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FATE AND TRANSPORT OF PFAS IN SURFACE WATER AND SEDIMENTS

Potential for Long Range Transport?

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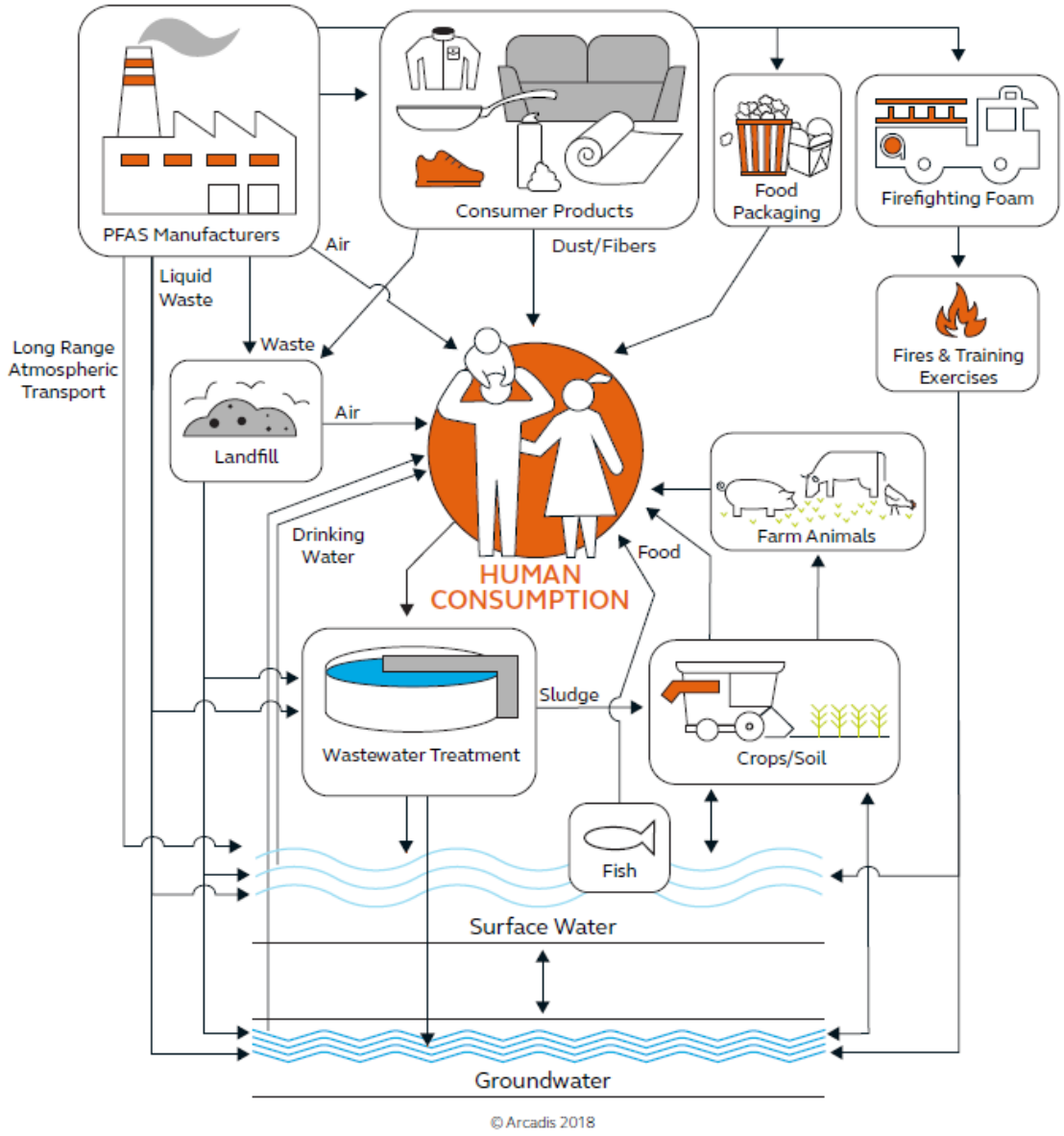
Presentation Overview

- Introduction
- Partitioning Properties and Transport Behavior
- Background Concentrations
- Case Studies and General Observations
- Keys to Conceptual Site Model (CSM) Development



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Poly- and Perfluoroalkyl Substances (PFASs)

More Commonly Regulated

Polyfluorinated compounds (over 4,000 compounds)

Perfluorinated Compounds (PFCs) aka Perfluoroalkyl Acids (PFAAs)
~25 common individual compounds but ~100's compounds
PFOS ,PFOA, PFHxS, PFBA, GenX

