PFAS Treatment

NEBC 2023 Business & the Environment

Presented by

Erik Naylor (Anchor QEA),
Emil Voges (Anchor QEA), and
Pierre Kwan (HDR, Inc.)

December 6, 2023

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PFAS Treatment

Regulatory Considerations, Fate and Transport In Groundwater, and Plume Remediation

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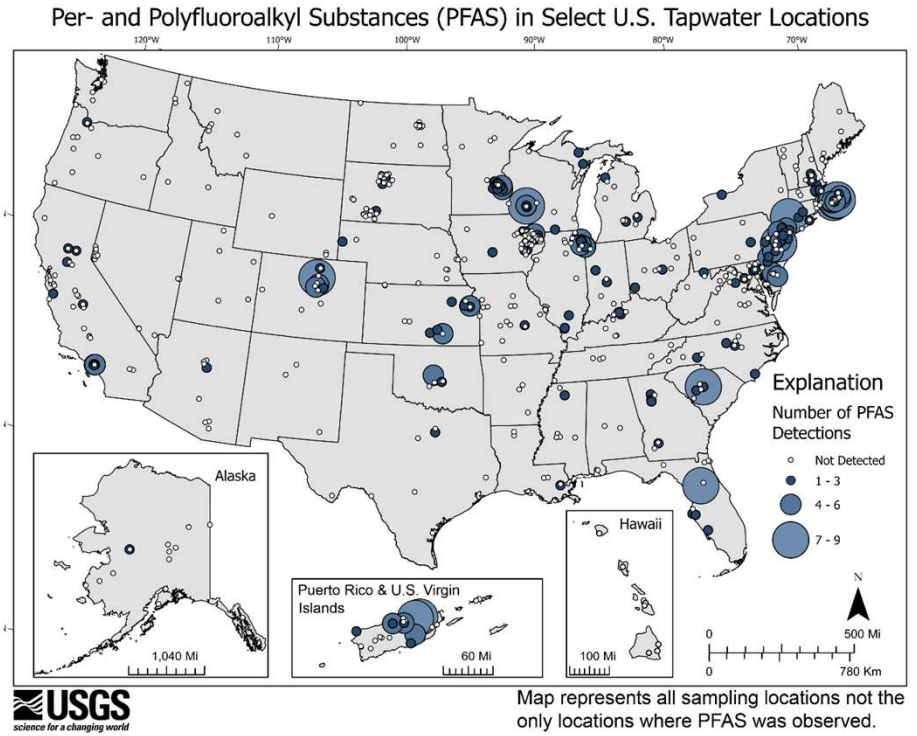
Why Are We Talking About Treatment?

- USGS, EPA, and other sampling programs have identified abundant detections of PFAS in public water systems (PWS) across the United States
- Treatment costs for drinking water alone are estimated in the billions
- Risk to human health and introduction of drinking water standards
- High public profile



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Drinking Water Limits In Nanograms Per Liter

Contaminant	WA SAL	OHA HAL	EPA Proposed MCL	EPA Interim HAL
PFOA	10	30 (sum)	4	0.004
PFOS	15		4	0.02
PFNA	9		1.0 Hazard Index (unitless)	—
PFHxS	65			—
PFBS	345	—		2,000
HFPO-DA (GenX)	—	—		10

- Washington has set state action levels (SALs) for five PFAS
- Oregon has set health advisory levels (HALs) for four PFAS
- EPA has set HALs for four PFAS and has proposed primary maximum contaminant levels (MCLs) for six PFAS
- EPA has proposed MCLs for six PFAS

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The Parts per Trillion (ng/L) Era of Drinking Water MCLs

Contaminant	EPA MCL in PPM
Nitrate	10
Fluoride	4
Lead	0.015
Arsenic	0.010
Benzene	0.005
TCE/PCE	0.005
PCBs	0.0005
PFOA	0.000004 (proposed)
PFOS	0.000004 (proposed)
PFNA	1.0 Hazard Index (unitless - proposed)
PFHxS	
PFBS	
HFPO-DA (GenX)	

- 4 parts per trillion (PPT) is 0.004 parts per billion (PPB)
- 0.004 PPB is 0.000004 parts per million (PPM)
- 4 PPT is equivalent to four drops of water in 20 Olympic-sized swimming pools
- Laboratory detection limits

