# PFAS Leaching in an AFFF-Impacted Source Area

BATTELLE

Twelfth International Conference on Remediation of Chlorinated and Recalcitrant Compounds

CDM Smith

WATER + ENVIRONMENT + TRANSPORTATION + ENERGY + FACILITIES

# Project Team

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# PFAS Leaching through the Unsaturated Zone at Sites with Historic AFFF Impacts

## <u>Need for Field-Scale Data:</u>

- Relationship between PFAS concentrations measured in collected soil samples, and porewater
- Extent to which air-water interfacial sorption impacts PFAS leaching
- PFAS mass flux vs. mass removal

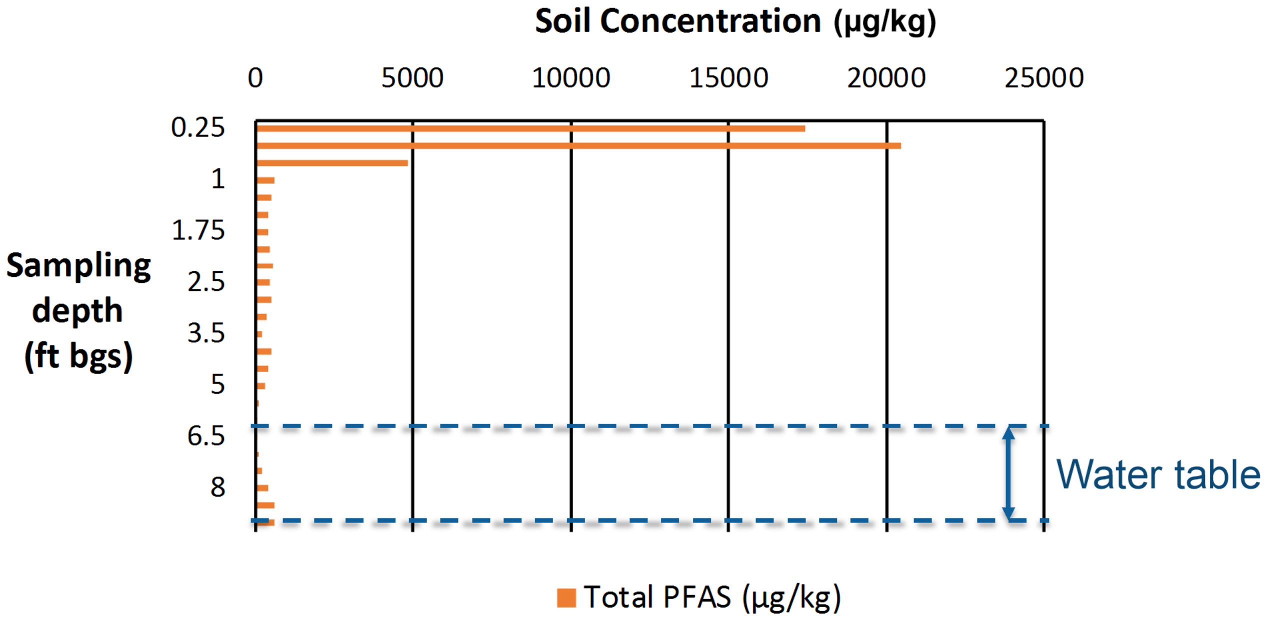
# Test Site

## Joint Base McGuire-Dix-Lakehurst (JBMDL)

HISTORICAL FIRE TRAINING AREA 1 (AFFF AREA 16)


- Monthly finished foam reading tests (1985-1997). *No reported firefighting*.
- Silty-sand
- Depth to water ~6 to 9 ft bgs

