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Los Angeles County Sanitation Districts
Converting Waste Into Resources

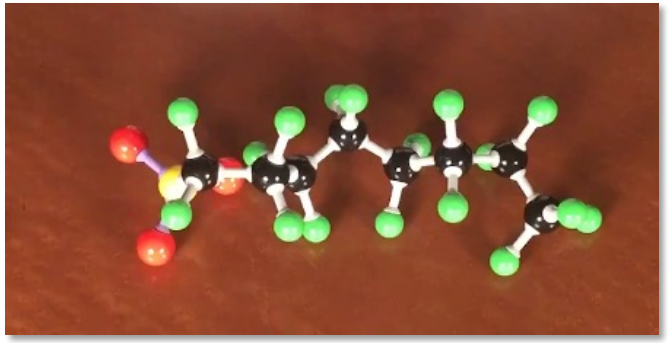
Stanley Consultants

LA DWP Los Angeles Department of Water & Power

We will begin our presentation in a few minutes…

Leadership and Excellence in Environmental Engineering and Science

Adapting to the Challenge of PFAS Remediation at Impacted Sites



Charles Newell, GSI Environmental Inc.
Randy Sillan, AECOM
Jeff McDonough, CDM Smith

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GSI ENVIRONMENTAL

AECOM

CDM Smith

Presenters

1.	PFAS Problem	Newell
2.	Chem & Tox	Newell
3.	Conceptual Models	Sillan
4.	F&T Unsaturated	Sillan
5.	F&T Saturated	Newell
6.	Treatment in-situ	McDonough
7.	Treatment ex-situ	McDonough
8.	Destruction	McDonough

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The PFAS Problem

PFAS History – Aqueous Film Foaming Foam (AFFF) for Fire Fighting

USS Forrestal Fire 1967

Milspec Aqueous Film Forming Foam (AFFF): PFAS

Lightwater, Ansulite, etc.

Potential PFAS Impacted Sites (Salvatore et al. 2022)

57,412 sites of presumptive PFAS contamination:

- *49,145 industrial facilities*
- *4,255 wastewater tmt. plants*
- *3,493 military sites*
- *519 major airports*

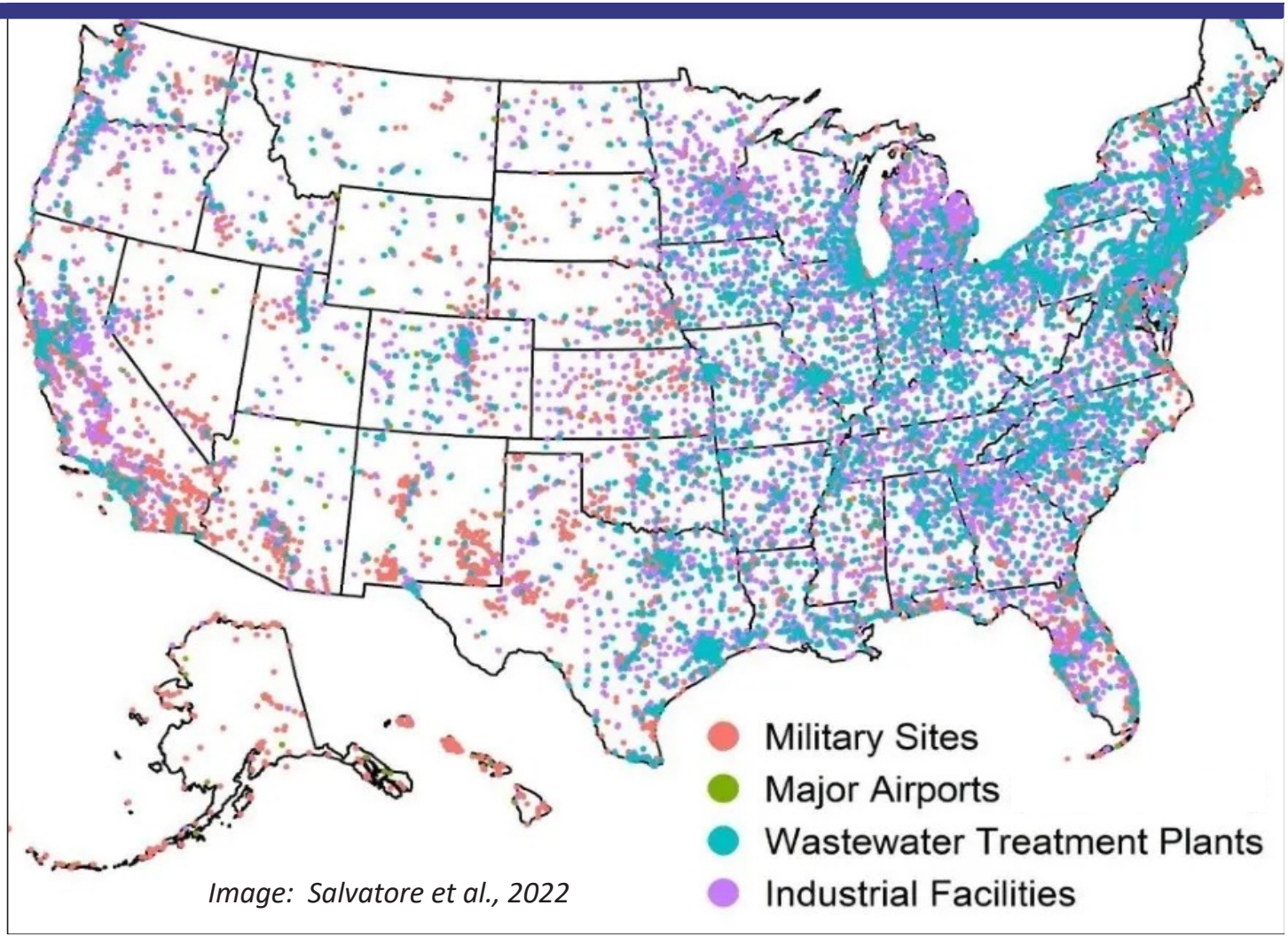

Image: Salvatore et al., 2022

The PFAS Problem: Focus Areas & Potential Costs

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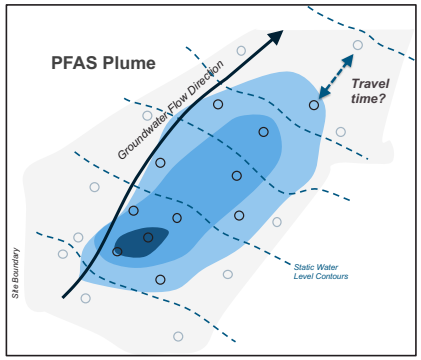
ENVIRONMENTAL BUSINESS JOURNAL®
Strategic Information for a Changing Industry
Vol. XXXVIII, Numbers 5/6, 2025 | *First 150 Days of Trump II* | Environmental Business International Inc.

- Remediation: $88 billion
- Drinking Water: $21 billion
- Wastewater: $24 billion
- **Total 30-Yr Costs: ~$132 billion**

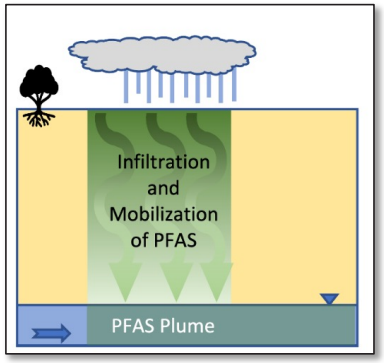
About two thirds associated with:

- Aviation AFFF sites
- PFAS Manufacturing
- Manufacturing Using PFAS
- Landfills

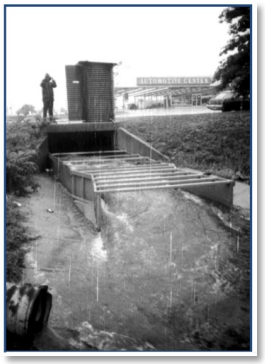
Groundwater



Soils



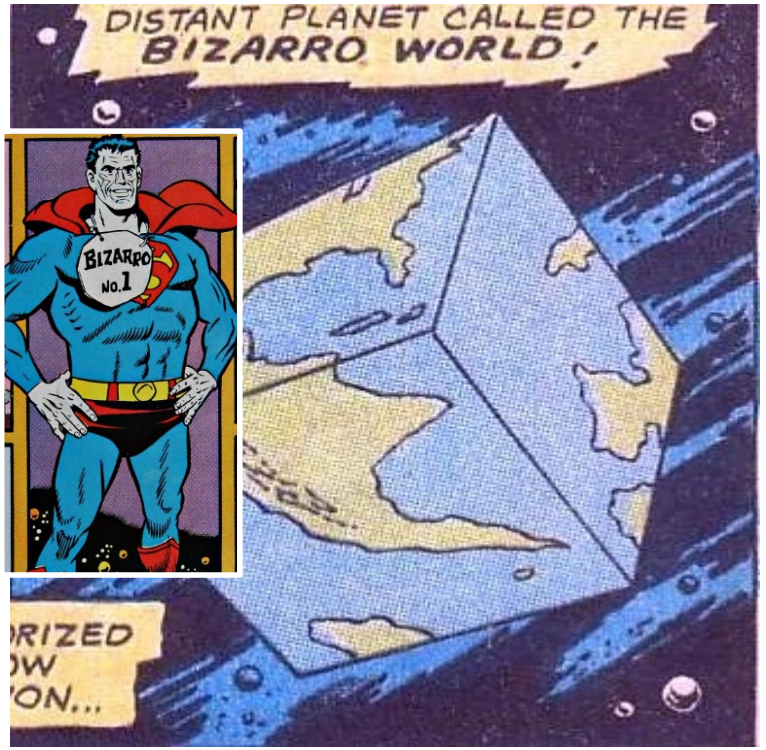
Stormwater



Updated Nov. 2025

Four Drivers for that Make PFAS "Bizzaro World" For Groundwater Remediation

- No current evidence of in-situ degradation of regulated PFAAs!
- Biodegradation doesn't help, it hurts!
- Front-line technology is Pump & Treat?
- Concentrations: single digit ng / Liter?



KEY POINT: "Business as Usual" won't work for PFAS Groundwater Cleanup

Perspective from PFAS Experts Symposium (2019)

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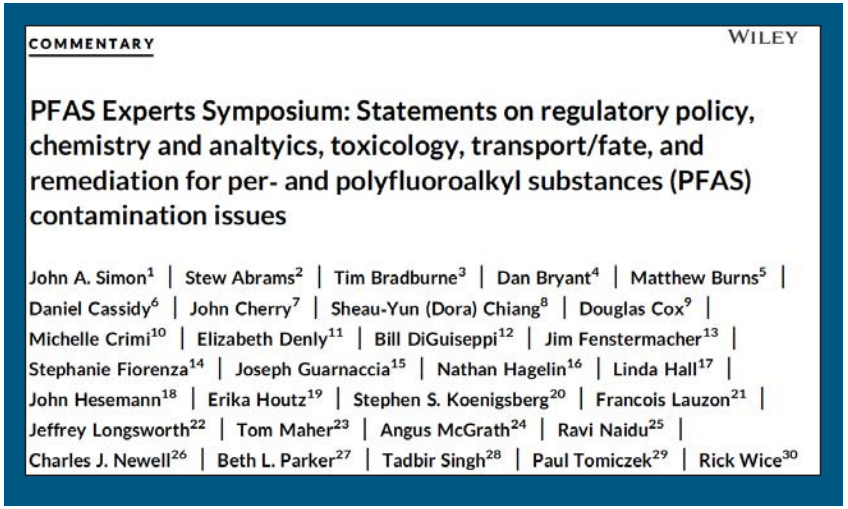
"The consensus message from the Symposium participants is that PFAS present far more complex challenges to the environmental community than prior contaminants."



COMMENTARY

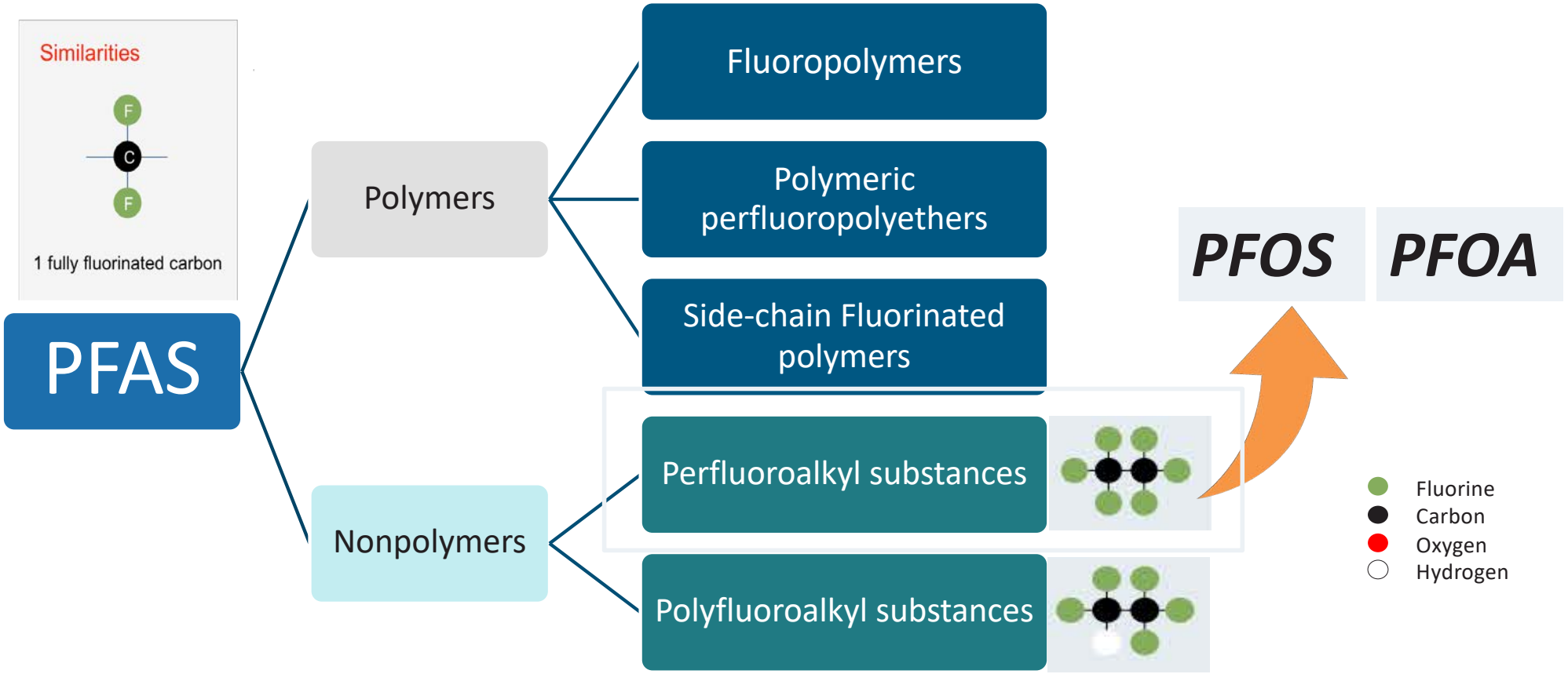
WILEY

PFAS Experts Symposium: Statements on regulatory policy, chemistry and analtyics, toxicology, transport/fate, and remediation for per- and polyfluoroalkyl substances (PFAS) contamination issues

John A. Simon[1] | Stew Abrams[2] | Tim Bradburne[3] | Dan Bryant[4] | Matthew Burns[5] | Daniel Cassidy[6] | John Cherry[7] | Sheau-Yun (Dora) Chiang[8] | Douglas Cox[9] | Michelle Crimi[10] | Elizabeth Denly[11] | Bill DiGuiseppi[12] | Jim Fenstermacher[13] | Stephanie Fiorenza[14] | Joseph Guarnaccia[15] | Nathan Hagelin[16] | Linda Hall[17] | John Hesemann[18] | Erika Houtz[19] | Stephen S. Koenigsberg[20] | Francois Lauzon[21] | Jeffrey Longsworth[22] | Tom Maher[23] | Angus McGrath[24] | Ravi Naidu[25] | Charles J. Newell[26] | Beth L. Parker[27] | Tadbir Singh[28] | Paul Tomiczek[29] | Rick Wice[30]

PFAS Chemistry and Toxicology

PFAS Family: *Three Main Groups*



Source: J Gamlin, GSI Environmental

3 Generalized Classes of Non-polymer PFAS

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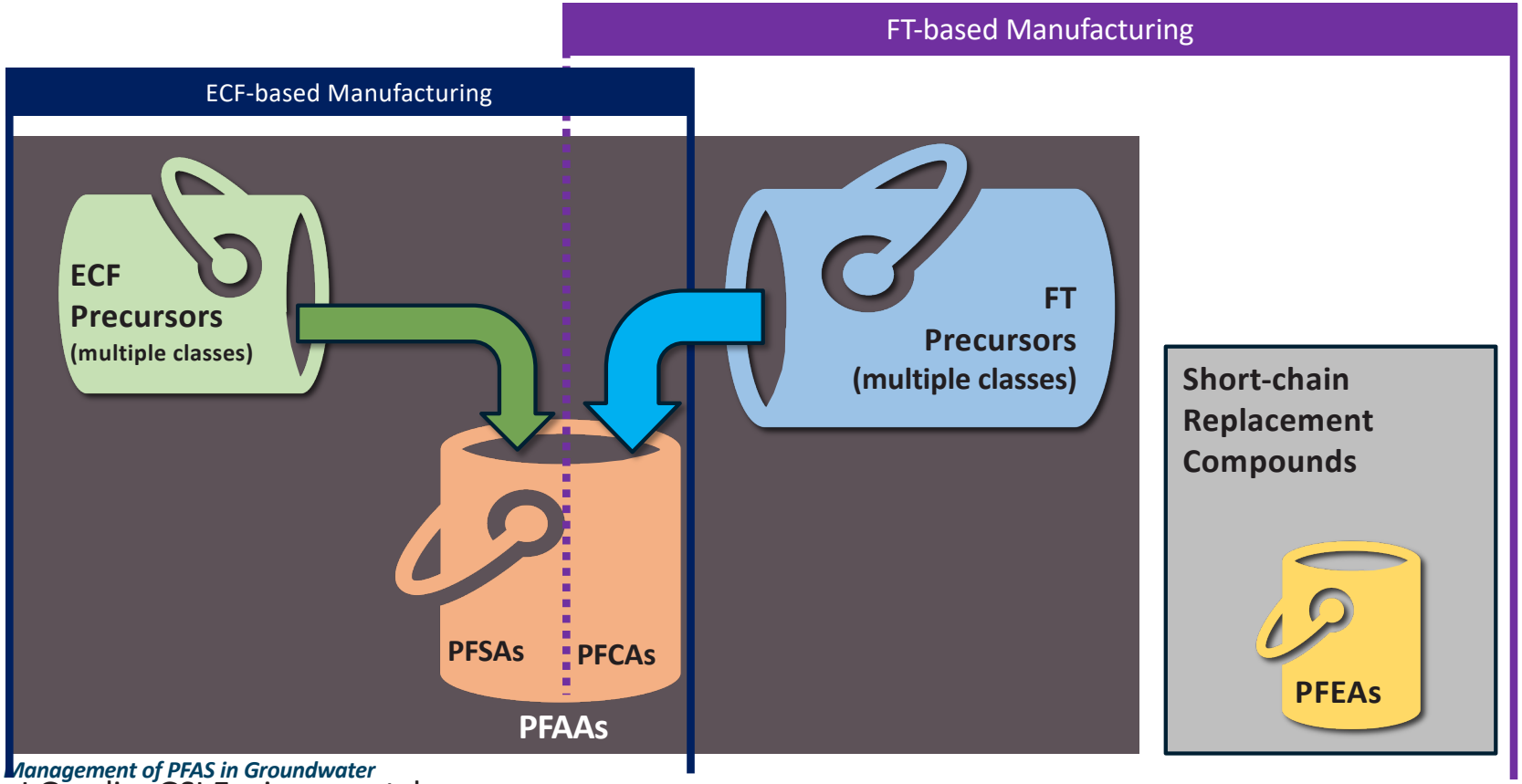
- **PFAAs: Perfluoroalkyl acids (fully fluorinated) (don't degrade)**
  - PFSAs: Perfluoroalkyl sulfonic acids (e.g., perfluorooctane sulfonic acid - PFOS)
  - PFCAs: Perfluoroalkyl carboxylic acids (e.g., perfluorooctanoic acid - PFOA)
- **Precursors: PFAS that turn into other PFAS (partially fluorinated) (bad thing?)**
  - ECF: Electrochemical fluorination-based precursors
  - FT: Fluorotelomerization-based precursors
- **PFEAs: Per- and polyfluoroalkyl ether acids ("replacements")**

Source: J Gamlin, GSI Environmental

Generalized PFAS "Buckets"



Source: J Gamlin, GSI Environmental

Evolution of PFAS Use in AFFF

- 1960s–1980s: Electrochemical Fluorination (3M "Light Water") (Key PFAA: PFOS)
- 1980s–2000s: Fluorotelomer-Based AFFF (C6 Precursors) (Ansul, others) fluorotelomer sulfonates that degrade into PFOA and shorter-chain PFAAs (e.g., PFHxA).
- **2000s–2010s: Phaseout of Long-Chain PFAS (C8s like PFOS PFOA)**
- 2010s–Present: Emergence of GenX and Short-Chain Replacements
- 2023–2024: U.S. Department of Defense Fluorinated AFFF Phaseout

Figure 1. Summary of AFFF manufacturing process and years on the U.S. Department of Defense (DoD) AFFF QPL. ECF AFFF was produced the earliest and production has since been phased out in the U.S. Production of FT AFFF began later and has shifted to shorter-chain PFAS formulations in recent years (noted by color change from green to light blue).