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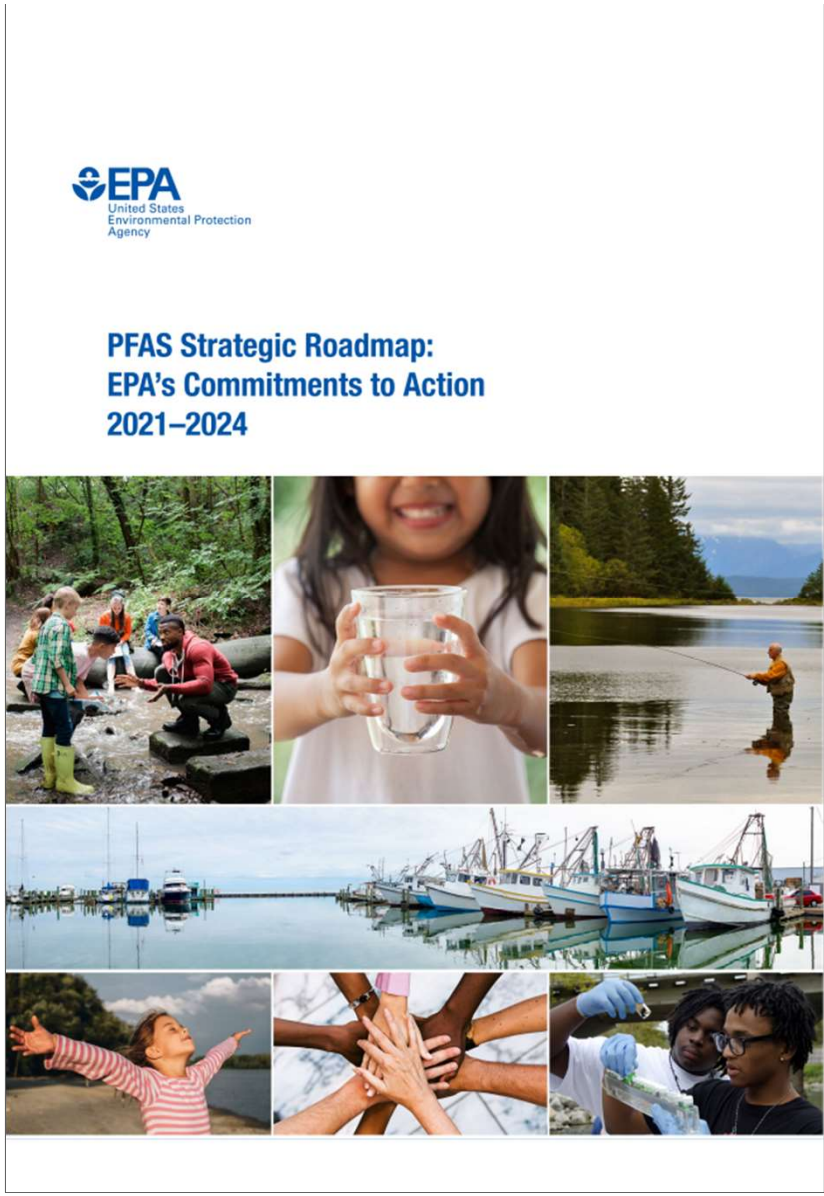
Washington State Model Toxics Control Act Groundwater Cleanup Levels

PFAS	Method B[29]	Method C[30]	DOH SAL[31]	Preliminary Groundwater Cleanup Levels	Units
PFOA	48	110	10	10	ng/L
PFOS	48	110	15	15	ng/L
PFNA	40	88	9	9	ng/L
PFHxS	160	340	65	65	ng/L
PFBS	4,800	11,000	345	345	ng/L
HFPO-DA (GenX)	24	53	—	24	ng/L

NPDES and PFAS

- December 6, 2022, EPA memorandum: "Addressing PFAS Discharges in NPDES Permits and Through the Pretreatment Program and Monitoring Programs"
- Provides states with EPA guidance for addressing PFAS discharges
- Applicable to industry categories known or suspected to discharge PFAS per *Strategic Roadmap*



Soil Background (Northeast United States)

PFOA (ug/kg)	Vermont	New Hampshire	Maine
Maximum	4.9	4.1	5.29
Median	0.4	0.8	Not reported
Percent Detect	91%	96%	65%

PFOS (ug/kg)	Vermont	New Hampshire	Maine
Maximum	9.7	5.4	4.35 (urban) 5.32 (non-urban)
Median	0.7	1.0	Not reported
Percent Detect	100%	100%	81% (urban) 63% (non-urban)

