Overview of SERDP & ESTCP Efforts in Bioremediation

Andrea Leeson
SERDP and ESTCP

June 5, 2020

DoD's Environmental Technology Programs

Strategic Environmental Research and Development Program

Science and Technology

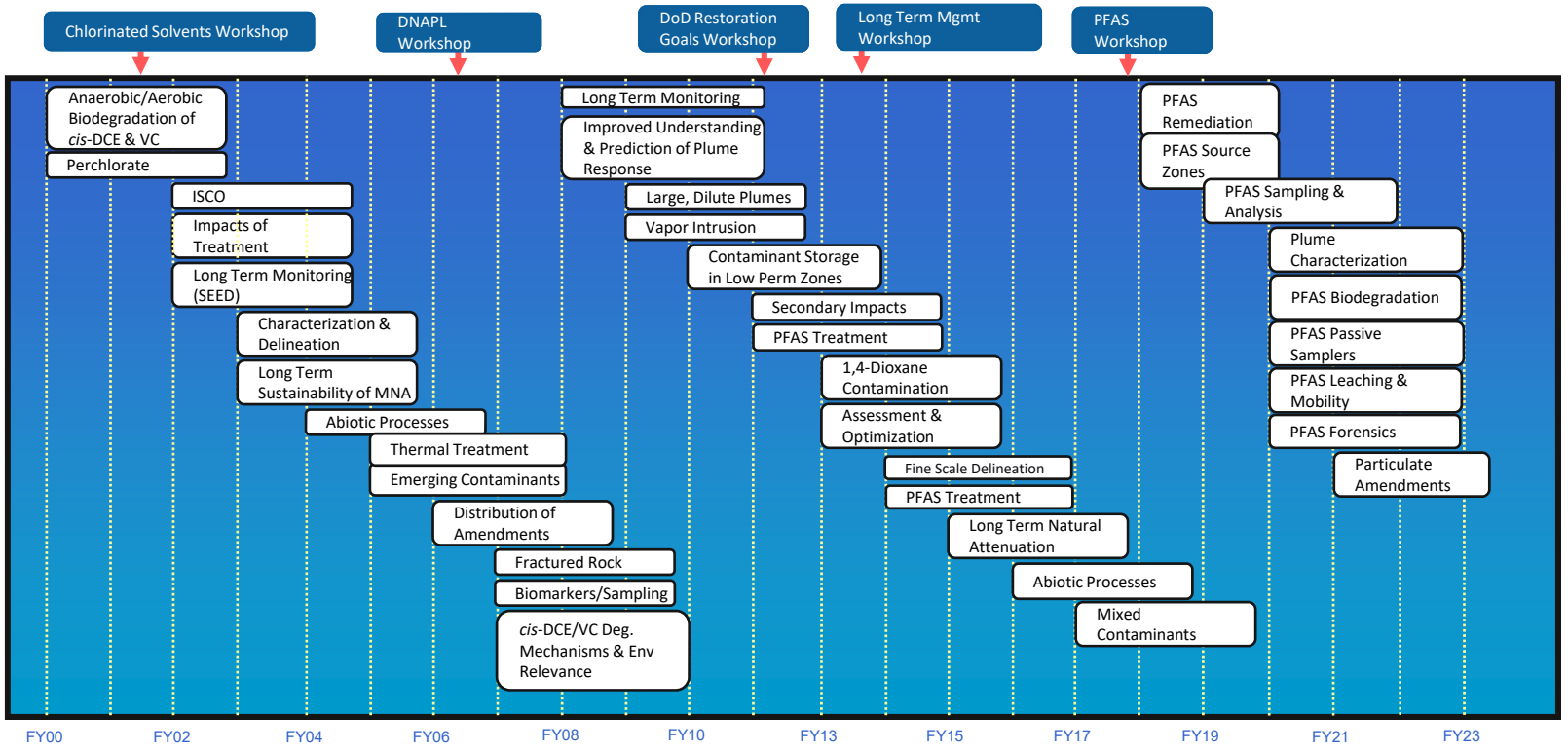
- Fundamental research to impact DoD environmental management
- Advanced technology development to address near-term needs