Source: Gamlin et al., 2024

PFAA Concentrations in Blood 1990-2018

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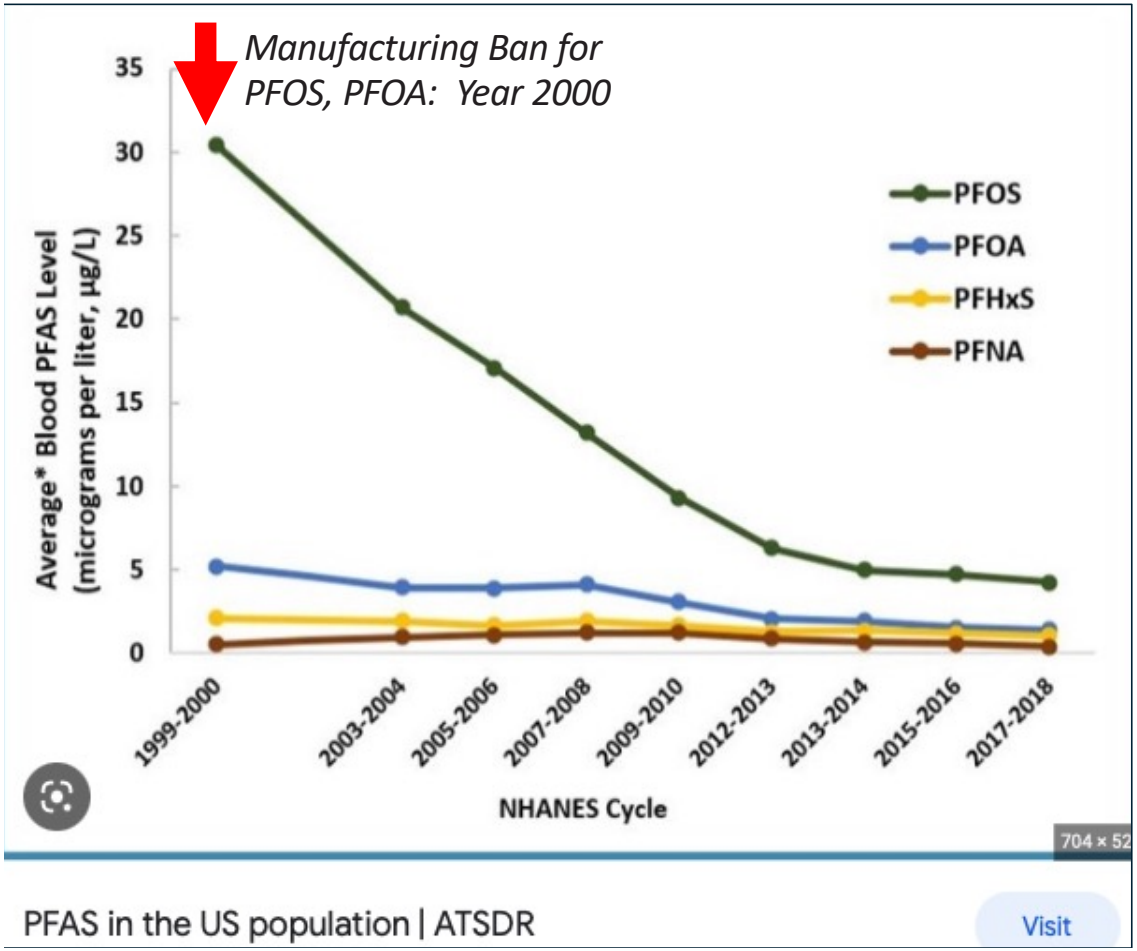
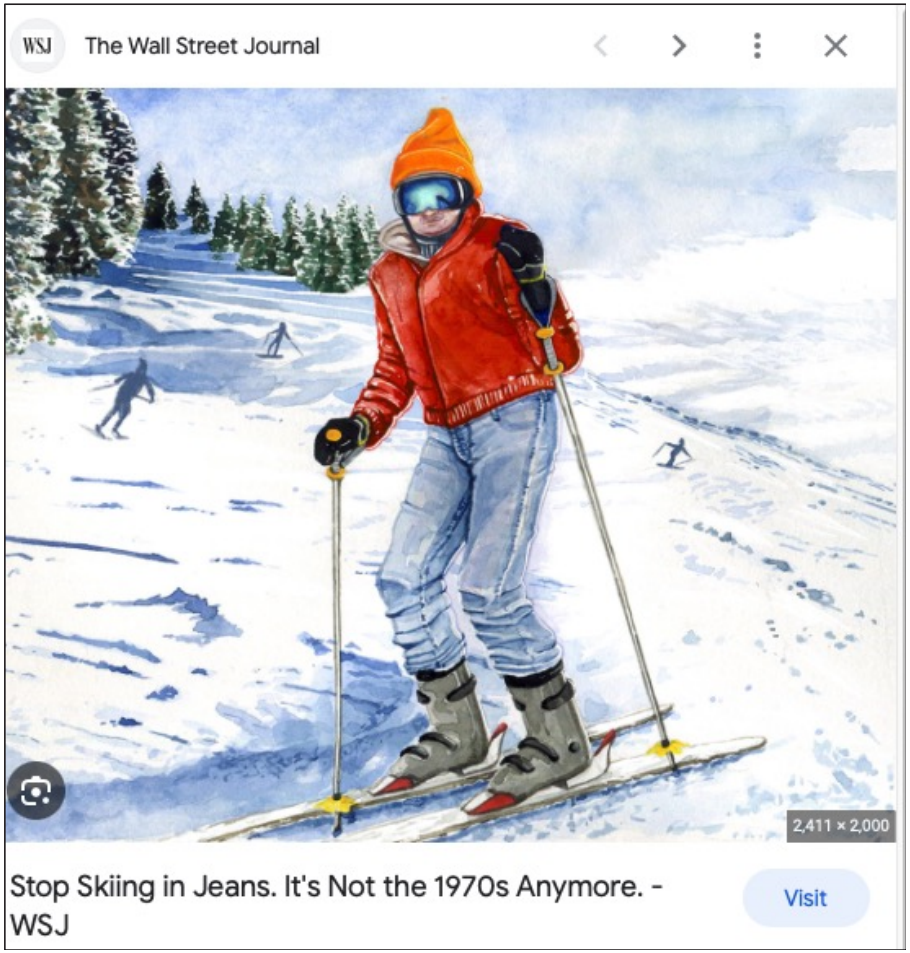
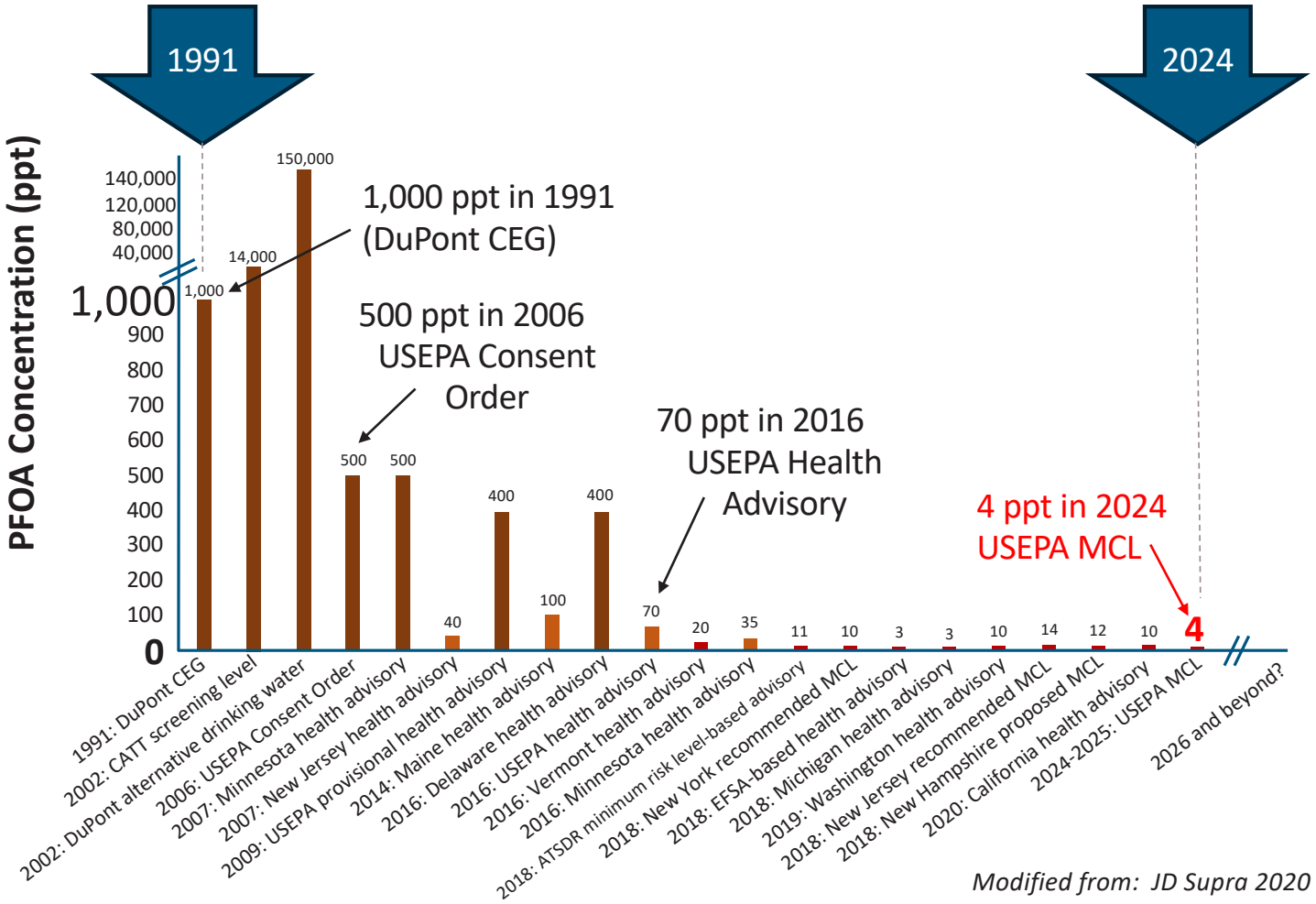




Evolving PFOA Drinking Water Advisory/Guideline Levels 1991 - 2024



Modified from: JD Supra 2020

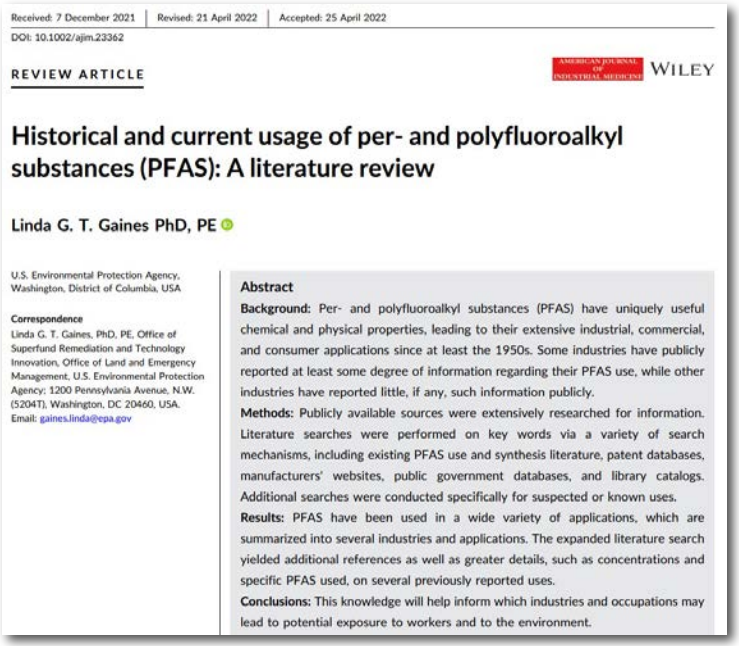
- **Ongoing debate among toxicologists that some PFAS criteria may be set too low (e.g., Burgoon et al. 2023)**

PFOA	MCL
USEPA	4.0 ng/L
Mid-Point Burgoon et al. 2023	280 ng/L
X Higher	**70X**

PFAS Conceptual Models

Literature Review of Potential PFAS "Sources"

- AFFF
- Metal Plating and Machining
- Landfills
- Septage and Wastewater
  - Personal Care Products and Cosmetics
- Paper and Packaging Products
- Textiles and Carpets
- Coatings and Adhesives
- Cleaning Agents and Waxes
- Pesticides and Herbicides
- Transportation Industry
- Plastics and Rubbers
- Printing, Etching, and Photography
- Medical Sector
- Electronics and Energy Sector
- Building and Construction Industry
- Mining, Oil, and Gas



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DOI: 10.1002/ajim.23362

REVIEW ARTICLE

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE WILEY

Historical and current usage of per- and polyfluoroalkyl substances (PFAS): A literature review

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U.S. Environmental Protection Agency, Washington, District of Columbia, USA

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Email: gaines.linda@epa.gov

Abstract

Background: Per- and polyfluoroalkyl substances (PFAS) have uniquely useful chemical and physical properties, leading to their extensive industrial, commercial, and consumer applications since at least the 1950s. Some industries have publicly reported at least some degree of information regarding their PFAS use, while other industries have reported little, if any, such information publicly.

Methods: Publicly available sources were extensively researched for information. Literature searches were performed on key words via a variety of search mechanisms, including existing PFAS use and synthesis literature, patent databases, manufacturers' websites, public government databases, and library catalogs. Additional searches were conducted specifically for suspected or known uses.

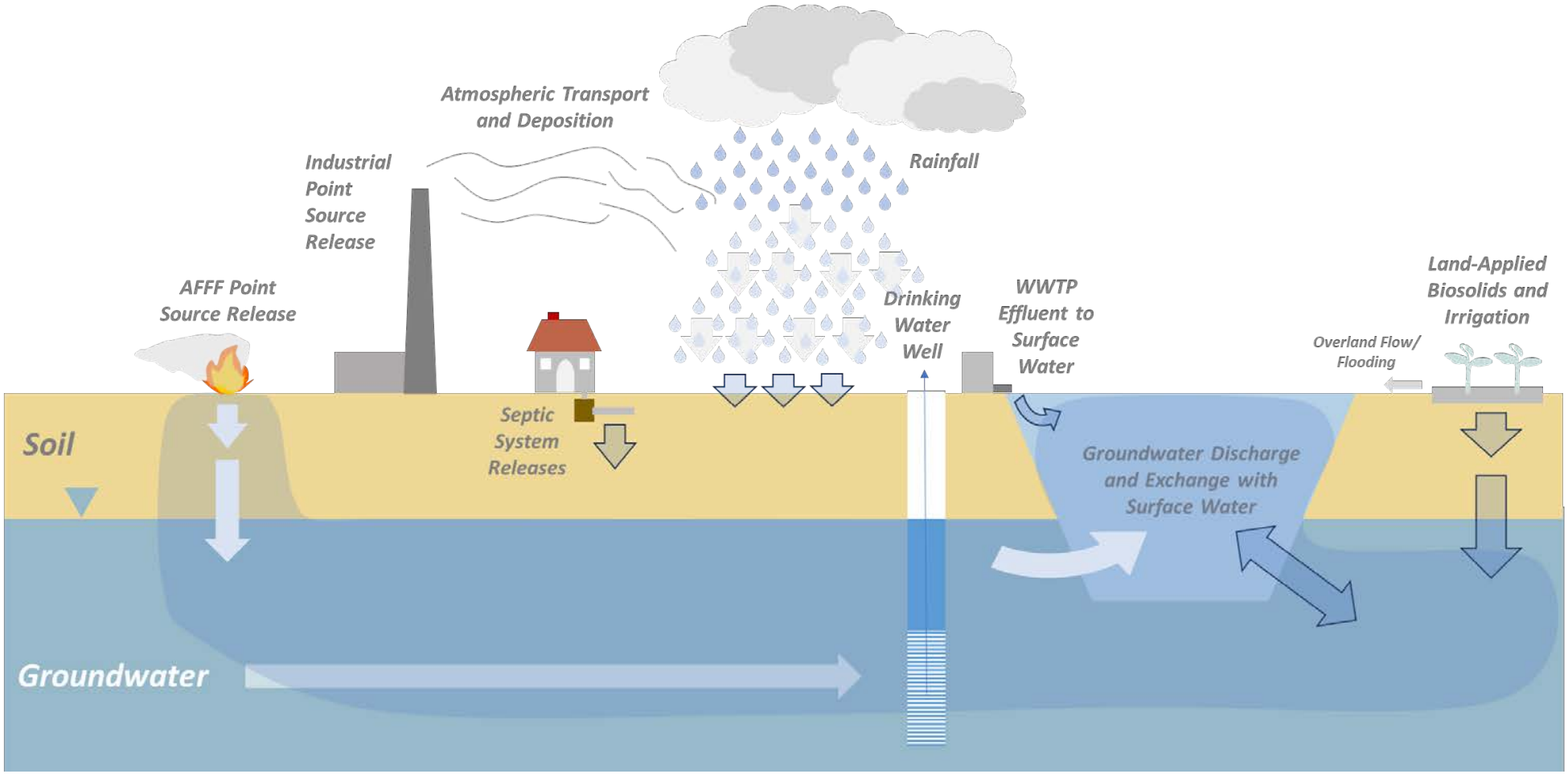
Results: PFAS have been used in a wide variety of applications, which are summarized into several industries and applications. The expanded literature search yielded additional references as well as greater details, such as concentrations and specific PFAS used, on several previously reported uses.