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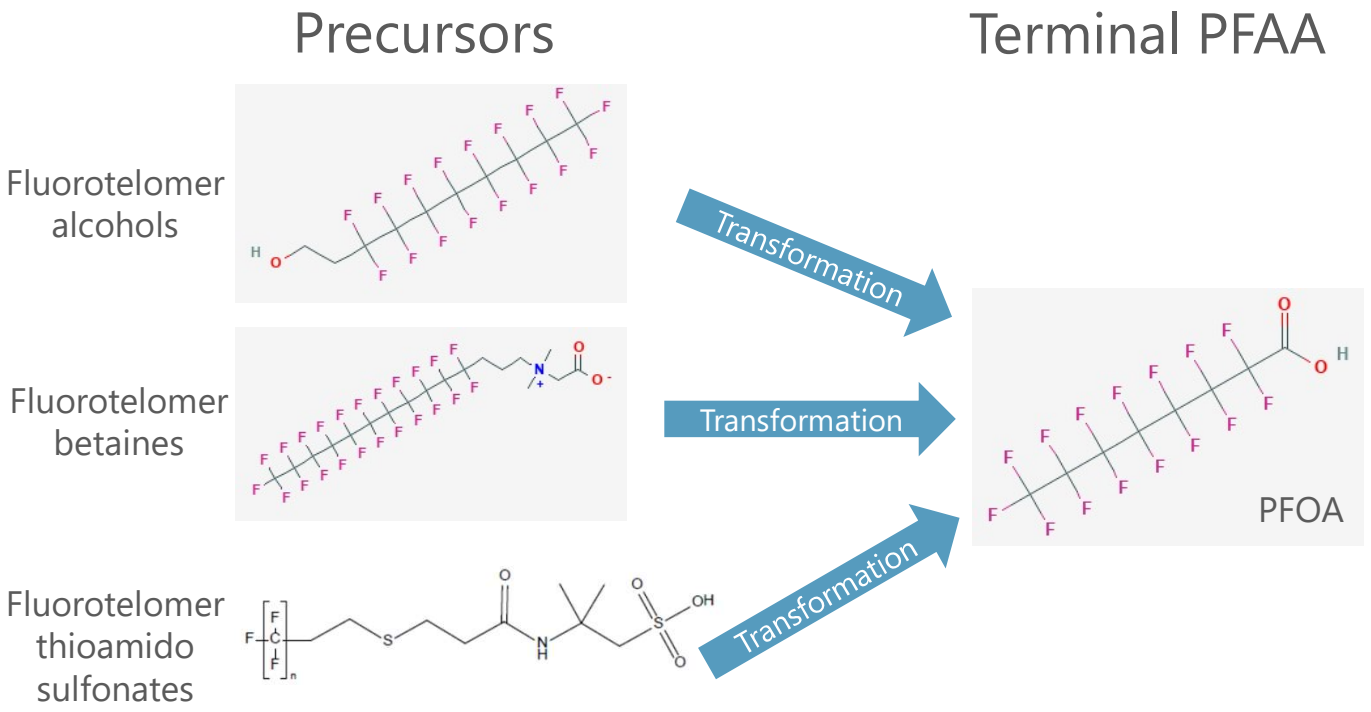
Rainfall and Atmospheric Deposition

Importance of Precursors and Transformations



Images from Chemspider 2021 and Houtz et al. 2013

Groundwater Model - Methods

- 3D MODFLOW/MT3D Model
  - Hypothetical alluvial aquifer with silty fine sand to clean sand and gravel
  - Heterogeneous hydraulic conductivity and organic carbon distribution
  - Two source-area conditions (precursor or PFOA Loading)
- Fate and transport simulated using literature values for PFOA and PFOA precursors, including transformation rate and yield from a generic PFOA precursor
- Hypothetical, realistic assumptions used to illustrate a modeling approach and compare results

Fate and Transport (F&T) Modeling Scenarios

Simulated Time Since Beginning of Release

Scenarios 1, 1a, 1b: Precursor loading 10,000 ng/L

Scenario 2: PFOA loading 840 ng/L

Stop loading, source removed (all simulations)