Microbial / Higher Organism Biotransformation

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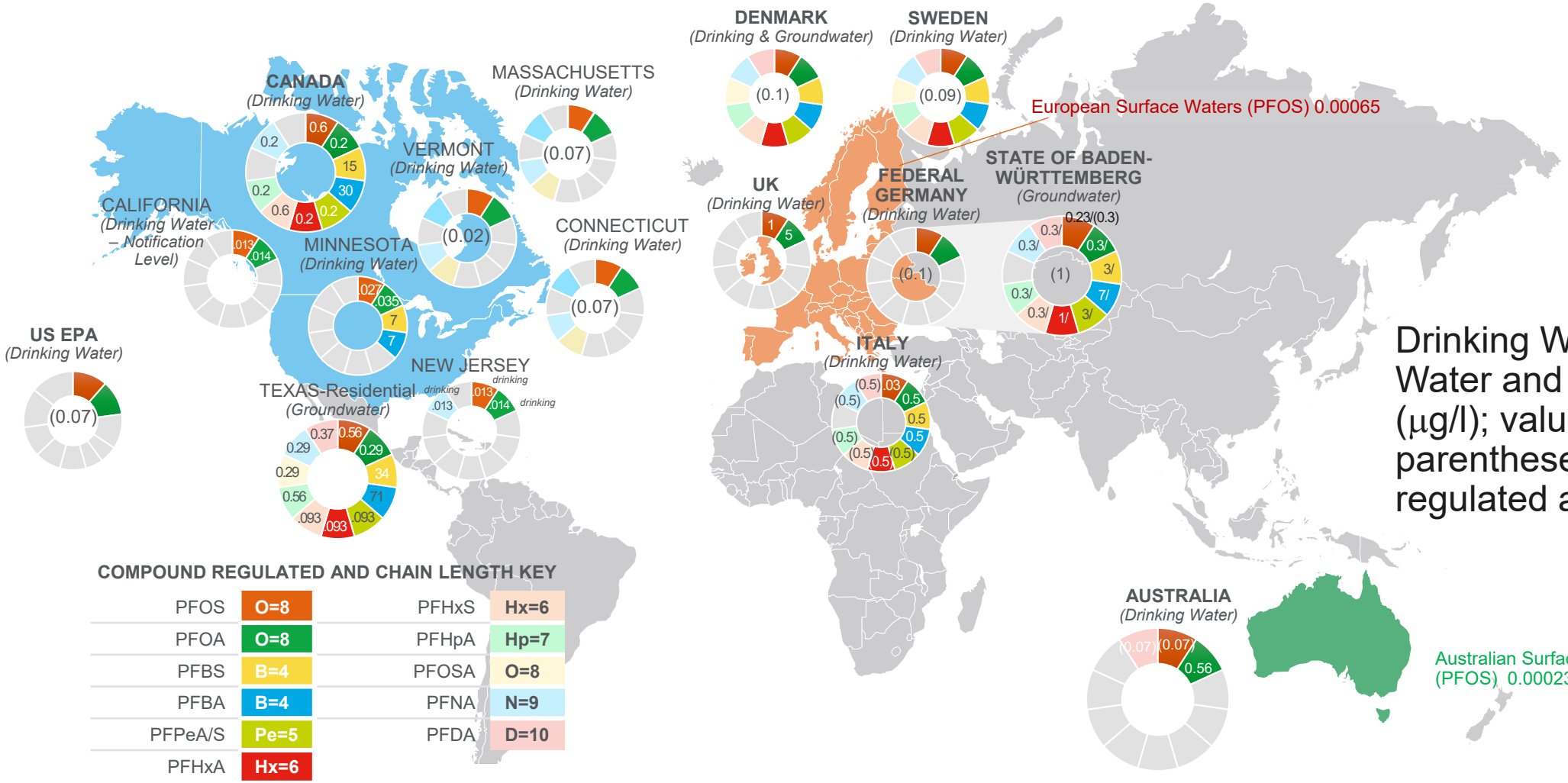
Evolving Regulatory PFAS Values



Drinking Water, Surface Water and Groundwater (µg/l); values in parentheses are regulated as a sum

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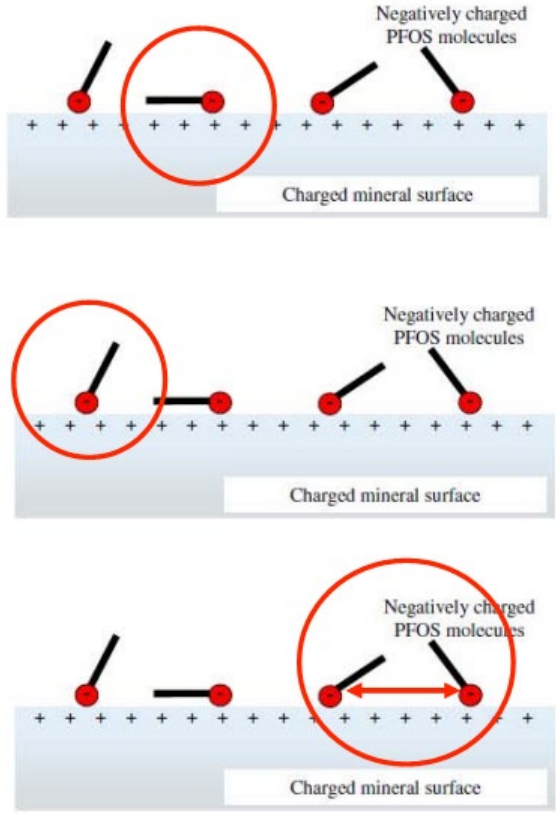
Partitioning Properties and Transport Behavior

Retardation of PFAS

- Hydrophobic interaction
  - Predominant sorption mechanism for long chain PFAS
  - ~0.5 log Koc increase for each CF_2 group (Higgins & Luthy 2006, ES&T)
  - Organic rich soils retard movement of PFAS
  - f_{oc} increases -> K_d increases
  - Oil and other organics may also increase sorption
- Electrostatic effects
  - Positively charged PFAS (*i.e.*, some precursors) sorb to negatively charged minerals
  - Negatively charged PFAS sorb to positively charged minerals
  - Electrostatic repulsion can decrease PFAS sorption
  - High ionic strength dulls electrostatic repulsion and attraction