Conclusions: This knowledge will help inform which industries and occupations may lead to potential exposure to workers and to the environment.

Modified from Glüge et al. (2020) and Gaines (2022) – this list is not intended to be all inclusive and may not be applicable in some cases

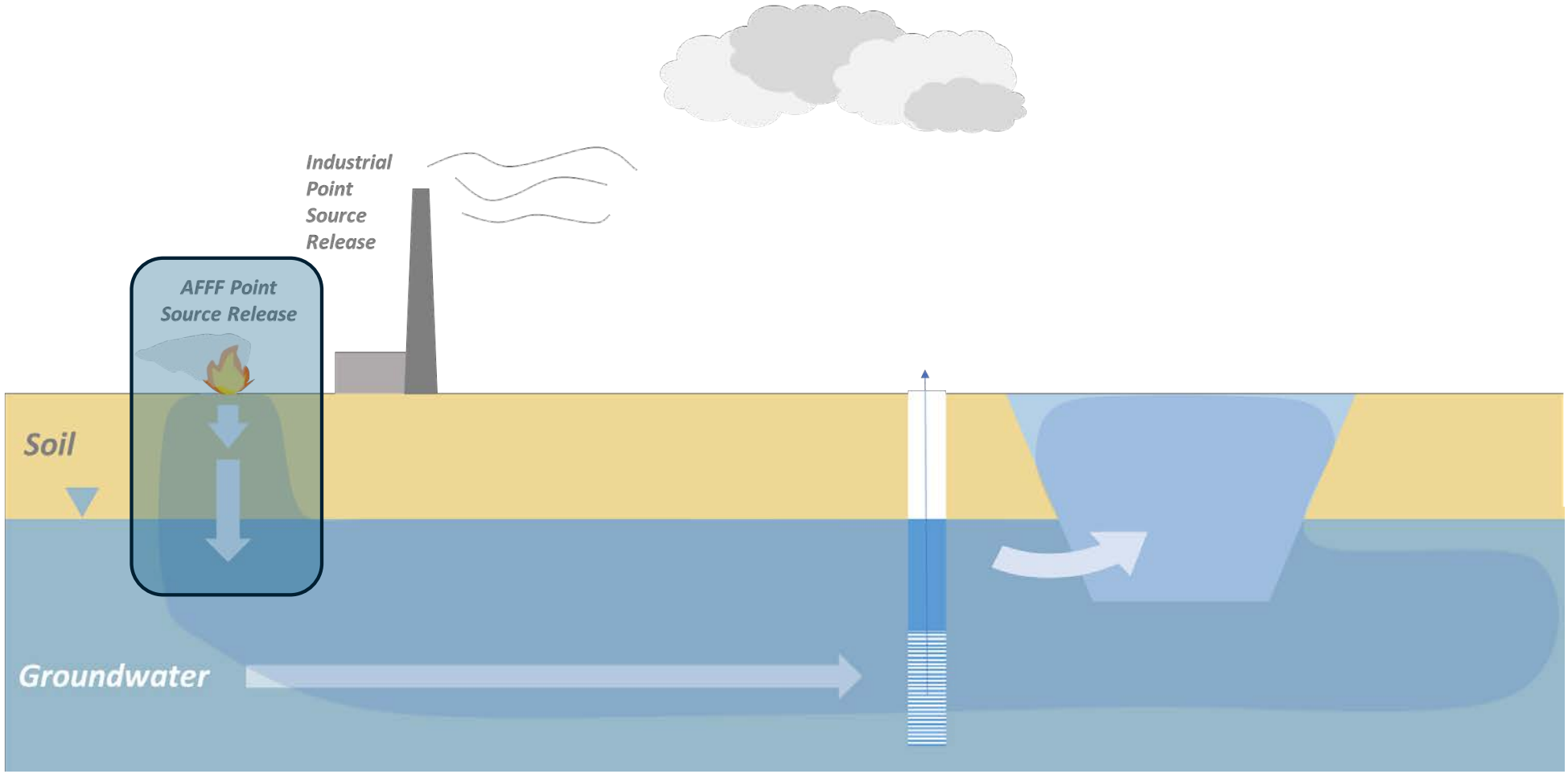
Source: D. Adamson, GSI Environmental Inc.

PFAS Sources



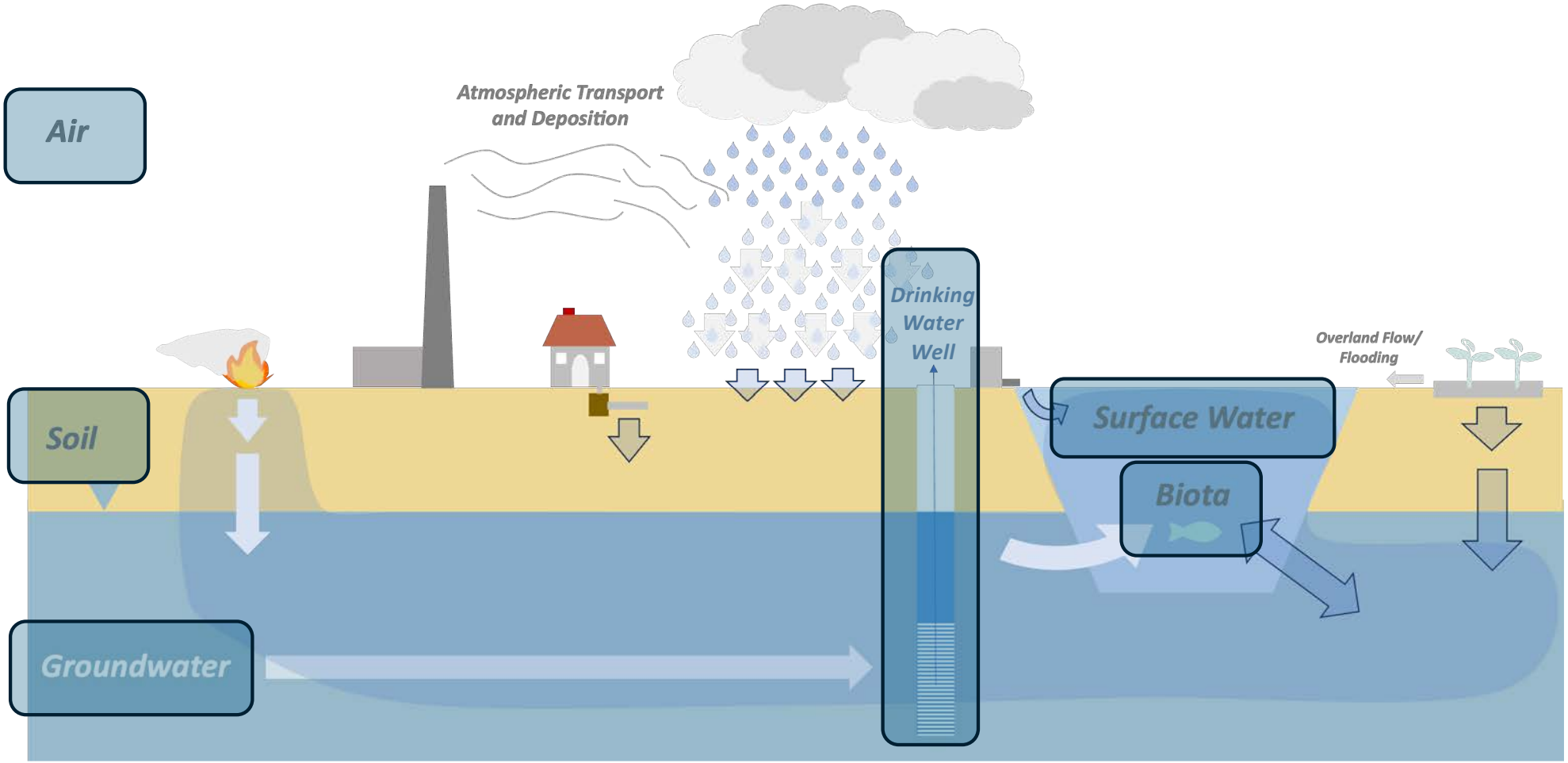
Source: D. Adamson, GSI Environmental Inc.

PFAS Sources – AFFF is the Priority Point Source



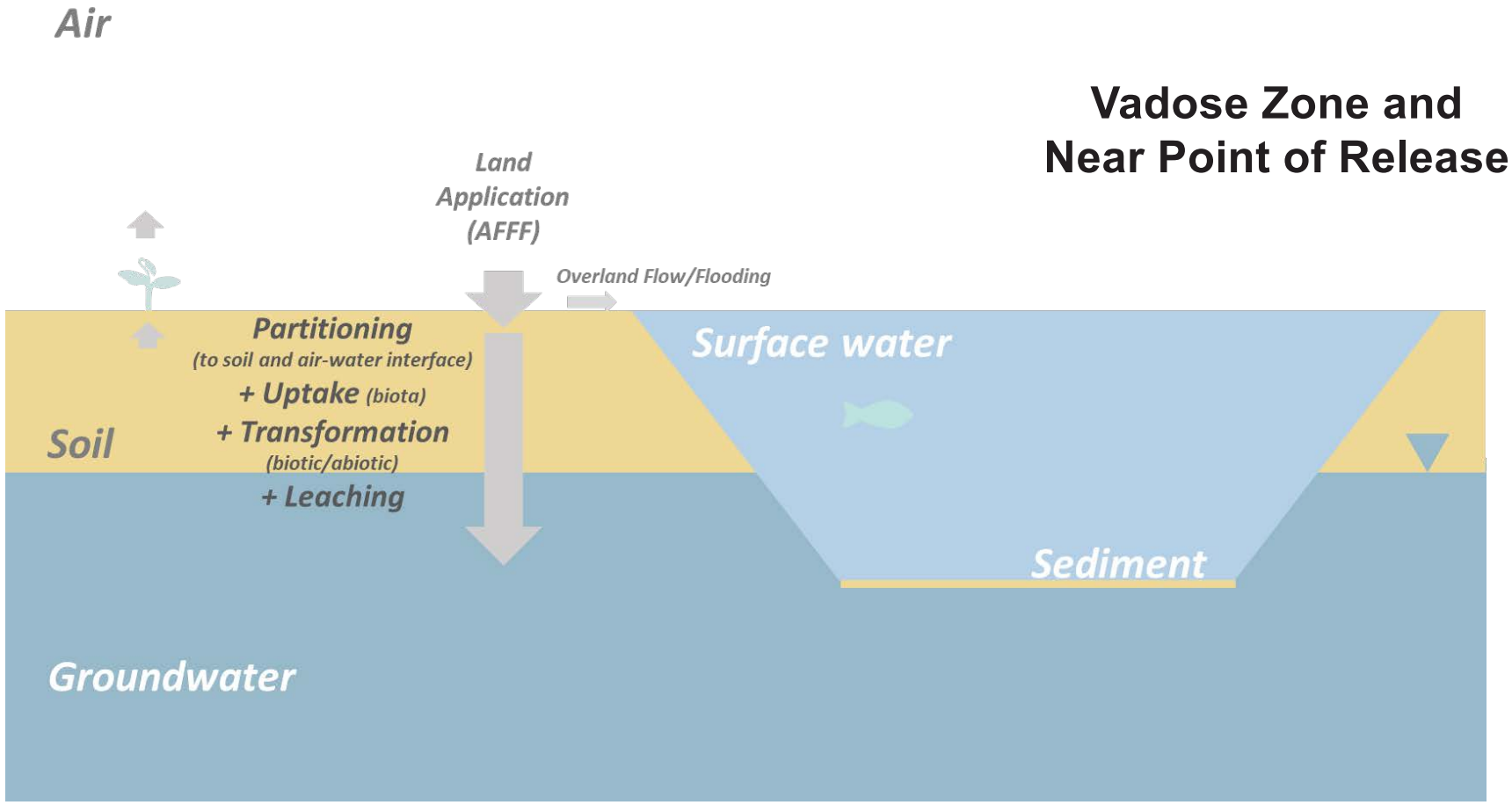
Source: D. Adamson, GSI Environmental Inc.

Relevant Media and Receptors



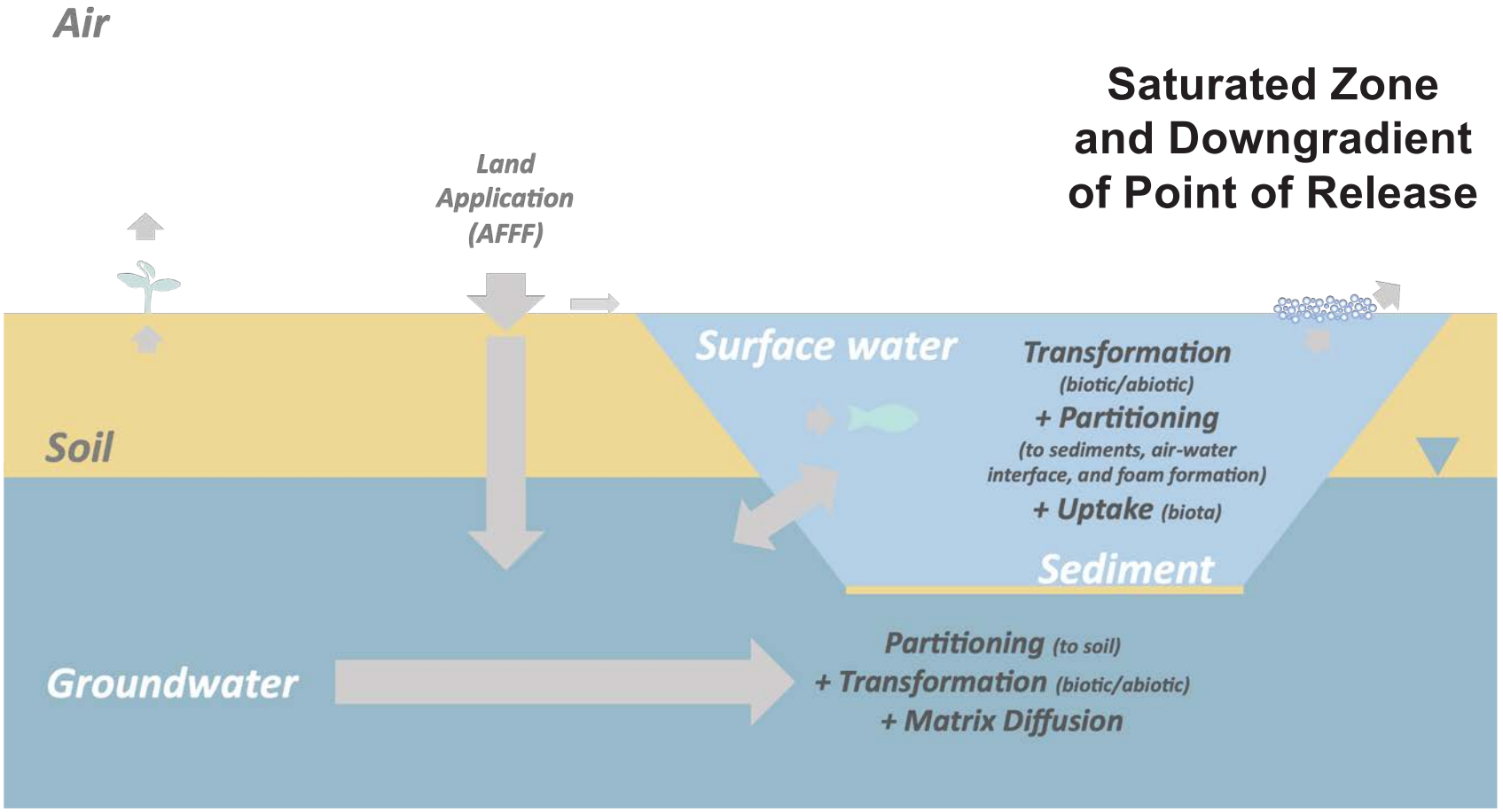
Source: D. Adamson, GSI Environmental Inc.

Overview of PFAS Fate and Transport Processes



Source: D. Adamson, GSI Environmental Inc.

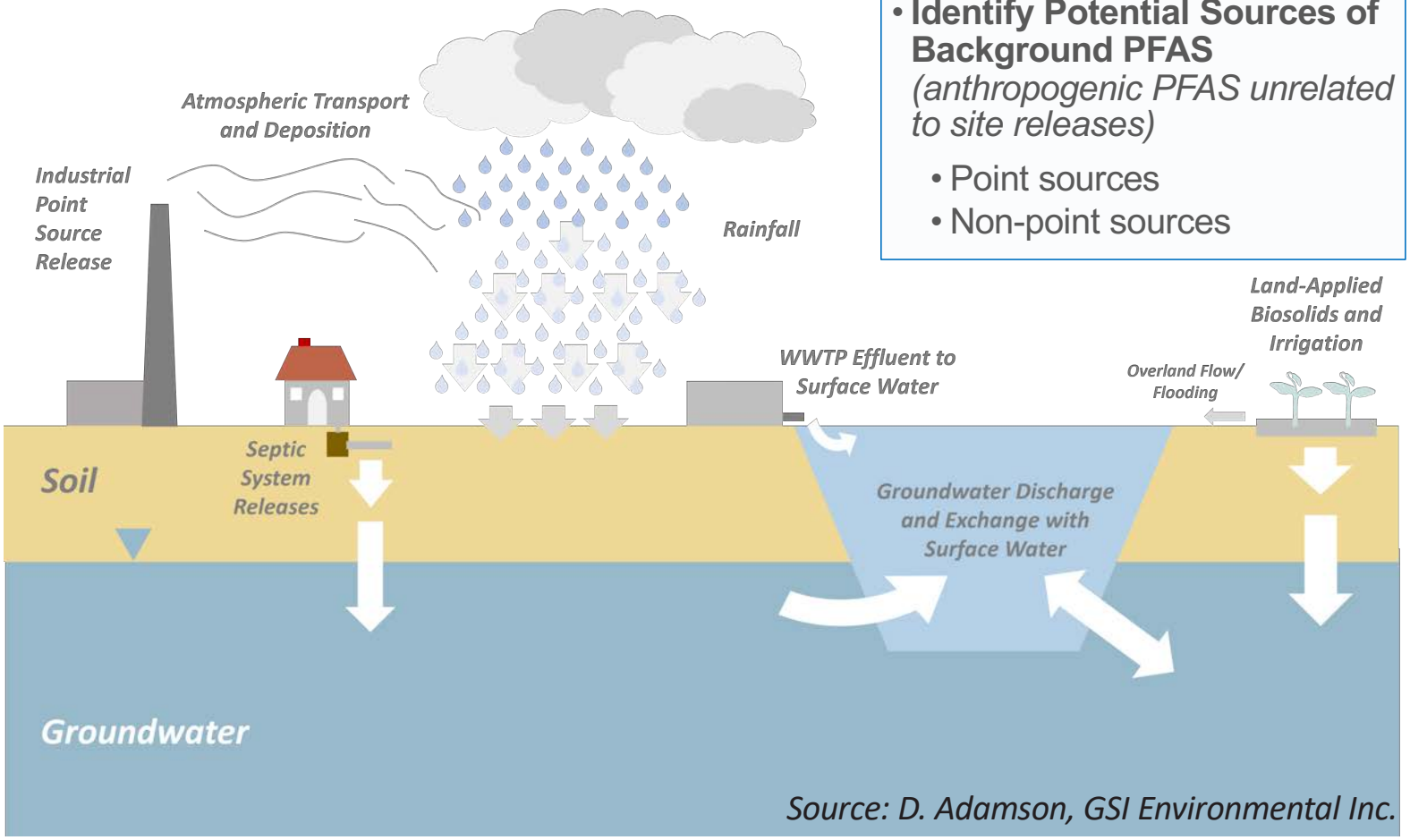
Overview of PFAS Fate and Transport Processes



Source: D. Adamson, GSI Environmental Inc.