Scenario 1a: Begin P&T
Scenario 1b: Install PRBs

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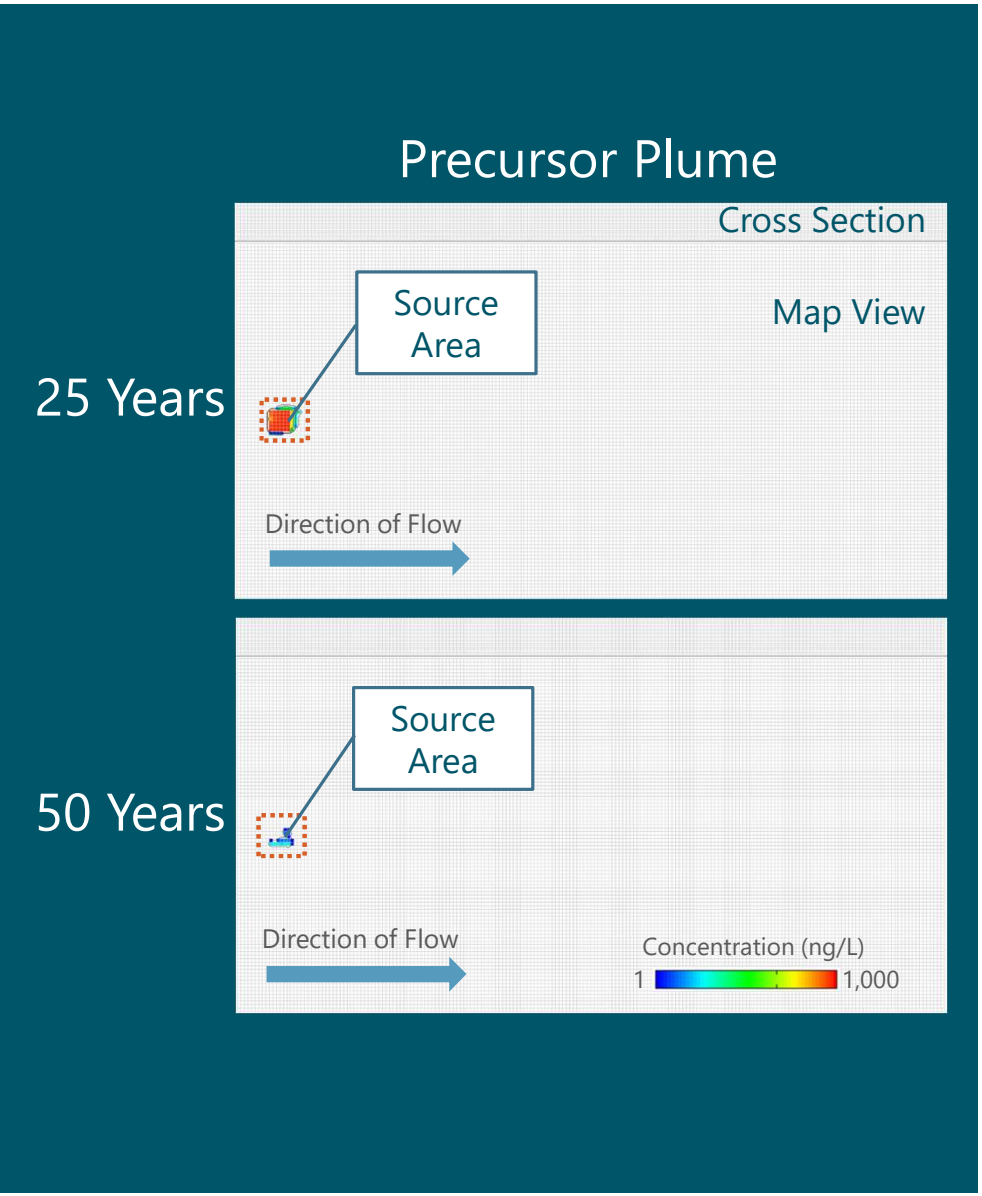

Results – Scenario 1: Precursor Loading

- Release occurs from t=0 to t=25 years
- Maximum 772 ng/L
- Precursor plume remains near source
- Precursor entirely transforms to PFOA before 75 years

