Research Initiatives and the Challenges of Technical and Risk Assessment

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DoD's Environmental Technology Programs

Science and Technology

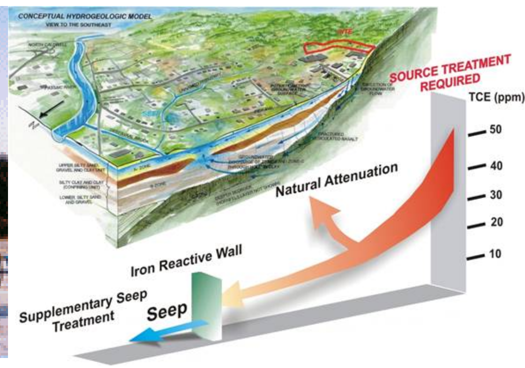
- Statutory Program Established 1991
- DoD, DOE, EPA Partnership
  - ♦ Advanced technology development to address near-term needs
  - ♦ Fundamental research to impact real world environmental management

Demonstration and Validation

- Demonstrate Innovative Cost-Effective Environmental and Energy Technologies
  - ♦ Transition technology out of the lab
  - ♦ Establish cost and performance
  - ♦ Partner with end user and regulator
  - ♦ Technology Transfer
    - Accelerate commercialization or broader adoption
    - Direct technology insertion

Environmental Drivers:
Reduction of Current and Future Liability

Contamination from Past Practices



- Groundwater, Soils and Sediments
- Large UXO Liability
- Emerging Contaminants
  - PFASs
  - 1,4-dioxane
  - Perchlorate

Pollution Prevention to Control Life Cycle Costs

- Elimination of Pollutants and Hazardous Materials in Manufacturing, Maintenance, and Operations
- Achieve Compliance Through Pollution Prevention
- Develop and Assess Alternative Technologies

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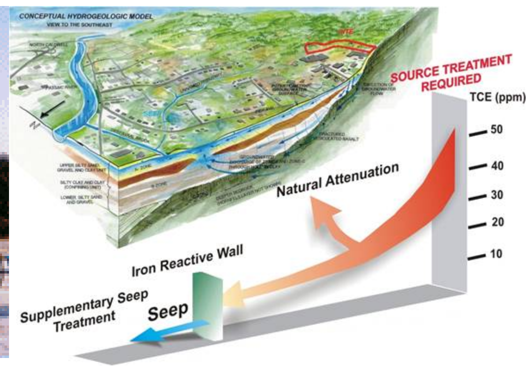