Environmental Security Technology Certification Program

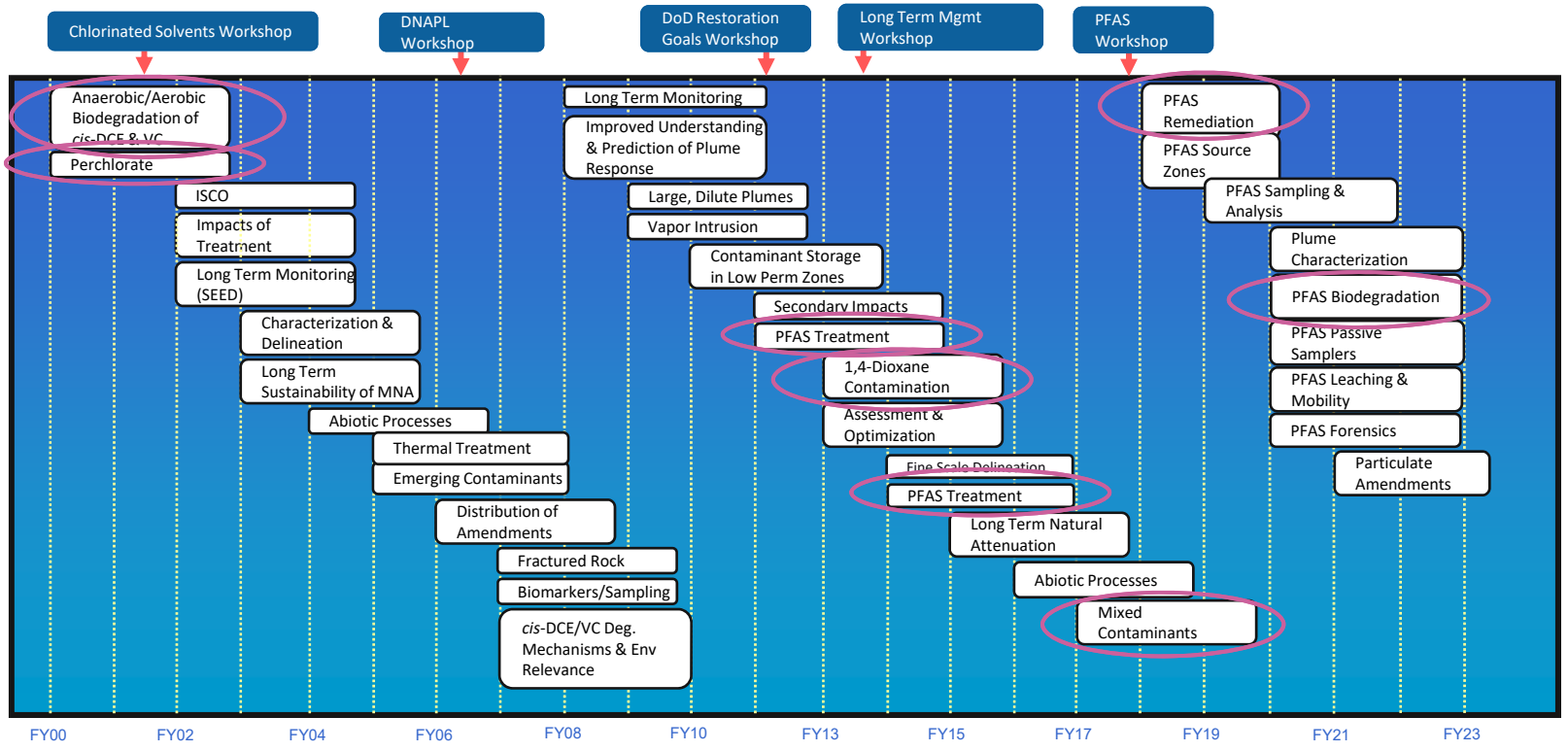
Demonstration/Validation

- Innovative cost-effective environmental and energy technology demonstrations
- Promote technology implementation by direct insertion and partnering with end users and regulators