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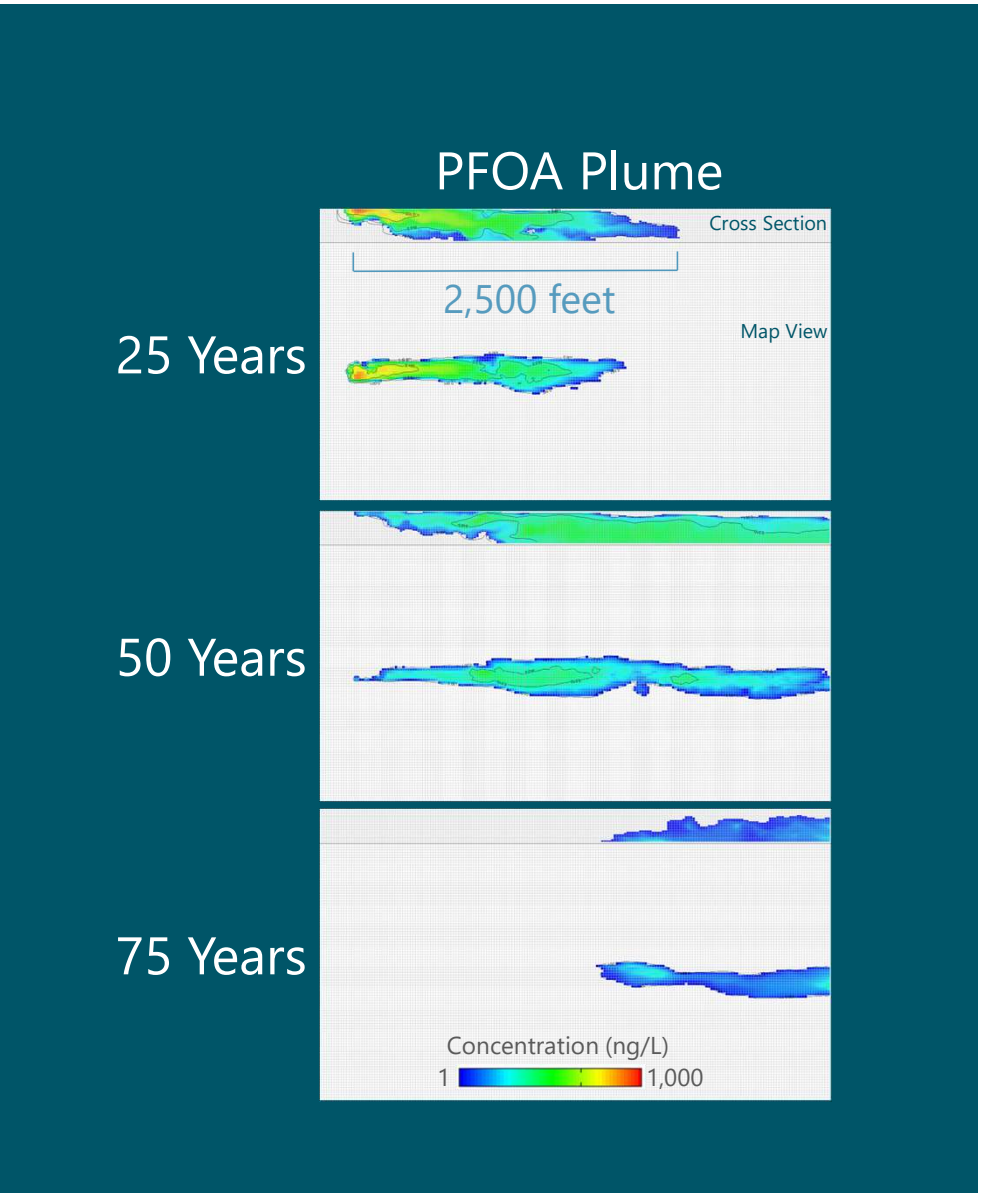

Results – Scenario 1: Precursor Loading (cont.)

- After 25 years loading, PFOA >1 ng/L extends 2,500 feet (maximum 870 ng/L)
- Plume still attached to source area after 50 years (25 years flushing)
- At 50+ years, plume extends beyond downgradient boundary
- Significant plume remains at 75 years

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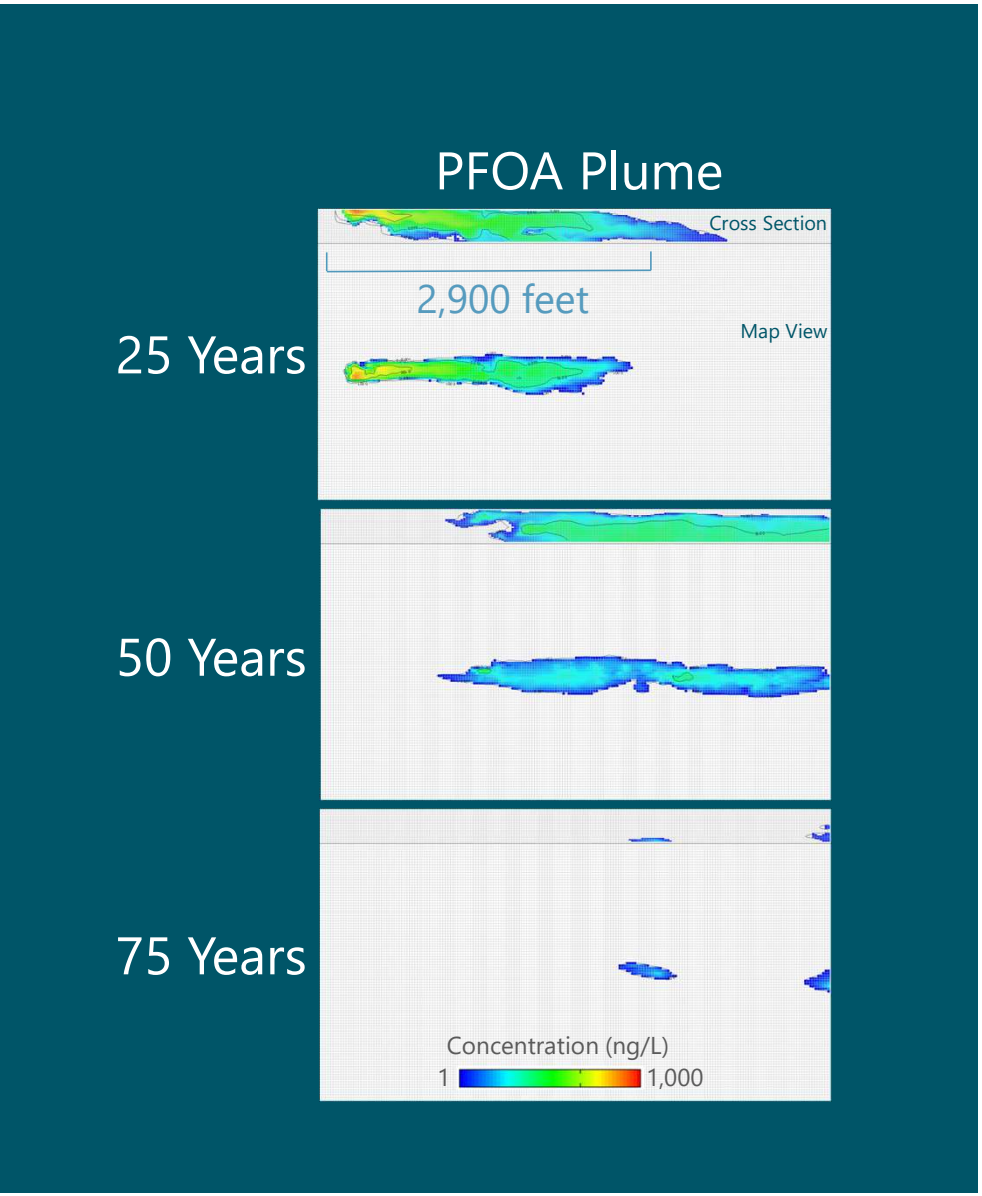