# Site Characterization

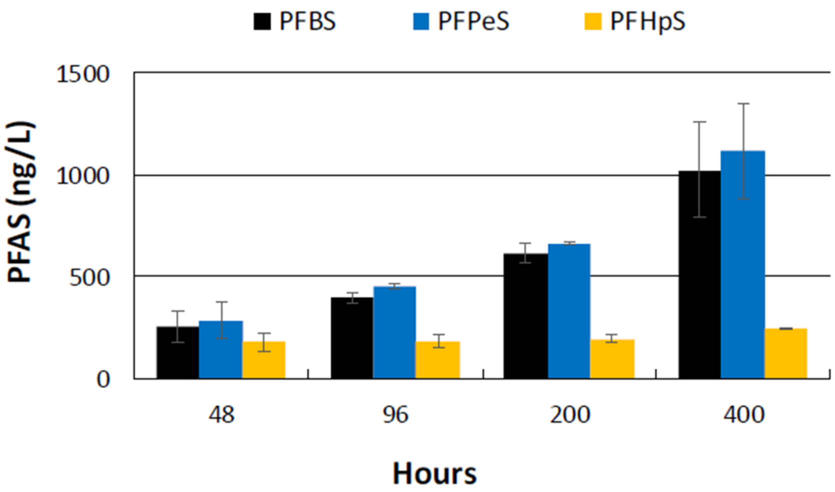



For bench-scale testing, soil divided into:

- <u>shallow</u> (0-3 ft bgs), $f_{oc}$=0.0034
- <u>deep</u> (3-8 ft bgs), $f_{oc}$<0.00068

# Desorption Kinetics

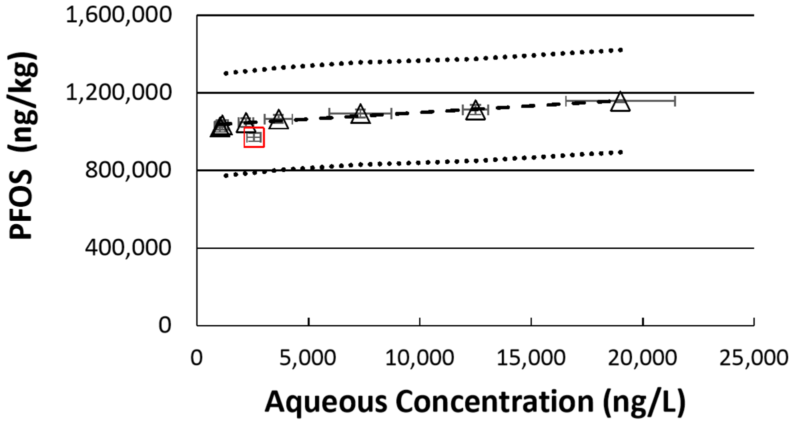
- For the <u>deep</u> soil, equilibrium generally observed within 48 hours
- For the <u>shallow</u> soil:

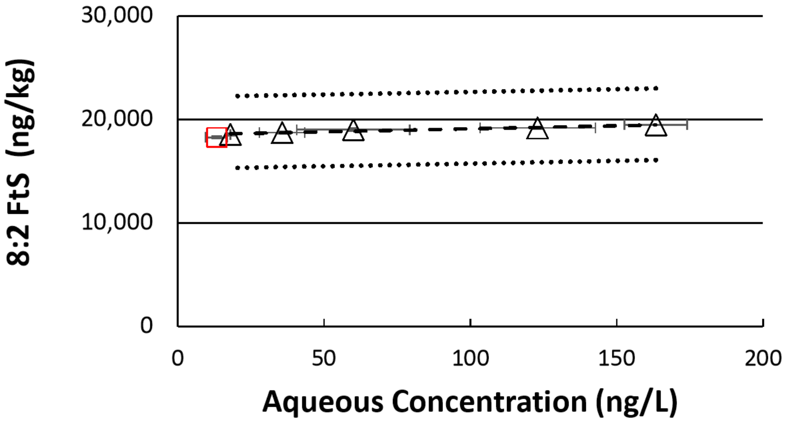



- PFHpS, PFOS, and PFNA: equilibrium within 48 hours
- All other PFAAs $\geq$ 400 hours
- Consistent with a 2-site desorption model