Background PFAS – Assessment Objectives

- **Identify Potential Sources of Background PFAS** *(anthropogenic PFAS unrelated to site releases)*
  - Point sources
  - Non-point sources

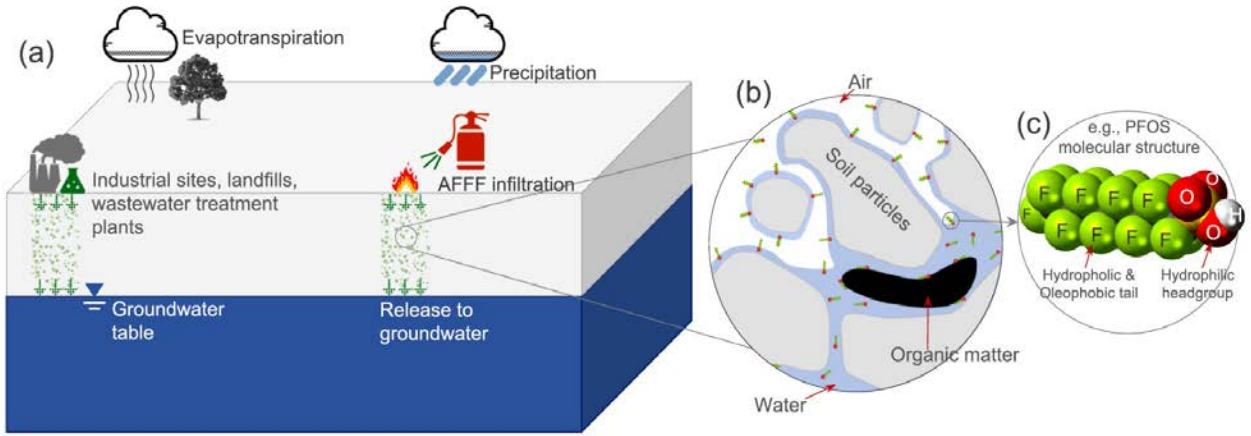


Source: D. Adamson, GSI Environmental Inc.

PFAS Fate & Transport: Unsaturated Zone

Key PFAS Retention Processes: Air-Water Partitioning

- PFAS are surfactants
- They like to accumulate at air/water interfaces
- This can retain some PFAS in the unsaturated zone for a long time
- Depends on site, but "can take several decades or longer for PFOS to reach groundwater."



Guo et al., 2020

Distribution of Maximum PFAA Concentrations in the top 10 Feet of the Soil Column in or Near the Source Zone (Kulkarni et al., 2025)

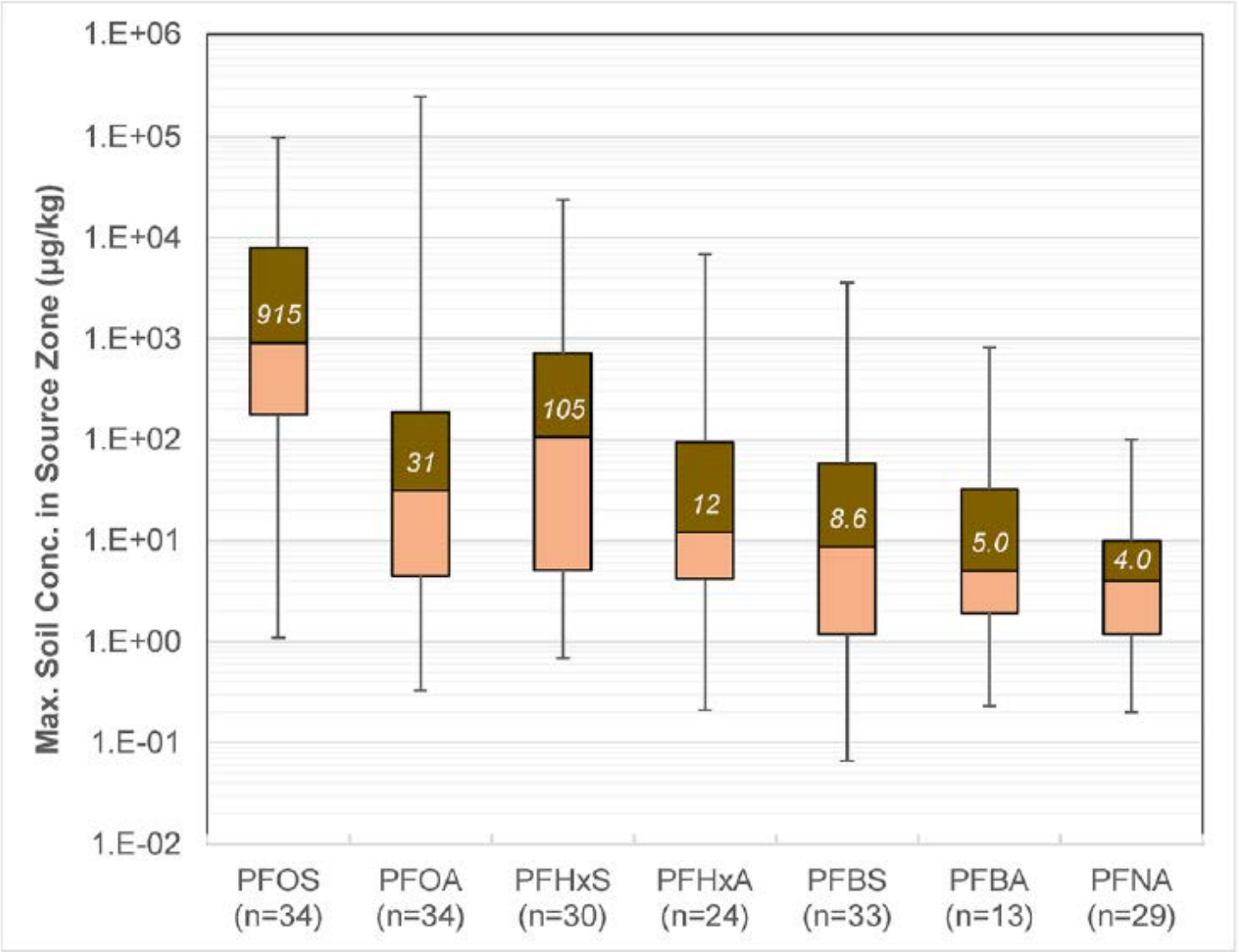
Contents lists available at ScienceDirect

Water Research

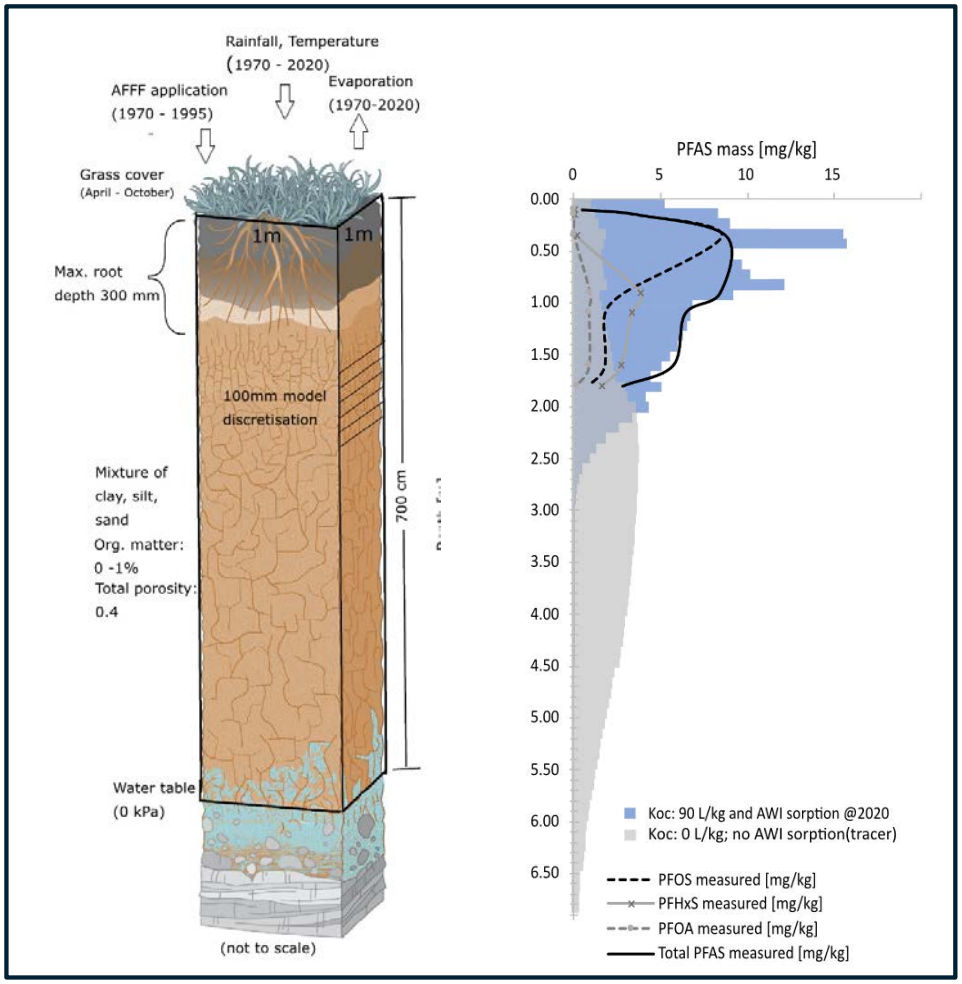
journal homepage: www.elsevier.com/locate/watres

Characteristics of aqueous film forming foam (AFFF) sites impacted with per- and polyfluoroalkyl substances (PFAS): A 37-site study

Poonam R. Kulkarni [a,*], Nicolette E. Andrzejczyk [b], Arun Gavaskar [b], Abigail Cartwright [a], David T. Adamson [a], John Cook [a], Charles J. Newell [a]



Vadose Zone Processes



Evapoconcentration

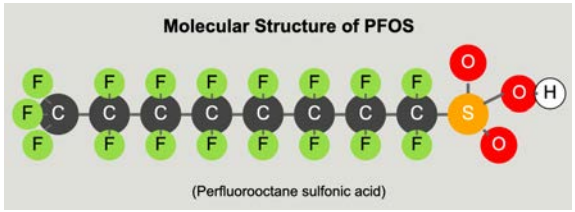
- During dry periods, evapotranspiration rates can be greater than rainfall rates
- Results in upward flow of porewater – and the PFAS present in that porewater
- Can contribute to **higher PFAS concentrations in shallow zones** above the "zero-flux plane" (divide where porewater travels upward vs. downward)

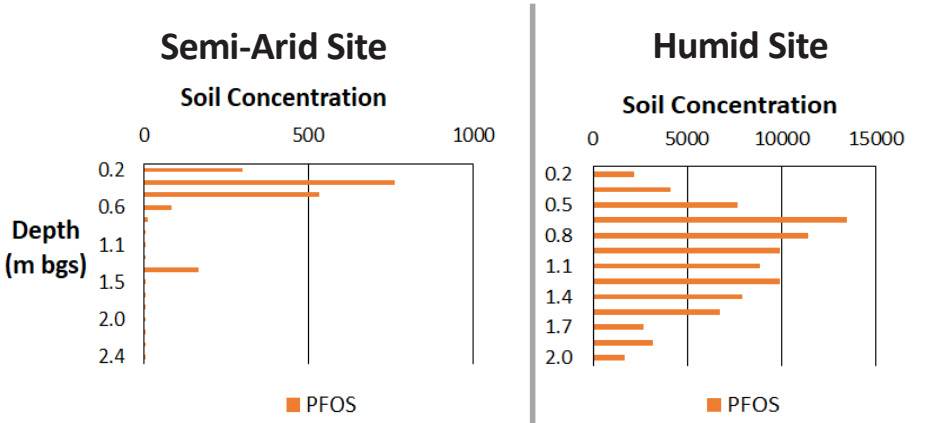
Source: Wallis et al. (2022)

PFAS Concentration vs. Depth

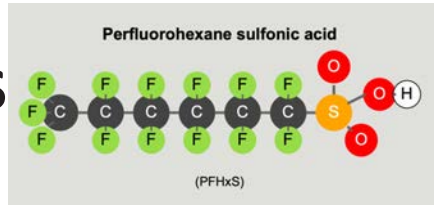
Schaefer et al., 2024

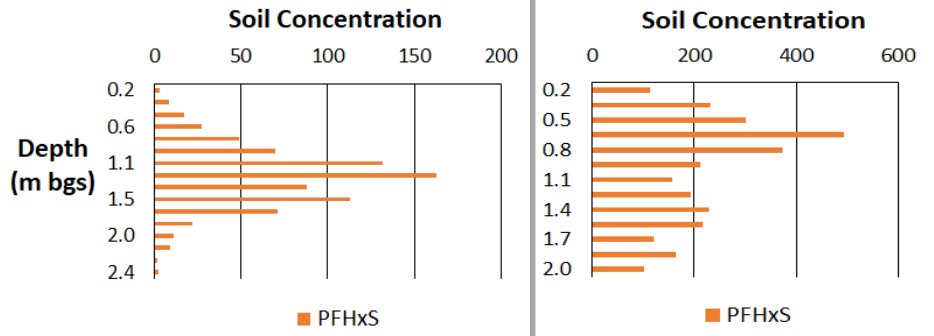
PFOS



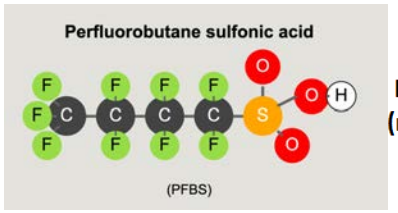


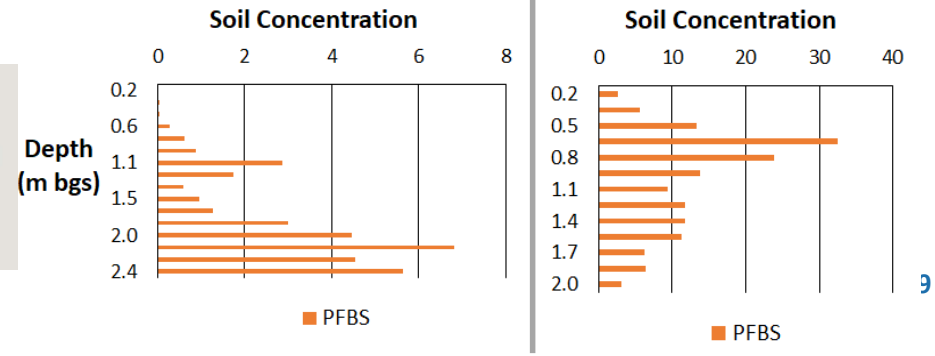
PFHxS





PFBS



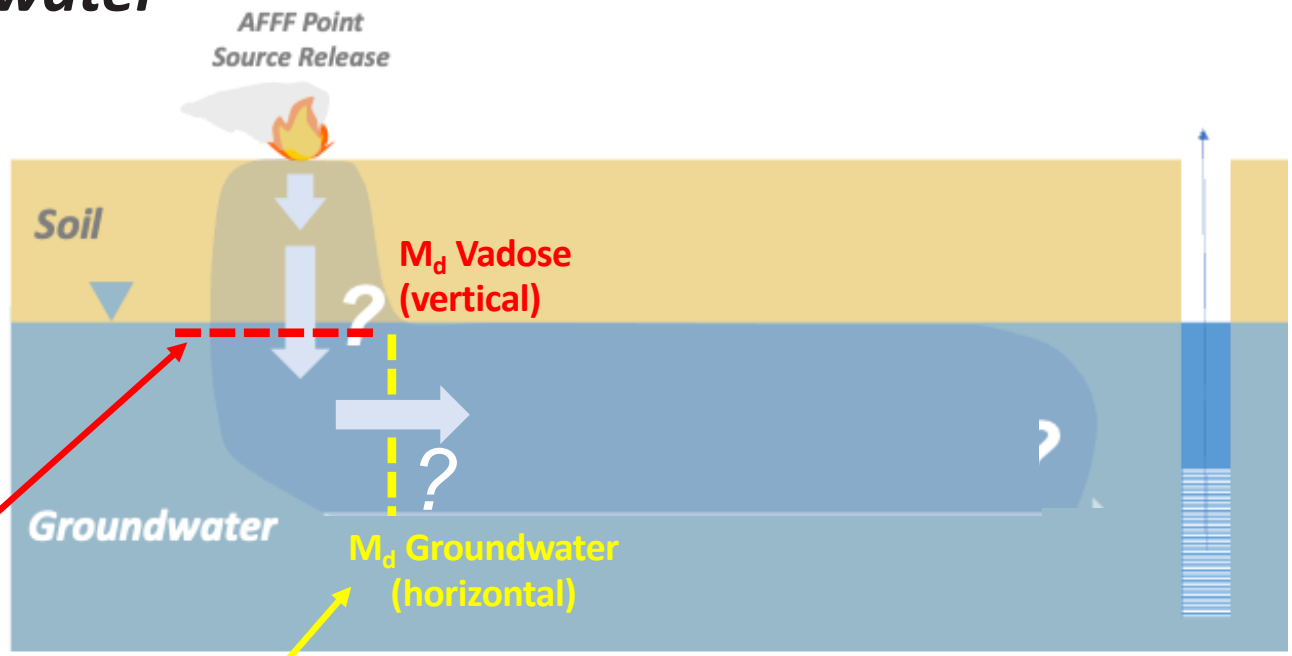


Schaefer et al. (2024) Journal Contaminant Hydrology
"PFAS Porewater concentrations in unsaturated soil"

One Key Goal: Compare PFAS Mass Discharge in *Vadose Zone vs Groundwater*

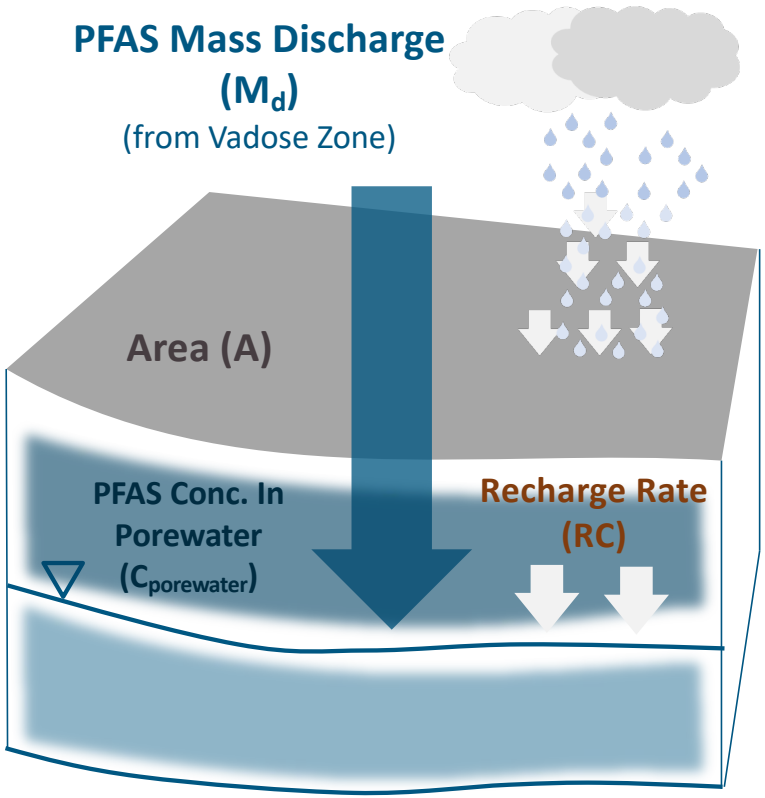
Original Figure:
D. Adamson, GSI Environmental

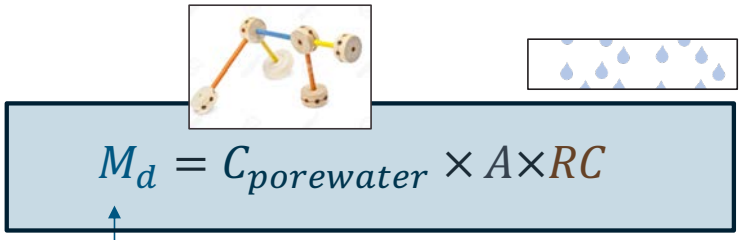
M_d (mass discharge) describes the strength of of a PFAS source in units of grams per year (e.g., "30 grams of PFOS per year)



	Mass Discharge in *Vadose Zone*	Mass Discharge in *Groundwater*	Implication
Scenario 1	High	Low	Vadose Zone Cleanup More Important
Scenario 2	Low	High	Vadose Zone Cleanup Less Important

Key Process: Vadose Zone Mass Discharge



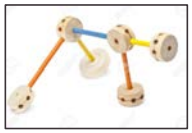


Measure of source strength (PFAS mass per time) integrated across entire source area

M_d (mass discharge) describes the strength of vadose zone sources in units of grams per year (e.g., "30 grams of PFOS per year" are being transported vertically from PFAS-impacted soils to groundwater)

Source: D. Adamson, GSI Environmental Inc.

