Quick & Dirty?
Mobility of PFAS in Ground and Surface Water:
A Four Site Case Study

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Introduction

A. Why should I care about differential PFAS retardation?

B. Status of Investigation of PFAS retardation

C. Factors Influencing Retardation

D. PFAS of Interest

E. PFAS Data Review from 4 Investigation Sites

F. Key Findings

Why differential PFAS Retardation is Important

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- Sensitive receptors normally not present PFAS source zone.
- Sensitive receptors commonly impacted down-gradient at either:
  A. Surface Water Discharge Point
  B. Groundwater Discharge Point
- The retardation of PFOS, PFOA, PFHxS & other PFAS can be multiple orders of magnitude different, particularly in groundwater…
- Remediation clean-up targets for soil @ source zone already consider leachability of PFAS *but they may now also need to consider* differential retardation of PFAS in surface and groundwater.
- i.e We may be worrying about the wrong PFAS!..

PFAS – They don't migrate the same

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- Recent-ish studies have found very few of the PFAS compounds present in groundwater were significant contributors to the AFFF formation (Anderson et a., 2016)
- PFCAs and FTSs are largely absent from AFFF formulations but are among the most prevalent PFAS in groundwater.
- Variable retardation of PFAS is most likely a combination of interfacial adsorption + organic carbon sorption + transformation of pre-cursers.
- Other factors likely to contribute are pH, ionic composition of aquifer, formulation of AFFF, co-contaminants present, remedial actions attempted & the degradation environment.

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Chemosphere

Volume 150, May 2016, Pages 678-685

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

R. Hunter Anderson [a], G. Cornell Long [a], Ronald C. Porter [b], Janet K. Anderson [a, 1]

Modelling of Retardation

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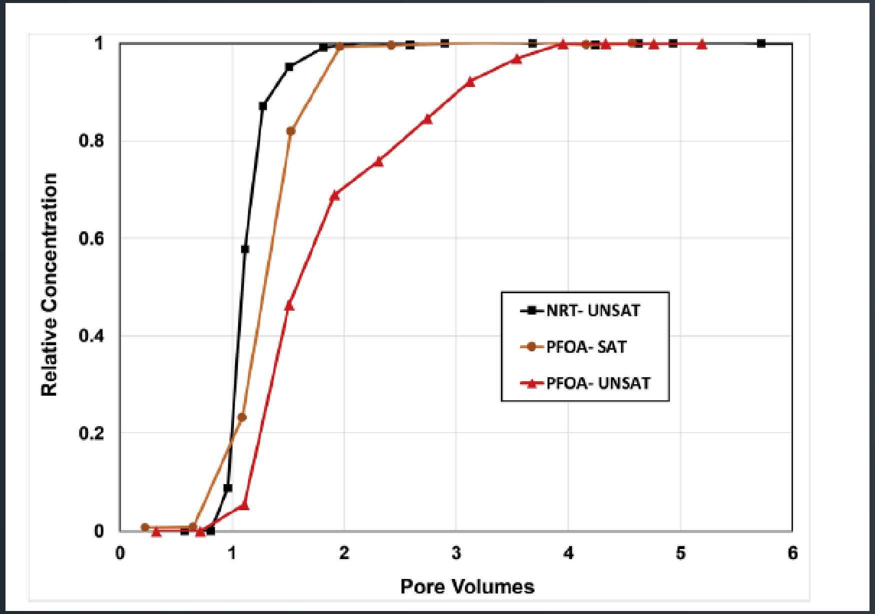
Attempts to model PFAS transport in source zones are now being undertaken (Brusseau et al., 2019).

- PFOS retardation factor in soil: 7.3 unsaturated V 3.6 saturated
- Air-water interfacial adsorption found to contribute **80% of retention in sand** and **32% in soil**.

Comprehensive retention model for PFAS transport in subsurface systems

Mark L. Brusseau [a, b, *], Ni Yan [b], Sarah Van Glubt [a], Yake Wang [a], Wei Chen [a], Ying Lyu [a, c], Barry Dungan [d], Kenneth C. Carroll [d], F. Omar Holguin [d]



- Modelling will improve ability to predict PFAS concentrations at points of discharge in the future.
- However, site specific data of multiple soil horizons / aquifers means precision will remain poor until large databases are made available.

Overview of Four Australian PFAS Contaminated Sites

Soil, groundwater and surface water collated from four Australia sites:

- **Site 1 - Airport**
- **Site 2 - Defence**
- **Site 3 - Energy Sector**
- **Site 4 - Fire Training**

- PFAS impact linked to historical fire training at all sites.
- All unconfined / semi confined aquifers ranging from 1 m to 60 m deep beneath source zones.
- Surface water samples obtained from Creeks / unlined drains between 10m – 4km from PFAS source zone.