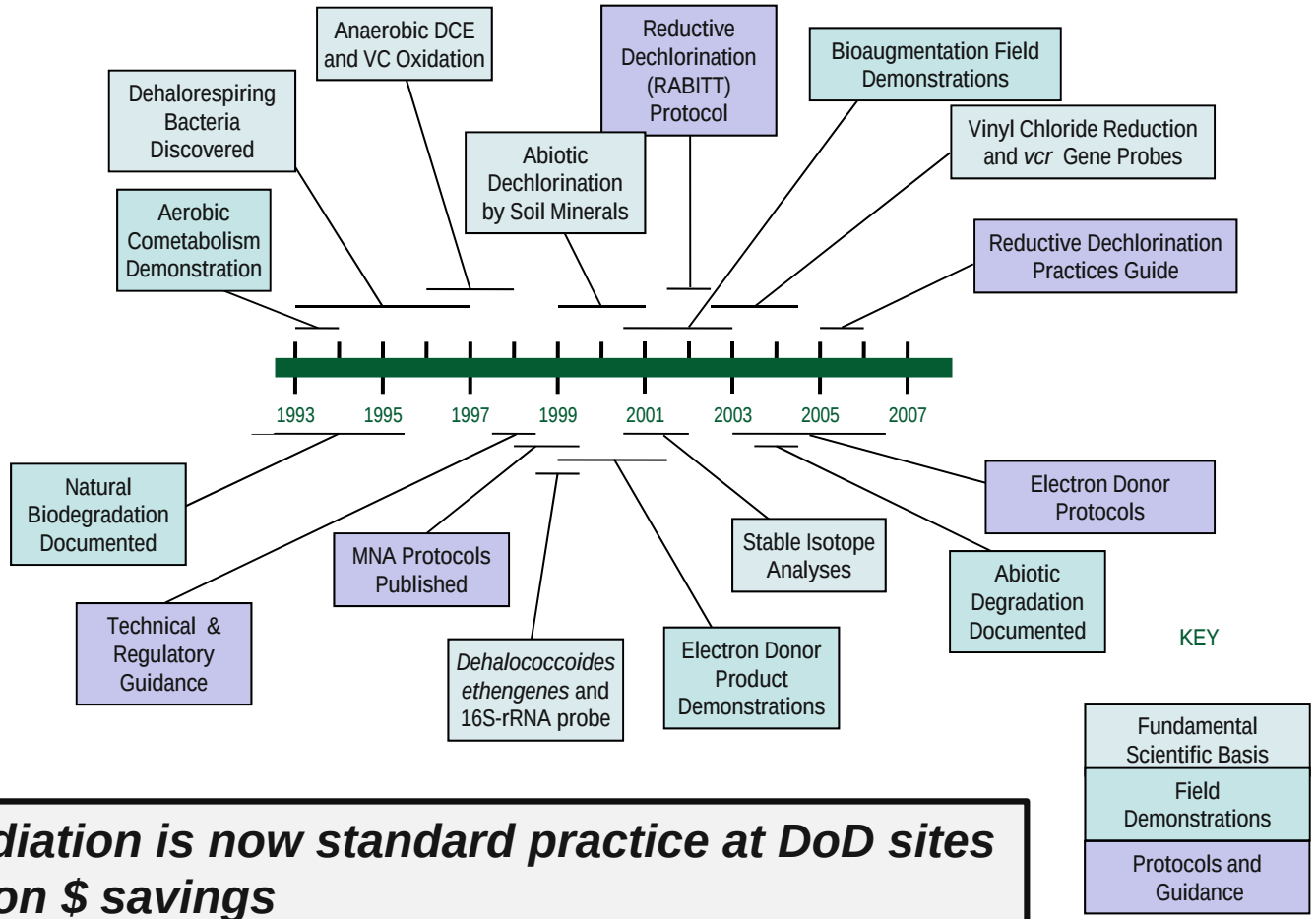
Groundwater Bioremediation



Groundwater Bioremediation



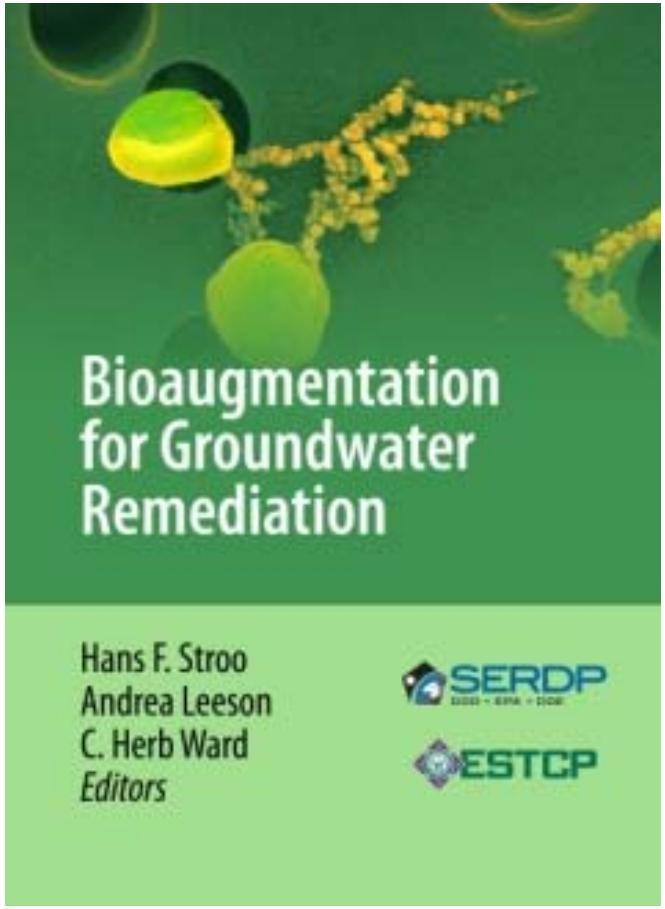
Timeline: Scientific Advances in Biotechnology



- ***Bioremediation is now standard practice at DoD sites***
- ***Multibillion $ savings***

Bioaugmentation

- Bioaugmentation is the addition of microorganisms to the subsurface to improve the biodegradation of contaminants.
- Basic microbial processes explored under SERDP in 1990s. Matured into field demonstrations and guidance documents within 10 years.
- Commercial bioaugmentation cultures now widely available, particularly for degradation of chlorinated solvents in groundwater.
- Total number of applications: ~900 sites