Results – Scenario 2: PFOA Loading

- After 25 years PFOA loading
  - **Same PFOA mass**
  - Very similar plume
  - Similar maximum (780 ng/L)
- Plume detached from source area after 50 years (25 years flushing)
- Plume noticeably smaller than Scenario 1 plume at 75 years

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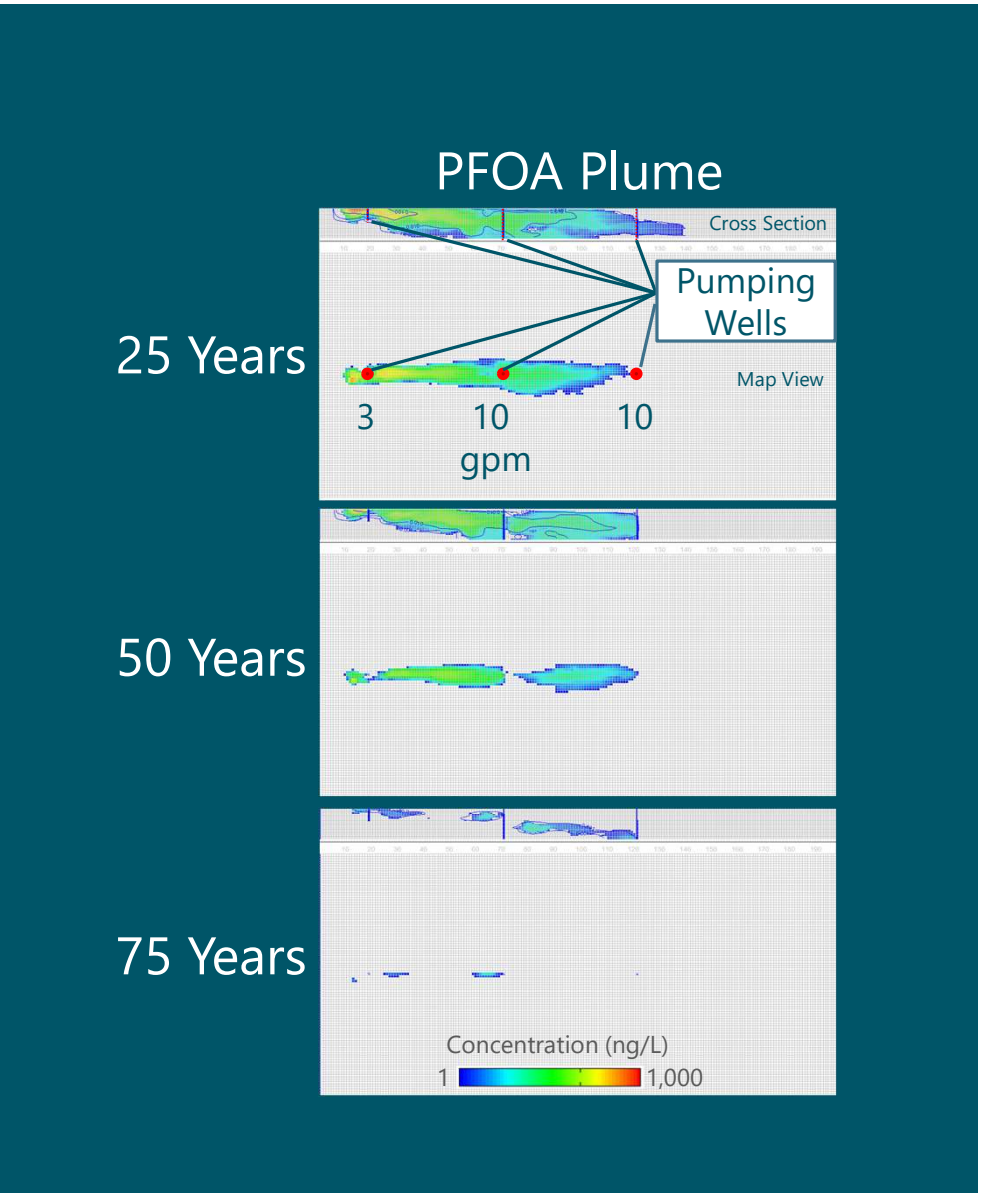