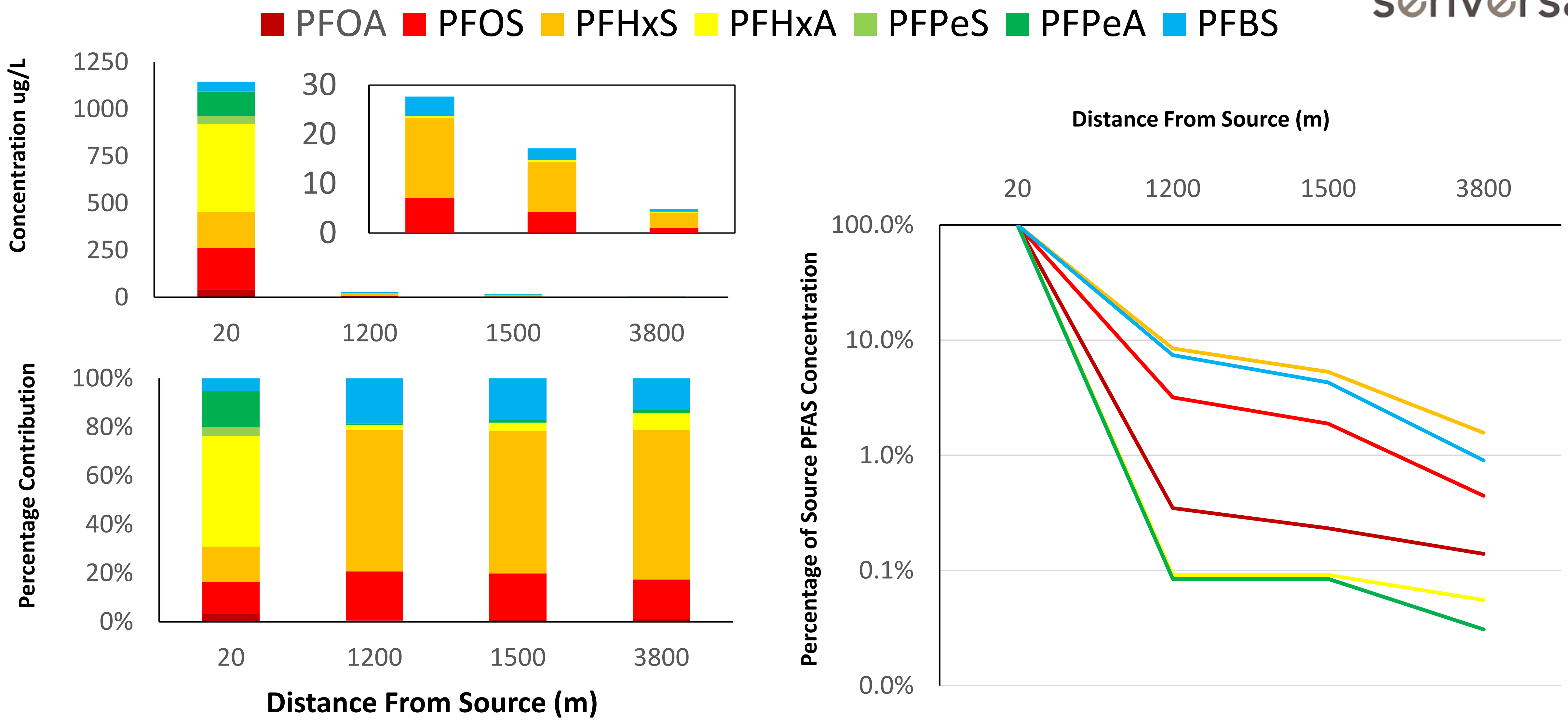
Key PFAS of Interest

Abbrievated Name	Carbon Chain Length	log K_{oc} (ml. g^{-1})	OECD Chain Length
PFOS	8 Carbons	4.2 - 4.5	Long-chain PFSA
PFOA	8 Carbons	1.89 - 3.5	Long-chain PFCA
PFHxS	6 Carbons	2.05 - 3.7	Long-chain PFSA
PFHxA	6 Carbons	1.31 - 2.1	Short-chain PFCA
PFPeS	5 Carbons	-	Short-chain PFSA
PFPeA	5 Carbons	1.37	Short-chain PFCA
PFBS	4 Carbons	1.22 - 1.79	Short-chain PFSA

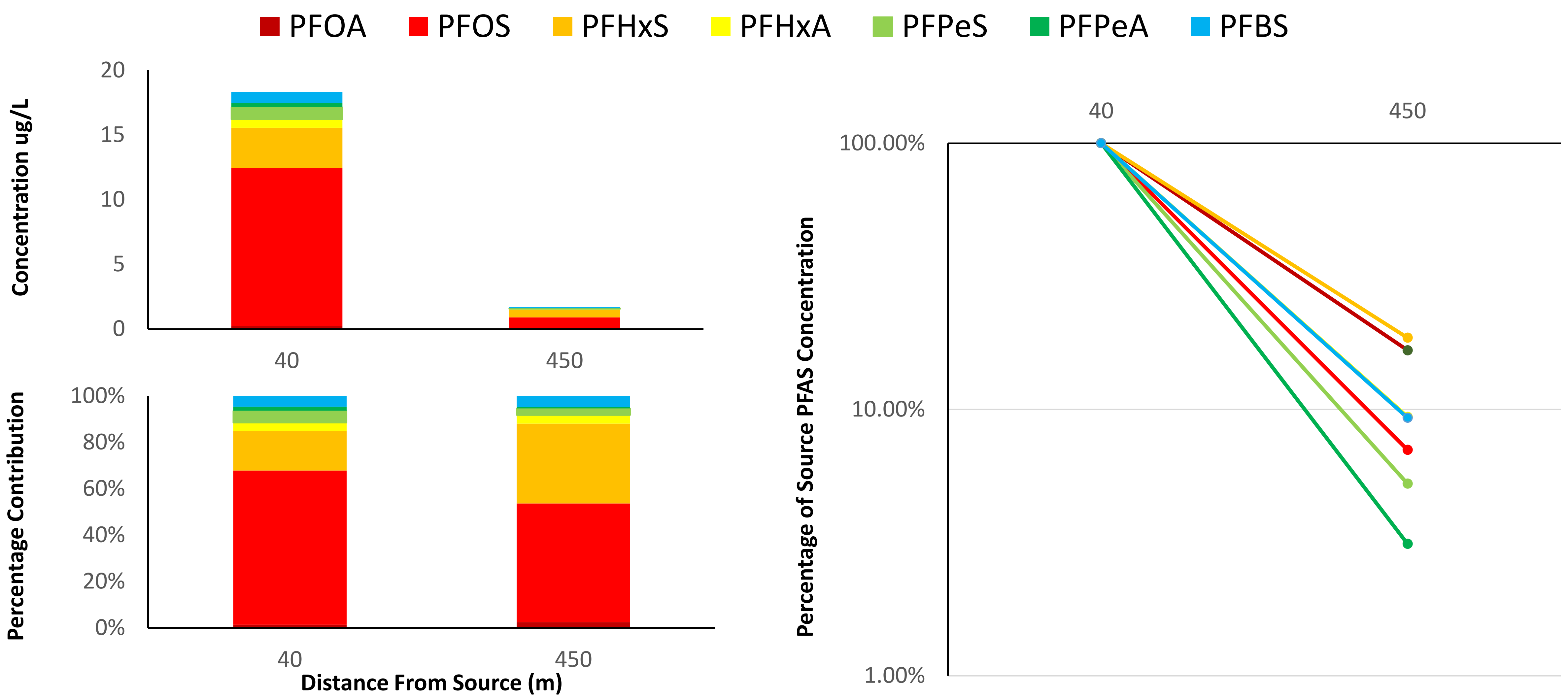
- Consistently present as main PFAS in groundwater at all sites.
- PFHpA, PFHpS and 6:2 FTS also present in groundwater on most sites, but not all.