- Application at DoD sites: ~100



SERDP Developed Technology

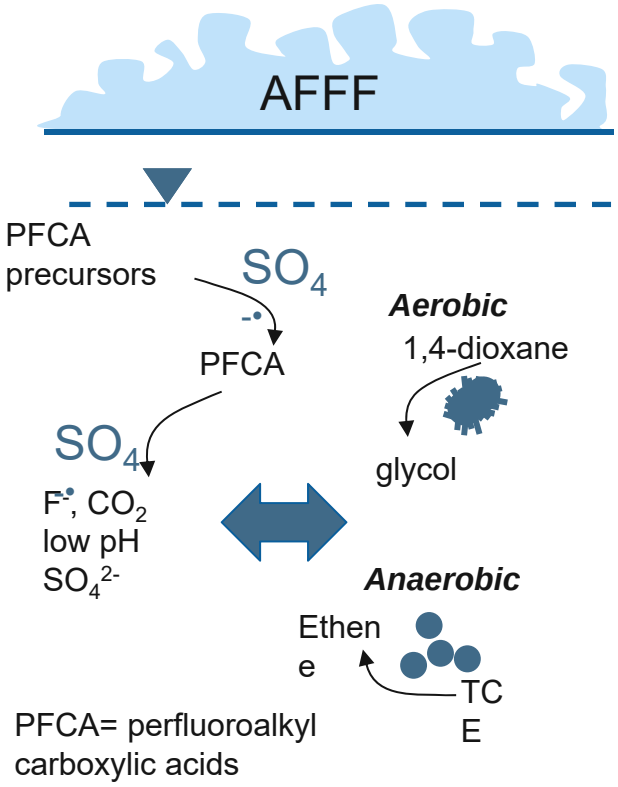
Remediation of Perchlorate-Contaminated Groundwater

- Broad use & occurrence
  - ♦ DoD
    - ▪ Rocket propellant
    - ▪ Insensitive munitions
  - ♦ Pyrotechnics & flares
  - ♦ Agricultural
  - ♦ Natural deposition
- Widespread groundwater contamination

- Dozens of field demonstrations
  - ♦ Cost effective in situ and ex situ biotreatment
  - ♦ Impacting all Services
  - ♦ Regulatory acceptance
  - ♦ Commercialized
- Future Cost Savings
  - ♦ Baseline technology: Pump and treat with IX
    - ▪ Large capitol costs and annual O&M costs
  - ♦ In situ treatment
    - ▪ Low capitol and annual O&M costs
  - ♦ $ Billions in savings projected