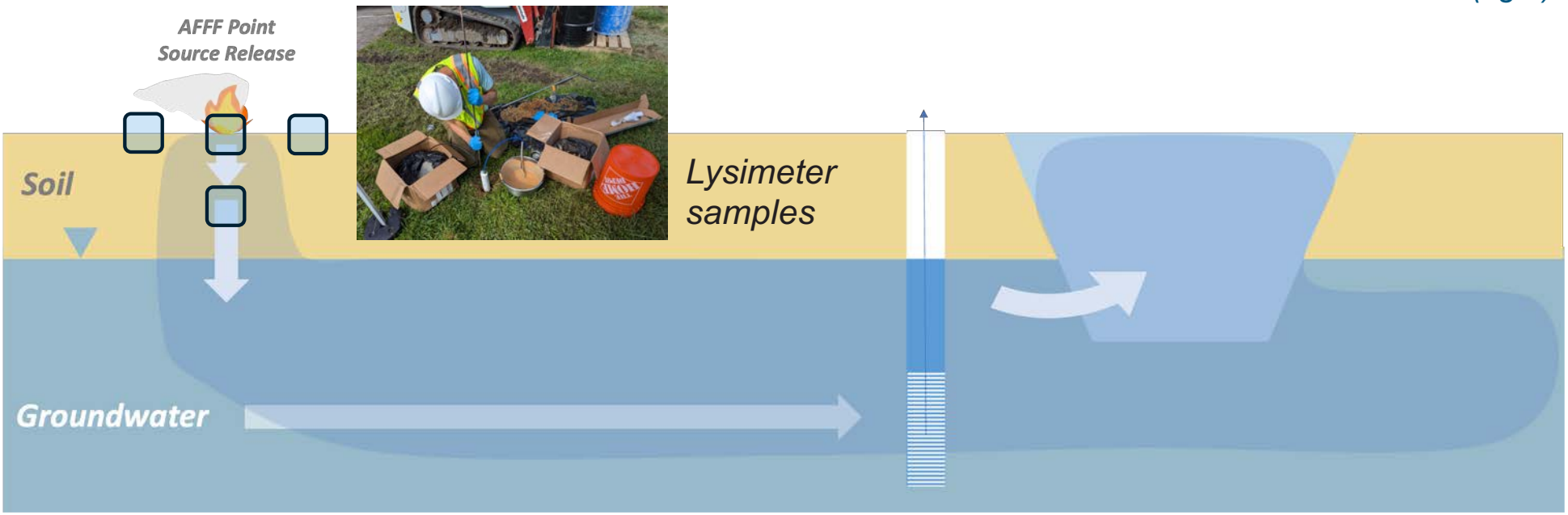
How Do You Get Porewater Concentrations?



- There are multiple methods (partitioning equations, leaching tests)
- One common approach uses **suction lysimeters** to directly measure porewater concentrations.

$$M_d = C_{porewater} \times A \times RC$$

Porewater concentration (ng/L)



Source: D. Adamson, GSI Environmental Inc.

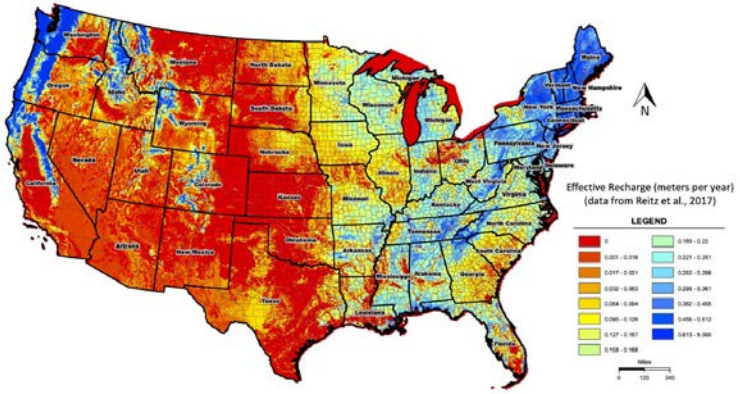
How Do You Get the Recharge Rate?

There are multiple methods divided into three separate Recharge Tiers:

$$M_d = C_{porewater} \times A \times RC$$

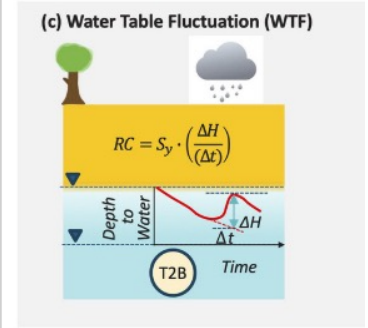
Recharge (inches per year)

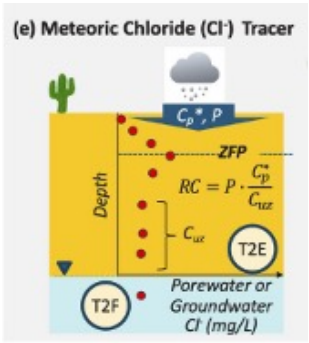
Tier 1 Desktop Methods Based on Equations, Maps, Settings



Example: Nationwide Runoff Map Method

Tier 2 Simple Methods Based on Site Data





Two Examples:

- Water Table Fluctuation (WTF) Method
- Meteoric Chloride Methods

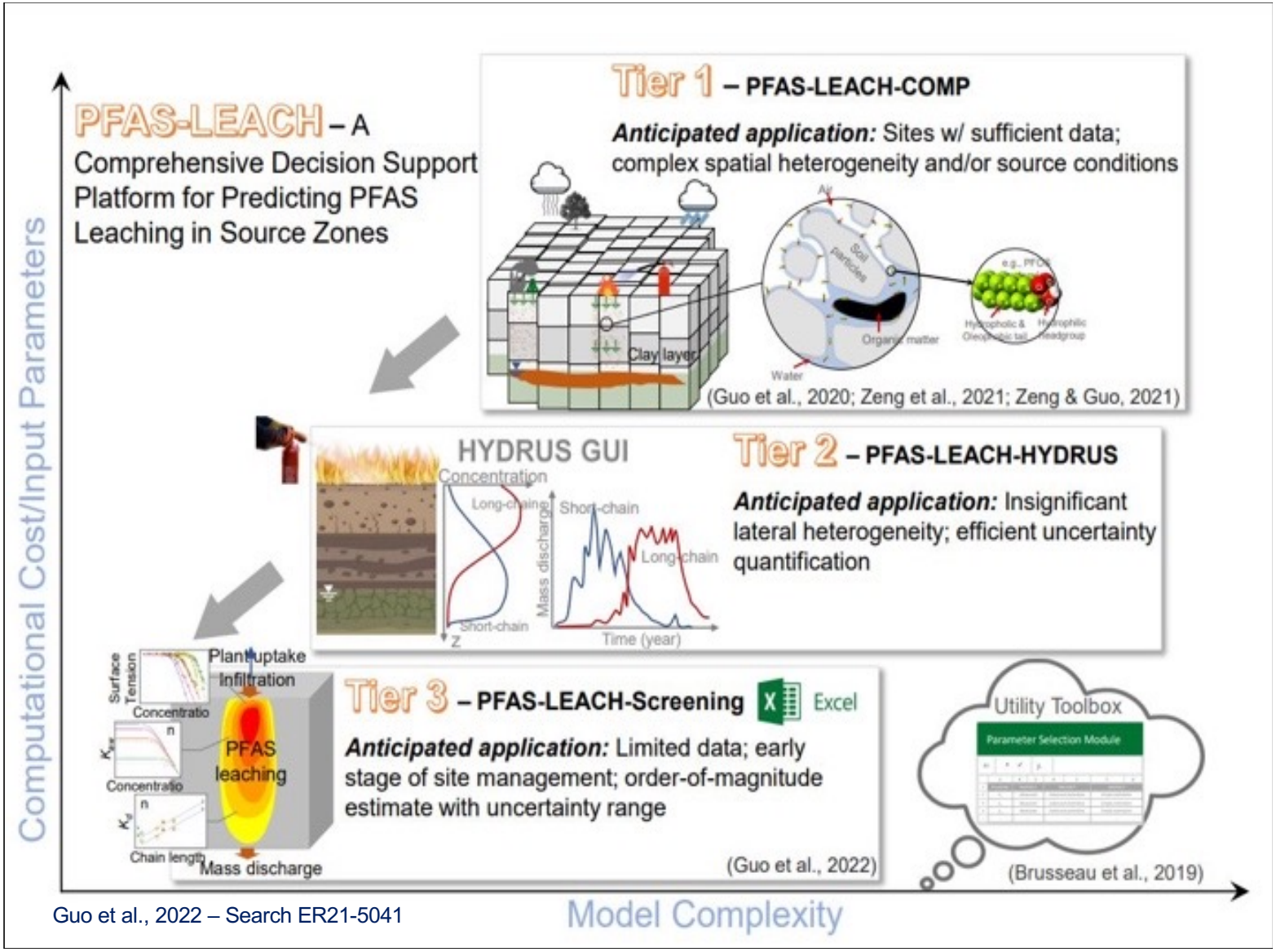
Tier 3 Detailed, More Complex Methods

Two Examples: Numerical modeling, applied tracers

ESTCP's PFAS Leach Platform (Guo et al.)

Tier 3 Screening Model
Tier 2 HYDRUS Model
Tier 1 Complex model

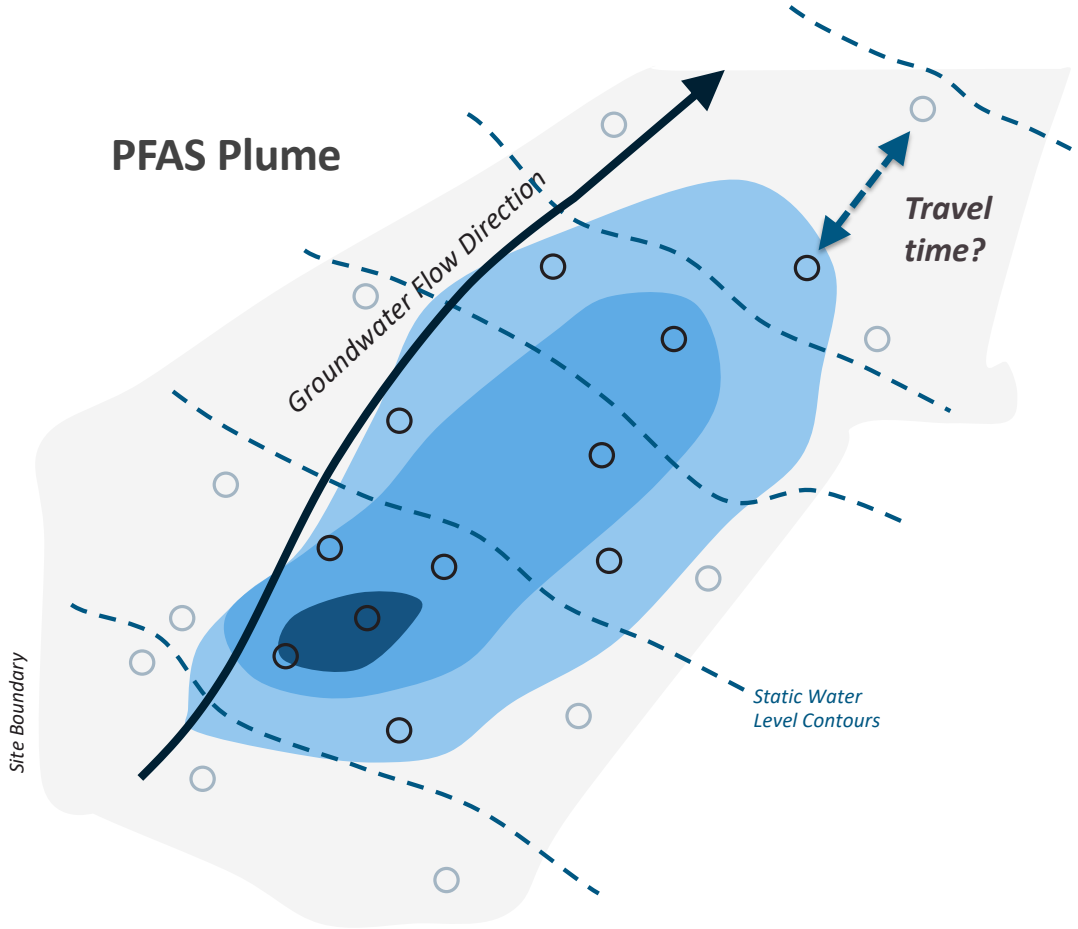
Enter in soil concentrations, climate data, soil data, groundwater data and these models estimate PFAS mass discharge to groundwater



Guo et al., 2022 – Search ER21-5041

PFAS Fate & Transport: Saturated Zone

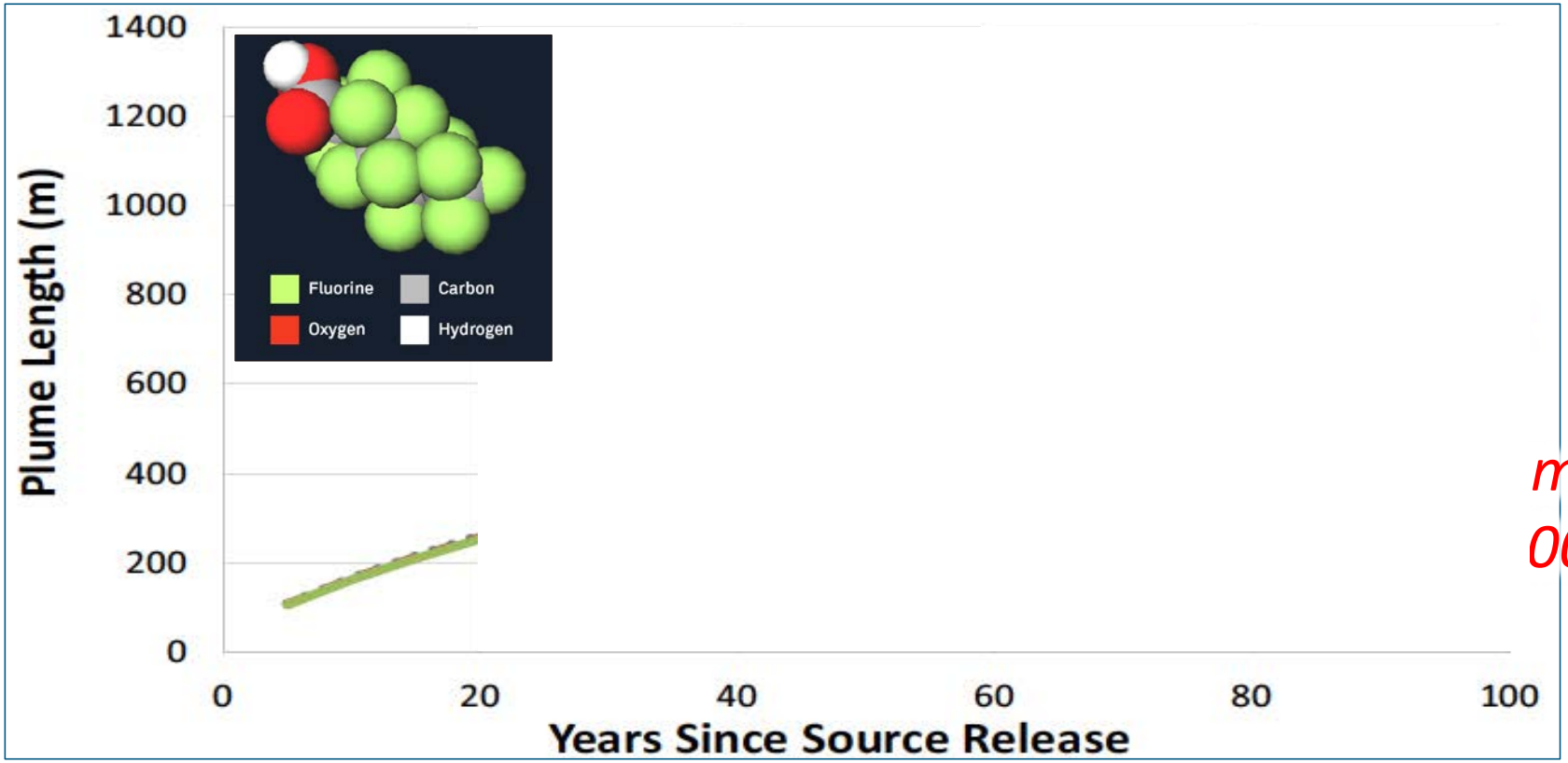
Advection, Dispersion, Sorption, Matrix Diffusion



- Migration of dissolved-phase PFAS is a function of the hydraulic gradient of groundwater
- Dispersion may also occur during advective transport, but effects on plume may be minor
- Advection is a strong influence on plume advancement rates, but other processes (e.g., sorption, matrix diffusion) can slow it down
- Matrix diffusion is key retention process for PFAS plumes

Source: D. Adamson, GSI Environmental Inc.

Remediation of PFAS in Groundwater:
Computer Modeling a Non-Degrading Groundwater Plume



Source: Farhat et al., 2022 Journal Contaminant Hydrogeology

mes were 00 years….