*Schaefer et al., JEE, 2021*

# Desorption Isotherms



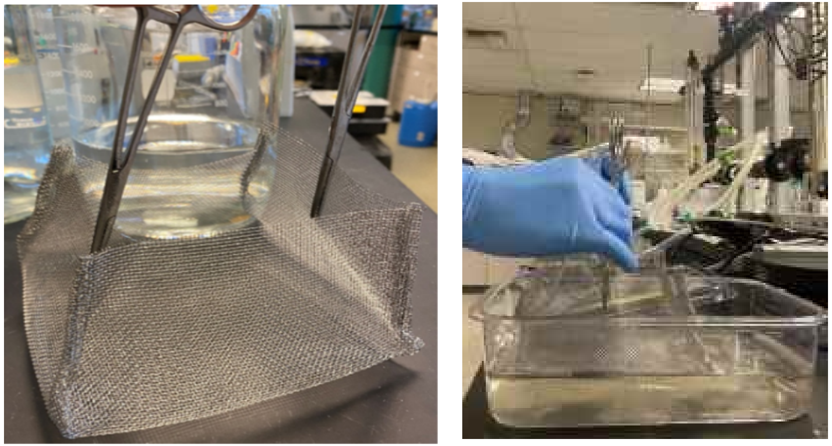




*Sequential batch dilution method*

$$C_s = K_d C + b$$

*Schaefer et al., JEE, 2022*

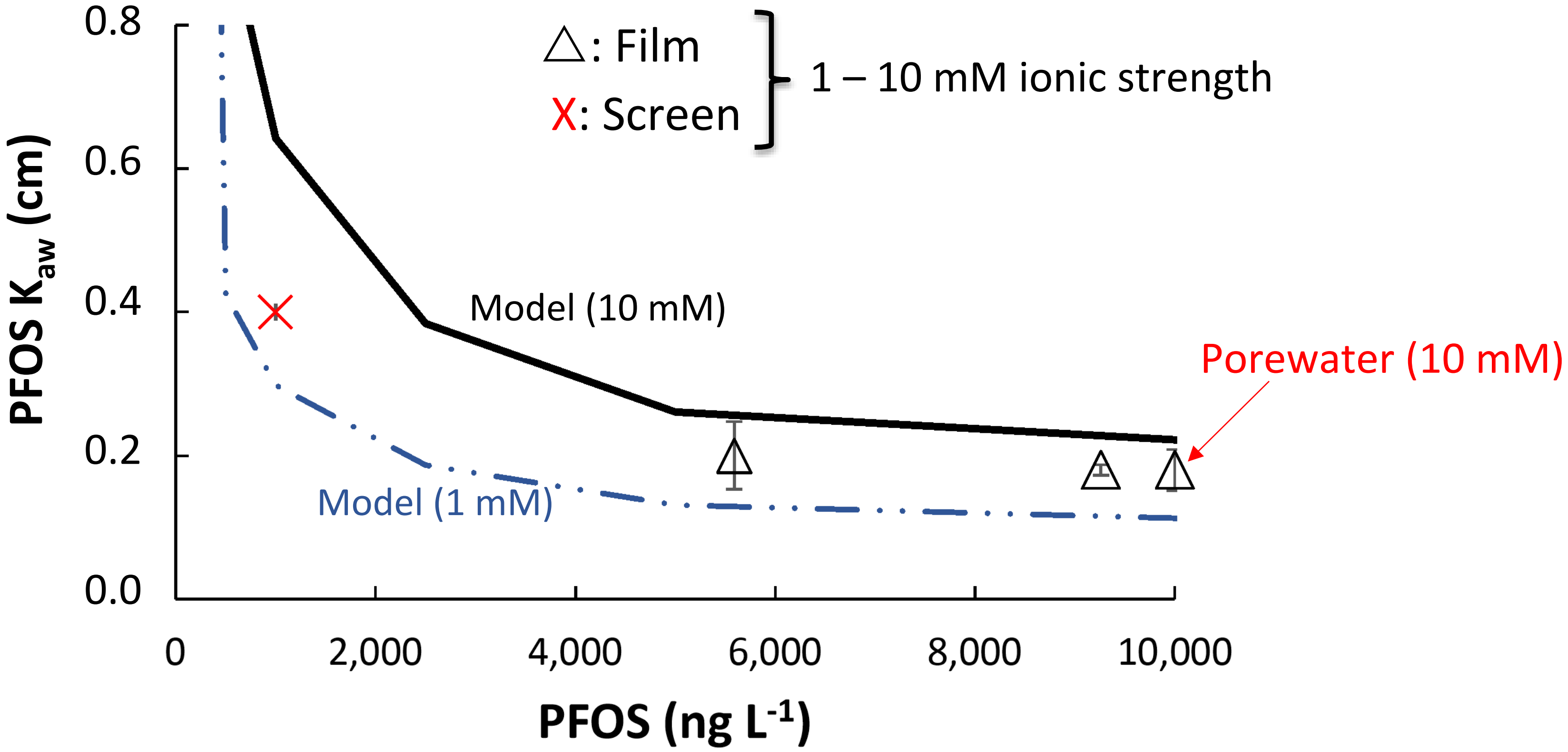
# PFAS Sorption at the Air-Water Interface