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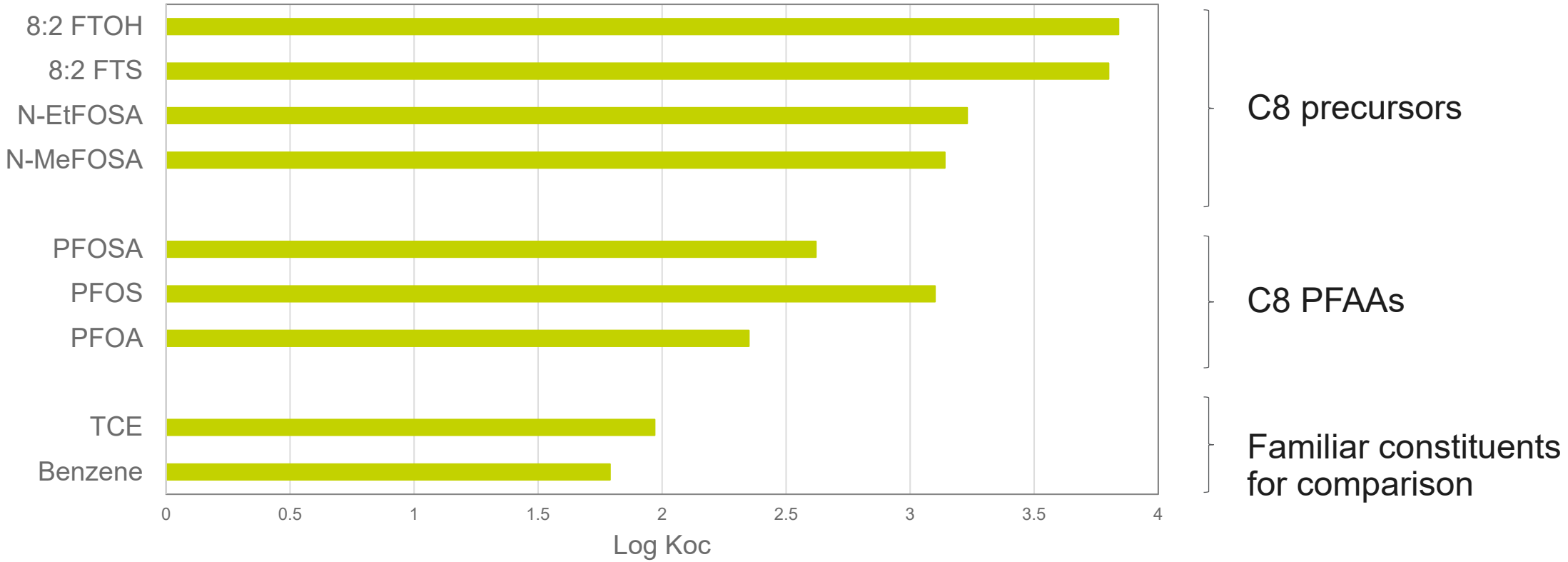
Comparison of Log Koc



Source: After Guelfo & Higgens, 2013 and references therein.

Some precursors may more readily sorb to soil

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ADD References

PFAA Precursor Transformation Rates

PFAA Precursor		Media	Temperature	Inferred Transformation Half Life	Dead End Transformation Product	
EtFOSE	N-Ethyl perfluorooctan sulfonamideothanol	Marine Sediments Batch Slurry	4°C	44 d		PFOS
		Aerobic biosolids - bottle test	30°C	0.71 d		
SAmPAP Diester	Sulfonamid-based Polyfluoroalkyl Phosphate diester	Marine Sediments - Batch Slurry	4°C	>379 d		PFOS
6:2 FTOH	6:2 Fluorotelmeralcohol	Aerobic contaminated Soil Column	--	1.3 d	PFBA, PFPeA, PFHxA	
		Anaerobic Soil Column	--	>> 200 d	PFHxA	
8:2 FTOH	8:2 Fluorotelmeralcohol	Anaerobic Soil Column	--	145 d	PFOA	

After Held & Reinhard, 2016 and references therein.

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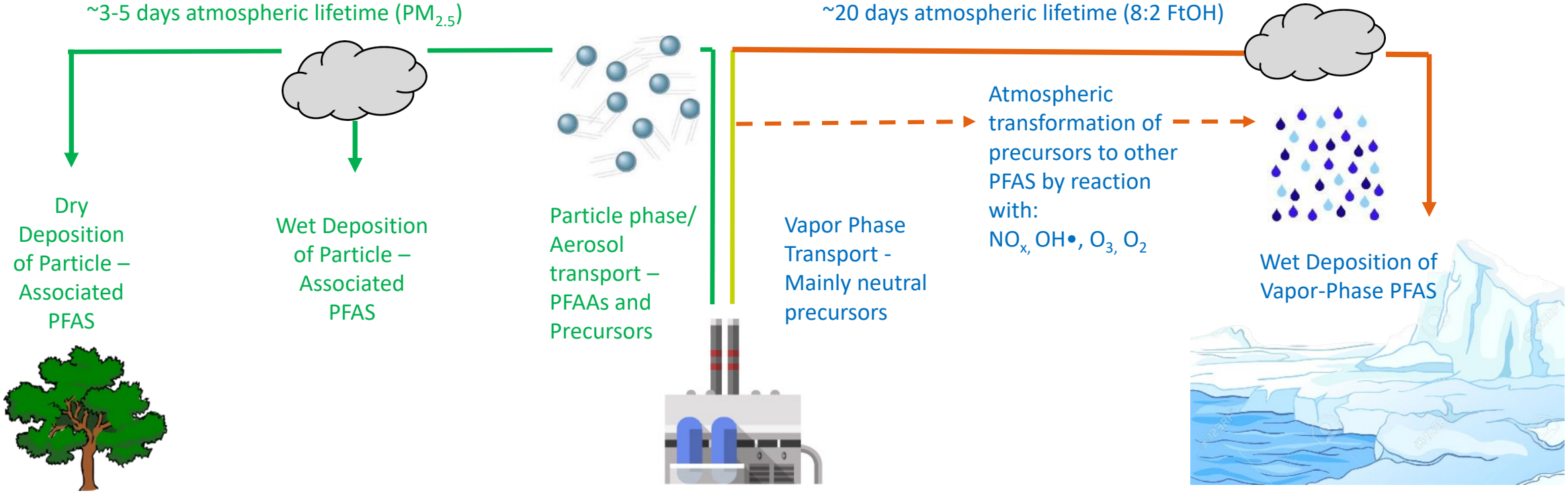
Background Concentrations

PFAS Atmospheric Fate & Transport

Shorter transport potential
~3-5 days atmospheric lifetime ($PM_{2.5}$)

Longer transport potential
~20 days atmospheric lifetime (8:2 FtOH)



PFOA associated with small particles (<0.14 um) and PFOS associated with larger particles (1.38 to 3.81 um) (A. Dreyer et al. Chemosphere 2015)