Short-chain PFCAs				Long-chain PFCAs				
PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
PFBS	PFPeS	PFHxS	PFHpS	PFOS	PFNS	PFDS	PFUnS	PFDoS
Short-chain PFSAs		Long-chain PFSAs						

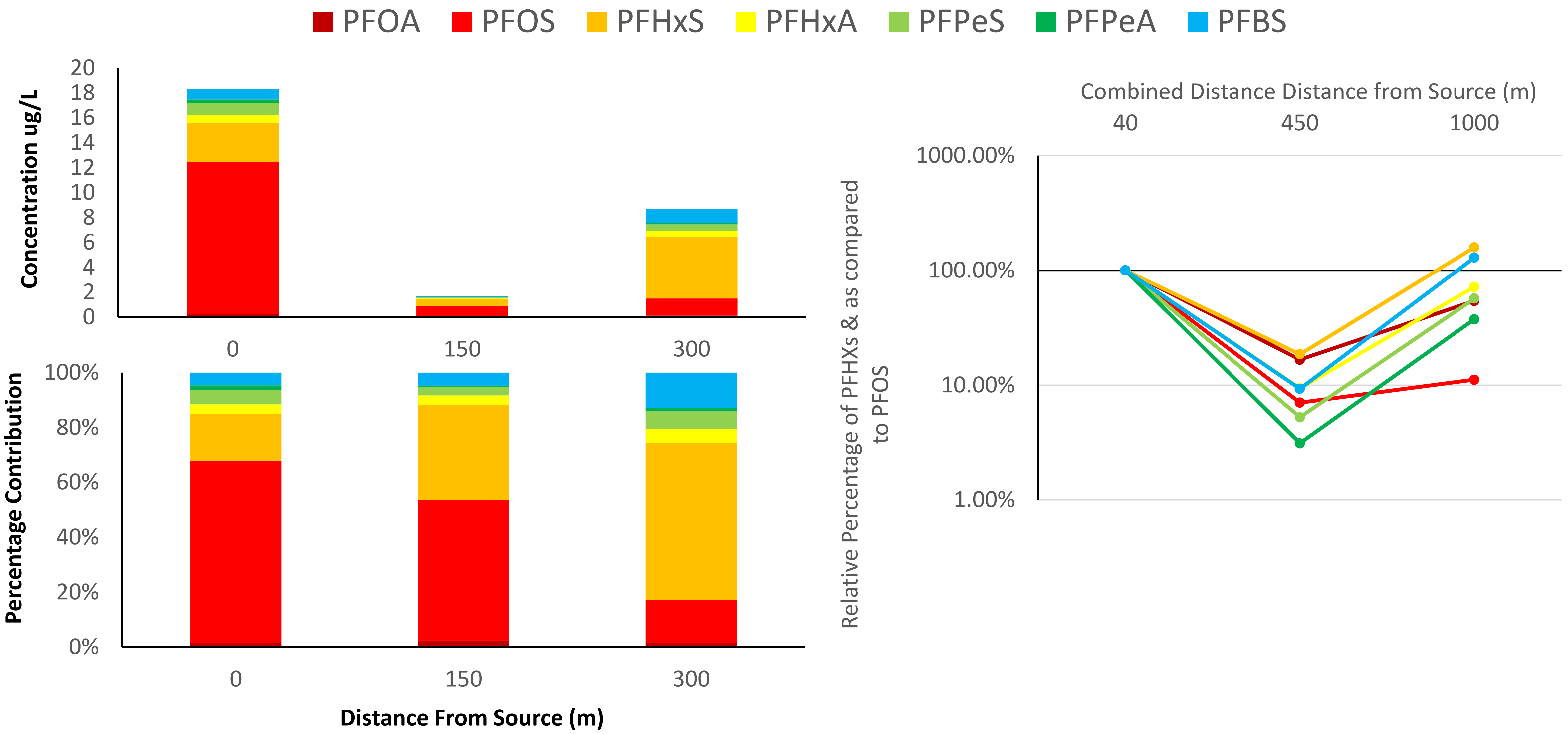
Site 1 Airport: Surface Water



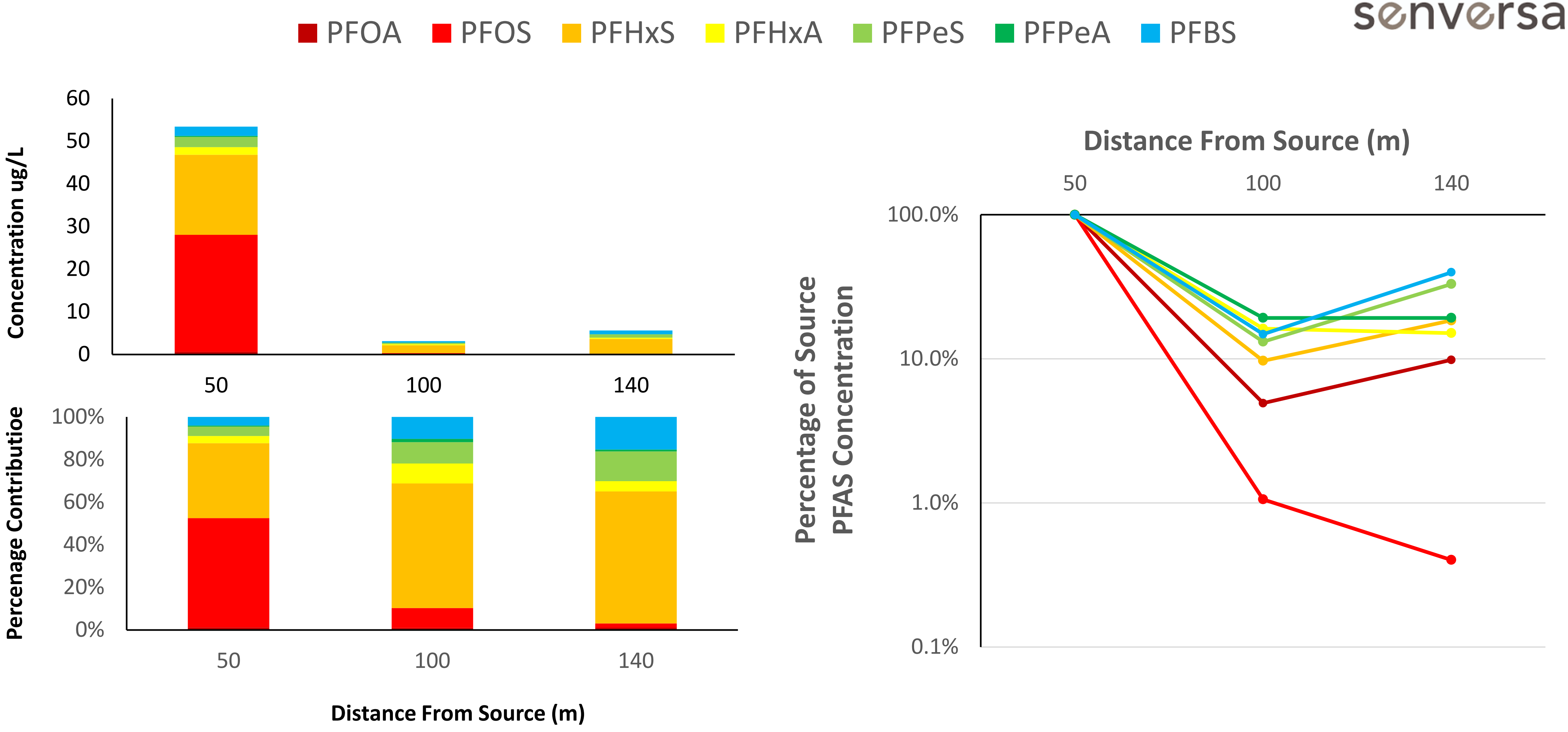
Site 1 Airport: Groundwater



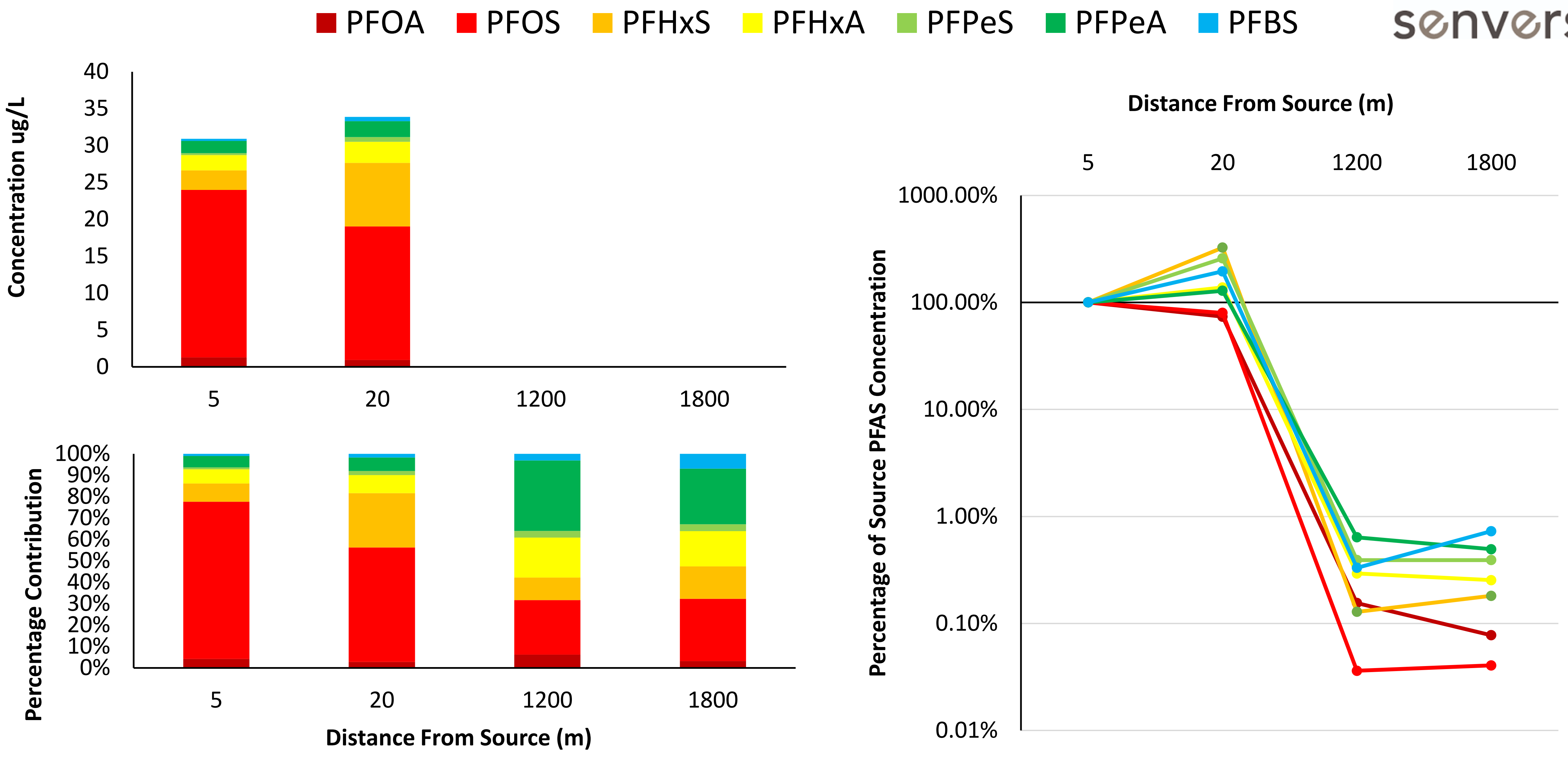