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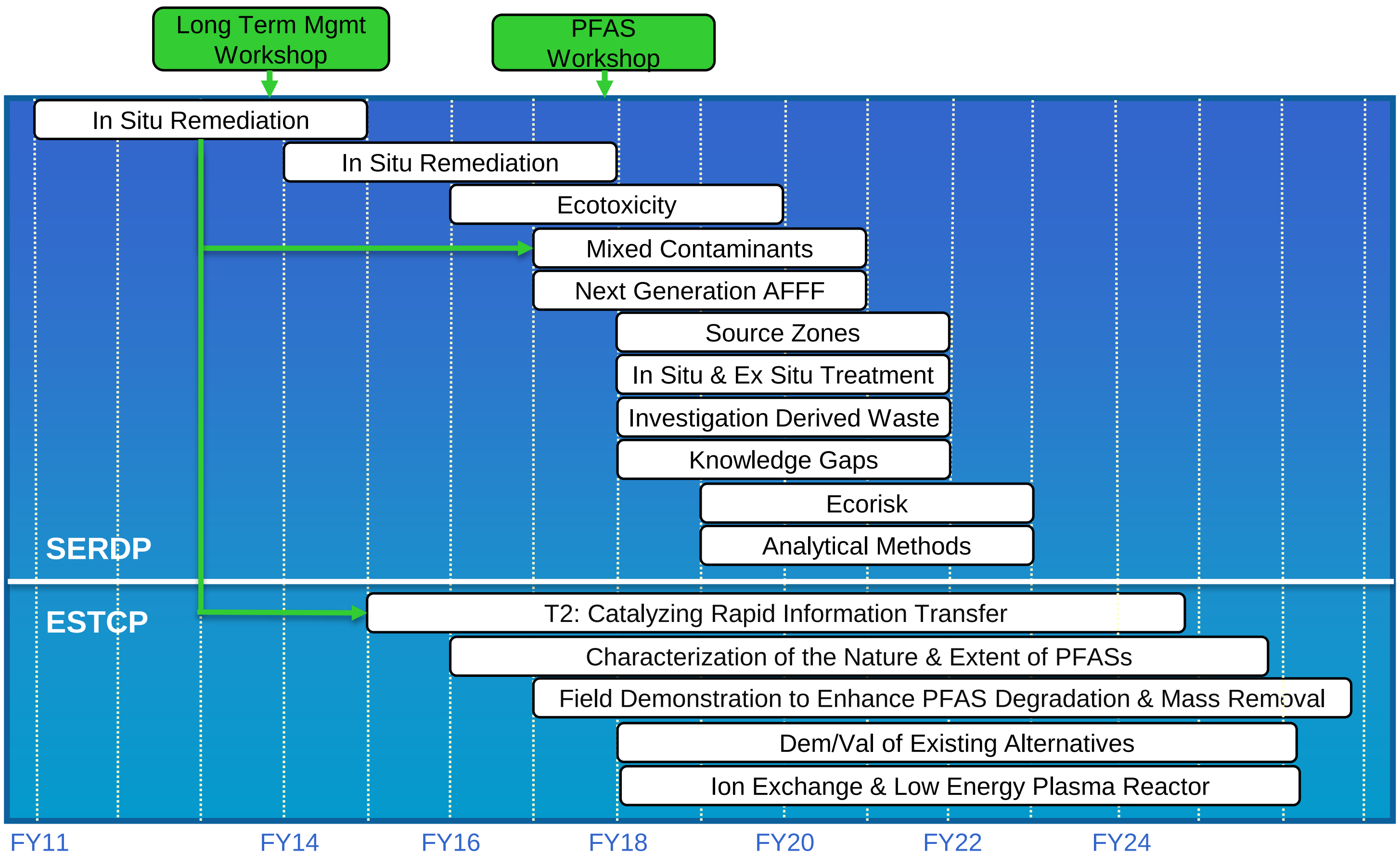
SERDP & ESTCP Efforts on PFASs



SERDP & ESTCP Efforts on PFASs

Long Term Mgmt Workshop

PFAS Workshop

In Situ Remediation

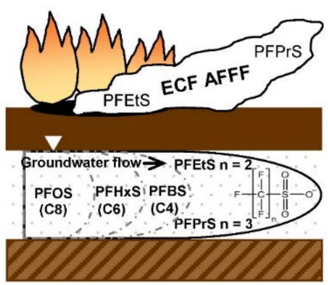
FY11

- Released shortly after the EPA released the Provisional Health Advisories for PFOS (0.2 µg/L) and PFOA (0.4 µg/L)

- Funded three projects:
  - ER-2126: Fate & transport under varying conditions (Higgins, CSM) **(complete)**
  - ER-2127: SEED, remediation technology (Huang, Georgia) **(unsuccessful)**
  - ER-2128: Delineate fluorochemicals that persist in AFFF-contaminated matrices & evaluate impact on priority pollutant transport & bioremediation (Field, OSU) **(complete)**

Characterization of the Fate and Biotransformation of Fluorochemicals in AFFF-Contaminated Groundwater at Fire/Crash Testing Military Sites