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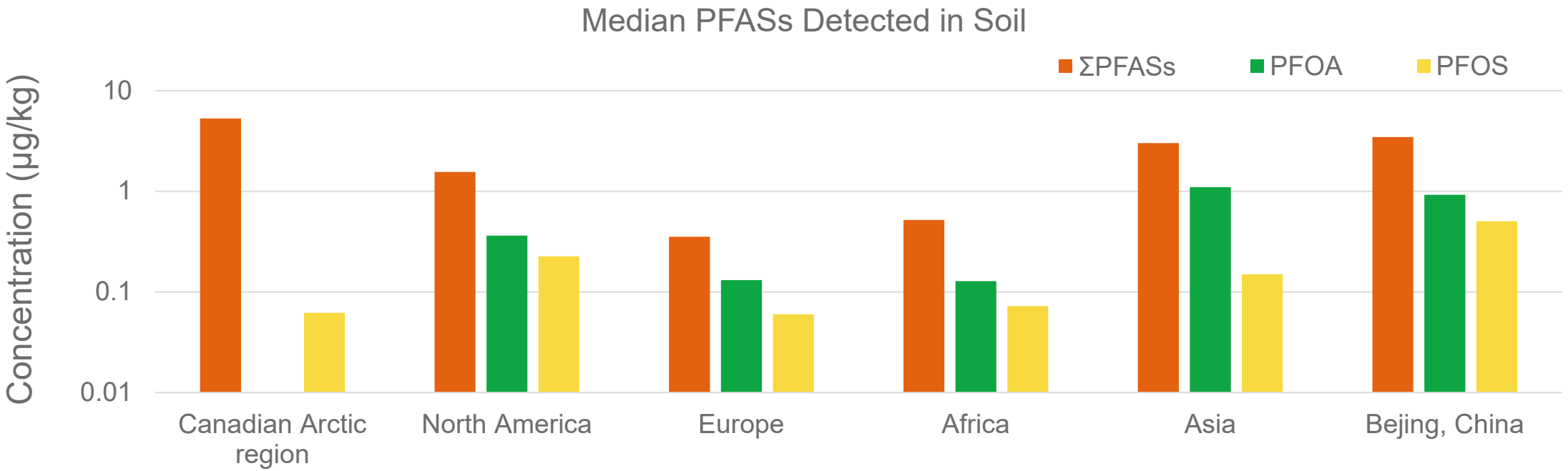
Wide Spread Use and Background Levels in Soil



Sources: Stock et al. 2007, Strynar et al., 2012, Wang et al., 2016

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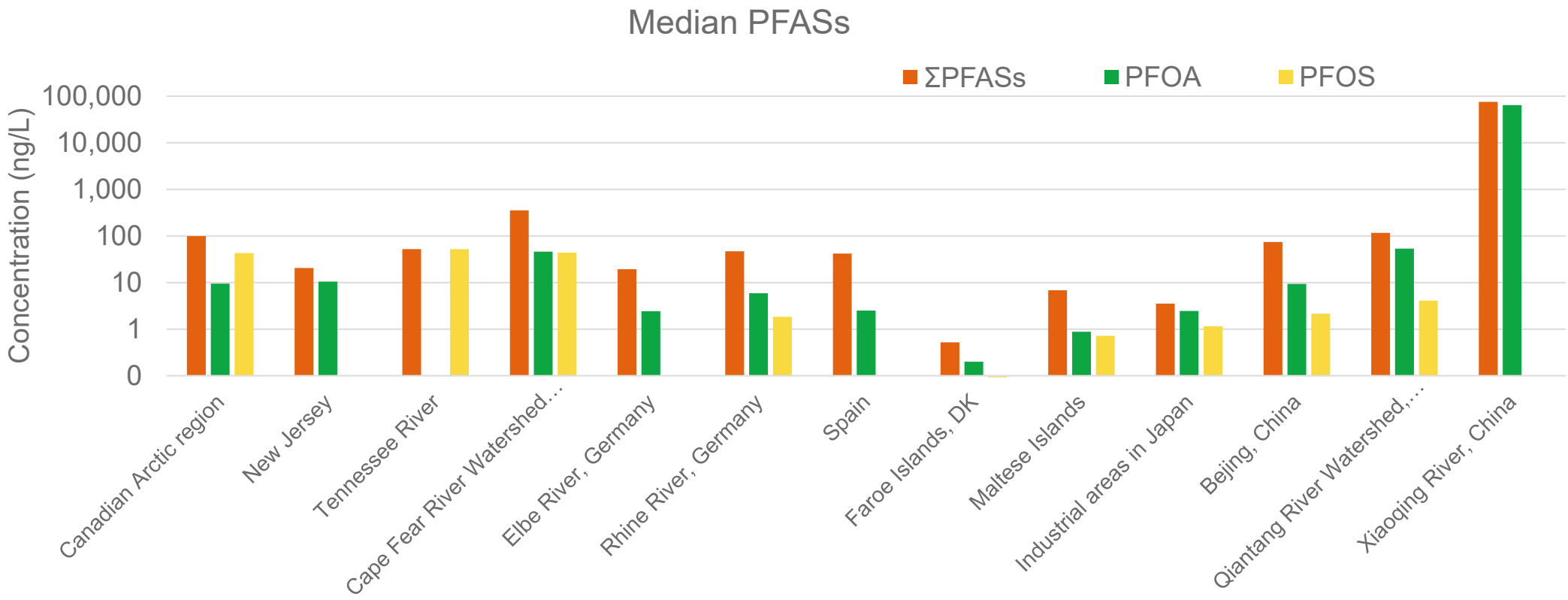
PFASs Detected in Surface Water



Sources: Filipovic et al., 2015, Hansen et al, 2002, Hydebreck et al., 2015, Llorca et al., 2012, Lu et al., 2017, NJDEP, 2014, Saito et al., 2004, Sammut et al., 2017, Stock et al, 2007, Sun et al, 2016, Wang et al., 2016