Site 2 Defence: Surface Water



Site 2 Defence: Groundwater



Site 3 Energy: Surface water



Site 3 Energy Sector: Groundwater

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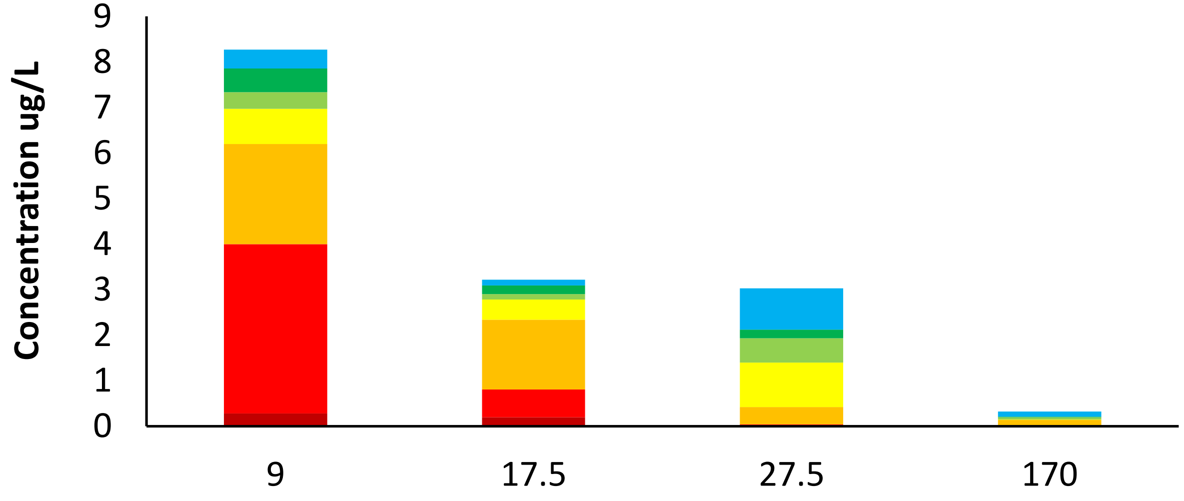