Professor Jennifer A. Field - Oregon State University



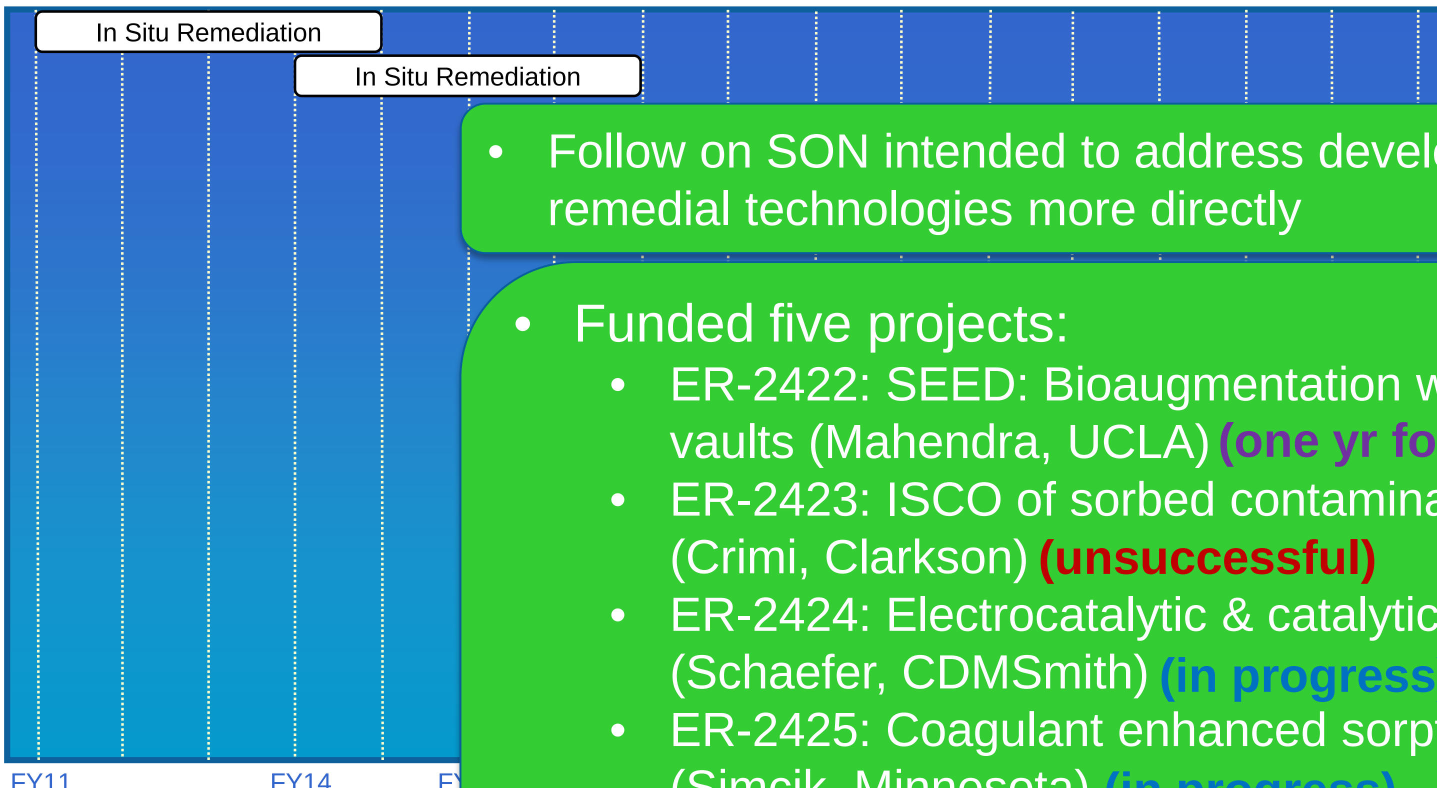
Results

- Developed analytical tools, including methods for quantifying individual perfluoroalkyl substances (PFASs) as well as precursors
- Provided analytical advances for more complete characterization of aqueous film forming foam (AFFF)-contaminated media
- Significantly improved understanding of the PFASs present at AFFF-contaminated sites

Benefits

- Identifying precursors will lead to a better understanding of the effectiveness of treatment technologies
- Biotransformation pathway of polyfluoroalkyl substances in fluorotelomer-based AFFF provides a framework for understanding the fate of the precursor and insight into the conditions that lead to high concentrations of persistent fluorotelomer sulfonates