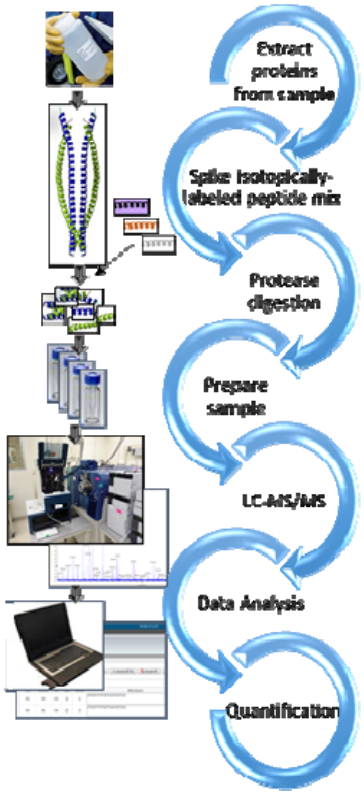
ER-2715: In Situ Remediation of Aqueous Film Forming Foams and Common Co-Contaminants with the Dual Approach of Chemical Oxidation and Bioremediation

- Performers: Drs. Lisa Alvarez-Cohen and David Sedlak, University of California, Berkeley
- Technology Focus: Persulfate in situ chemical oxidation (ISCO) combined with bioremediation
- Research Objectives: Develop/optimize persulfate-ISCO for AFFF in-situ remediation in combination with bioremediation for co-contaminants or ISCO reagent savings. Success will be efficient AFFF oxidation and co-contaminant treatment.
- Project Progress and Results: Determined that high solids buffering could reduce ISCO treatment efficiency and developed pre-acidification as treatment step.



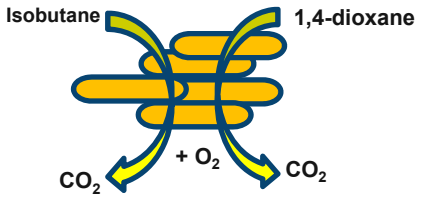
ER-201726: Validation of Advanced Molecular Biological Tools (MBTs) to Monitor Chlorinated Solvent Bioremediation and Estimate Degradation Rates

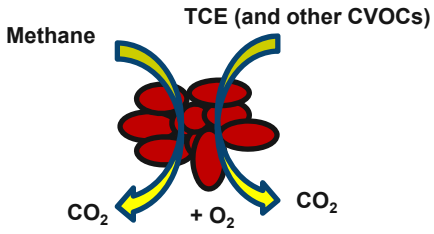
- Principle Investigator: Dr. Mandy Michalsen, U.S. Army ERDC
- Technology Focus: Vinyl chloride reductive dehalogenase (RDase) genes bvcA and vcrA serve as biomarkers for ethene formation at cVOC-impacted sites. Whereas RDase gene abundance alone provides a measure of reductive dechlorination (RD) potential, the quantitative assessment of RDase gene transcripts and proteins can possibly provide information about actual activity (i.e., rates).
- Demonstration Objectives:
  - Demonstrate that advanced MBTs can establish a direct link between quantitative biomarker gene, transcript and protein measurements with RD rates.
  - Demonstrate quantitative proteomics (qProt) for measuring the absolute abundance of key RDases in consortium SDC-9™ and contaminated site groundwater samples,
  - Establish correlations between RDase abundances and the RD rate (e.g. kcDCE, kVC) through laboratory microcosm tests,
  - Validate qProt for RD monitoring against and integrated with other MBTs at military sites through a series of replicated field tests.
- Project Progress and Results: Replicated microcosms were prepared by amending groundwater from Joint Base Lewis-McChord with varied SDC-9™ cell densities and lactate, then spiking cisDCE and quantifying resulting RD rates (kcDCE, kVC). Biomarker (peptides, genes, transcripts) were quantified. Preliminary results show biomarker abundance are positively correlated.



