



Innovation that provides
sustainable solutions to
complex challenges worldwide

Environmental Forensics Applied to Per- and Polyfluoroalkyl Substances (PFAS)



April 9, 2018

Jim Hatton, Principal Technologist, Jacobs
Bill DiGuseppi, Global Emerging Contaminants
Practice Leader, Jacobs

CH2M is now Jacobs

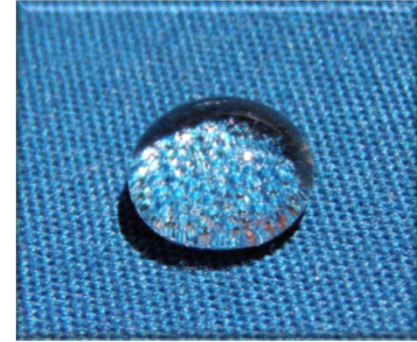
JACOBS[®]

www.jacobs.com | worldwide

Introduction/Topics

PFAS – Synthetic Organic Compounds with adverse health effects, detected in a number of drinking water supplies

- Important Considerations in Differentiating Sources
 - Sources of PFAS
 - Test Methods
 - Transformation
- Field Examples



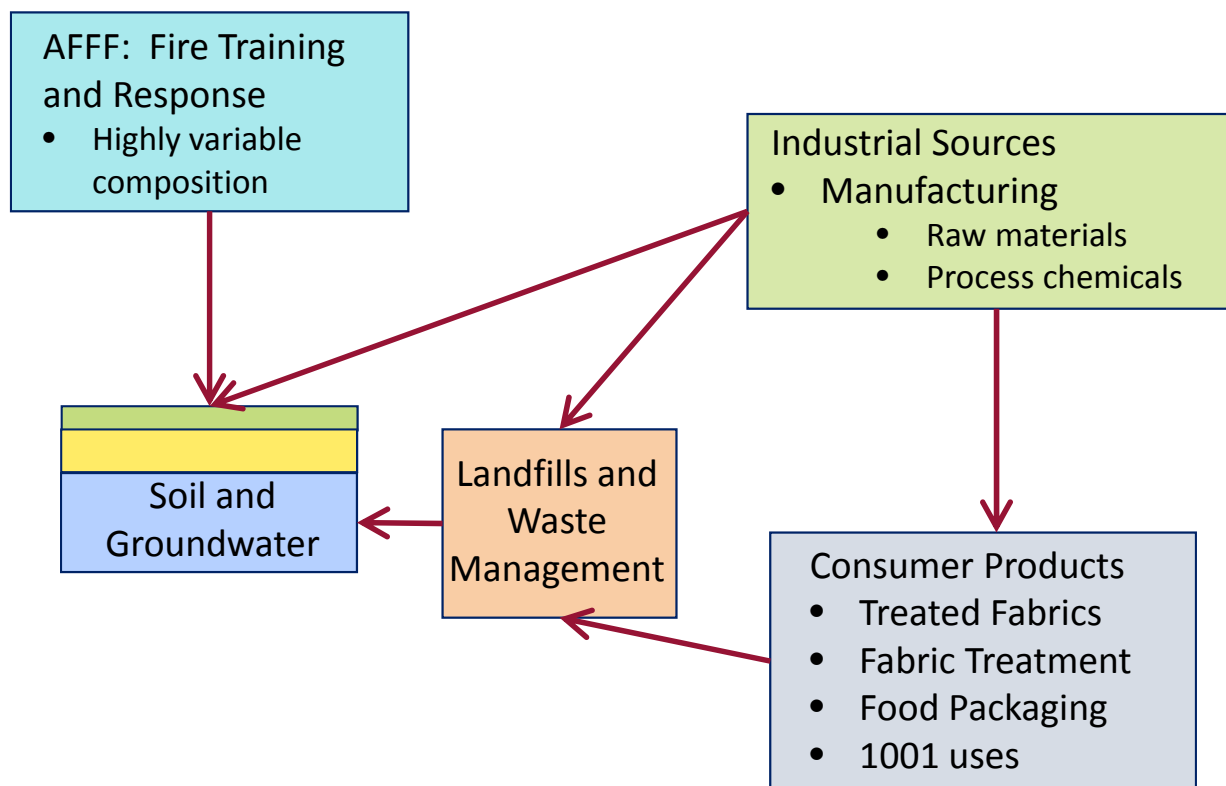
Innovation that provides
sustainable solutions to
complex challenges worldwide

Environmental Forensics Applied to Per- and Polyfluoroalkyl Substances (PFAS) - Considerations