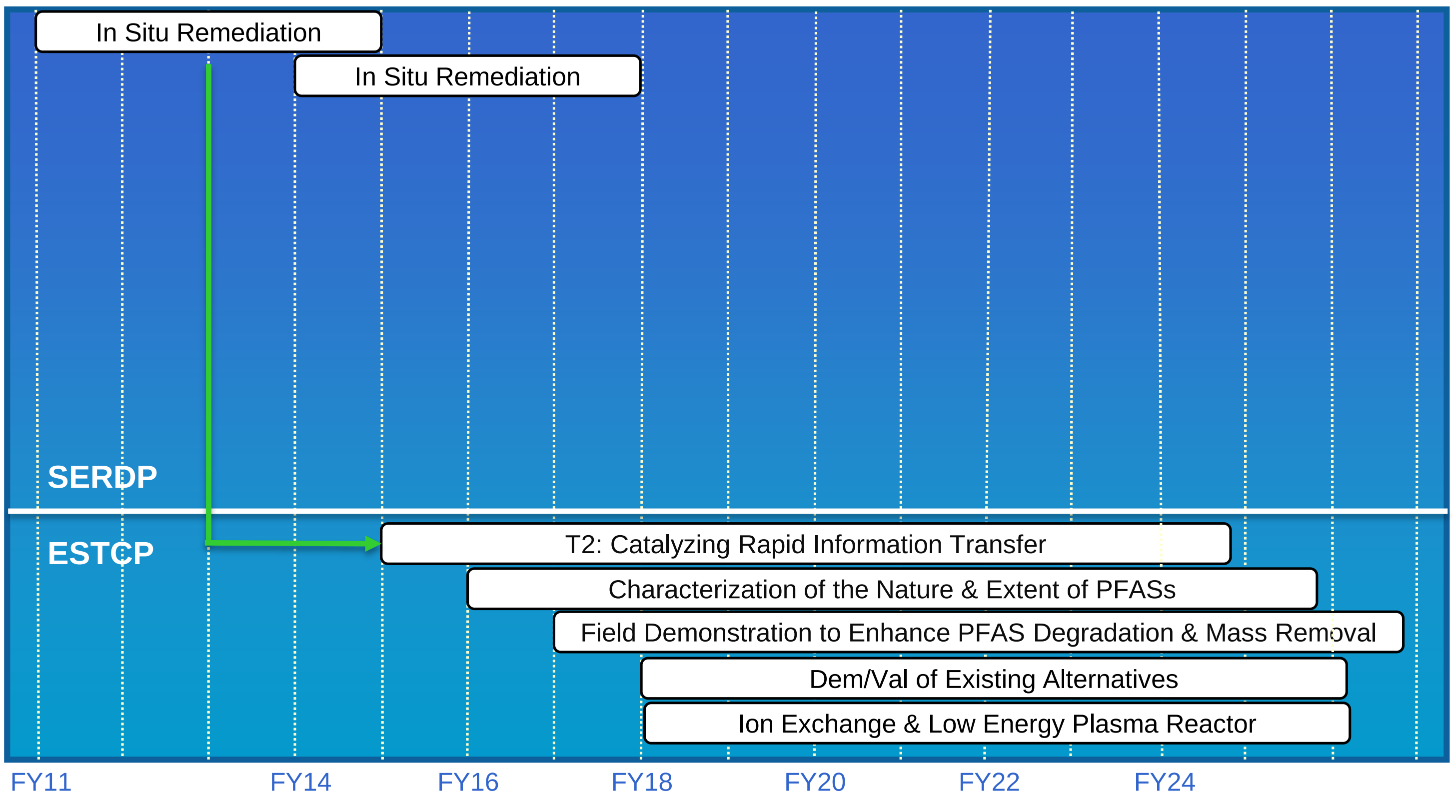
SERDP & ESTCP Efforts on PFASs



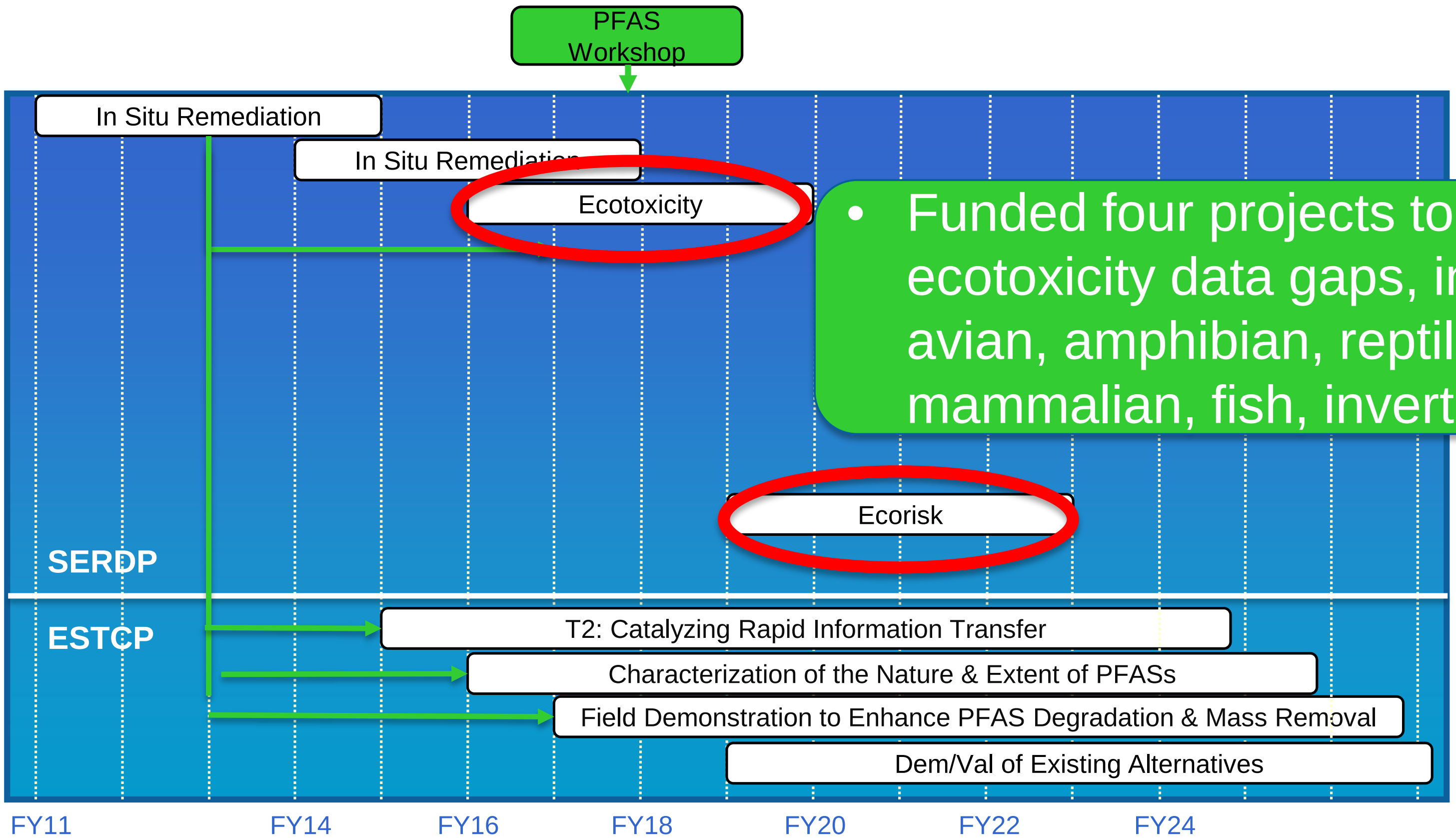
- Follow on SON intended to address development of remedial technologies more directly

- Funded five projects:
  - ER-2422: SEED: Bioaugmentation with vaults (Mahendra, UCLA) **(one yr follow on)**
  - ER-2423: ISCO of sorbed contaminants (Crimi, Clarkson) **(unsuccessful)**
  - ER-2424: Electrocatalytic & catalytic (Schaefer, CDMSmith) **(in progress)**
  - ER-2425: Coagulant enhanced sorption (Simcik, Minnesota) **(in progress)**
  - ER-2426: In Situ Chemical Reductive Defluorination (Lee, Purdue) **(in progress)**

SERDP & ESTCP Efforts on PFASs



SERDP & ESTCP Efforts on PFASs



- Funded four projects to fill ecotoxicity data gaps, including avian, amphibian, reptiles, mammalian, fish, invertebrates

FY18 Statement of Need Defining Knowledge Gaps in the Understanding of PFASs in the Subsurface

- Objective: Address specific knowledge gaps identified in the May 2017 PFAS Workshop. The knowledge gaps of interest are those that require collection and analysis of existing data on PFASs, not additional experimental work. Specific areas of interested are as follows:
  - Develop basis for an approach for assessing PFAS risks to TES.
  - Form the basis for future development of innovative on-site technologies for concentrated PFAS waste streams by summarizing characteristics of waste streams from common approaches as well as theorizing the waste composition of potential innovative approaches.
  - Define lines of evidence for assessing effectiveness of proposed remediation technologies based on the current state of the science.