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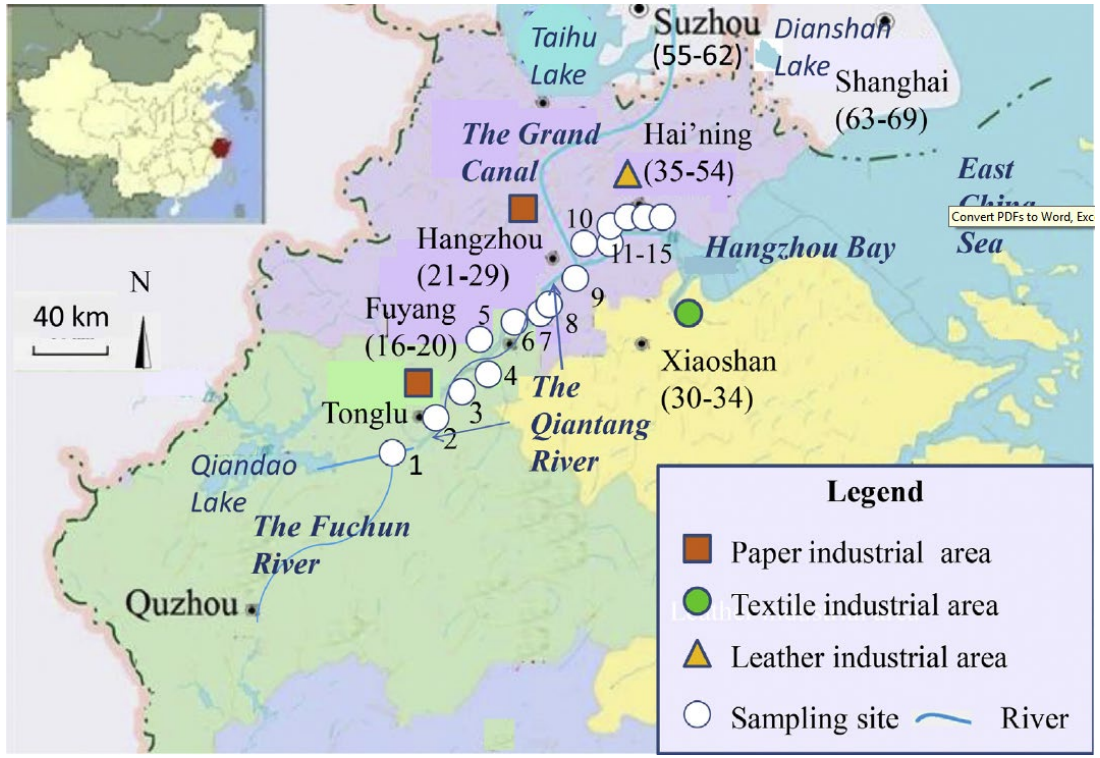
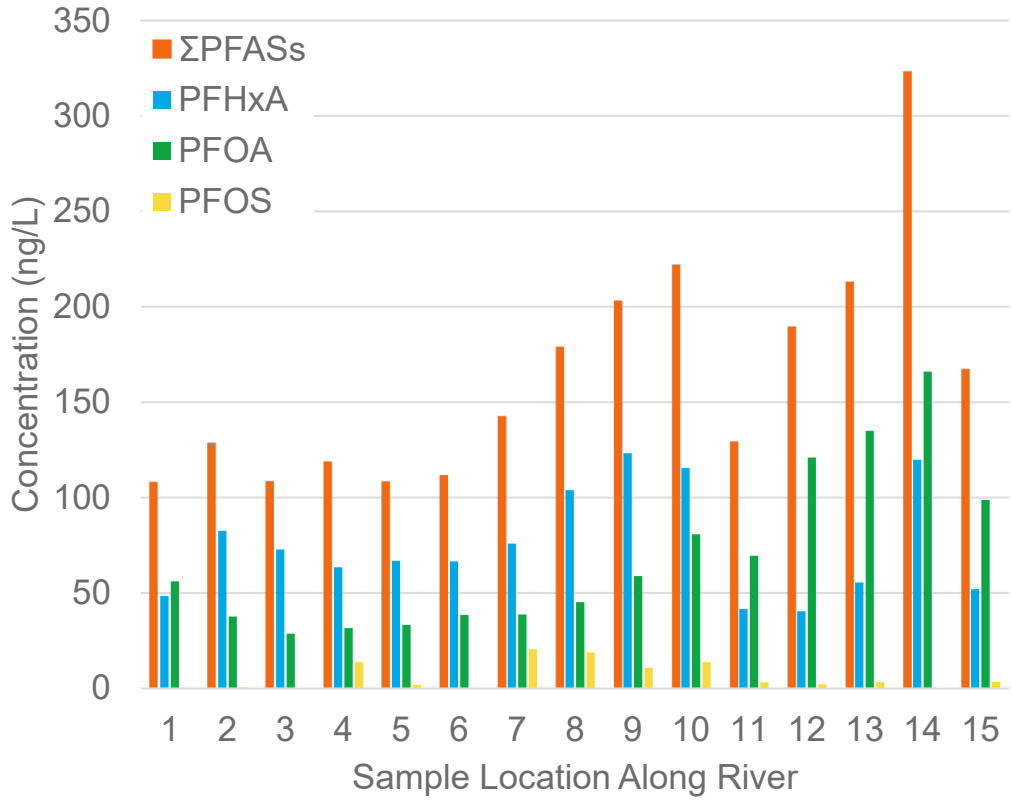
Consideration for Industrial Land Use Scenarios





As presented in G.-H. Lu et al. Chemosphere 185 (2017) 610-617.
http://dx.doi.org/10.1016/j.chemosphere.2017.06.139

