 kg PFOA at DoN Site
Vendor 1	9.65E+03	$8,300.20
Vendor 2	9.66E+03	No cost data available
Vendor 3	9.48E+03	$17,628.99
Vendor 4	9.81E+03	$98,122.91
Vendor 5	2.27E+04	$1,749,522.86

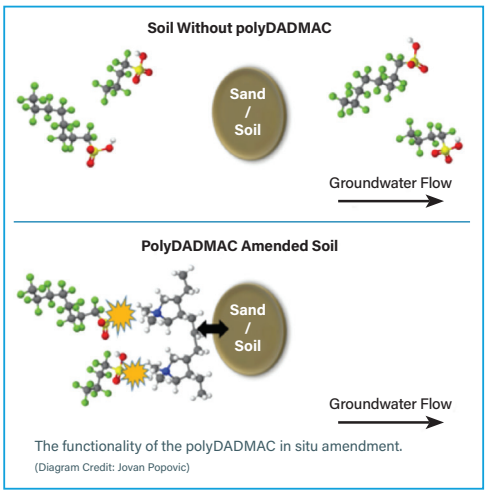
Field Demonstration of Colloidal Activated Carbon for In-situ Sequestration of Per- and Polyfluoroalkyl Substances

PI: Tony Danko, project no. 569

The objective of this study is to demonstrate and validate the field application of colloidal activated carbon (CAC) for in situ sequestration of PFAS in groundwater, thus mitigating plume expansion, as well as assessing the influence of chlorinated volatile organic compounds (VOC) on the efficacy of CAC. More specifically, this study seeks to determine the potential for joint adsorptive treatment of these two classes of compounds in comingled plumes.



(Illustration Credit: Nancy Horvat)



The functionality of the polyDADMAC in situ amendment.
(Diagram Credit: Jovan Popovic)

Demonstrating the Use of a Novel, Hybrid Polyelectrolyte/Hydrophilic Polymer for In situ PFAS Treatment

PI: Jovan Popovic, project no. 577

The overarching goals of this demonstration are to study the potential for a cationic polymer for use as a PFAS plume retardant in in situ treatment applications and understand, if any, site specific environmental factors which may influence PFAS binding to this polymer over time. Ultimately, this effort is demonstrating that PFAS mass flux reduction will be greatly diminished in the presence of an injectable amendment.

About the NESDI Program

The NESDI program is the Navy's environmental research and development demonstration and validation program, sponsored by the Chief of Naval Operations Energy and Environmental Readiness Division and managed by the Naval Facilities Engineering Systems Command from the Engineering and Expeditionary Warfare Center in Port Hueneme, CA. The mission of the program is to provide solutions by demonstrating, validating and integrating innovative technologies, processes and materials and by filling knowledge gaps to minimize operational environmental risks, constraints and costs while ensuring Navy readiness and lethality.

Visit the program's public website at https://epl.navfac.navy.mil/NESDI for more information.

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