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  - ♦ Develop basis for an approach for assessing PFAS risks to TES.

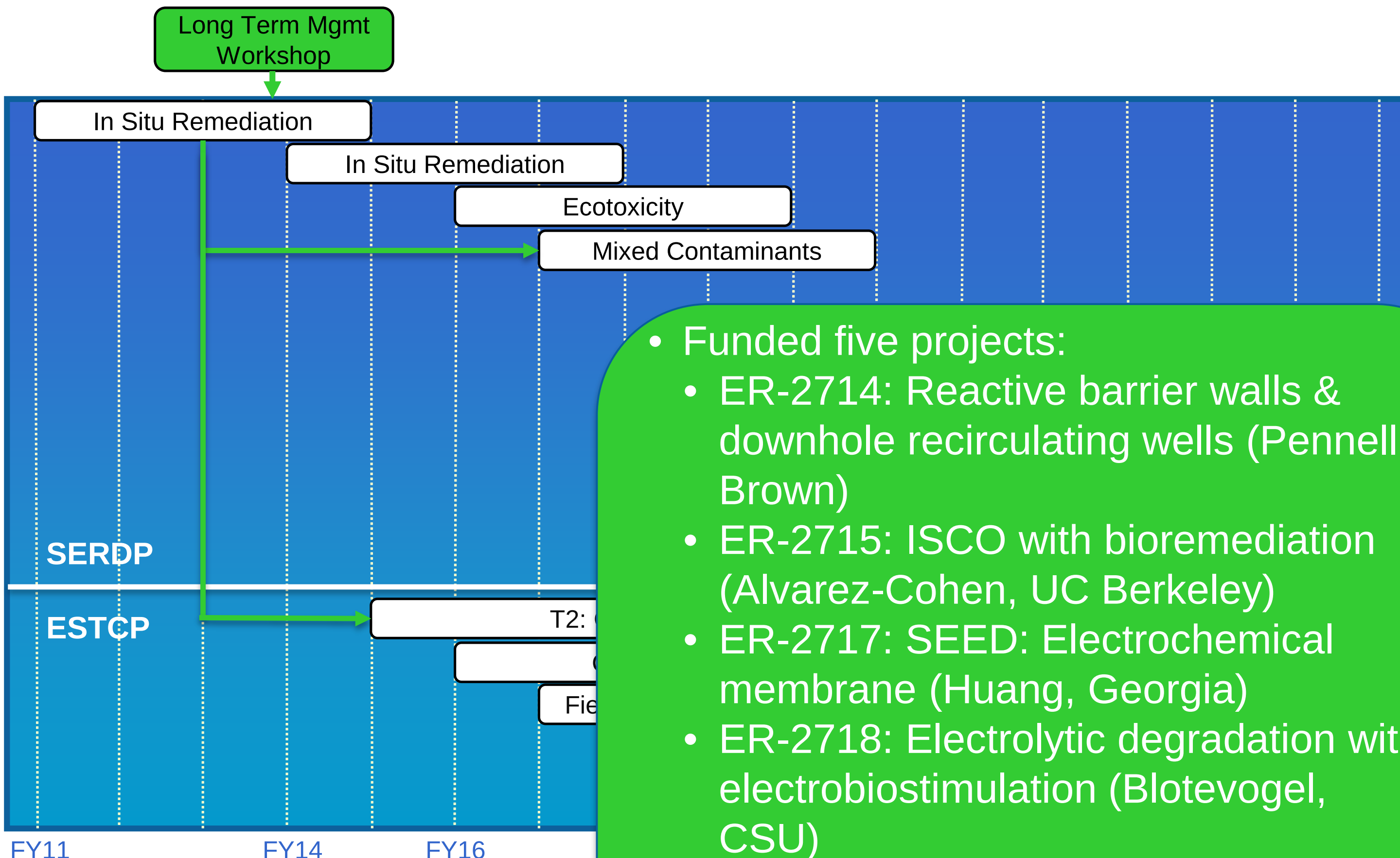
Four proposals selected; projects will be initiated this year with results within 12 – 24 months