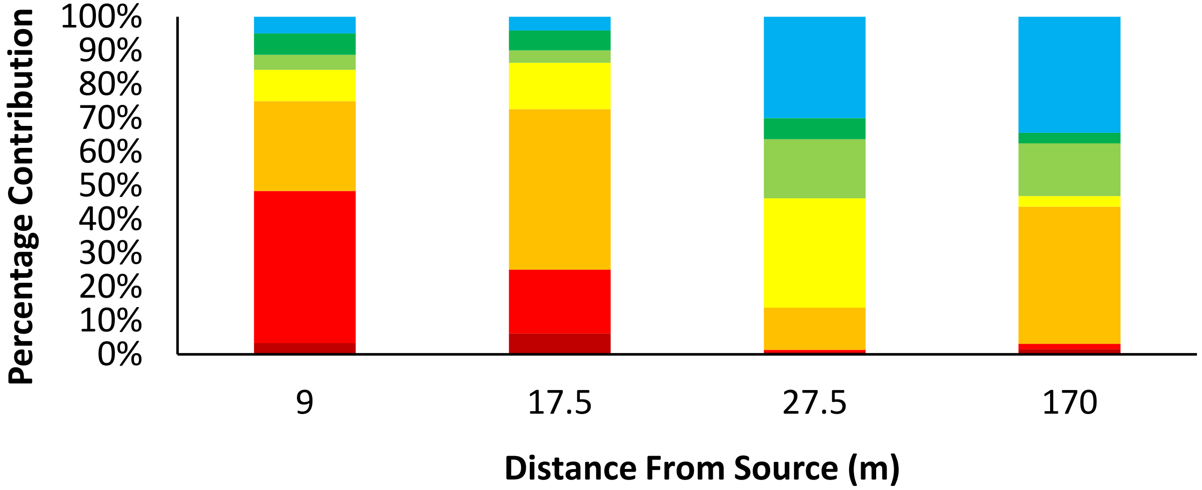
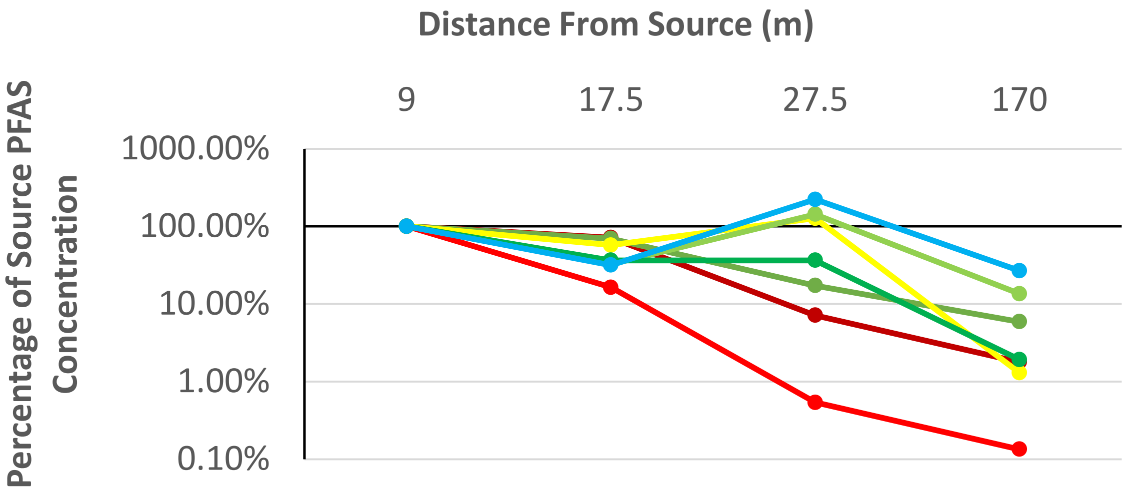
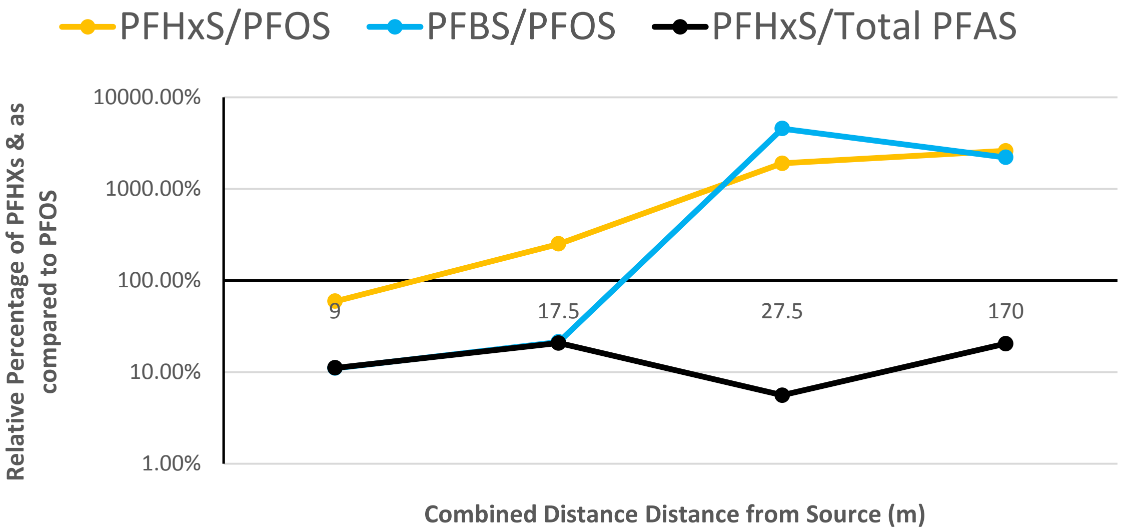
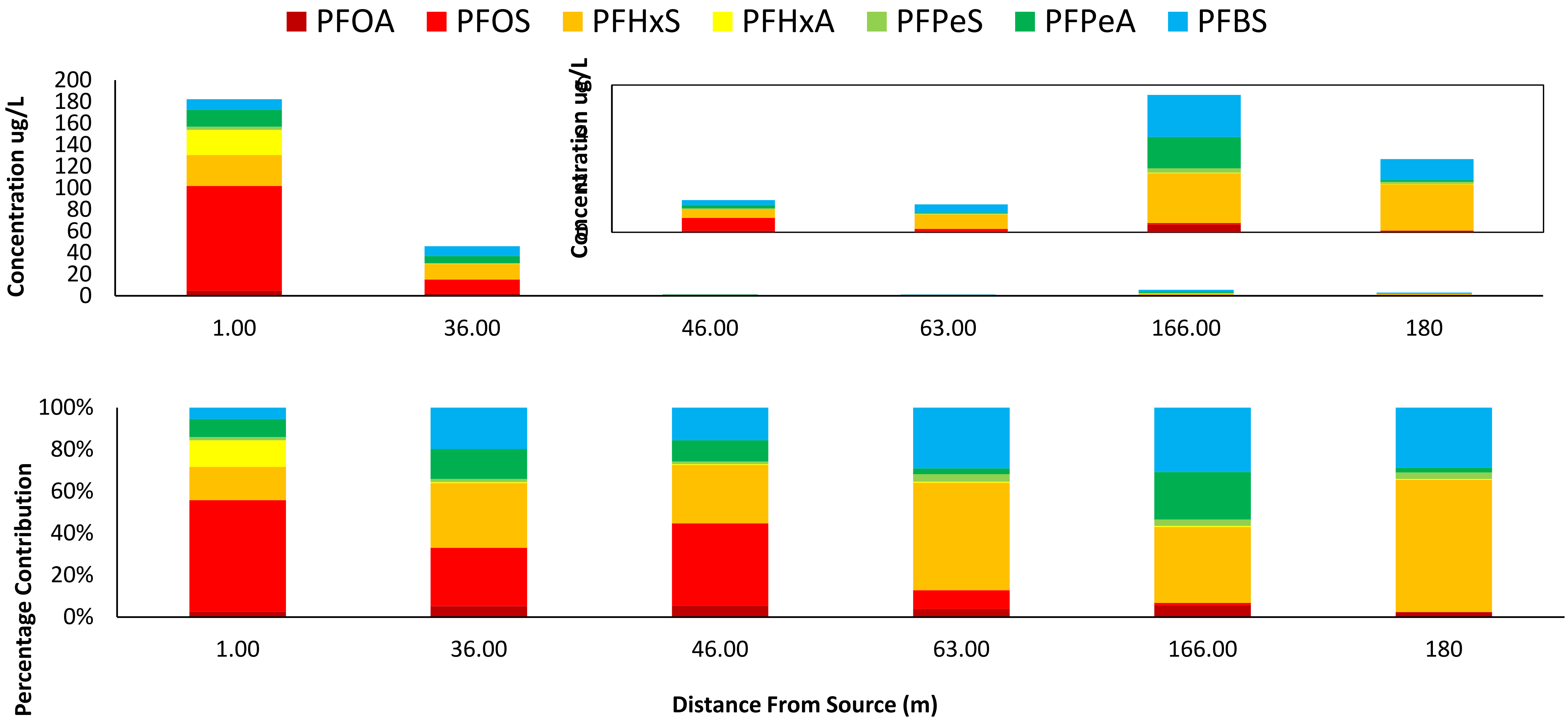




