Developing Robust Conceptual Site Models for PFAS Site Management

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A phased program involving advanced site characterization approaches and tools is required to complete Remedial Investigations of complex PFAS sites

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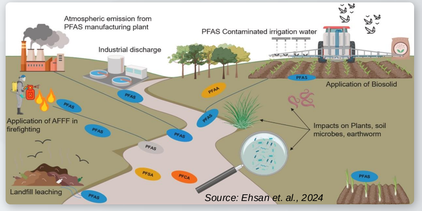
Technical Challenge

Developing comprehensive conceptual site models (CSMs) is challenging because of many PFAS sources in the environment, extremely low screening levels, and complex PFAS properties that all result in unique fate, transport, and exposure pathways.

PFAS Sources in the Environment

- Thousands of individual PFAS compounds
- Primary and secondary release sources
- Multiple sources of PFAS in various environmental media (soil, groundwater, surface water, sediment) and atmosphere
  - Groundwater discharge
  - Stormwater runoff
  - Surface water (e.g., lakes, streams, rivers)
  - Storm sewer lines and stormwater outfalls
  - Atmospheric deposition

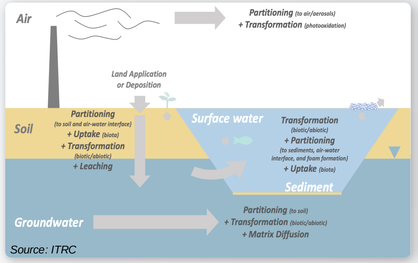


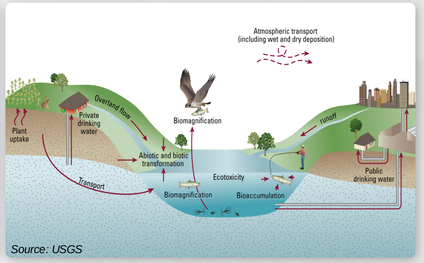
Regulatory Drivers

National Defense Authorization Act (NDAA)	Resource Conservation and Recovery Act (RCRA)	Clean Water Act (CWA) Safe Drinking Water Act (SDWA)	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
Congress annually enacts and mandates the DoD comply with many actions related to PFAS. *Not regulations or guidance, but Important in advancing PFAS toxicity studies, R&D*	Proposed (not adopted yet) ***RCRA to list 9 PFAS*** *(PFOS, PFHxS, PFBS, HFPO-DA, PFDA, PFNA, PFOA, PFHxA, PFBA)* as hazardous constituents (February 2024), ***subject to Corrective Action*** *under RCRA*	*Promulgated National Potable Drinking Water Regulations* to establish ***MCLs for 5 PFAS (PFOS, PFOA, PFHxS, PFNA, HFPO-DA)****;* and *limit mixture* containing *PFNA, PFHxS, PFBS, and HFPO-DA* using a hazard index	Designated ***PFOA and PFOS as "hazardous substances"*** pursuant to Section 102(a) of the CERCLA, effective July 2024. EPA has ***authority to order*** *investigation and remediation, and reopen closed sites*

CWA Effluent Limitation Guidelines (ELG) Program	National Pollutant Discharge Elimination System (NPDES)	PFAS Discharges in State-Issued Discharge Elimination Permits	Toxic Substances Control Act (TSCA)
Issuance of Preliminary Effluent Guidelines Program Plans 15 and 16 outlining the approach to developing and revising national, technology-based *ELGs to reduce pollutants* including PFAS	Issuance of standard process for *developing effluent limits for pollutants* Recent release of Notice of Proposed Rulemaking (NPRM) on *NDPES requiring PFAS monitoring*	Issuance of guidance stating permittee and pretreatment authorities to address PFAS; Less than half of states have PFAS monitoring requirements; fewer states established PFAS ELGs	Requires that all entities that manufactured, imported PFAS *electronically report information regarding PFAS uses, production volumes, disposal, exposures and hazards* NLT 8 May 2025