FY19 Statement of Need: Ecological Risk Characterization of PFASs in the Subsurface

- Objective: Improve our understanding of bioavailability, bioaccumulation & biomagnification of PFASs in the subsurface. Specifically:
  - ♦ Improved understanding of uptake & excretion rates of PFASs by organisms throughout the food web
  - ♦ Determine rate & … oils & water by lower-trophic lev… tential biotransformation of PFAA precursors
  - ♦ Identification of physical and geochemical factors affecting bioavailability of PFASs in sediments and soils.
  - ♦ Compare potency of PFASs in relation to chain length (C8 vs. C6 sulfonates), functional group (carboxylic acid vs. sulfonate), and varying levels of fluorination.
  - ♦ Assess PFAS bioaccumulation/biomagnification throughout a food web.

Proposals rcvd March 2018
Final selections July 2018

SERDP & ESTCP Efforts on PFASs



- Funded five projects:
  - ER-2714: Reactive barrier walls & downhole recirculating wells (Pennell, Brown)
  - ER-2715: ISCO with bioremediation (Alvarez-Cohen, UC Berkeley)
  - ER-2717: SEED: Electrochemical membrane (Huang, Georgia)
  - ER-2718: Electrolytic degradation with electrobiostimulation (Blotevogel, CSU)
  - ER-2720: Fate & transport in mixed contamination (Higgins, CSM)

PFAS Workshop

- In May 2017, SERDP and ESTCP sponsored a two-day workshop: Research and Development Needs for Management of DoD's PFAS Contaminated Sites to:
  - Review the current state of the science regarding PFAS contamination in general, and AFFF in particular
  - Evaluate current and potential characterization and remediation technologies
  - Prioritize research and demonstration opportunities that can improve remediation performance and efficiency, and ultimately redu[illegible]es.
  - Summarize findings in a workshop report.

28 Research, Demonstration and Technology Transfer Needs Identified

PFAS Workshop – Major Findings

- Fate and transport properties
- Bioavailability, biomagnification
- Toxicity
- Development of on-site technologies for concentrated PFAS waste streams
- PFAS forensics
- Sampling
- Treatment technology demonstrations
- Technology transfer needs

FY18 Statement of Need: Improved Understanding of PFAS Source Zones

- Objective: Improve our understanding of PFASs in source zones resulting from the use of Aqueous Film Forming Foam (AFFF) formulations by the DoD. Proposed following objectives:
  - ♦ Increase u FFF source zone areas (vad eas) that affect the risk that PF
  - ♦ Developme ize the key source zone prope
  - ♦ Investigate dation mechanisms, and the po or enhanced attenuation
  - ♦ Fill key dat transport of PFASs in AFFF sou
  - ♦ Develop analytical or mathematical tools to predict the fate and impacts of PFASs in source zones and the potential for continuing releases to groundwater plumes.

- Funded five projects:
  - ER18-1204: Vadose zone (Schaefer, CDM Smith)
  - ER18-1259: Saturated phase (Field, Oregon State)
  - ER18-1389: Air/water Interface (SEED) (Silva, GSI)
  - ER18-1149: Predictive tools & decision support (Abriola, Tufts)
  - ER18-1280: Field sampling & assessment (Sunderland, Harvard)