Potential for multiple source discharges to surface water

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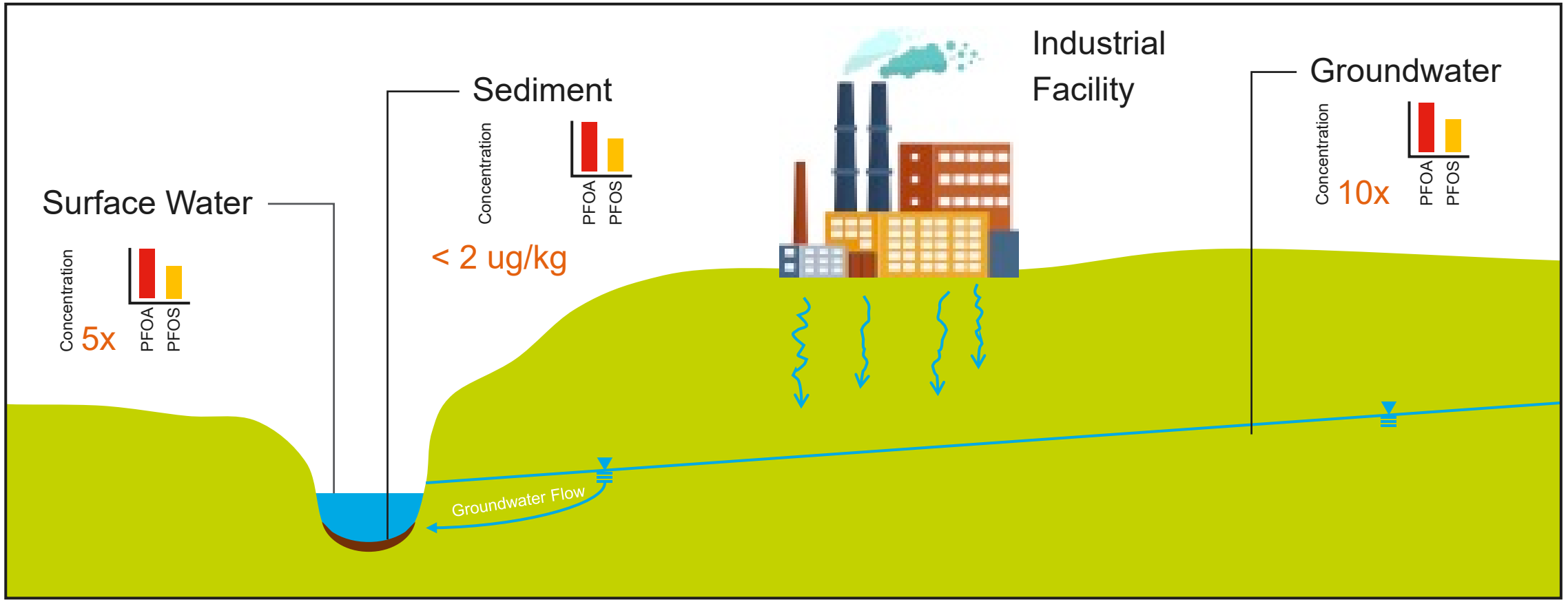
Case Studies and General Observations

PFOS Distribution CSM



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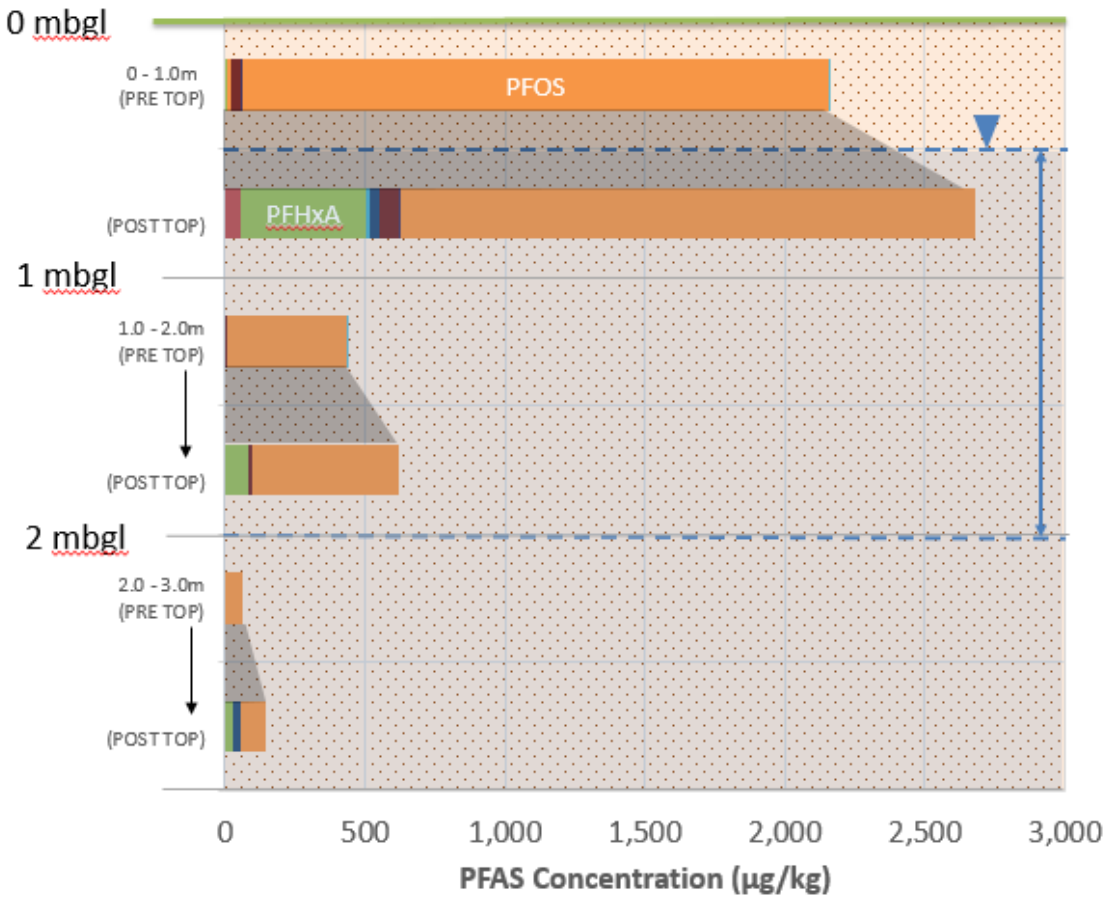
Soil PFAS Profile – Fire Training Area



- Majority of PFAA and Precursors in shallow soil
- 95% of stored mass in top 3 ft of soil
- Implications for sediment erosion and transport
- Simple and cost efficient remediation opportunity