PFAS Mass Balances

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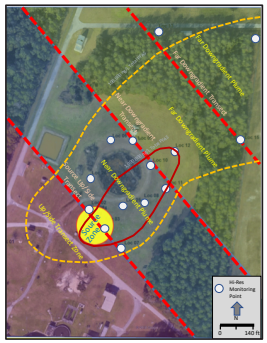
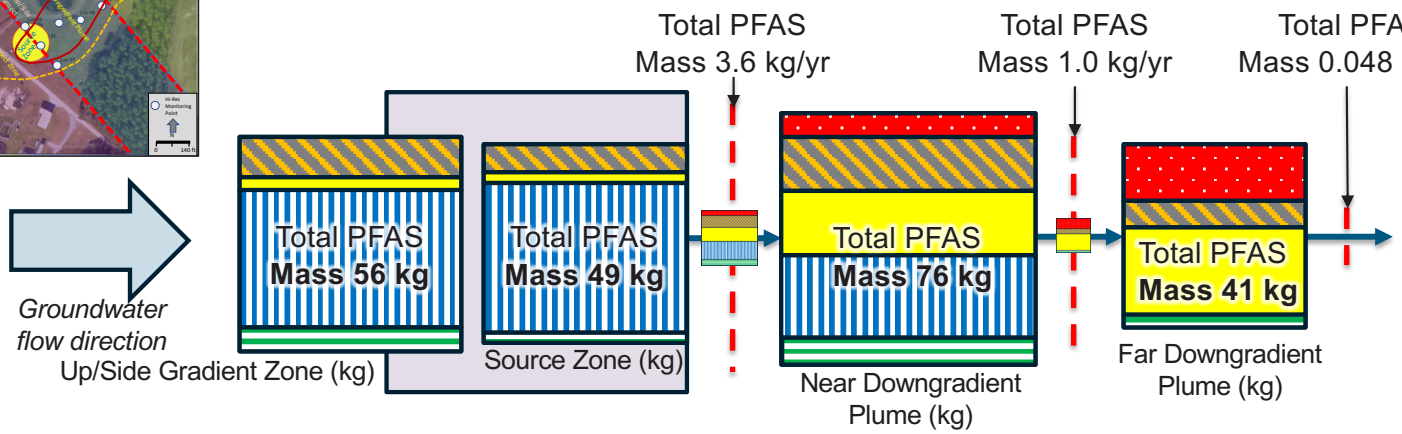
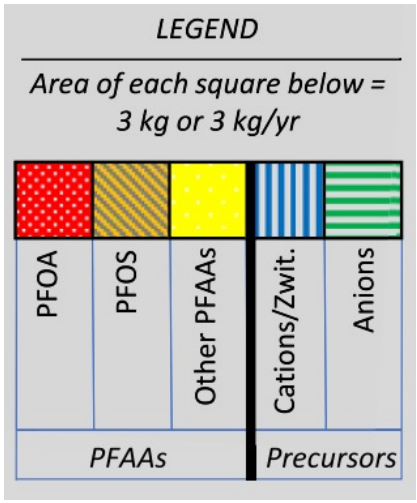


AFFF Release Site (modified from Adamson et al., 2020)





KEY POINT: PFAS spatial distribution was explainable based on site conditions and expected F&T processes

- Precursors & long-chain PFAAs tended to stay closer to source area
- Short-chain PFAAs tend to migrate farther from the source area
- PFCAs tend to migrate farther than PFSAs of similar chain length

PFAS *Groundwater Cleanup Calculus*

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Non-Degrading Plumes + *Lack of In-Situ Destructive Technologies* = **More Expanding Plumes Than We Are Used To?**

More Expanding Plumes Than We Are Used To? + Low Action Levels (e.g., 4 ng/L) = **Lots and Lots of Pump & Treat & Permeable Sorption Barriers?**

PFAS are Not *Immobilized* in the Subsurface. But at Some Sites PFAS are *Retained* for Long Timescales

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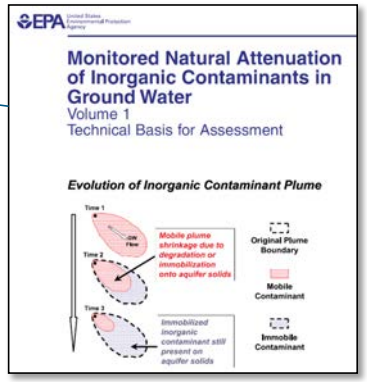
- **Immobilization:** Permanent trapping & isolation of a chemical in the environment.
- **Retention:** The storage of a chemical in the environment so that the chemical is isolated from potential receptors for a certain time.



Key Point: At some PFAS sites, PFAS Monitored Retention (PMR) may be appropriate via strong air/water partitioning, sorption, matrix diffusion retention processes.

~~MNA~~ → PMR

Source: D. Adamson, GSI Environmental Inc.

PFAS Transport in Groundwater:

Matrix Diffusion is Potential Key Process

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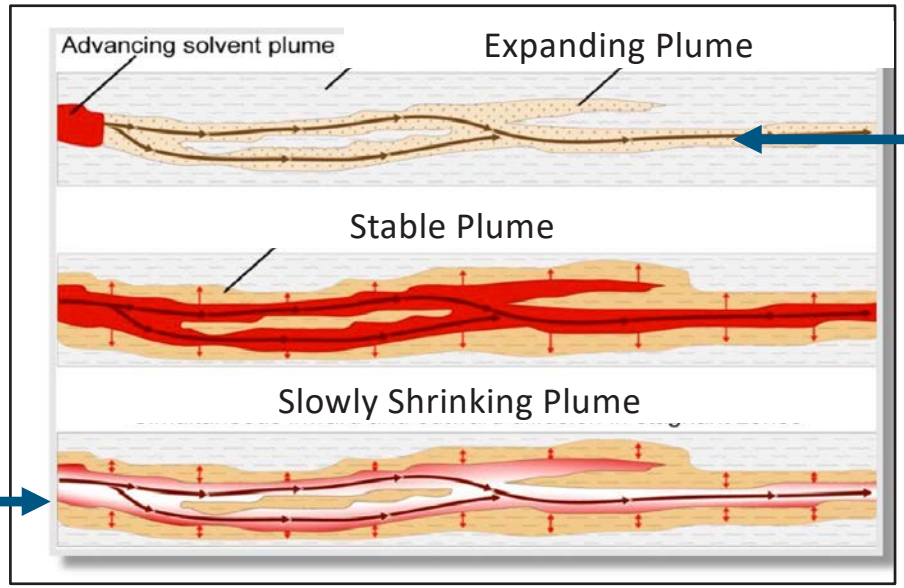
Most chlorinated sites down here: Matrix diffusion makes it harder to remediate

Matrix Diffusion Bad



PFAAs don't readily degrade, so there may be more expanding PFAS plumes.

But matrix diffusion is retaining PFAS, therefore slowing plume expansion

Matrix Diffusion Good!

Potential PFAS Management Framework

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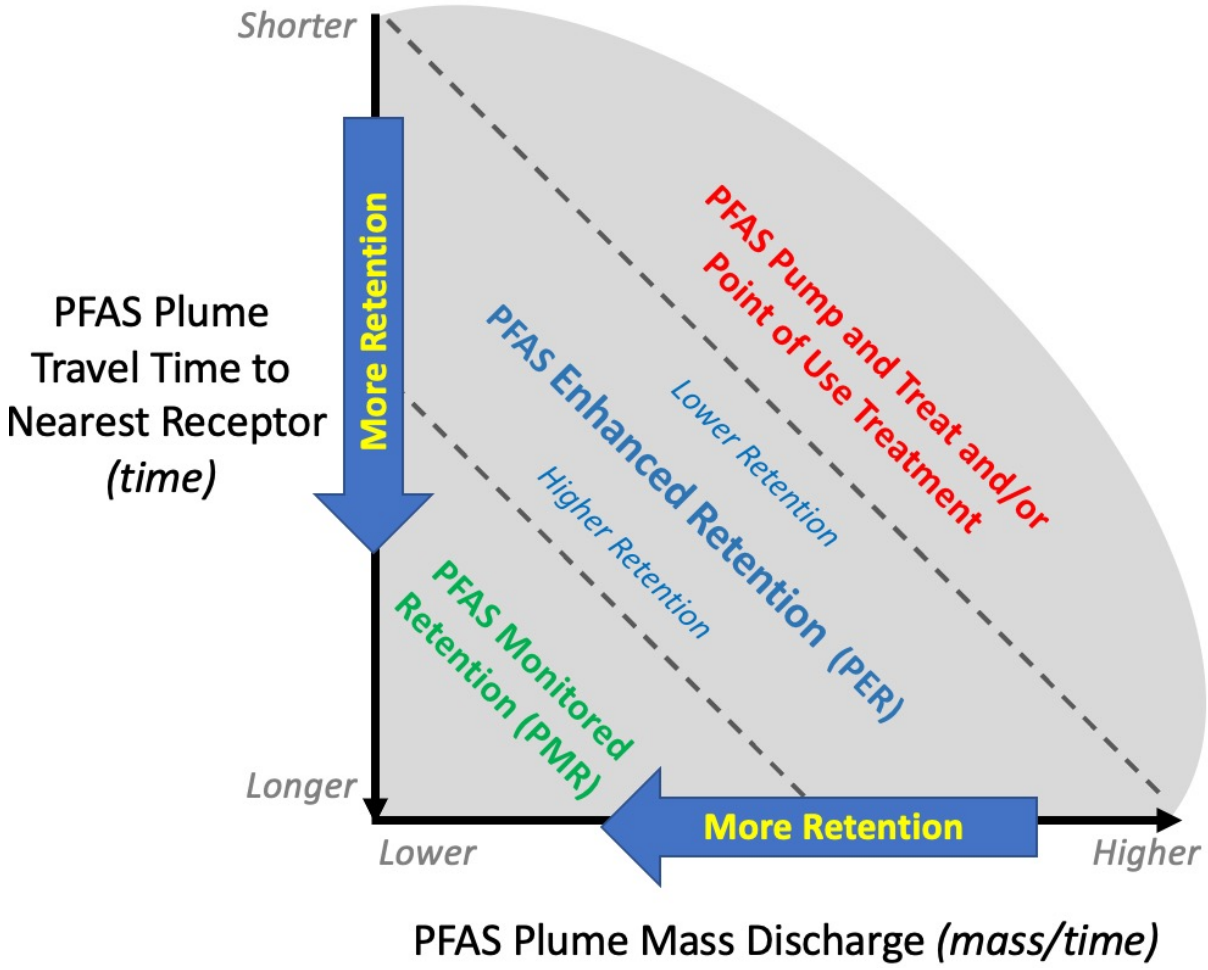
Knowing a Site's
- *Mass Discharge*
- *Travel Time to Nearest Receptor*

May be useful for
- *Selecting interim actions*
- *Prioritizing remediation*
- *Managing scare resources*

Adamson et al., 2025 (GWMR)
PFAS Monitored Retention A Framework for Managing PFAS (open access)



Two PFAS Models from ESTCP

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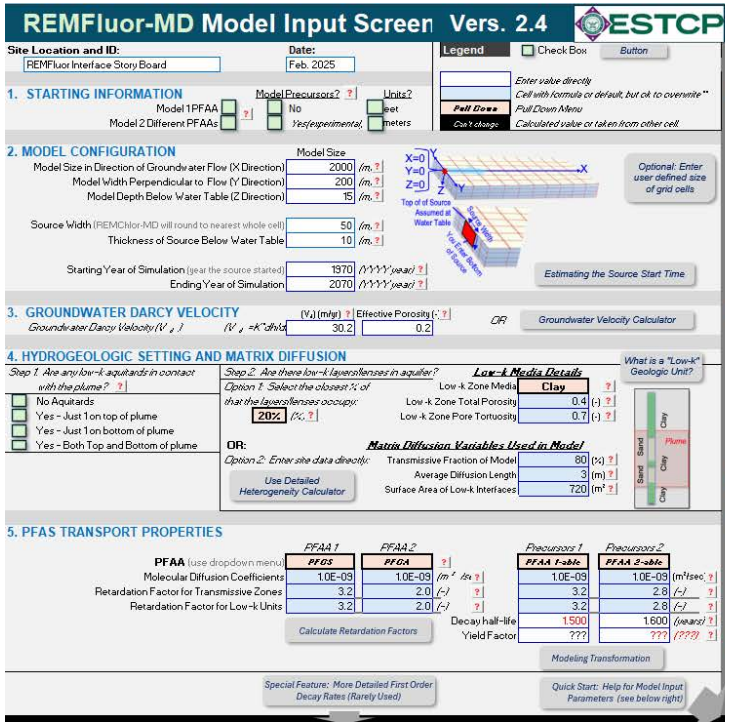
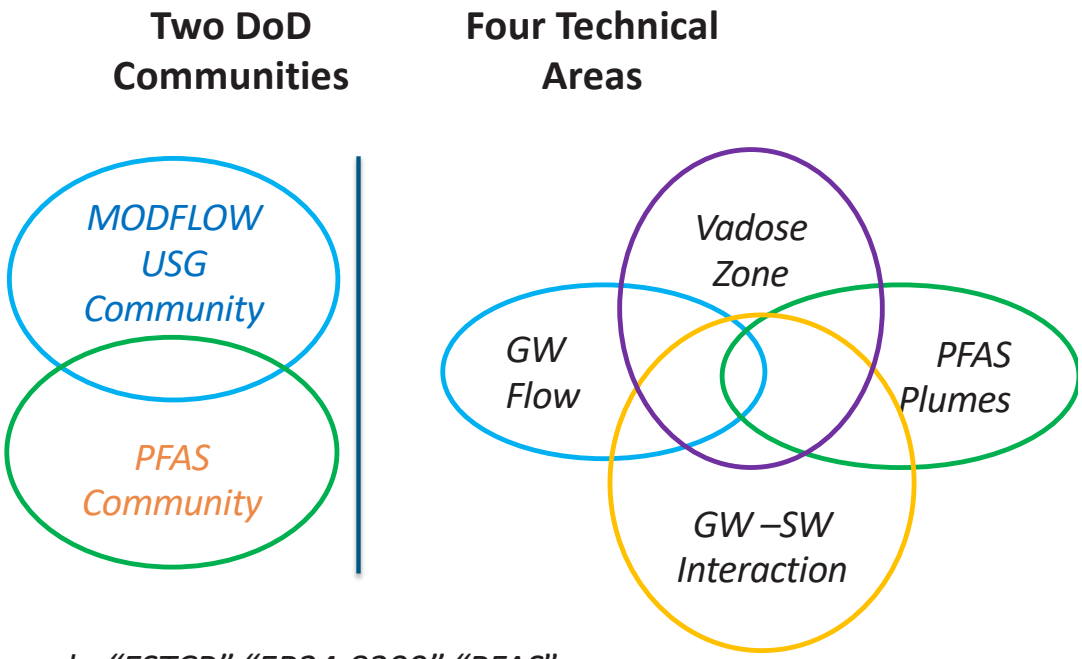
REMFluor-MD Model

- Mid-complexity groundwater model
- Answers "How long, how far" plume questions
- **Available early 2026**



USGT-PFAS Model

- More powerful but more complex model
- New capability to model PFAS in Unsat. Zone
- **Already developed**, ready for more testing



Search: "ESTCP" "ER24-8200" "PFAS"

PFAS Treatment Approaches

No endorsement is intended for any technology
Some technology providers are identified as a resource for the audience and is not meant to be exhaustive

PFAS Remediation: State of the Practice

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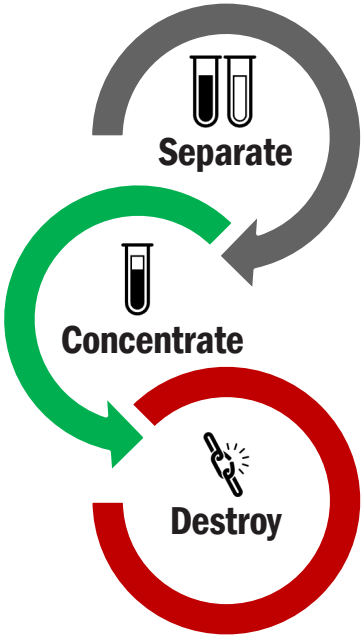

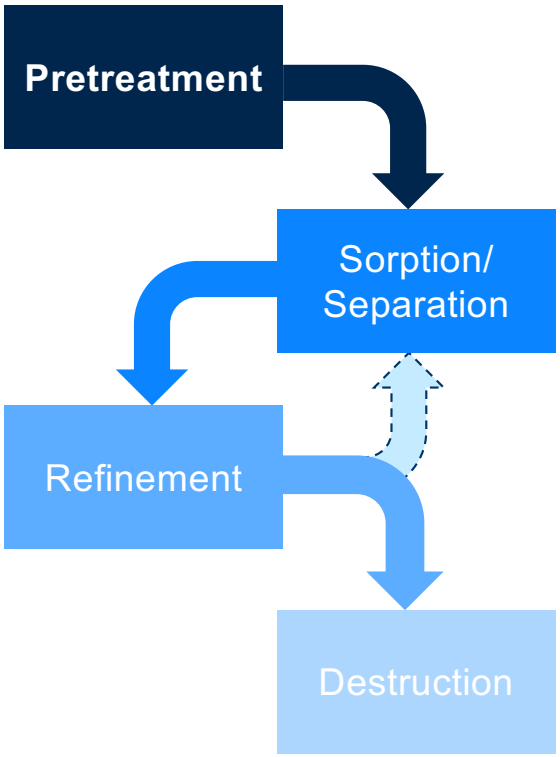

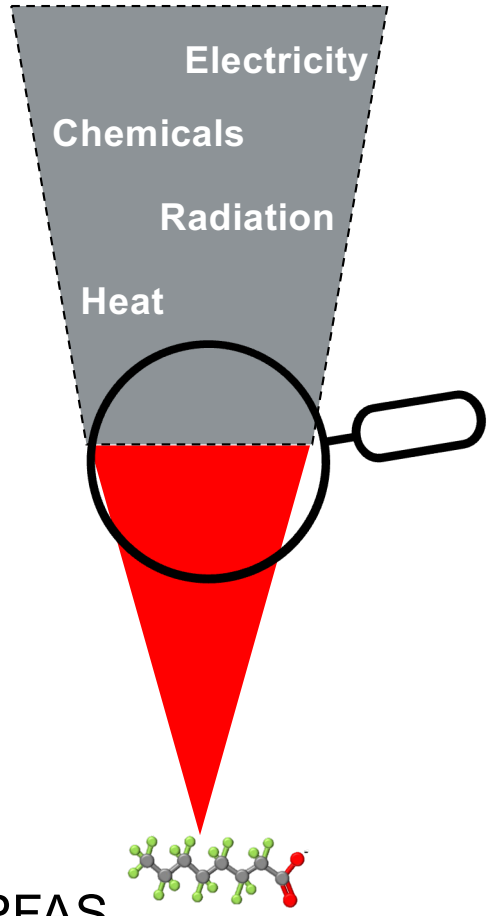

<u>State of the Practice</u>: Serial treatment to concentrate PFAS and reduce the volume requiring energy intensive destruction

In Situ Treatment Technology Development for PFAS

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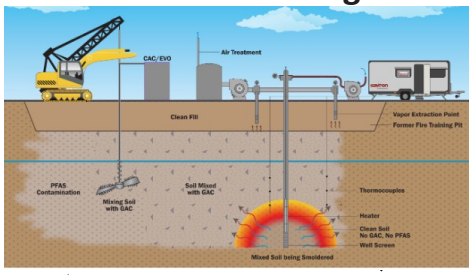
In Situ