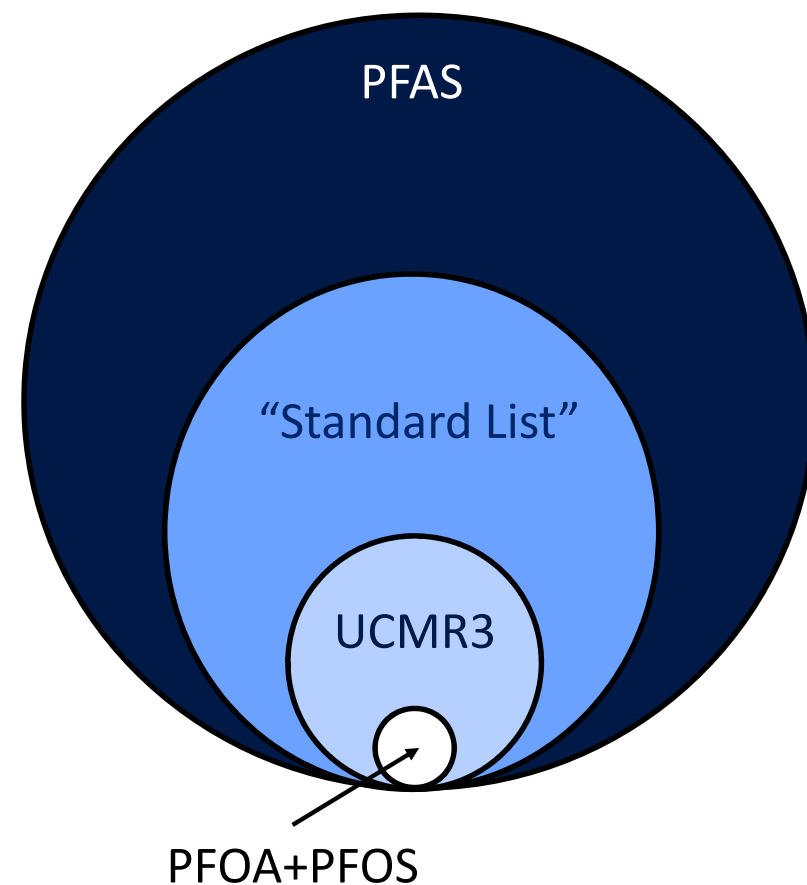
JACOBS

Sources of PFAS in Soil and Groundwater



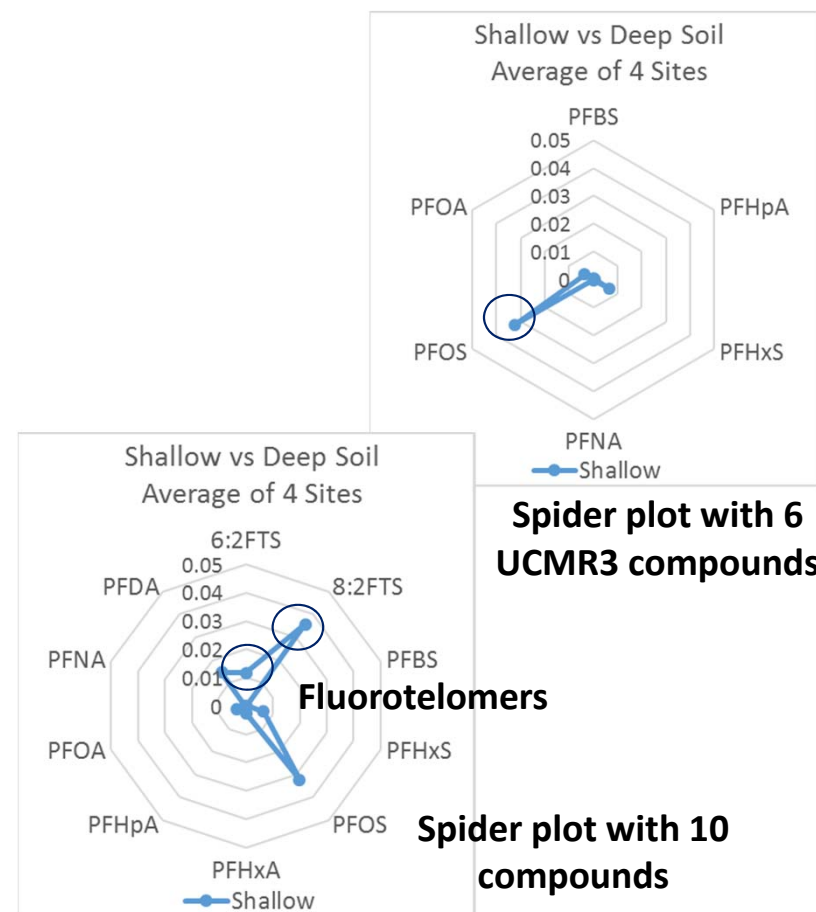
Where did my PFAS come from?

- Not an easy question to answer
 - Many sources of PFAS and many different PFAS compounds, we typically only look at a few
 - Many products (like AFFF) are “impure” and contain many compounds; some sites have seen many types of products
 - PFAS migration is complex and the forces that control migration tend to transform and segregate PFAS



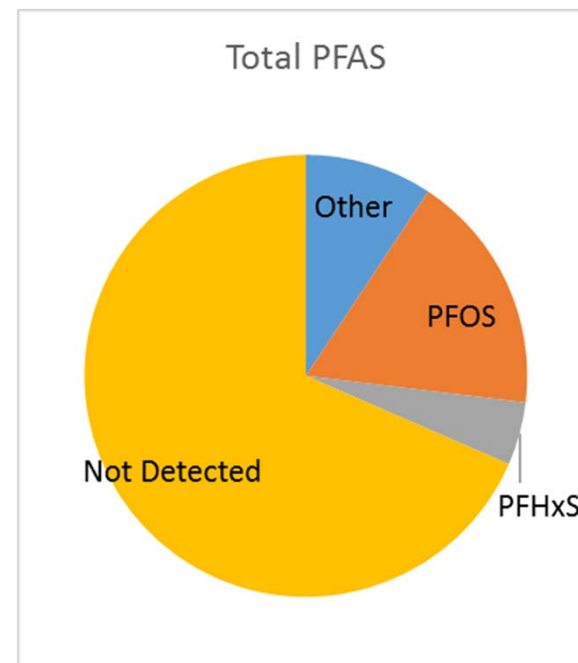
Finding the PFAS

- “EPA 537” can identify many PFAS compounds
 - This method is designed for potable water analysis
 - Issues with modifying the method, especially extraction
- The USEPA UCMR3 list of PFAS are stable end products (once produced do not readily break down); these end products are common to most sources of PFAS
- Ways to distinguish PFAS sources:
 - More compounds (FtS, “University” analysis)
 - Branched versus liner compounds
 - TOP Assay
- More sophisticated analysis under development but not generally available



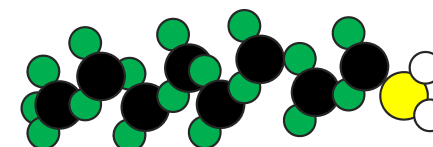
Finding the PFAS

- Total Oxidable Precursor Assay (TOPA or TOP Assay)
 - Precursor compounds – PFAS that are not detectable using available suites of compounds but can be converted into detectable compounds
 - Provides an estimate of the total load of compounds that might convert to detectable compounds
 - The test (TOP Assay) uses oxidation for conversion; results can vary
 - In the field, conversion would typically be by biological activity; could also be converted by abiotic reactions or remediation