Results – Scenario 1a: P&T Plume Remediation

- Three wells start pumping after 25 years precursor loading
- Downgradient end of plume contained
- Stagnation zones between wells limit flushing

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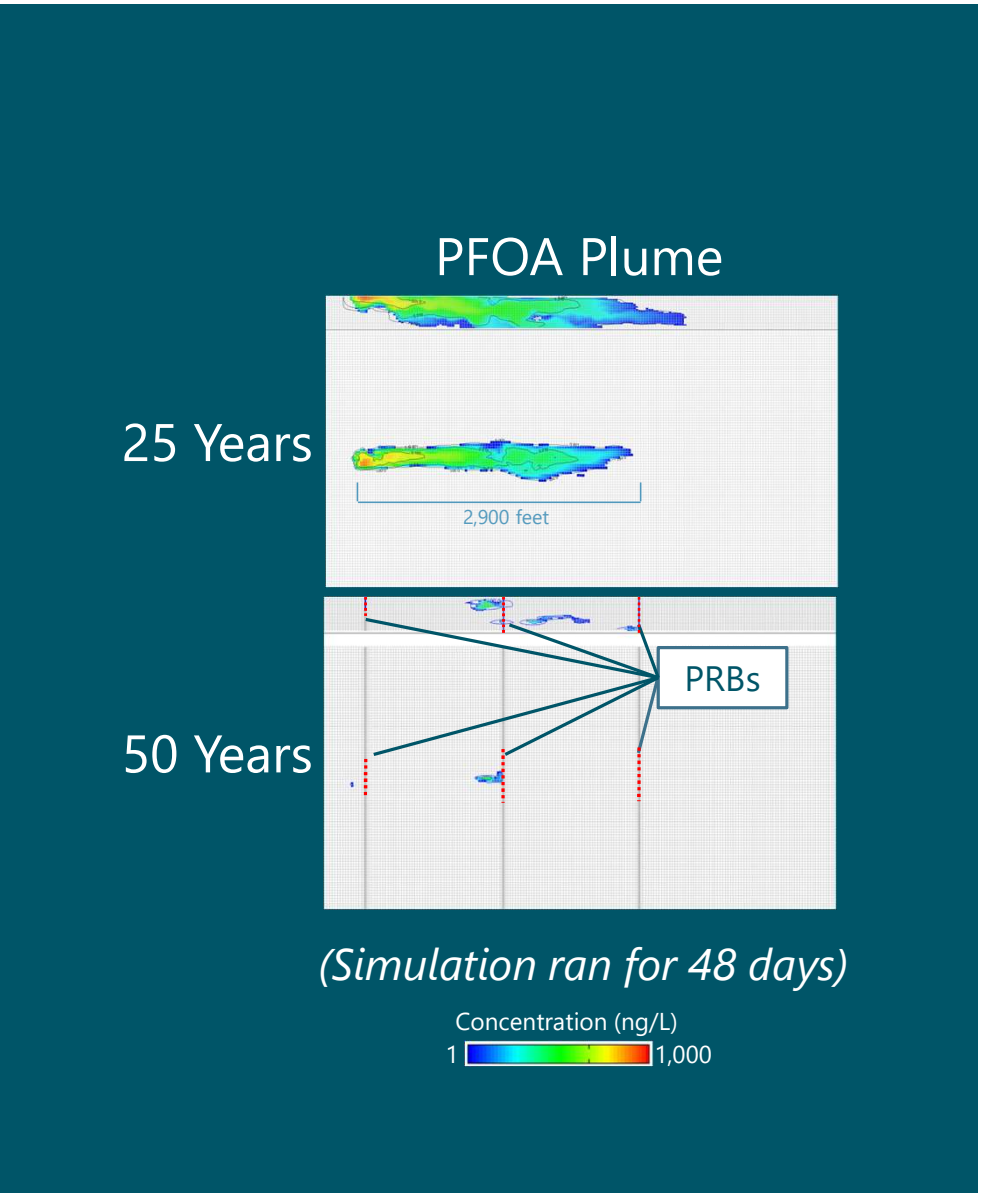