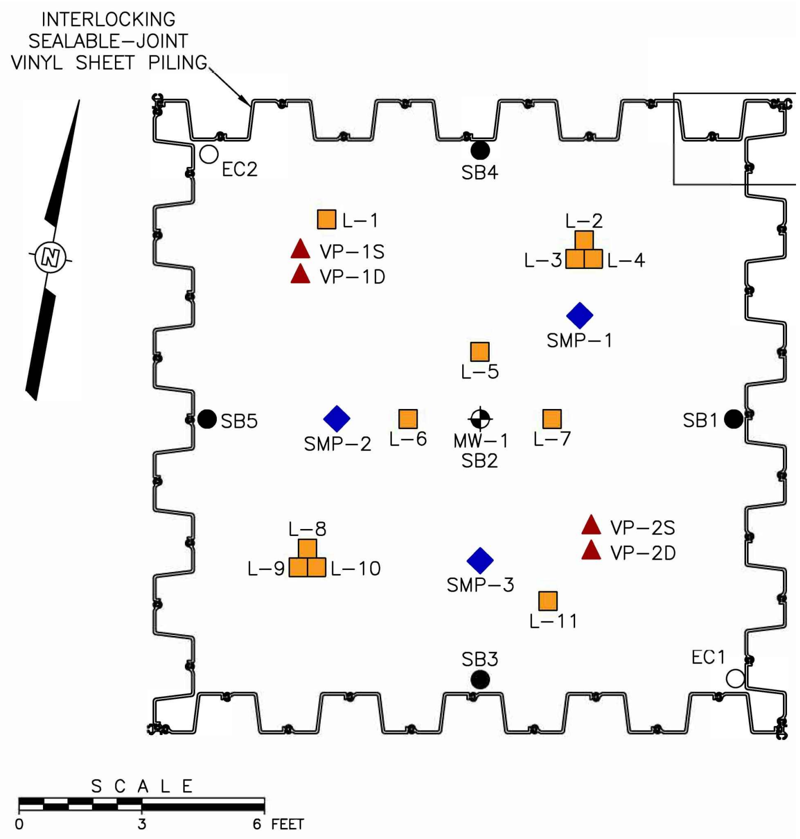
Garrett metal screen sampler for surface microlayer (~230 μm thick) and determining $K_{aw}$

Film method for determining $K_{aw}$

# Measured Air-Water Interfacial Partition Coefficient ($K_{aw}$)



# Field Test System - Lakehurst



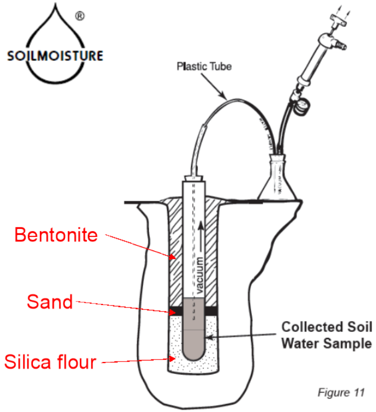

- 11 suction cup lysimeters (0.5 to 5 ft bgs)
- 3 moisture probes
- 1 shallow monitoring well
- Rain gauge
- Irrigation system
  (*for enhanced flushing*)