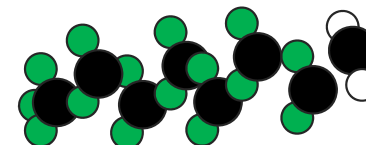


Transformation of PFAS

- Transformation of PFAS
 - Must have a perfluorinated group to form a perfluorinated daughter compound
 - Carboxylates (PFCAs) and sulfonates (PFSA) tend to be conservative
 - The linkage between the perfluorinated group and the functional groups is important in understanding tendencies in daughter compounds
 - Decomposition to PFSA appears to be fairly straightforward: compounds with sulfur linkage lose functional groups until nothing is left but the PFSA
 - Many other compounds degrade to form carboxylates
 - Fluorotelomers may partially defluorinate during conversion

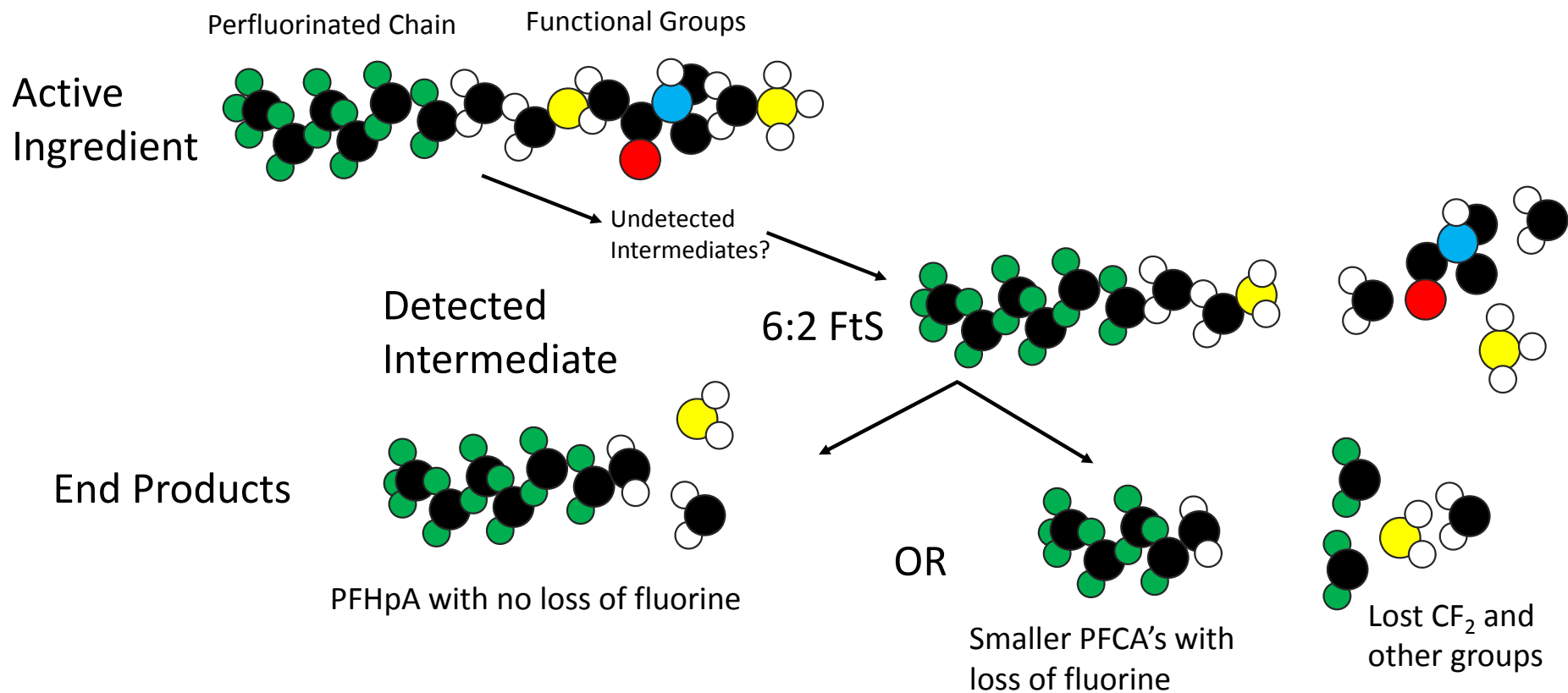


PFOS



PFOA

Example of Degradation: Fluorotelomer



Innovation that provides
sustainable solutions to
complex challenges worldwide

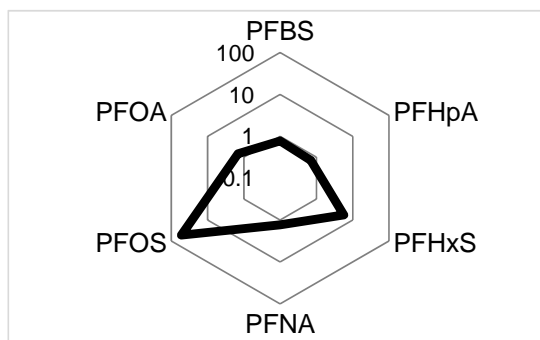
Environmental Forensics Applied to Per- and Polyfluoroalkyl Substances (PFAS) - Examples



