SON Number: ERSON-20-C1 **25 October 2018**

Strategic Environmental Research and Development Program (SERDP)

FY 2020 STATEMENT OF NEED

Environmental Restoration (ER) Program Area

BIODEGRADATION OF PER- AND POLYFLUOROALKYL SUBSTANCES FOUND IN AQUEOUS FILM FORMING FOAMS

1. Objective of Proposed Work

The objective of this Statement of Need (SON) is to develop an improved understanding of biodegradation processes and biological treatment strategies for per- and polyfluoroalkyl substances (PFAS) in the subsurface. Specific research areas of interest include:

- Identification and/or isolation of microorganisms capable of degrading perfluoroalkyl acids (PFAAs), particularly perfluorooctane sulfonate (PFOS).
- Improved understanding of biodegradation processes that could lead to PFAS biological treatment alone or as part of a treatment train.
- Biological treatment strategies capable of destroying PFOS and related PFAAs in or extracted from aqueous film-forming foam (AFFF)-contaminated groundwaters.
- Biological treatment strategies to degrade potential PFAA precursors without production of PFAAs.
- Identification of enzymes capable of defluorination of PFAAs and/or genes coding for such enzymes.

Proposals may address one or more of the objectives listed above. Research and development activities at laboratory-, bench-, and field-scale will be considered. Work does not necessarily have to culminate in a field-scale effort.

2. Expected Benefits of Proposed Work

Demonstrating the potential for a biological mechanism capable of treating PFAS could serve as the basis for ex situ or in situ treatment. In particular, the ability to degrade PFOS and/or prevent its production would be valuable to DoD and other AFFF users. A viable biological treatment technology could significantly reduce the costs of remediating AFFF sites. Finally, a better understanding of the potential and limitations of PFAS biodegradation could lead to further development of a promising approach, or prevent further spending if PFAAs prove to be truly recalcitrant or if it proves impossible to prevent precursor transformations to PFAAs.

3. Background

PFAS are present in AFFF used by the DoD and other organizations to extinguish hydrocarbon fires. Different AFFF formulations have been used, but all contain a complex mixture of PFAS, including those of greatest regulatory concern - the PFAAs and potential PFAA precursors (Field et al., 2017; ITRC, 2017). EPA has recommended a Health Advisory Level for perfluorooctanoic acid (PFOA) and PFOS, and several states have promulgated standards for PFOA, PFOS, and some of the related PFAAs (ITRC, 2018a).

SERDP has been funding research on AFFF contamination for several years to improve PFAS analysis, to develop tools for assessing the fate of PFAS in the subsurface, and to evaluate the potential for in situ remediation. A recent SERDP & ESTCP-sponsored workshop identified a number of research needs, and proposers should view the Workshop Report to obtain additional detail concerning these discussions. PFOS is of particular concern to DoD, as it is the predominant PFAS in some AFFF formulations, and a significant dead-end metabolite in others, and therefore it is typically the predominant PFAS in AFFF-impacted groundwaters (Anderson et al., 2016). PFOS appears to be particularly resistant to destructive technologies, and like the rest of the PFAAs it is generally considered nonbiodegradable (ITRC, 2018b).

Previous work has shown that several PFAS can be partially biodegraded to PFAAs under aerobic conditions, but complete biodegradation of PFAAs has not been demonstrated (e.g., Harding-Marjanovic et al., 2015; Liu and Mejia-Avendaño, 2013). Partial biodegradation of precursors has been observed under anaerobic conditions as well, but again, the PFAAs appear to be recalcitrant (Hamid et al., 2018).

Nevertheless, there is significant interest in the potential for biodegradation to reduce the risks posed by PFAS present in AFFF formulations, and there have been some studies suggesting biological defluorination could occur (e.g., Kwon et al., 2014). SERDP has funded prior work demonstrating that PFAA precursors were transformed to PFAAs, and confirming that PFAAs are recalcitrant under typical environmental conditions (ER-2128). Fungal biodegradation of PFAS was evaluated in project ER-2422, and enzyme-catalyzed reactions were tested as part of a possible permeable reactive barrier in ER-2127. Ongoing SERDP projects are further exploring the potential use of fungi (ER-2718), and evaluating the feasibility of combining in situ chemical oxidation (ISCO) and bioremediation to treat AFFF and its common co-contaminants (ER-2715).