Source/Release

Plume

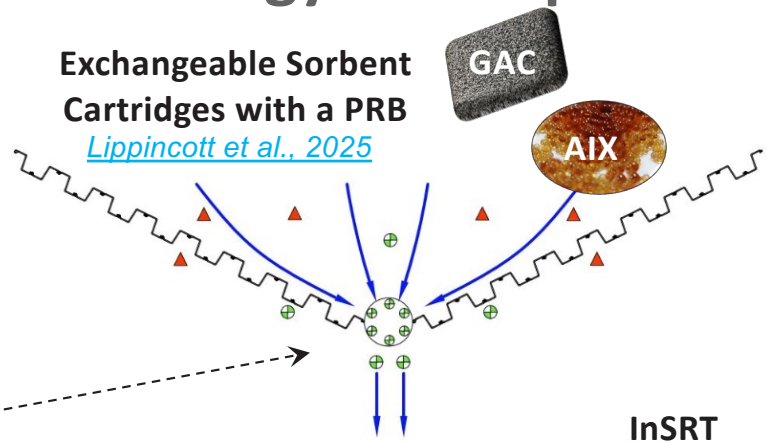
Major et al., 2024

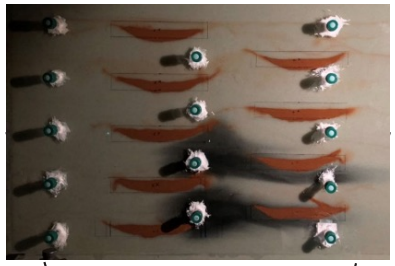
Smoldering



Exchangeable Sorbent Cartridges with a PRB

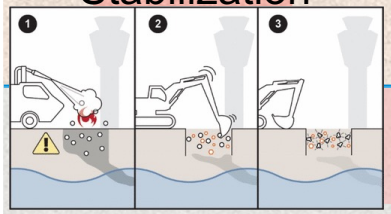
Lippincott et al., 2025





Liu et al., 2020

Thermal Desorption Stabilization



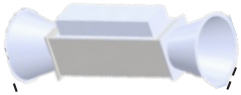
McDonough et al., 2021

In Situ Foam Fractionation (in well or PRB)

Gas Sparging Removal/ Sequestration

Newell 2025

InSRT (sonolysis)



Crimi et al., 2021

Sorptive Media Cartridge

Divine et al., 2020

PRB

HRX Well

Injected Adsorbents

Ex Situ PFAS Treatment Technologies

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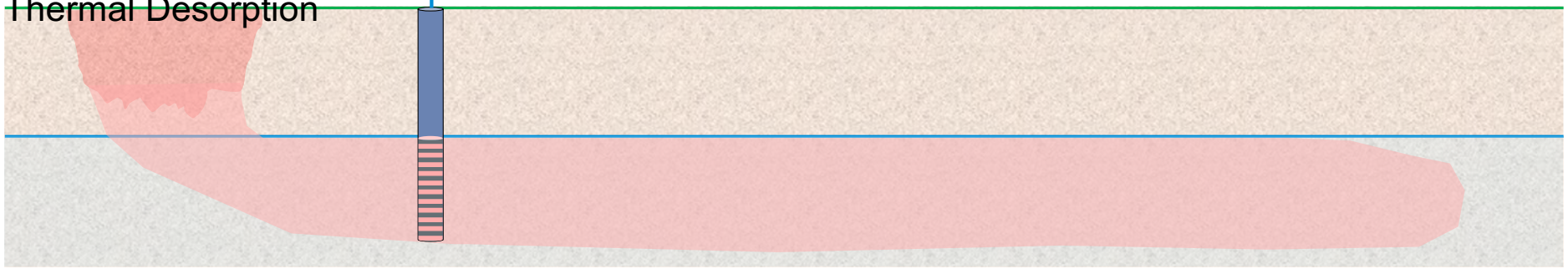
Ex Situ

Excavation
Soil Washing
Ball Milling
Capping
Thermal Desorption

In Situ

Groundwater Extraction

Sorption	Separation	Destruction
Activated Carbon (granular [GAC], powdered [PAC], sub-micron [SPAC])	**Reverse Osmosis**	**Incineration**
Ion Exchange (IX)	**Nanofiltration**	Hydrothermal
Biochar, Graphene Based Sorbents, Modified Clays, Hydrogels/Fluorogels, Polymeric Adsorbents, Metallic Organic Frameworks (MOF), Layered Double Hydroxides (LDH)	**Foam Fractionation**	Electrochemical Oxidation
	Electrocoagulation	UV-radiated Sensitizers
	Flocculation	Nonthermal Plasma
	Evaporators	Sonolysis
		Photolysis/Photocatalysis
		Thermal Plasma
		Decarboxylation/Thermal
		Electron Beam (Ebeam)
		Chemical Oxidation



Source/Release **Plume**

PFAS-Relevant Sorption: Its not just GAC and Resin!!!

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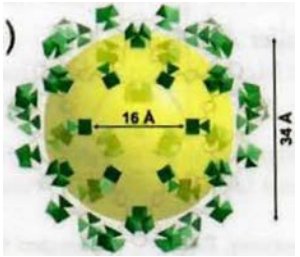
GAC/ Resins	• "Go to" sorbents • Economical, scalable, accepted
Modified clays, biochar	• Fluorosorb®; pyrolyzed cellulose • Available & competitive
Polymeric Sorbents	• DEXSORB®; PQ-Osorb®; Puraffinity® • Promising, improving scalability
Experimental	• MOFs[1]; Hydro/Fluorogels; LDHs[2]; 2-phase composites • Esoteric, high sorption capacities

[1]*Metallic Organic Frameworks;* [2]*Layered Double Hydroxides*

DEXSORB
(Cyclopure 2025)

FluoroSorb
(CETCO, 2023)

PQ-Osorb
(ABS Materials 2018)



MOF Concept
Barpaga et al., 2019

PFAS-Relevant Sorption: Optimization

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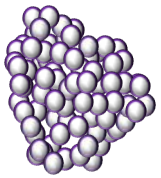
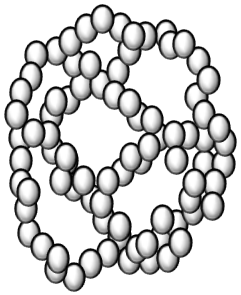
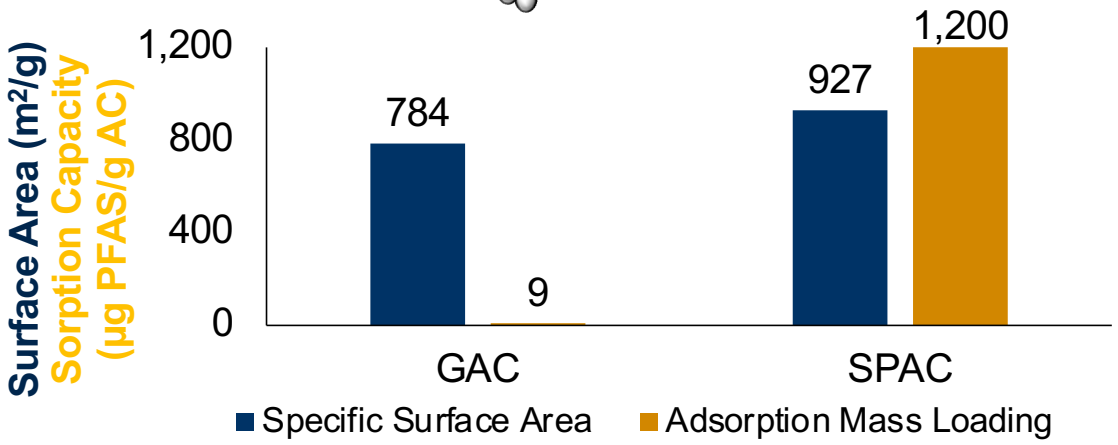
Increased Access to Surface Area



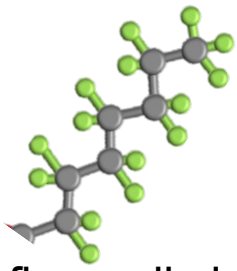
Edmiston 2020



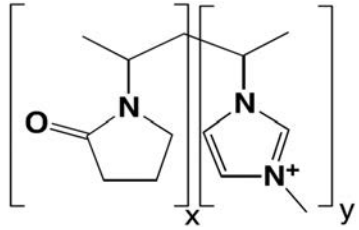


Adapted from Murry et al., 2019

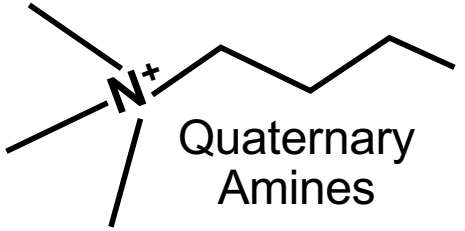
Functionalizing



Perfluoroalkyl group



Polymers of Quaternary Amines



Quaternary Amines

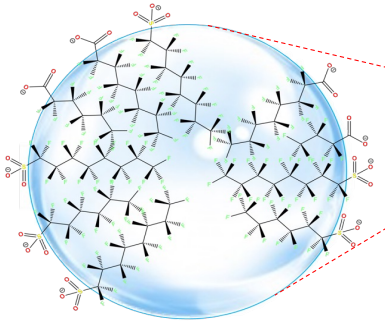
Reactivation (GAC) and Regeneration (other sorbents)

Various solvents

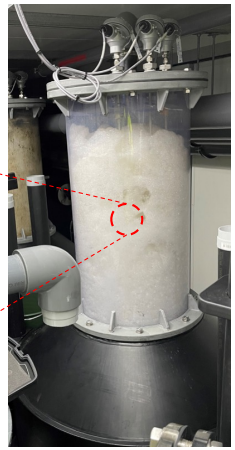
Electro-Sorption/Desorption

Separation Developments

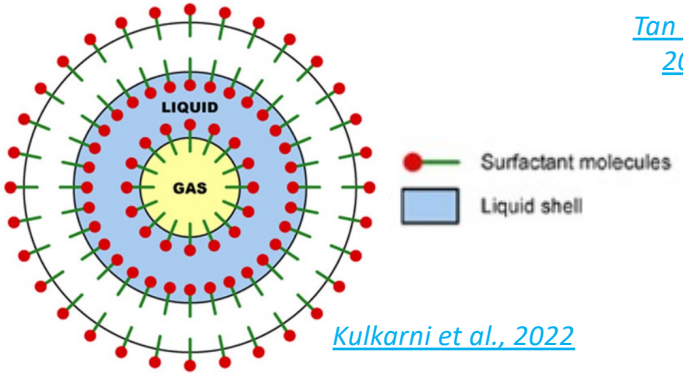
Foam Fractionation



McDonough and Ross et al., 2019

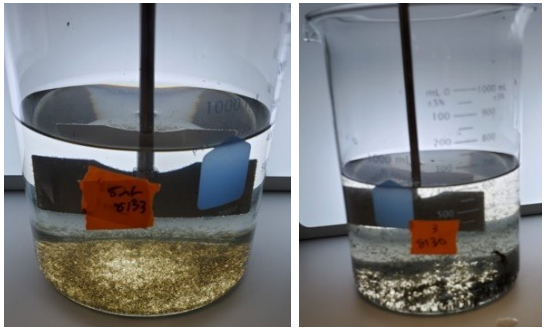


Foam fractionate (EPOC, 2023)



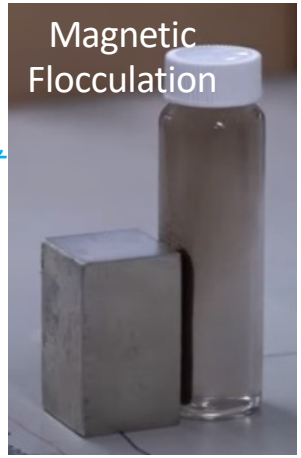
Kulkarni et al., 2022

Flocculation/ Coagulation



Cationic Coagulants (Menkhaus 2020)

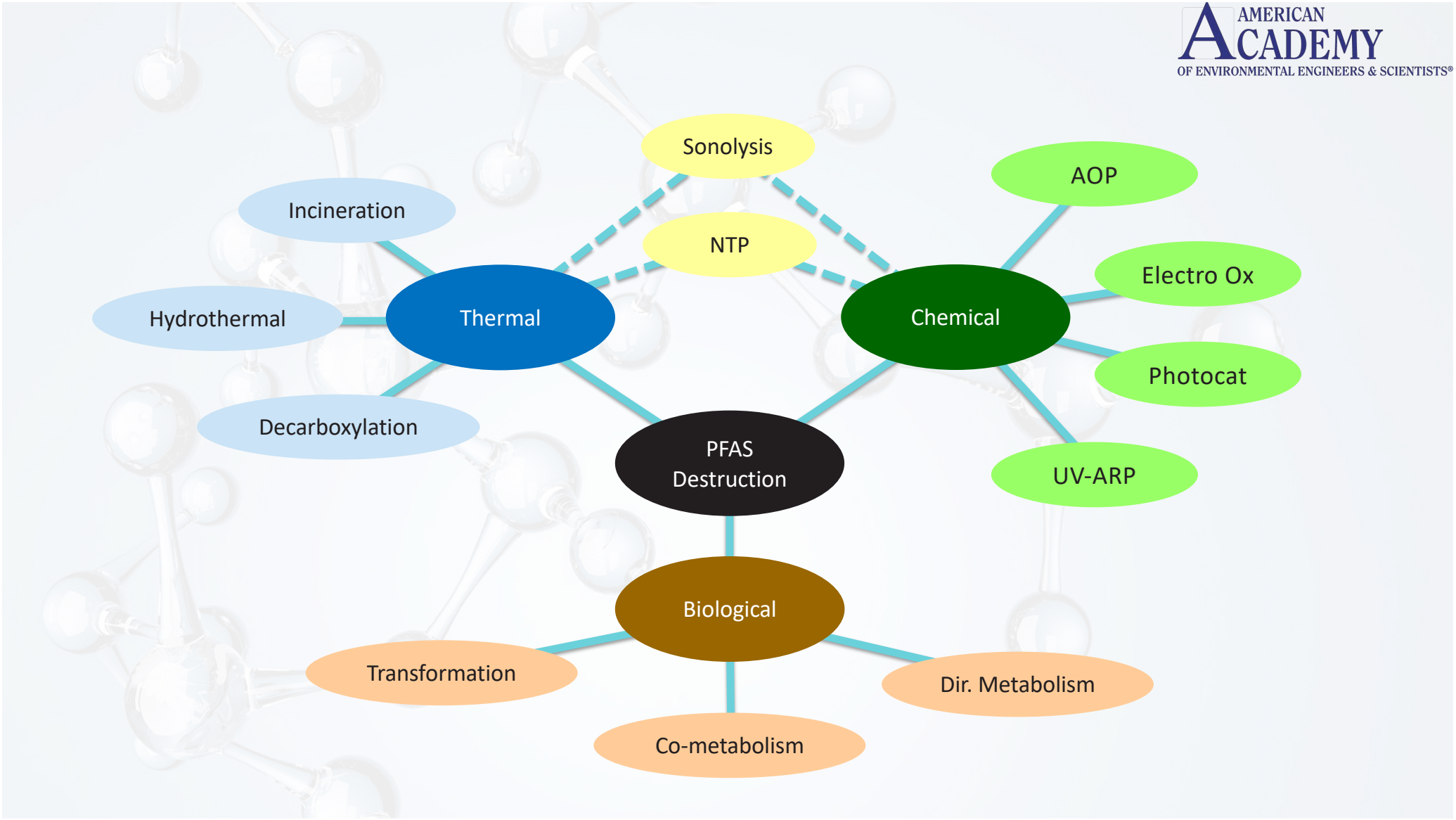
Tan et al., 2022



Membrane Separation

Field-Scale RO (Storch, 2018)

Municipal-Scale RO (Bellona, 2023)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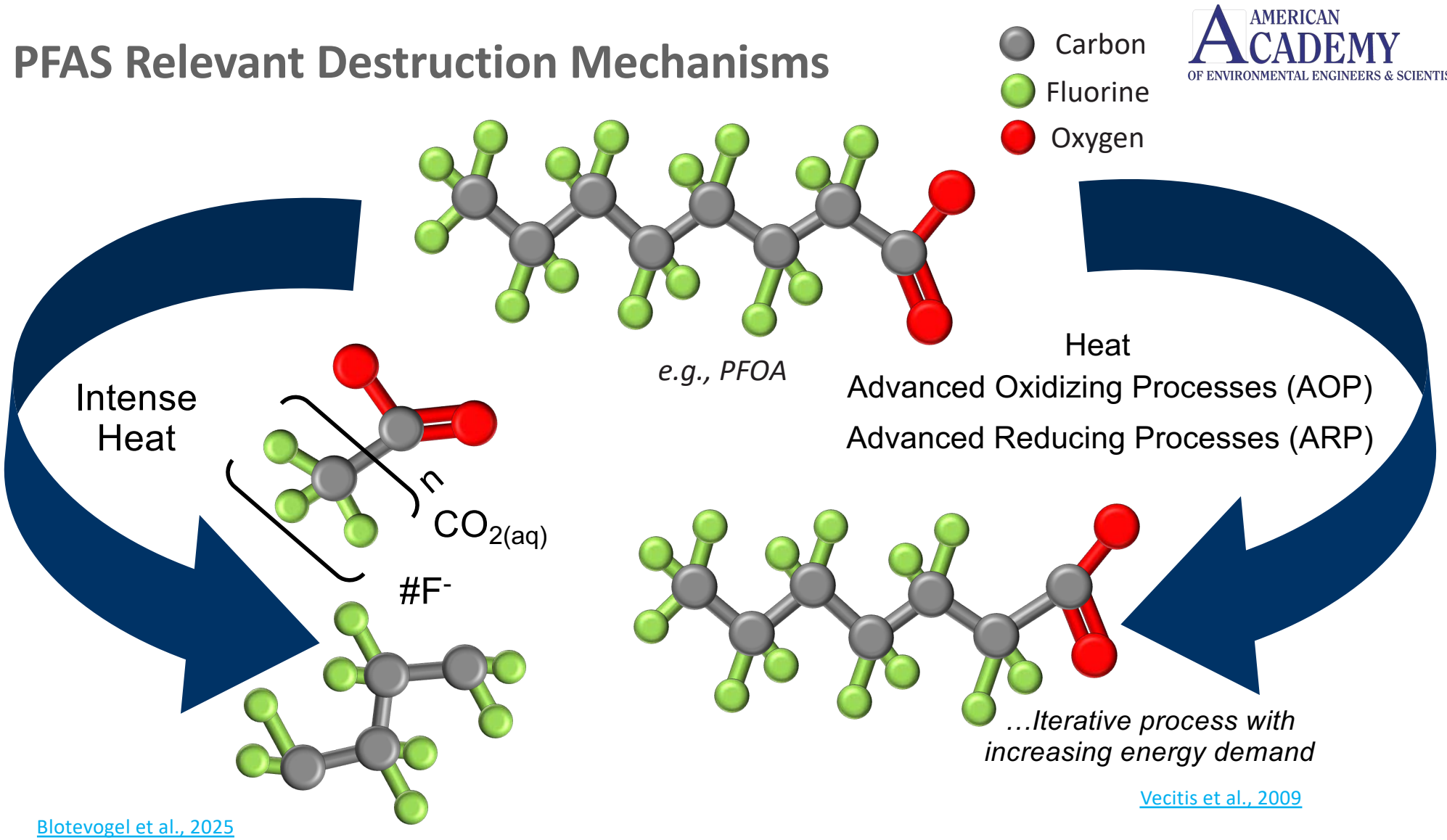
Sonolysis
AOP
Incineration
NTP
Electro Ox
Thermal
Chemical
Hydrothermal
Photocat
Decarboxylation
PFAS Destruction
UV-ARP
Biological
Transformation
Dir. Metabolism
Co-metabolism

PFAS Relevant Destruction Mechanisms



There's no silver bullet…

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Preferable

Manageable, but less preferable

Photocat	ARP	Electro	Sono	HALT	SCWO
UV Transmittance, Low turbidity		Specific Conductance, Salinity		Organics, High Caloric Waste	
Organics					TDS/metals
Salinity		TSS		TSS	