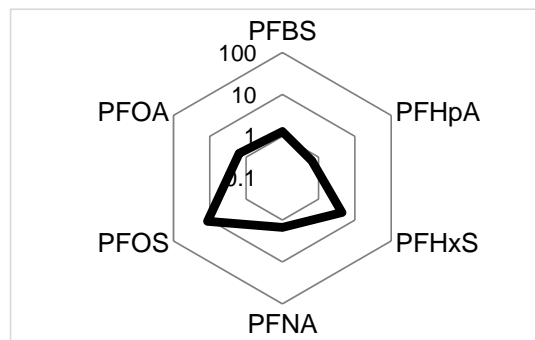
JACOBS

Distribution in AFFF-Impacted Media at Military Sites

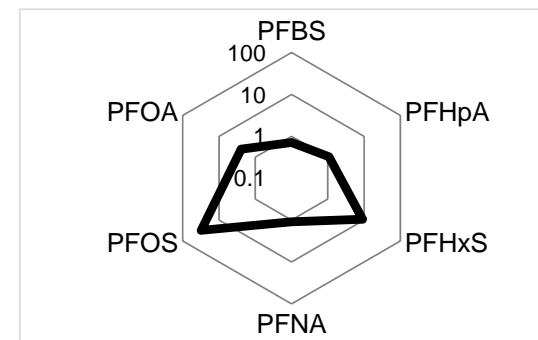
Surface Soil



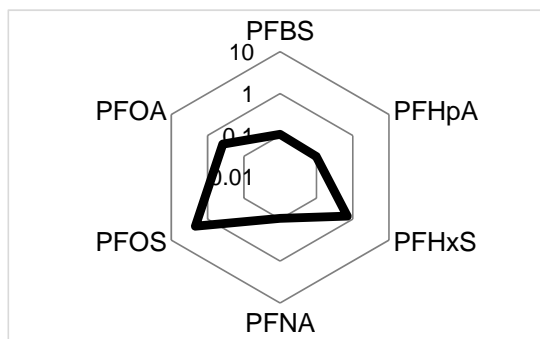
Subsurface Soil



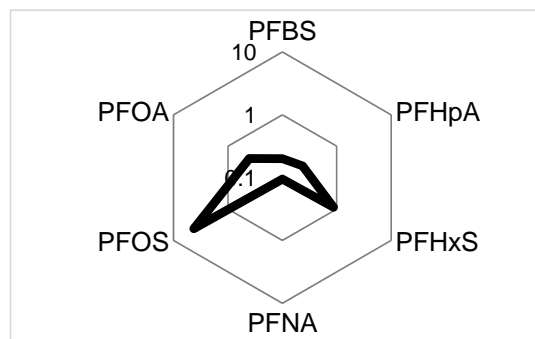
Sediment



Surface Water



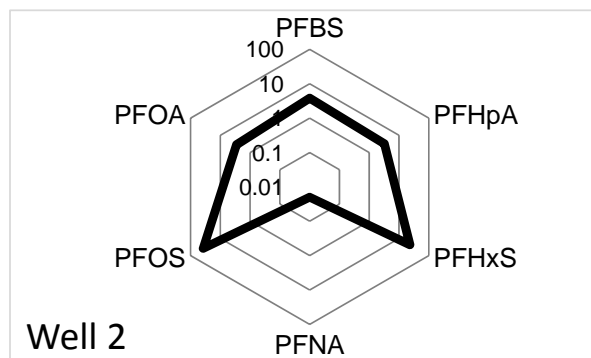
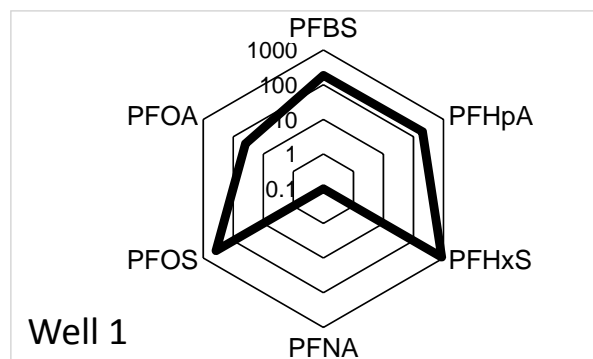
Groundwater



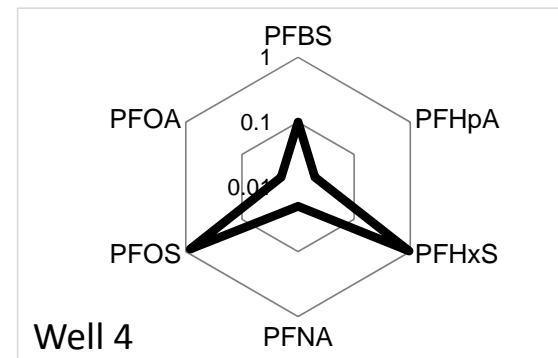
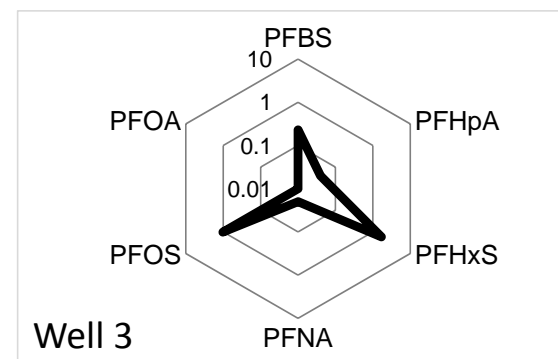
Sorption Effects in Groundwater

- Mature Site
- GW data from 2 wells near the source zone and 2 wells down-gradient
- C7 and C8 carboxylates drop out over distance
- Even-numbered carbon sulfonates most mobile/persistent

Near Source Zone

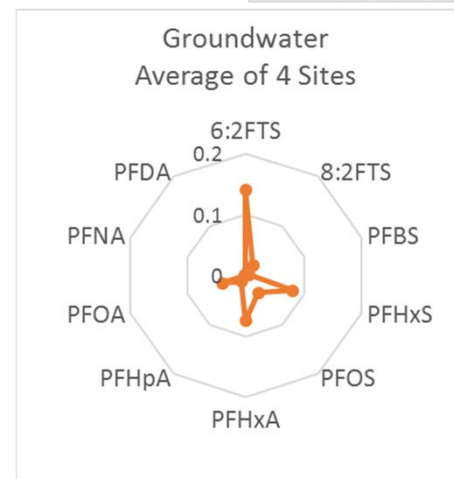
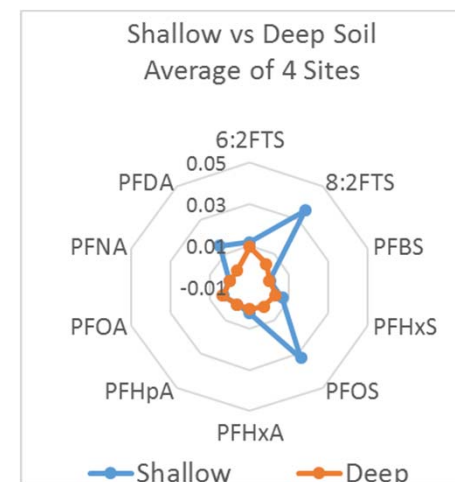