Treatment Projects Overview

Projects				
Electrocatalytic (ER2424; CDMSmith)	In situ coagulents (ER2425; Minnesota)	In situ chemical reductive defluorination (ER2426; Purdue)	Coupled reactive nanoscale materials & bioremediation; mixed contaminants (ER2714; Brown)	
In situ chemical oxidation & bioremediation; mixed contaminants (ER2715; UC Berkeley)	Electrolytic degradation with electrobiostimulation; mixed contaminants (ER2718; Colorado State)	Key F&T properties impacting attenuation & treatment; mixed contaminants (ER2720; Colorado School of Mines)	Thermally enhanced persulfate oxidation followed by P&T (ER201729; Navy)	
In situ & ex situ treatment train: ISCO or amendment, plasma destruction, IX (1306; Clarkson)	Ex situ treatment train: pre & post oxidation, adsorption, adsorption material regeneration (1289; UC Riverside)	Polymer adsorbents In or ex situ (1026; Cornell)	Commercially available regenerable resins Ex situ (1063; CSM)	IX resins, electrochemical &/or ultrasonic treatment for regenerant Ex situ (1027; Aptim)

Proof of Concept (Ex situ/drinking water or pump-and-treat)					
Protein based adsorbents (1417; U.S. Army)	Electrically enhanced adsorption onto AC, electrically discharge to regenerate (1395; NCSU)	Electrochemical oxidation (1320; Univ of GA)	Mesoporous organosilica sorbents Ex situ (1300; Wooster)	Cationic polyaniline (PANI) & polypyrrole (PPy) polymers (1052; Univ of AZ)	Electrocoagulation (1278; AECOM)

Proof of Concept (Investigation Derived Waste)				
Advanced oxidation-reduction & membrane concentration (1497; UC Riverside)	Modified SiC based catalysts (1513; Research Triangle Institute)	Reductive defluorination by hydrated electrons (1526; Miami)	Thermal treatment (1556; Aptim)	Nonthermal plasma technology (1570; Drexel)
Combined photo/electrochemical reduction (1595; UCLA)	Electron beam technology (1620; Texas A&M)	Plasma based treatment (1624; Clarkson)	Hydrothermal technologies (1501; Colorado School of Mines)	Indirect thermal desorption with thermal oxidation (1572; EA Engineering)

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Destruction

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Sequestration

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Treatment Trains

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Mixed Contamination: PFASs & Chlorinated Solvents

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Investigation Derived Waste

Funding to Date

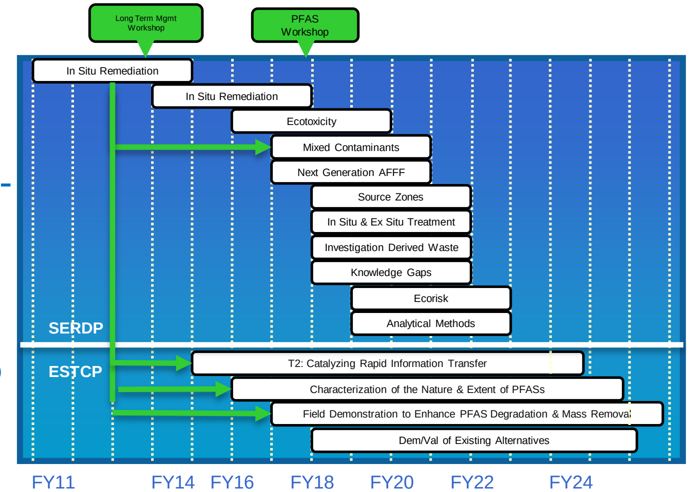
- Total: $39M (FY11 – FY20)
- Ecotoxicity
  - ♦ $5.4M
  - ♦ FY19 solicitation associated with bioavailability & bioaccumulation – no funding associated with this yet

Summary

- Additional research and demonstrations needed in all remediation areas: ex situ (drinking water), in situ groundwater and soil treatments
- Good progress on several fronts
- Toxicology information needed to inform remediation; which PFASs are of most concern

Resources

http://map.serdp-estcp.org/Featured-Initiatives/Per-and-Polyfluoroalkyl-Substances-PFASs/



- Workshop report
  - ♦ https://serdp-estcp.org/content/download/45585/425201/file/PFAS%20Workshop%20Report%20Final%20September%202017.pdf
- FAQ and Reference Document
  - ♦ https://www.serdp-estcp.org/content/download/46353/431598/file/FAQ%20ER-201574%20September%202017.pdf
  - ♦ In what environmental media have PFASs been found?
  - ♦ What is the fate and transport of PFASs in the environment?
  - ♦ What characterization & remedial tools are available/effective for PFASs?
  - ♦ What are human & ecological exposure pathways & health effects?