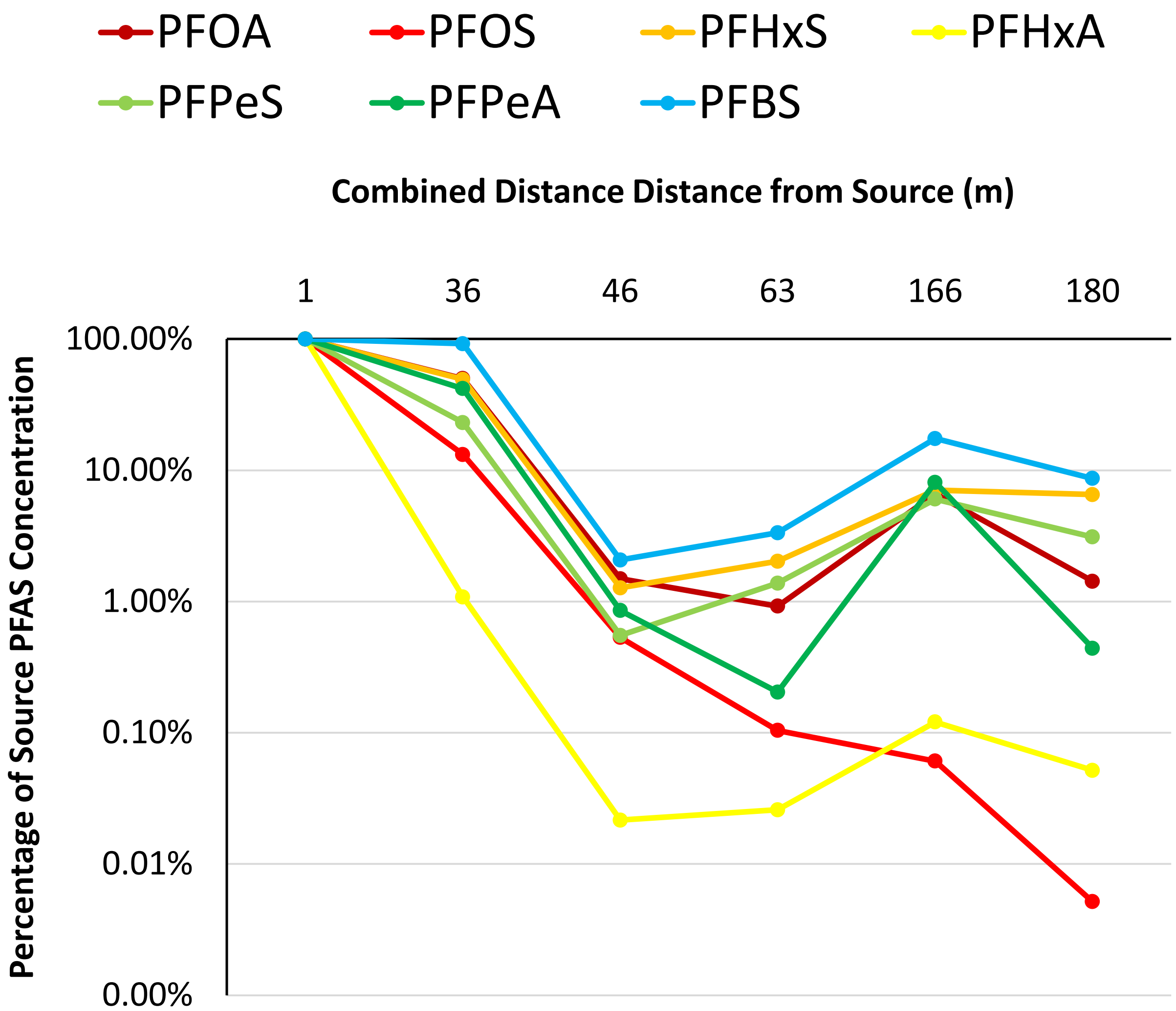


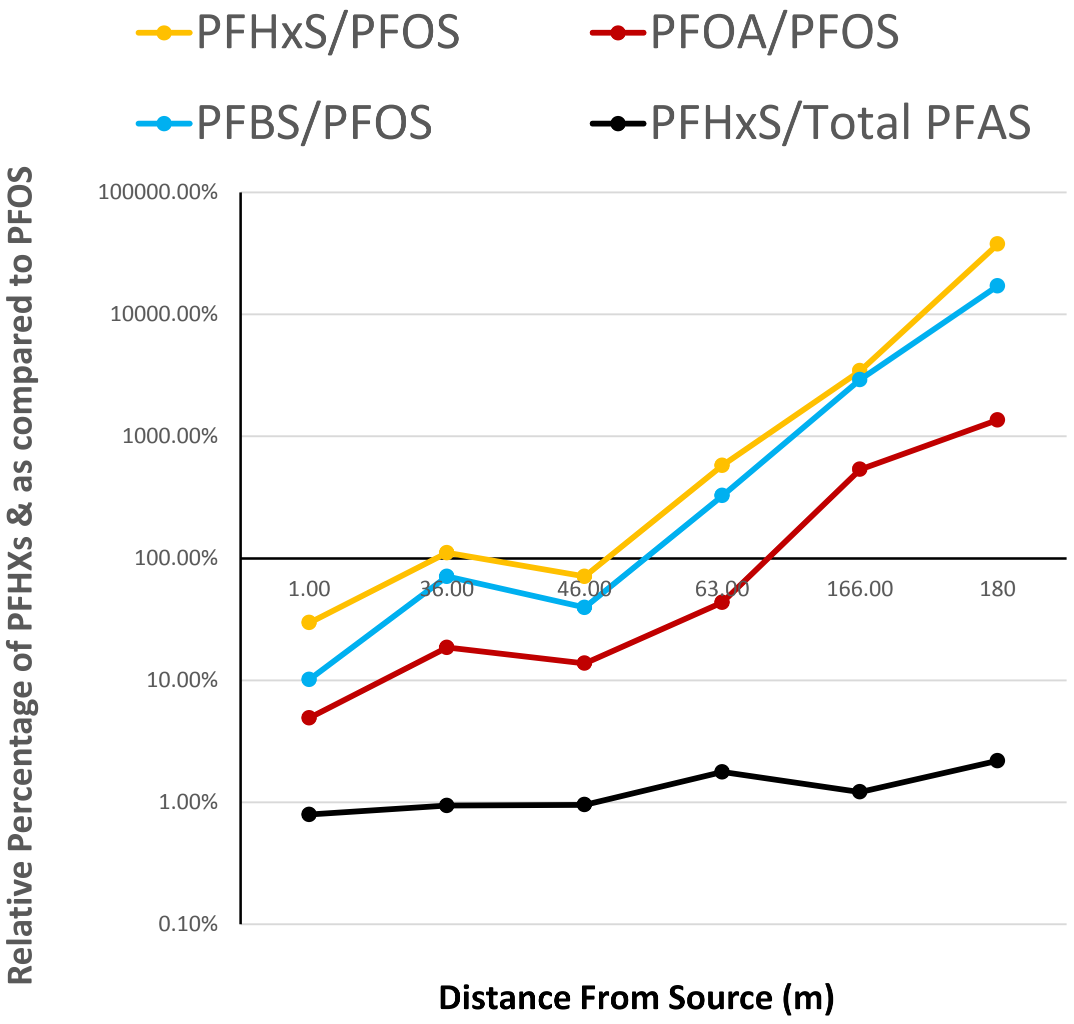


Site 4 Fire Training: Groundwater



Site 4 Fire Training: Groundwater





PFAS Retardation Findings

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- PFHxS was retarded significantly less than PFOS in surface water and groundwater at all four site.
  - Between 50 and 80,000 times less retardation in groundwater.
  - Between 2 and 100 times less retardation in surface water.
- PFOA was consistently less retarded than PFOS in both surface and groundwater.
- PFHxA was unexpectedly present at lower concentrations on 2 of 4 sites.
- Retardation in groundwater was consistent with chain length in 2 of 4 sites.
- Less consistent and lower rates of retardation of PFAS in surface water.

Key Points

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A. Consistent evidence of differential retardation of PFAS compounds in groundwater and surface water. In particular increased concentrations of PFHxS relative to PFOS.

B. Further work required to understand / quantify factors impacting migration.

C. Higher concentrations of PFOS as compared to PFHxS may be able to remain in source areas due to higher retardation of PFOS and lower likelihood of impacting sensitive receptors.

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