# Field System

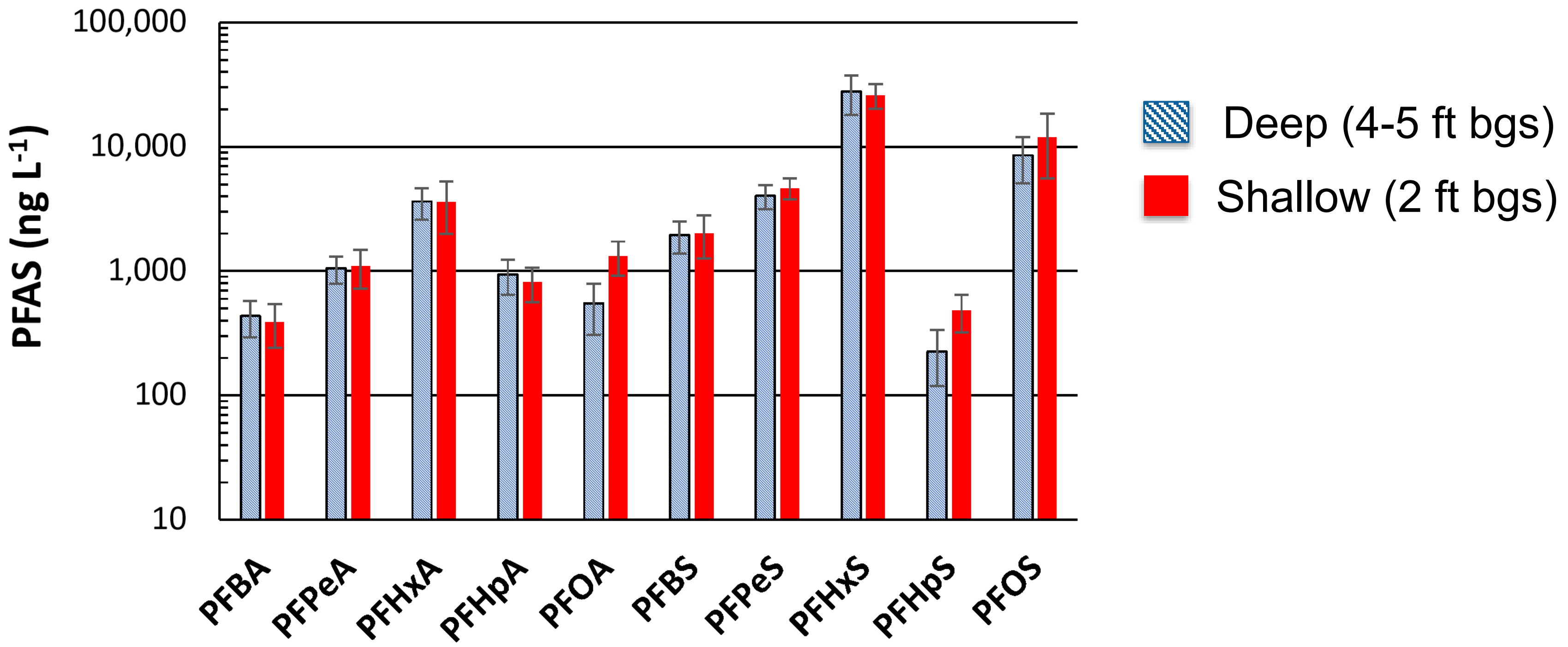
Test Cell & Control Center

Lysimeter lengths (1’- 5’)