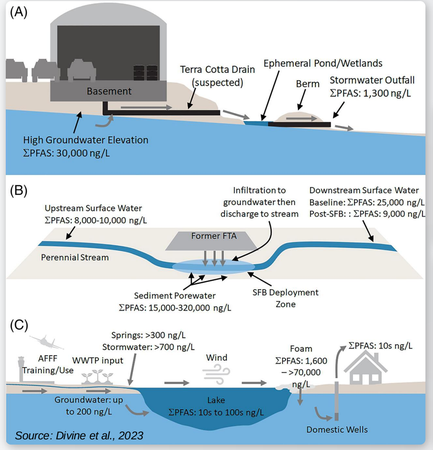
PFAS Behavior in the Environment





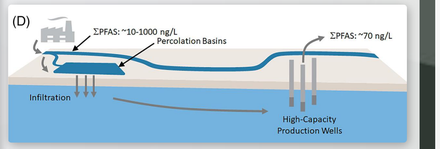
PFAS Transport Pathways

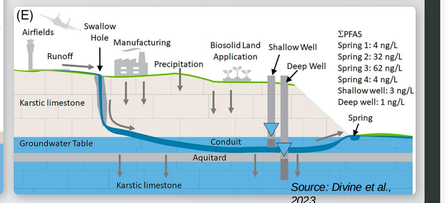
PFAS properties and hydrogeologic processes result in complex distribution and exposure pathways to receptors.



Factors affecting transport pathways include:

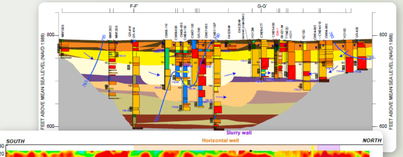
- Soil and water composition
- PFAS partitioning to solids, organic matter, and air-water interface
- Biogeochemical conditions and biotransformation
- Co-contaminants





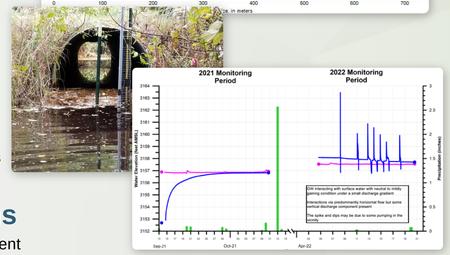
High Resolution Site Characterization

- Environmental sequence stratigraphy (ESS)
- Geophysics – electric resistivity tomography (ERT), seismic resistance, electromagnetic, and nuclear magnetic resonance (NMR)
- Hydraulic profiling tools (HPT), Membrane interface hydraulic profiling tools (MIHPT), optical image profiler; lysimeters
- Vertical aquifer profiling (VAP) and Flute



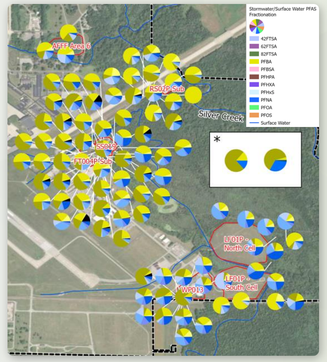
Groundwater-Surface Water Interaction

- Stilling wells and piezometers
- Tracer study
- Passive flux meters
- Distributed temperature sensing
- Point velocity probe and passive flux meters
- Seepage meter and trident probe



Stormwater Investigations

- Groundwater infiltration and runoff assessment
- In-line video camera survey
- Flow measurements
- Stormwater and sediment sampling in catch basins and at outfalls
- PFAS fractionation in stormwater and groundwater



Key Takeaways

Robust CSMs for complex PFAS sites require:

- ✓ Determination of primary and secondary release sources
- ✓ Delineation of nature and extent, and PFAS fractionation
- ✓ Comprehensive understanding of geology, hydrogeology, aquifer properties, and hydrology
- ✓ Identification of prominent migration and exposure pathways
- ✓ Determination of source strength and leaching to groundwater
- ✓ Evaluation of areas of high mass retention and mass flux