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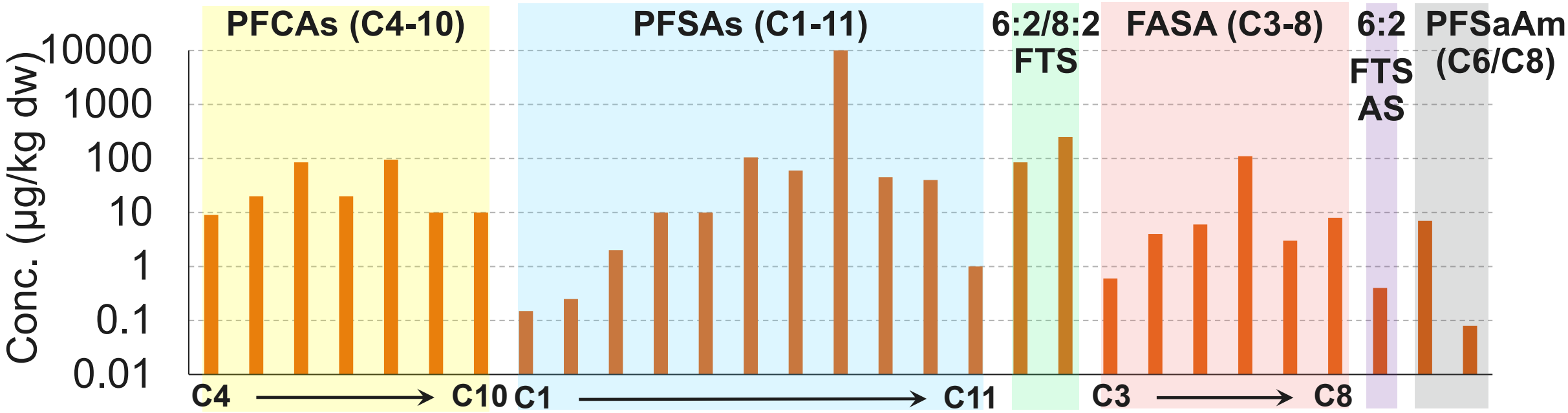
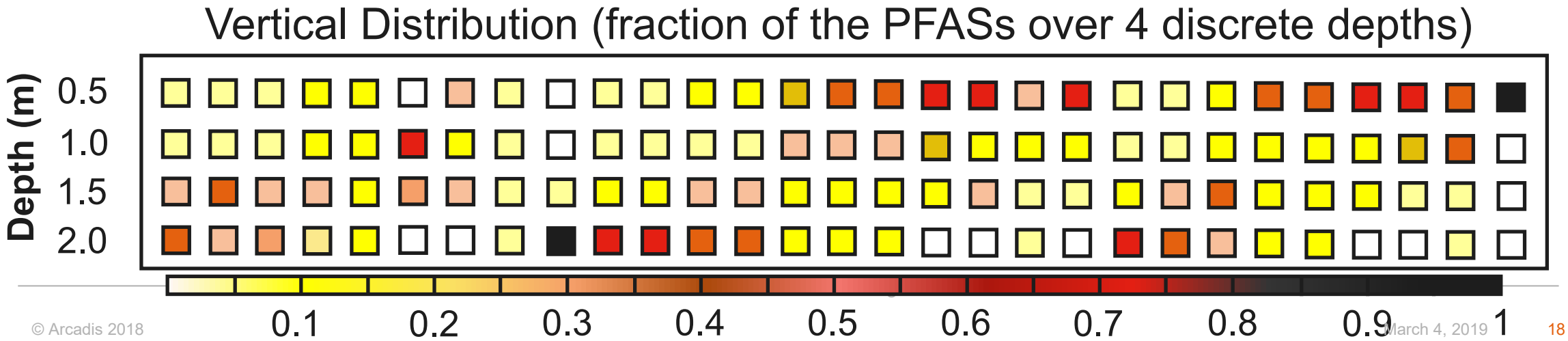
Vertical Distribution of PFASs (4 discrete depths; 2 cores)





Modified after Baduel et al. 2017

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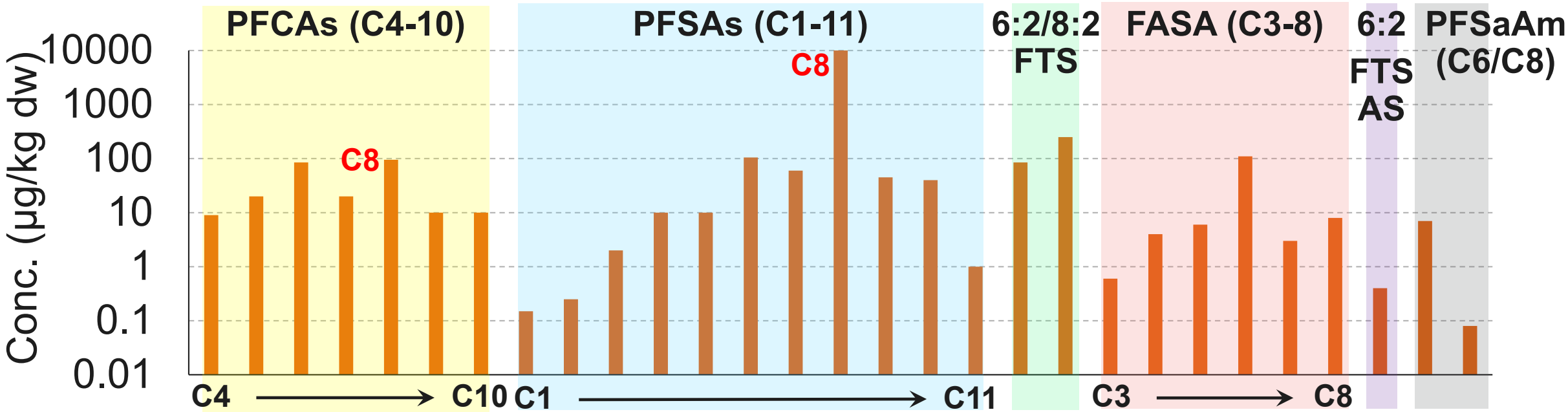
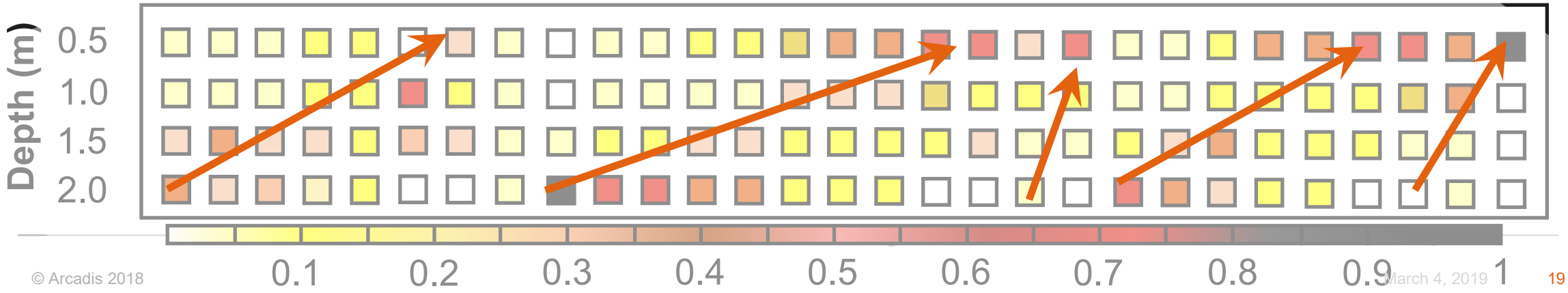