4. Cost and Duration of Proposed Work

The cost and time to meet the requirements of this SON are at the discretion of the proposer with two options described below; however, given the state of the science, limited scope proposals are preferred, although full proposals will be carefully considered with sufficient justification and supporting data.

Standard Proposals: These proposals describe a complete research effort. The proposer should incorporate the appropriate time, schedule, and cost requirements to accomplish the scope of work proposed. SERDP projects normally run from two to five years in length and vary considerably in cost consistent with the scope of the effort. It is expected that most proposals will fall into this category.

Limited Scope Proposals: Proposers with innovative approaches to the SON that entail high technical risk or have minimal supporting data may submit a Limited Scope Proposal for funding up to $200,000 and approximately one year in duration. Such proposals may be eligible for follow-on funding if they result in a successful initial project. The objective of these proposals should be to acquire the data necessary to demonstrate proof-of-concept or reduction of risk that will lead to development of a future Standard Proposal. Proposers should submit Limited Scope Proposals in accordance with the SERDP Core Solicitation instructions and deadlines.

5. Point of Contact

Andrea Leeson, Ph.D.
Program Manager for Environmental Restoration
Strategic Environmental Research and Development Program (SERDP)
4800 Mark Center Drive, Suite 16F16
Alexandria, VA 22350-3605
Phone: 571-372-6398
E-Mail: Andrea.Leeson.civ@mail.mil

For Core proposal submission due dates, instructions, and additional solicitation information, visit the SERDP website.

6. References

Anderson RH, GC Long, RC Porter, and JK Anderson. 2016. Occurrence of select perfluoroalkyl substances at U.S. Air Force aqueous film-forming foam release sites other than fire-training areas: Field-validation of critical fate and transport properties. *Chemosphere* 150:678-685.

Field J, C Higgins, R Deeb and J Conder. 2017. FAQs Regarding PFASs Associated with AFFF Use at U.S. Military Sites. http://www.dtic.mil/dtic/tr/fulltext/u2/1044126.pdf.

Hamid H, LY Li, and JR Grace. 2018. Review of the fate and transformation of per- and polyfluoroalkyl substances (PFASs) in landfills. *Environmental Pollution* 235:74-84.

Harding-Marjanovic KC, EF Houtz, S Yi, JA Field, DL Sedlak, and L Alvarez-Cohen. 2015. Aerobic biotransformation of fluorotelomer thioether amido sulfonate (lodyne) in AFFF-amended microcosms. *Environmental Science & Technology* 49:7666-7674.

Interstate Technology and Regulatory Council (ITRC). 2017. History and use of per- and polyfluoroalkyl substances (PFAS). https://pfas-1.itrcweb.org/wp-content/uploads/2017/11/pfas_fact_sheet_history_and_use__11_13_17.pdf.

ITRC. 2018a. Regulations, guidance, and advisories for per- and polyfluoroalkyl substances (PFAS). https://pfas-1.itrcweb.org/wp-content/uploads/2018/01/pfas_fact_sheet_regulations__1_4_18.pdf.

ITRC. 2018b. Environmental fate and transport for per- and polyfluoroalkyl substances. https://pfas-1.itrcweb.org/wp-content/uploads/2018/03/pfas_fact_sheet_fate_and_transport__3_16_18.pdf.

Kwon BG, H Lim, SH Na, BI Choi, DS Shin, and SY Chung. 2014. Biodegradation of perfluorooctanesulfonate (PFOS) as an emerging contaminant. *Chemosphere* 109, 221-225.

Liu J, and S Mejia-Avendano. 2013. Microbial degradation of polyfluoroalkyl chemicals in the environment: A review. *Environment International* 61:98-114.