Results – Scenario 1b: PRB Plume Remediation

- Three PRBs installed after 25 years precursor loading and source removal
- Each PRB: 3 feet thick (six model columns), 10% GAC, used published PFOA isotherm
- PRBs more effective than P&T; plume nearly gone after 50 years
- No stagnation points; uniform flushing

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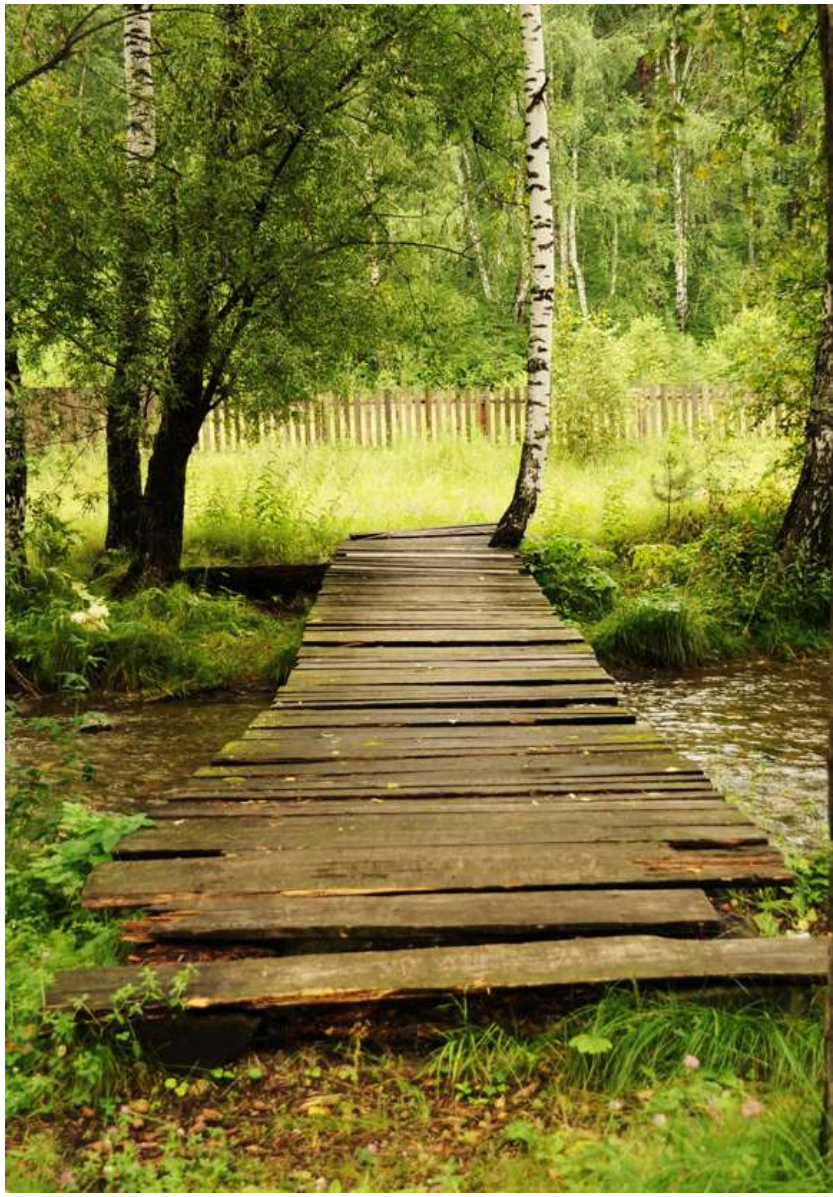
Key Takeaways

- Drinking water/groundwater standards and widespread contamination from various sources are driving the need for treatment
- NPDES permits are likely to include PFAS sampling in the near future (some already have)
- Understand background is important
- Precursors can increase PFAA plume longevity, so precursor presence or absence should be carefully considered
- P&T can expedite downgradient plume remediation, but beware of stagnation zones
- PRBs may remediate PFOA plumes more quickly than P&T
- In situ remediation is useful for groundwater plumes, but not necessarily applicable for drinking water treatment



THANK YOU

Erik Naylor

Managing Scientist
Anchor QEA
enaylor@anchorqea.com

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