Lysimeter manifold system

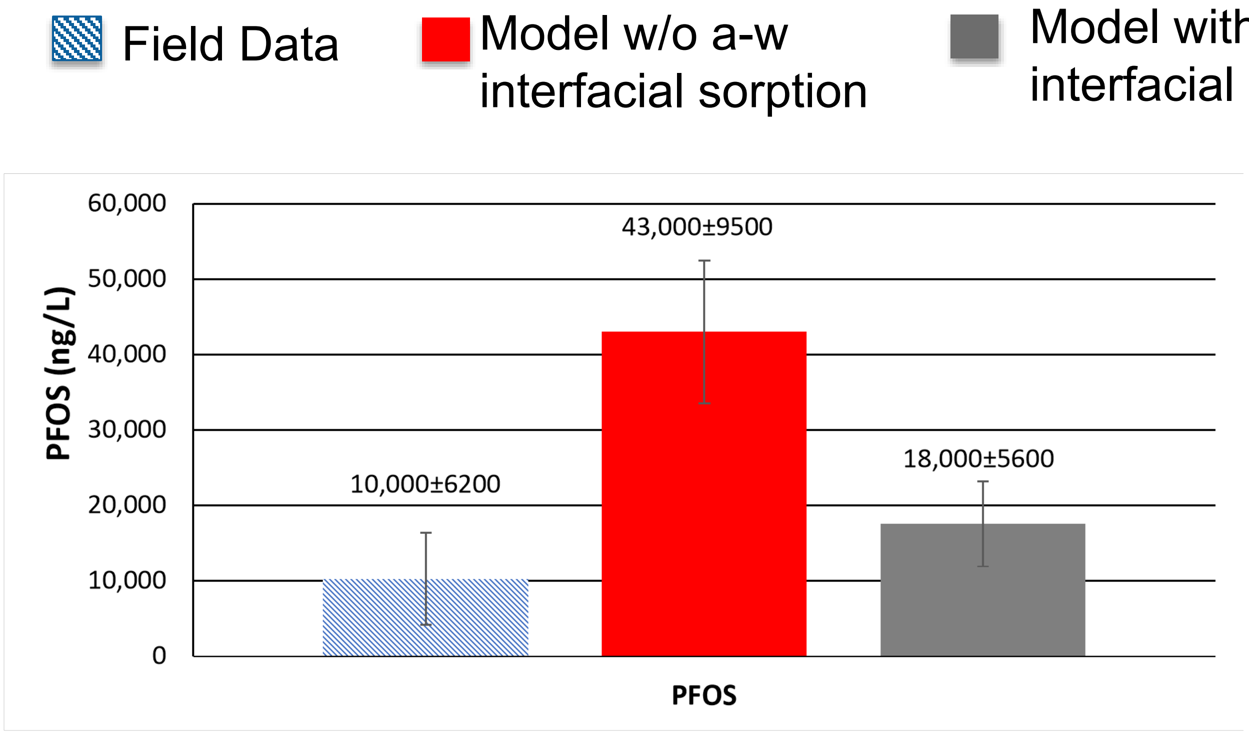


# Initial 3 Rounds of Lysimeter Sampling (Ambient)




*Average of 3 rounds from 4 deep and 4 shallow lysimeters*

# Model Predictions Compared to Field Lysimeter Data




$$M_T = M_w + M_s + M_{aw}$$

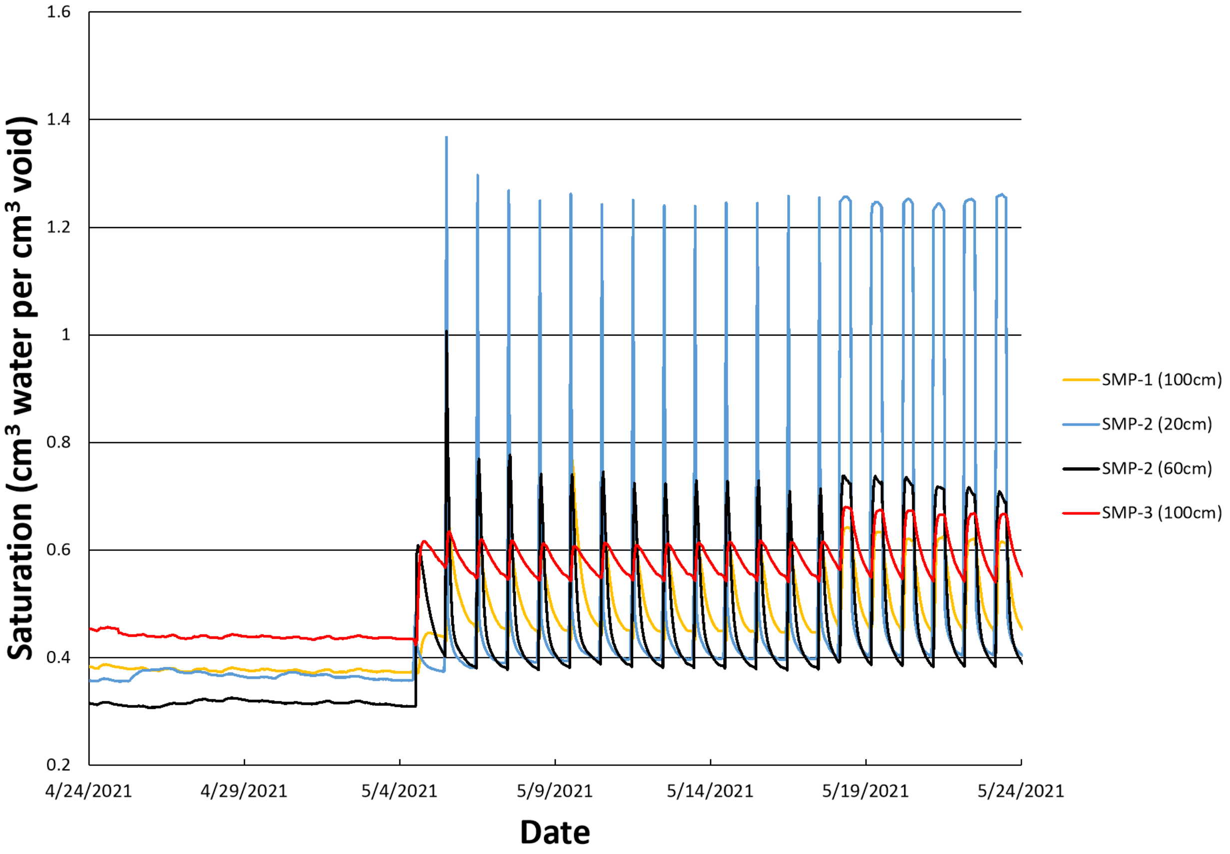
$$K_{aw} = \frac{\Gamma}{C}$$

$$K_d = \frac{C_s - b}{C}$$

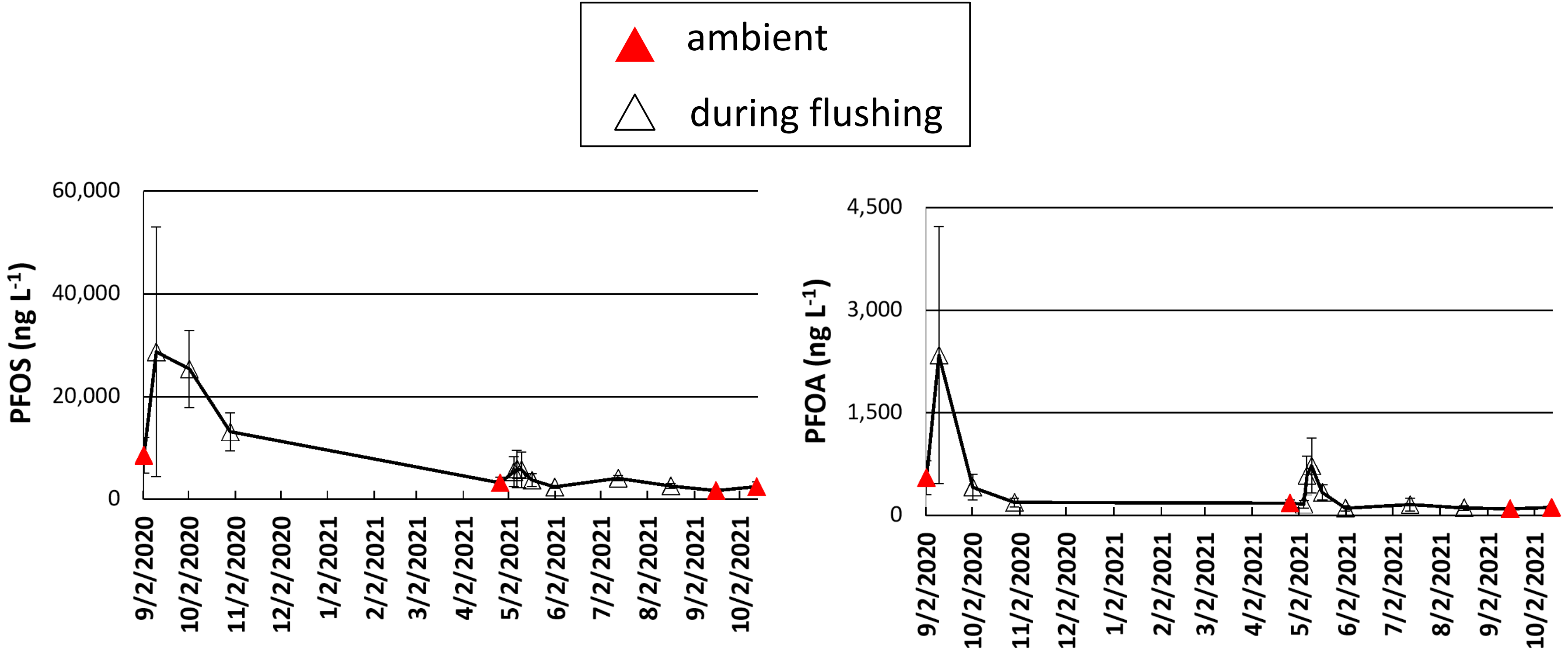