ER-201733: Evaluation of A Novel Multiple Primary Substrate (MPS) Cometabolic Treatment Technology for In Situ Bioremediation of 1,4-Dioxane & Chlorinated Solvents in Groundwater

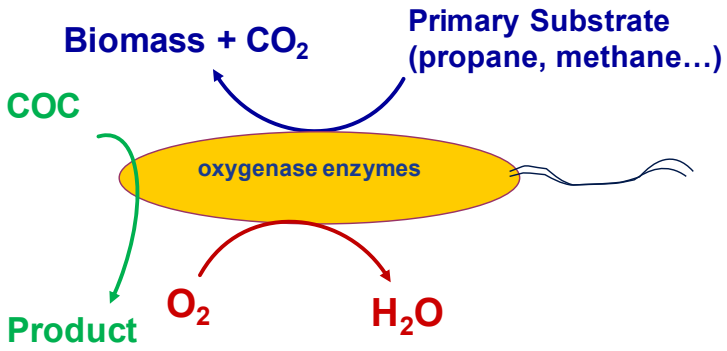
- Principle Investigator: Dr. Anthony Danko, NAVFAC EXWC
- Technology Focus: Demonstrate that MPS cometabolic treatment technology can meet DoD needs for effective treatment of co-mingled 1,4-D and CVOC plumes.
- Demonstration Site: Naval Air Station North Island (NASNI) OU11 (CA)
- Demonstration Objectives: Adequate gas (alkanes, O_2) distribution; System reliability and ease of use; Compare baseline versus treatment for 1,4-D and CVOC concentrations
- Project Progress and Results:
  - Site Selection and Site Characterization completed
  - Laboratory Treatability tests completed
  - Approach suggests first step of isobutane with bioaugmentation followed by methane with bioaugmentation
  - Implementation
  - Treatment system (hybrid biosparging with groundwater recirculation) construction expected to begin in late 2020





ER20-5036: Applying Cometabolism for Treatment of Traditional and Emerging Contaminants at DoD Sites

- Principle Investigator: Dr. Paul Hatzinger, APTIM Federal Services
- Research Objectives: Develop a multi-faceted technology transfer to both explain the fundamentals of cometabolism and describe applications of cometabolic technologies at DoD sites.
- Planned Technology Transition
  - Online and onsite training seminars;
  - A video tour and/or an onsite-tour of an operational cometabolic treatment system; and
  - Comprehensive open-access review paper compiling and describing applications of cometabolic remediation with a focus on DoD chemicals of concern (CoC).



FY20 SON:
Biodegradation of Per- and Polyfluoroalkyl Substances (PFAS) Found in Aqueous Film Forming Foam

- The objective was to develop an improved understanding of biodegradation processes and biological treatment strategies for per- and polyfluoroalkyl substances (PFAS). Specifically, the goal was to address the following research needs:
  - Identify and/or isolate microorganisms capable of degrading perfluoroalkyl acids (PFAAs), particularly perfluorooctane sulfonate (PFOS).
  - Improve the understanding of biodegradation processes that could lead to PFAS biological treatment alone or as part of a treatment train.
  - Identify biological treatment strategies capable of destroying PFOS and related PFAAs in or extracted from aqueous film forming foam (AFFF)-impacted groundwaters.
  - Identify biological treatment strategies to degrade potential PFAA precursors without production of PFAAs.
  - Identify enzymes capable of defluorination of PFAAs and/or gene coding or such enzymes.

5 Projects Selected for Funding

FY20 SERDP Funded PFAS Biodegradation Projects

Project Number/Title	PI Name/Organization
ER20-1023: Microbially-Mediated Defluorination of High-Priority Per- and Polyfluoroalkyl Substances: Microorganisms, Genetics, and Biochemistry	Jinxia Liu McGill University
ER20-1219: Biotransformation and Potential Mineralization of PFOS, PFHxS, and PFOA by *Acidimicrobiaceae* sp. A6 under Iron Reducing Conditions (Proof-of-Concept)	Peter Jaffe Princeton University
ER20-1286: A Synergistic Platform for Defluorination of PFAAs through Catalytic Reduction Followed by Microbial Oxidation (Proof-of-Concept)	Bruce Rittman Arizona State University
ER20-1430: Biodegradation of PFAS via Superoxide-Hyper-Producing Bacteria (Proof-of-Concept)	Pedro Alvarez Rice University
ER20-1541: Identification, Characterization, and Application of Reductive Defluorinating Microorganisms	Yujie Men University of California, Riverside

December 1-3, 2020 at the Marriott Wardman Park

Plenary session the first morning then two days of technical sessions and one day of short courses

The technical sessions will include several talks on bioremediation as well as posters for all currently funded bioremediation-related project.

Expected Attendance: 1000