2.5 Km Downgradient



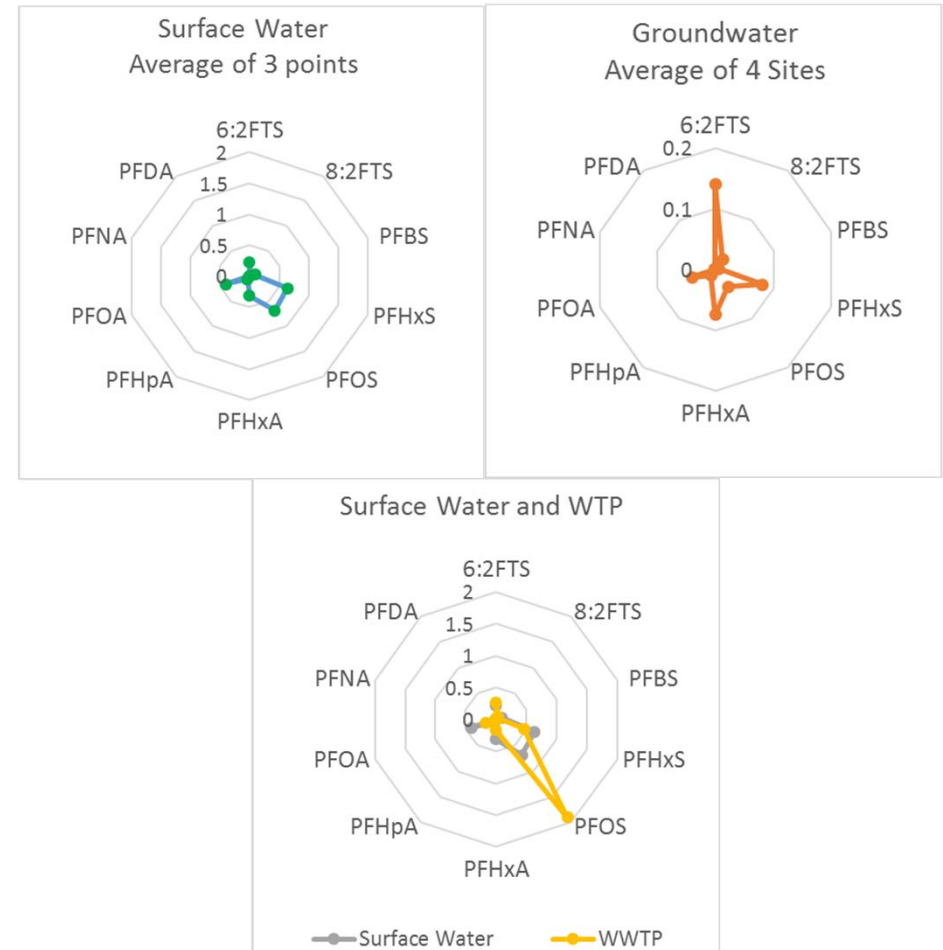
Losses in Soil

- Data from a Fire Training Area, Deep Groundwater (>45 feet)
 - Likely a mixed release of several different AFFFs
 - Shallow soil contains high concentrations of PFOS and 8:2 FtS, and detectable PFNA
 - Migration through soil appears to mitigate PFNA, PFOS and 8:2 FtS
 - PFBS, PFHxS, PFOA and 6:2 FtS are not mitigated
 - Groundwater is dominated by 6:2 FtS with PFBS, PFHxS, and PFOA
 - Heavier compounds mitigated in soil column