*Schaefer et al., JCH, 2022*

# Soil Flushing

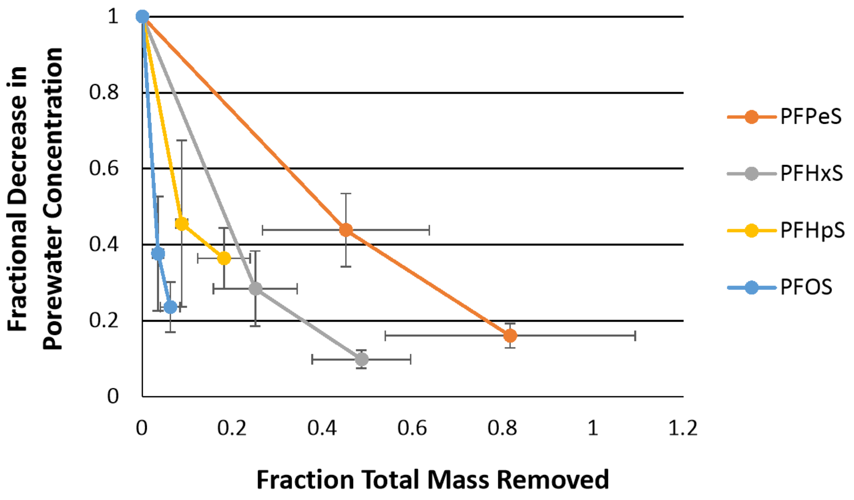
- 154 days flushing via irrigation
- 886 inches rainfall
- Intermittent and final ambient sampling

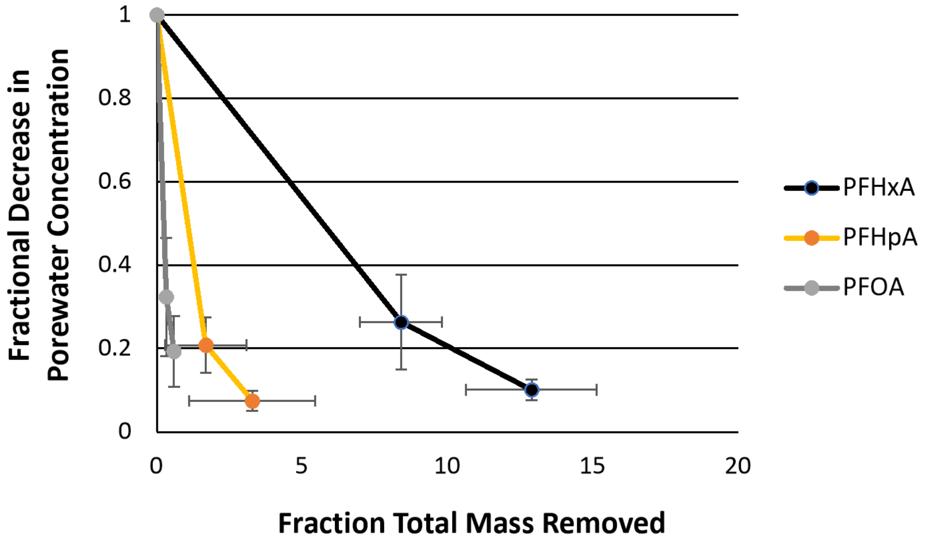


# Results: Flushing



# Results: Perfluorinated Sulfonates & Carboxylates



# Summary

- Kinetic and/or thermodynamic resistance to desorption likely plays a key role in leaching behavior

- Sorption at the air-water interface also likely mitigates mass flux to groundwater for long-chained PFAS

- While PFAS mass is likely to persist in soil for several decades, mass flux to groundwater may diminish much more rapidly

# Acknowledgement

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DOD ▪ EPA ▪ DOE

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