Increased fraction of precursors and long-chain PFAAs at shallow depths



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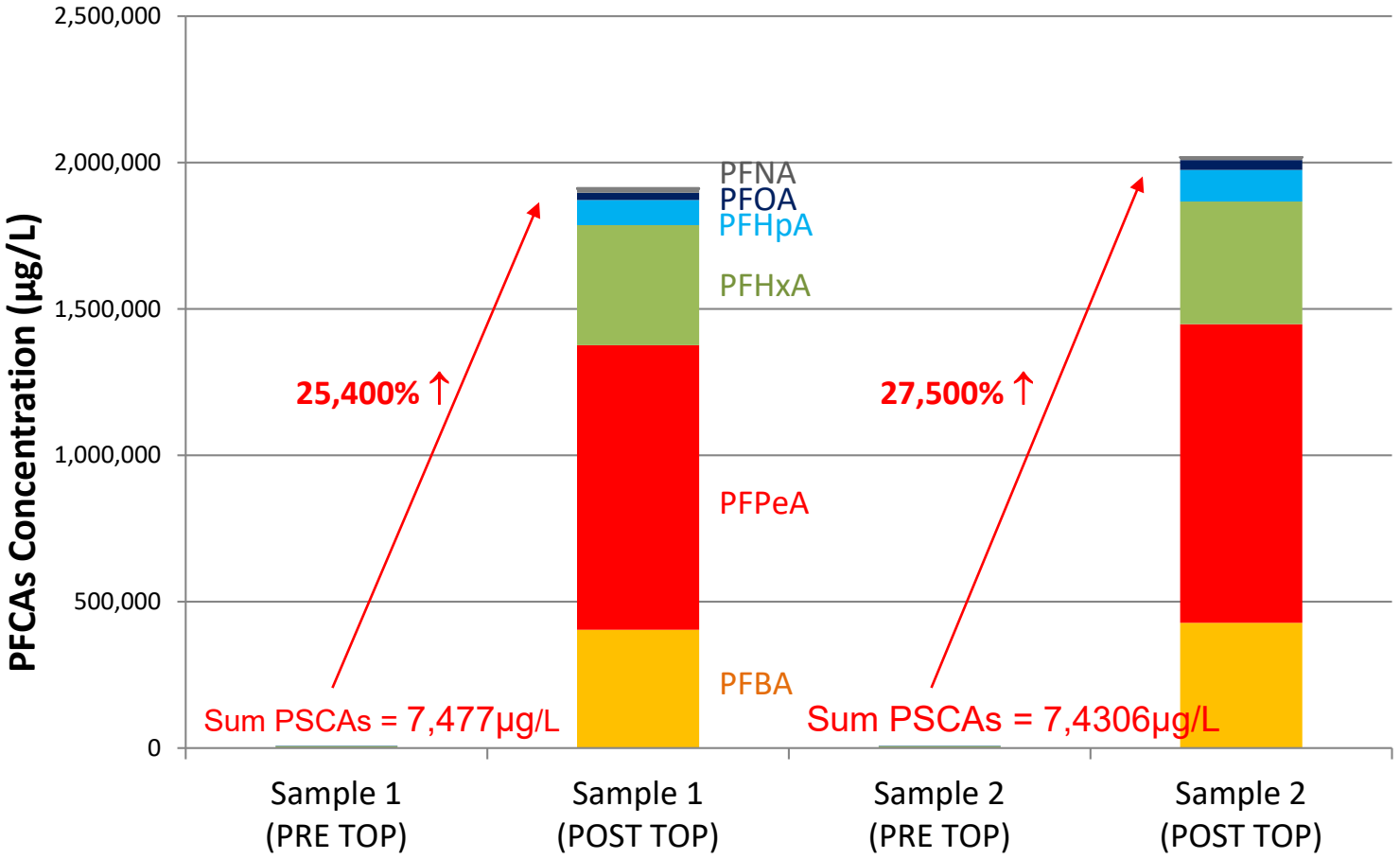
Recent AFFF Spill to Surface Water – TOP Assay



- TOP Assay analysis dominance of PFAA precursors - little time for biotransformation
- Age of AFFF impacts is key factor to consider
- PFPeA > PFHxA and PFBA post TOP indicates C6 ECF foam

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Summary

- Sediment sorption – differences between short-chain and long-chain compounds
- Surface water transport – potential for long range migration driven by Groundwater/surface water discharge relationship
- Erosion and sediment transport – potential for exporting source mass further downgradient

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