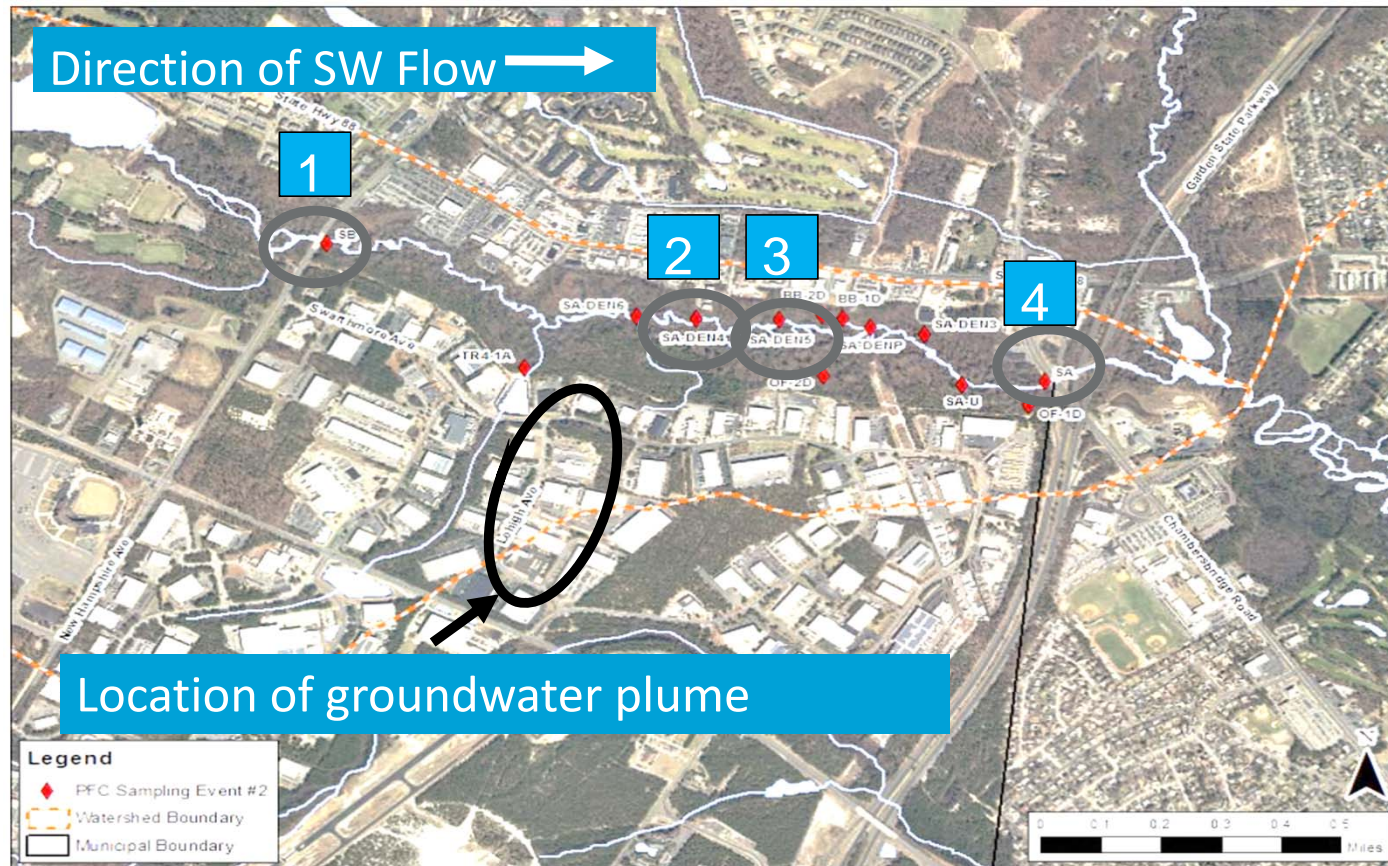


Additions in Surface Water

- Data from nearby Surface Water
 - Adjacent to groundwater release discussed above
 - Much less 6:2 FtS, more PFOS
- WWTP Effluent into Surface Water
 - Heavy on PFOS
- Surface water appears has picked up PFOS