Unlikely to be only 1 ideal PFAS Destruction Technology

TDS = total dissolved solids
TSS = total suspended solids

PFAS Destruction is Energy Intensive

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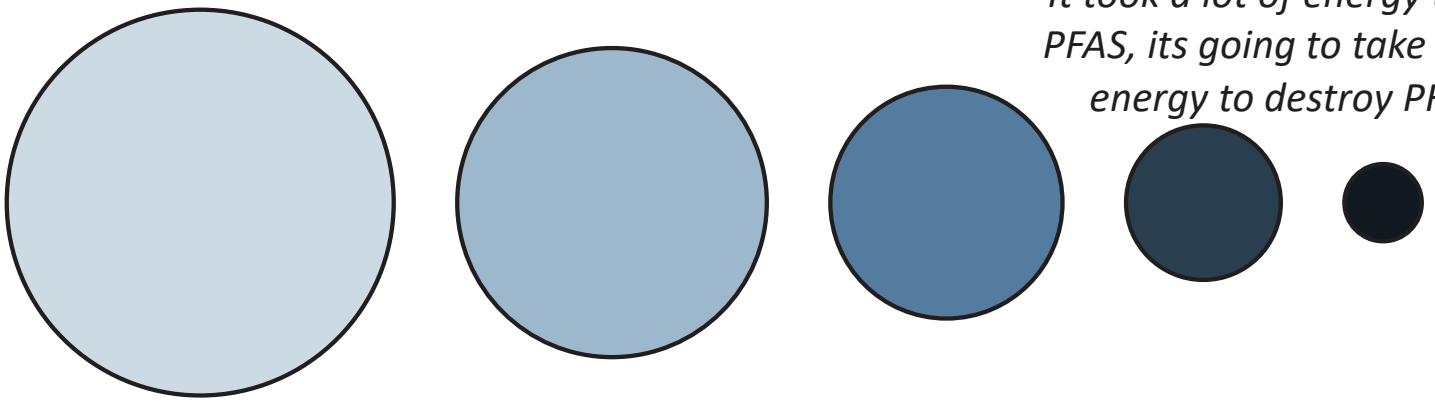
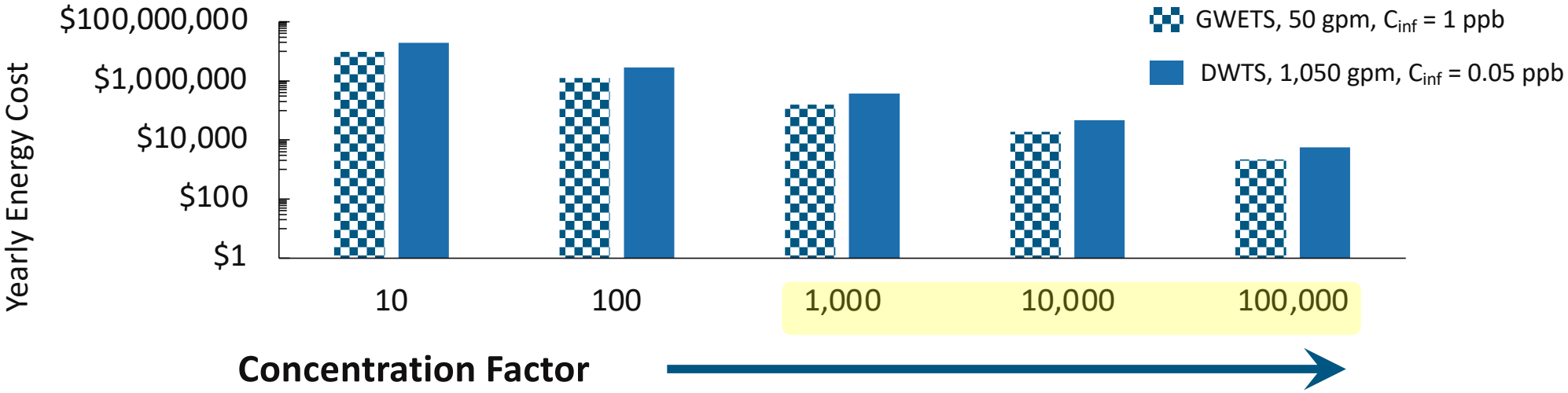
"It took a lot of energy to make PFAS, its going to take a lot of energy to destroy PFAS."





Main Incineration Takeaways

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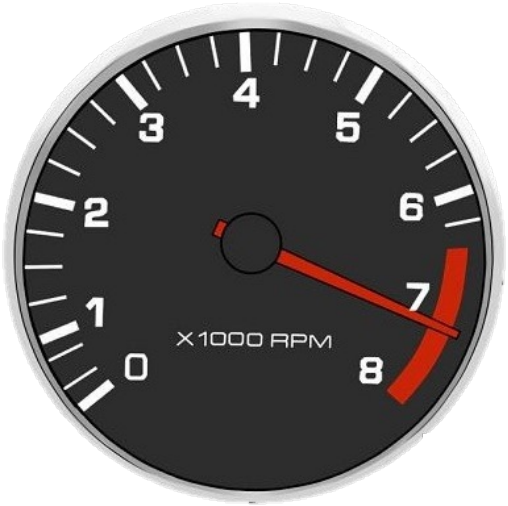
Approaching industry consensus: **>1,000°C** for **>2 s** gas phase residence time with **proper mixing** and excess hydrogen for adequate destruction (atmospheric pressure)



Complete Mineralization

Method Limitations

Adequate Destruction

USEPA 2024 (Section 3a, pg 44)

USEPA Sept 2025 HWI Confirmation Study

June 2025 Confirmation Study

Biological Processes for Perfluoroalkyl Acids (PFAAs)

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Unsaturated C-F bonds*

Feammox*

Fungal transformation*

Partial defluorination*

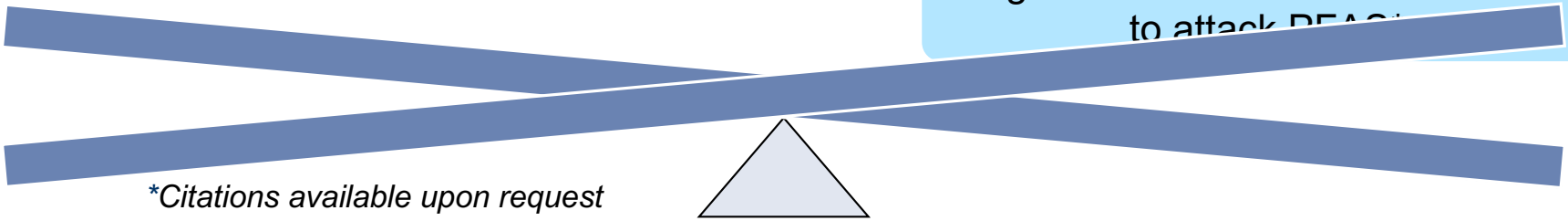
Plausible alternative explanations*

Impractical rate kinetics*

Aerobic/anaerobic competition*

Electronegativity, C-F density yields stability/recalcitrance*

Indigenous bacteria have not evolved to attack PFAS



*Citations available upon request

Biological defluorination is not currently a viable remedial strategy

Considerations for Commercially Available PFAS RDTs

- Field-scale capacity: 100s to 1,000s of gallons per day
- CAPEX: $1.5 to $4 M each
- Immature understanding of OPEX (intense reaction conditions + complex waste streams = high cost)
- Multiple field-scale studies performed

Electrochemical Oxidation

(*Axine, 2025*)

Hydrothermal

(*Aquagga, 2025*)

Non-Thermal Plasma

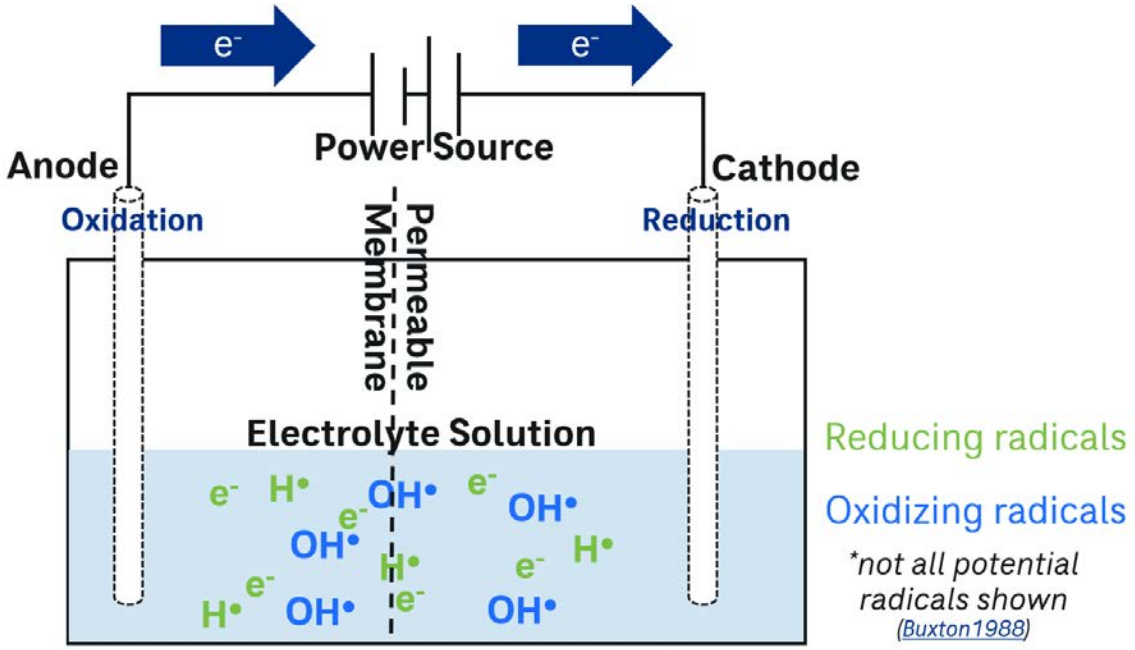
(*DMAX Plasma, 2022*)

UV-Radiated Sensitizers

(*Claros Technologies, 2025*)

Electrochemical Oxidation

- Mechanism(s): Direct electron transfer at the surface of an anode and/or electrolysis generates reactive radicals within the electrolyte
- Some Commercial Vendors: OXbyEL, Blue Eden Clean Technologies, Aclarity, Dynamic Water Technologies, Axine Water Technologies, Gradiant, Lummus Technology, Ovivo
- Some Concerns: Long residence times, secondary water quality, anode durability and PFASs retention



1) Direct electron transfer from PFAS to anode
2) Achieves electrolysis within electrolyte solution

Hydrothermal: HALT vs SCWO

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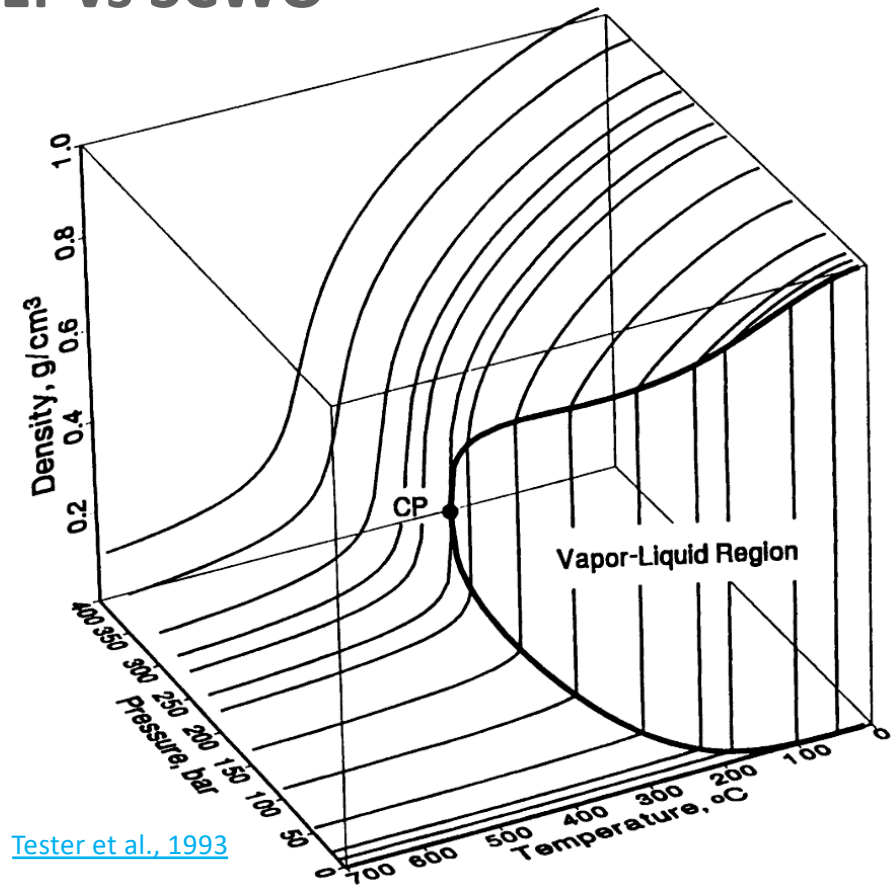
Super Critical Water Oxidation

Pressure > 22 Mpa / 3,200 psi / 220 bar

Temperature > 374°C

Oxidant (air, peroxide, etc.)



Tester et al., 1993

Hydrothermal Alkaline Treatment

Pressure > 22 Mpa / 3,200 psi / 220 bar

Temperature < 374°C*

Strongly alkaline pH (~13)

**High TDS may support a higher temperature while staying in the subcritical region*

UV-Radiated Sensitizers

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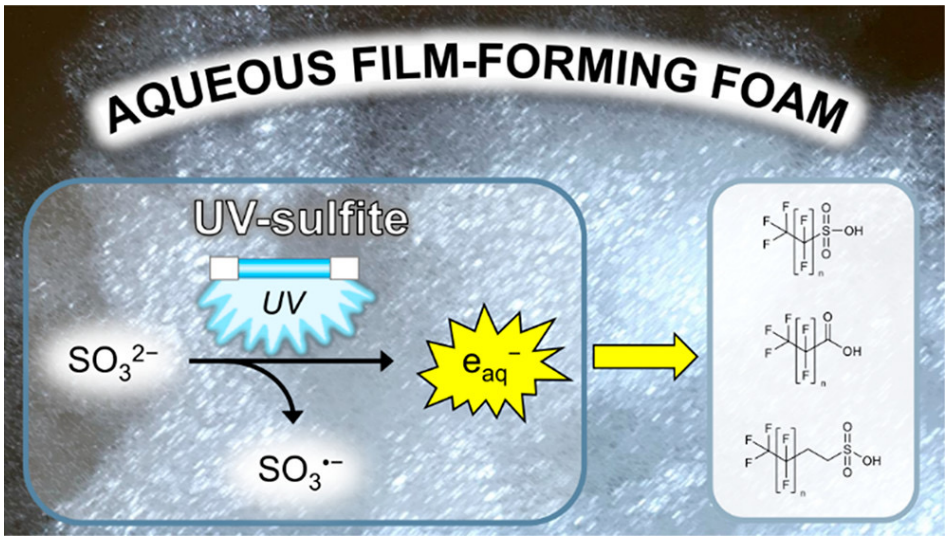
- Mechanism(s): Ultra-violet light (either negative or positive pressure under STP or ozone atmosphere) excites a catalyst (often a reductant) to liberate e_{aq}- sequentially defluorinating PFAS (reductants: $S_2O_4^{2-}$, SO_3^{2-}, I^-, NTA, IAA)

- Some Commercial Vendors: Claros, Enspired Solutions, Moss Parker, Invicta, Water Illumination, Inc., EradiFluor

- Some Concerns: Long residence times, secondary water quality, onsite ozone management



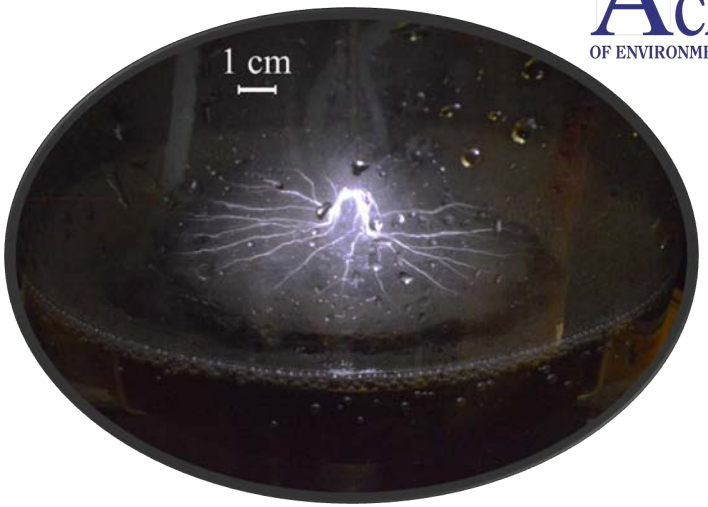
Tenorio et al., 2020

Non-Thermal Plasma

- Mechanism(s): Electrolysis/heat results in ionic plasma species comprised of reactive radicals ($OH^{\bullet}$, e_{aq}^{-}, $H^{\bullet}$, O, $HO_2^{\bullet}$, H_2, O_2, H_2O_2) the subsequently and sequentially defluorinated PFAS

- Some Commercial Vendors: OnVector, DMaxPlasma, PlasmaLeap

- Some Concerns: Long residence times, secondary water quality, some reactor configurations can struggle with short chain PFAS



Stratton et al 2017

Singh et al., 2019

Final Thoughts about Human Ingenuity

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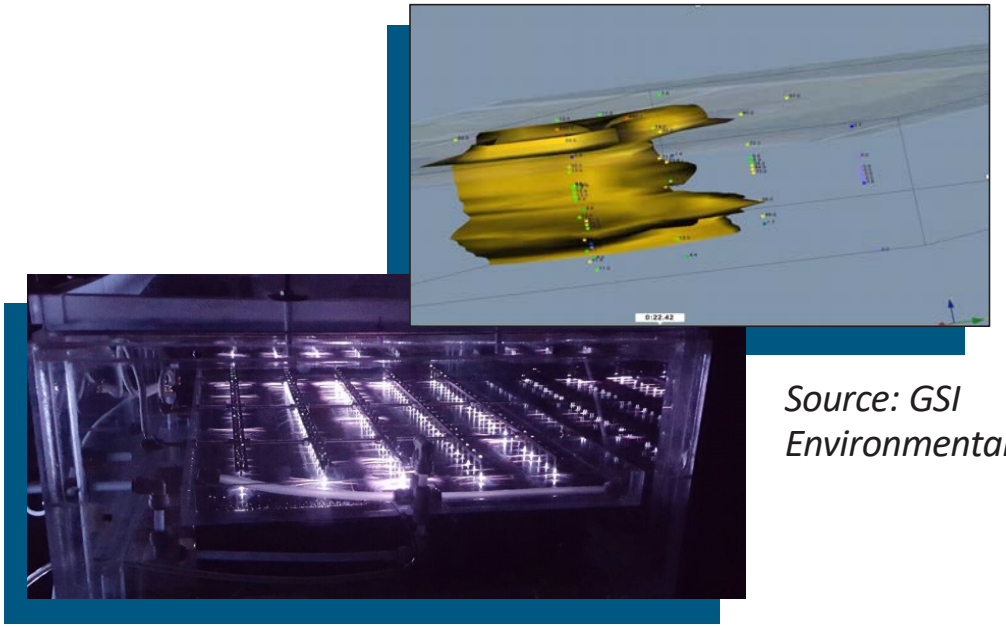
"Although the problem of PFAS in groundwater appears to be a daunting one, we feel confident that a similar level of ingenuity (invented for previous contaminants) will lead to surprising technical developments in remediating PFAS sites in the future as well"

"Comparing PFAS to other groundwater contaminants: Implications for remediation" Newell et al., 2020



Source: GSI Environmental

Source: Clarkson University

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Questions?
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