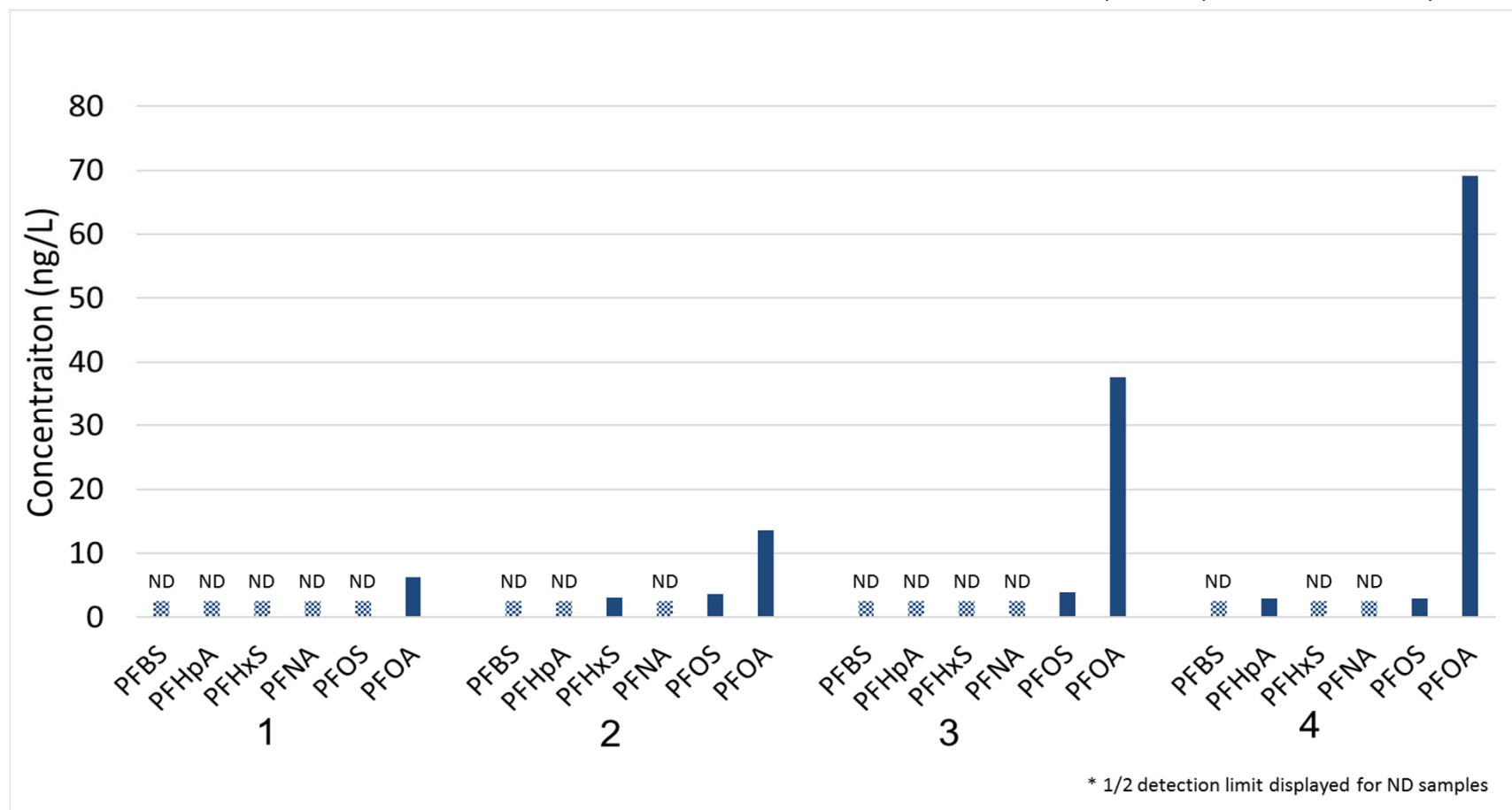


Transformation in Surface Water

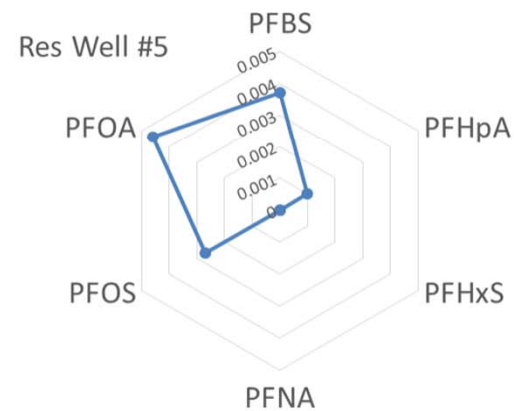
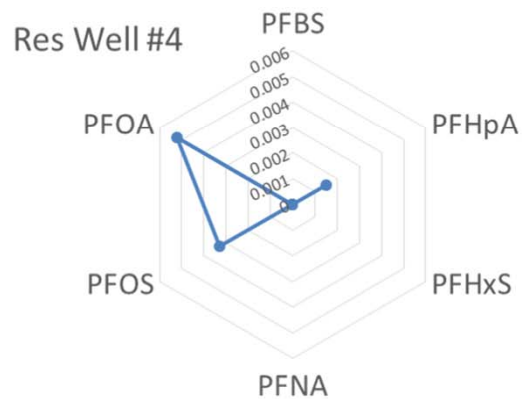
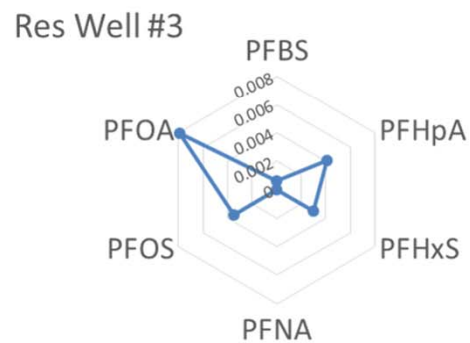
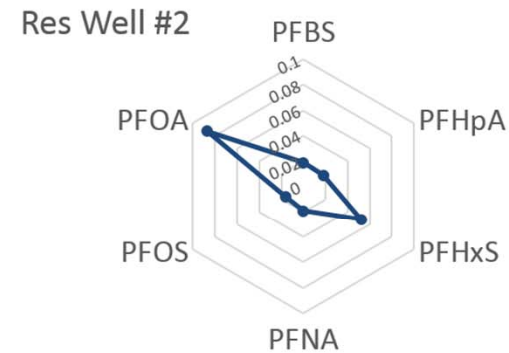
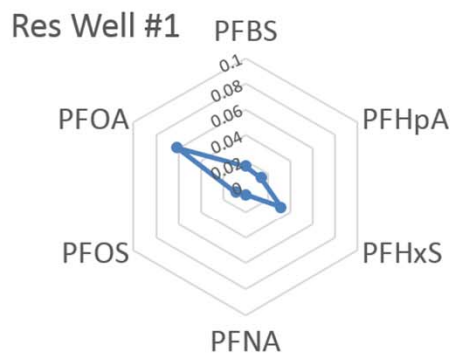
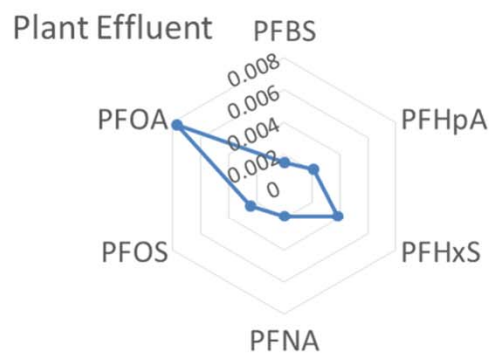


Transformation in Surface Water

Brick Township Municipal Utilities Authority, 2015

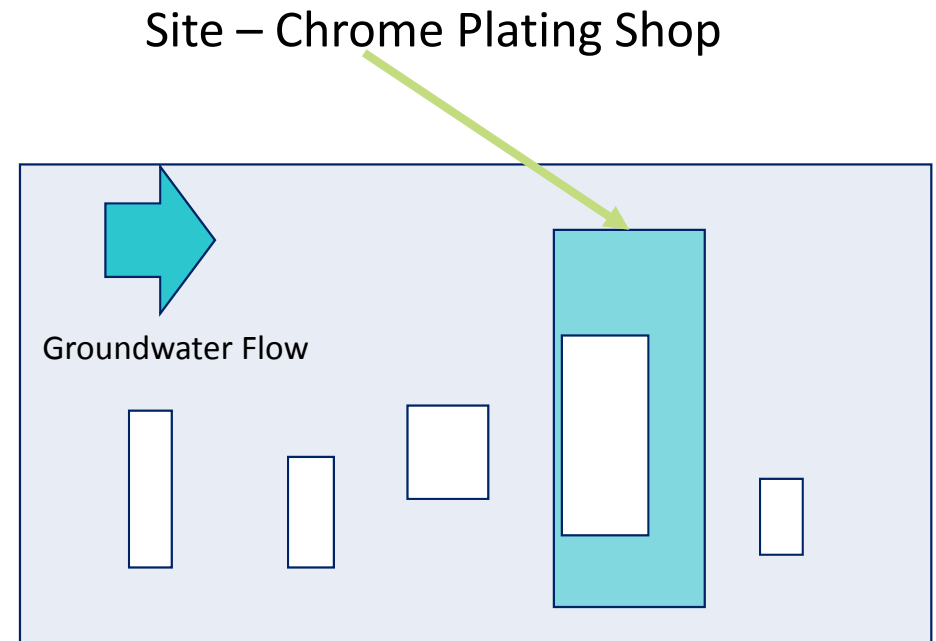


Groundwater Plume vs Leaching Fields

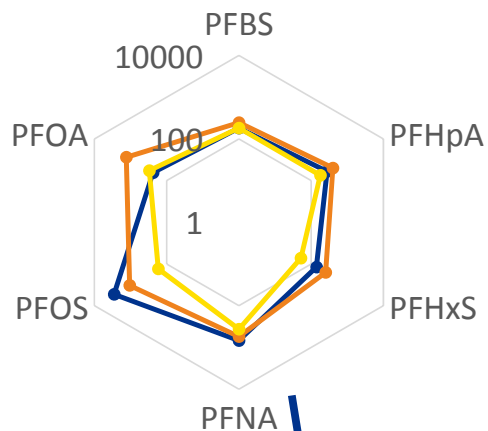


Multiple Source Identification

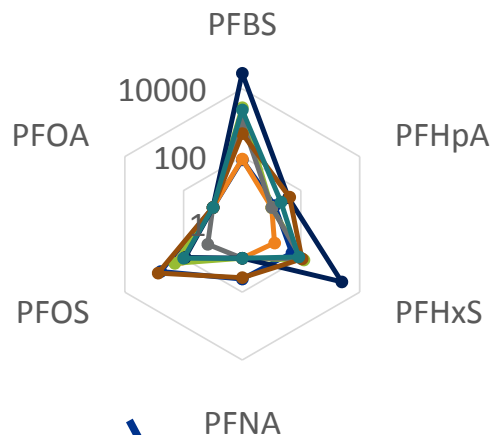
- Industrial site in an industrial area
- Chrome plating shop, unknown whether they used a foam mist suppressant
- Had a fire, unknown whether AFFF was used
- PFAS assessment required after 5-year review



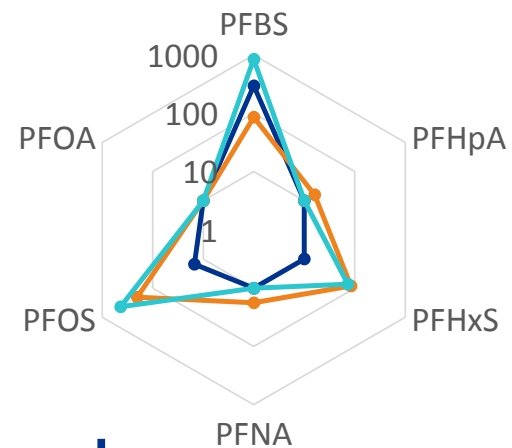
Off-Site South: More Carboxylates



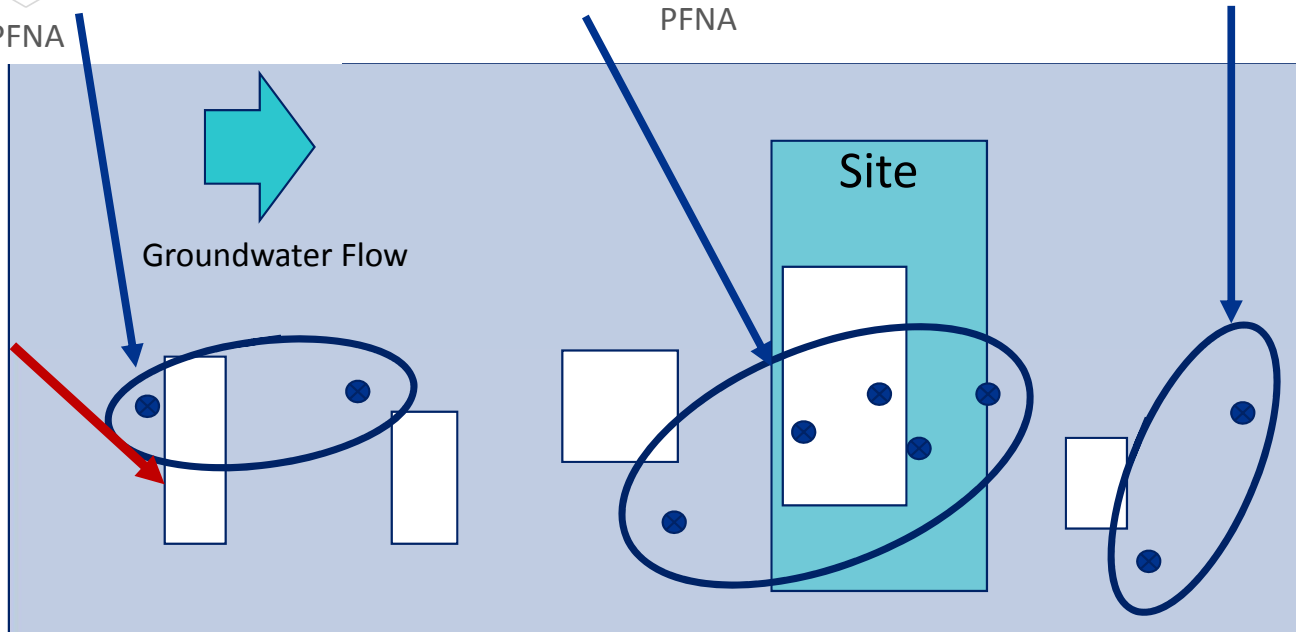
On-Site: Sulfonate Rich



Downgradient: Sulfonate Rich



Carpet cleaning and treating company



JACOBS

Conclusions/Takeaways

- PFAS are a complicated suite of chemicals, use that to your advantage
 - Understand what was released, the CSM and the forces acting on the releases
 - Understand the limitations of degradation
- Analysis beyond what is standard is incredibly helpful:
 - Precursors
 - Branched isomers
 - Fluorotelomer sulfonates
 - “University” type analysis
- What you detect can help you understand the sources

Thank you!

Jim Hatton

james.hatton@ch2m.com

Acknowledgements:

Special thanks to Elizabeth Pina, Chase Holton,
Nicole Badon, and Stephanie McClure-
Hammond for data crunching

© Copyright Jacobs
May 9, 2018

JACOBS®

www.jacobs.com | worldwide