38th Annual Spring Biosolids Symposium

PFAS – Overview and Consultant's Perspective

FOLLOWING [DOING] LEADING

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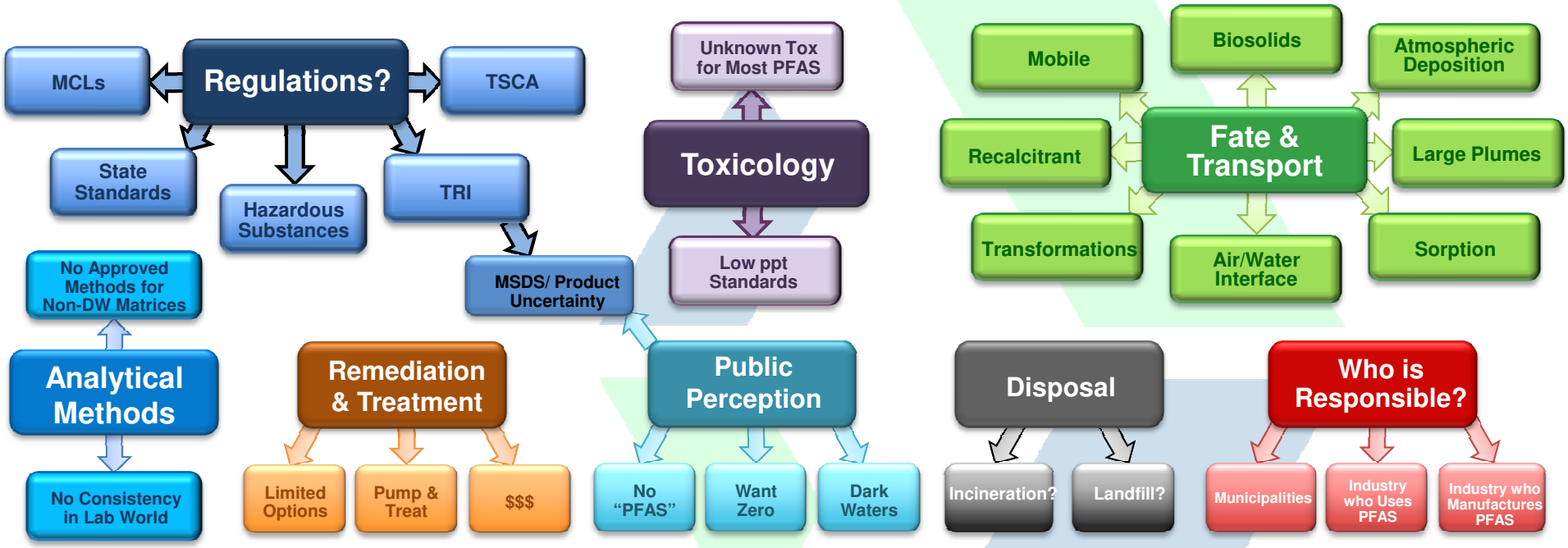
March 9, 2021

PFAS Landscape

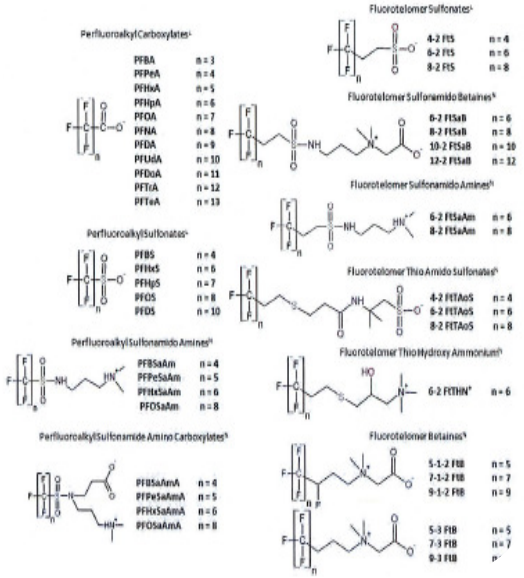


PFAS Mobility + PFAS Persistence + Toxicological Uncertainties + Treatment Obstacle + Strict Regulatory Standards + Public Perception

Increase in # of Sites → $ $ $

Topics

- PFAS
  - History & Use
  - Chemistry & Nomenclature
  - Exposure and Toxicity
  - Fate and Transport
  - Sampling and Analysis
  - Treatment and Remediation



What Are Per- and Polyfluoroalkyl Substances (PFAS)?

- A class of over 9,200 synthetic/ man-made chemicals (EPA Master List of PFAS Substances)

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- Fluorinated aliphatic compounds (Buck et. al. 2011)

- Developed commercially beginning in the 1940's

- Used in thousands of industrial and commercial products

- Ubiquitous in the environment

Class Properties

-> Stable

-> Heat-Resistant

-> Persistent

-> Hydrophobic

-> Oleophobic

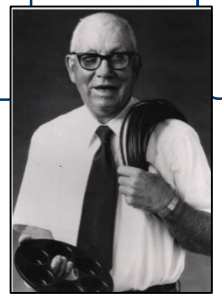
-> Surfactant

Where Are PFAS Used?

Teflon®
GORE-TEX®
Scotchguard®
Stainmaster®

A Brief History of PFAS

1938
- Polytetrafluoroethylene (PTFE) discovered by DuPont
- Roy Plunkett



1949
- PTFE used in products

1956
- Stain-resistant products (PFOS)

1968
- Navy developed AFFF

1978
- Detected in blood of manufacturing workers

2002
- *Jack W. Leach vs. du Pont* (WV)
- C8 (PFOA) Health Project
-
- PFOS manufacturing phased out

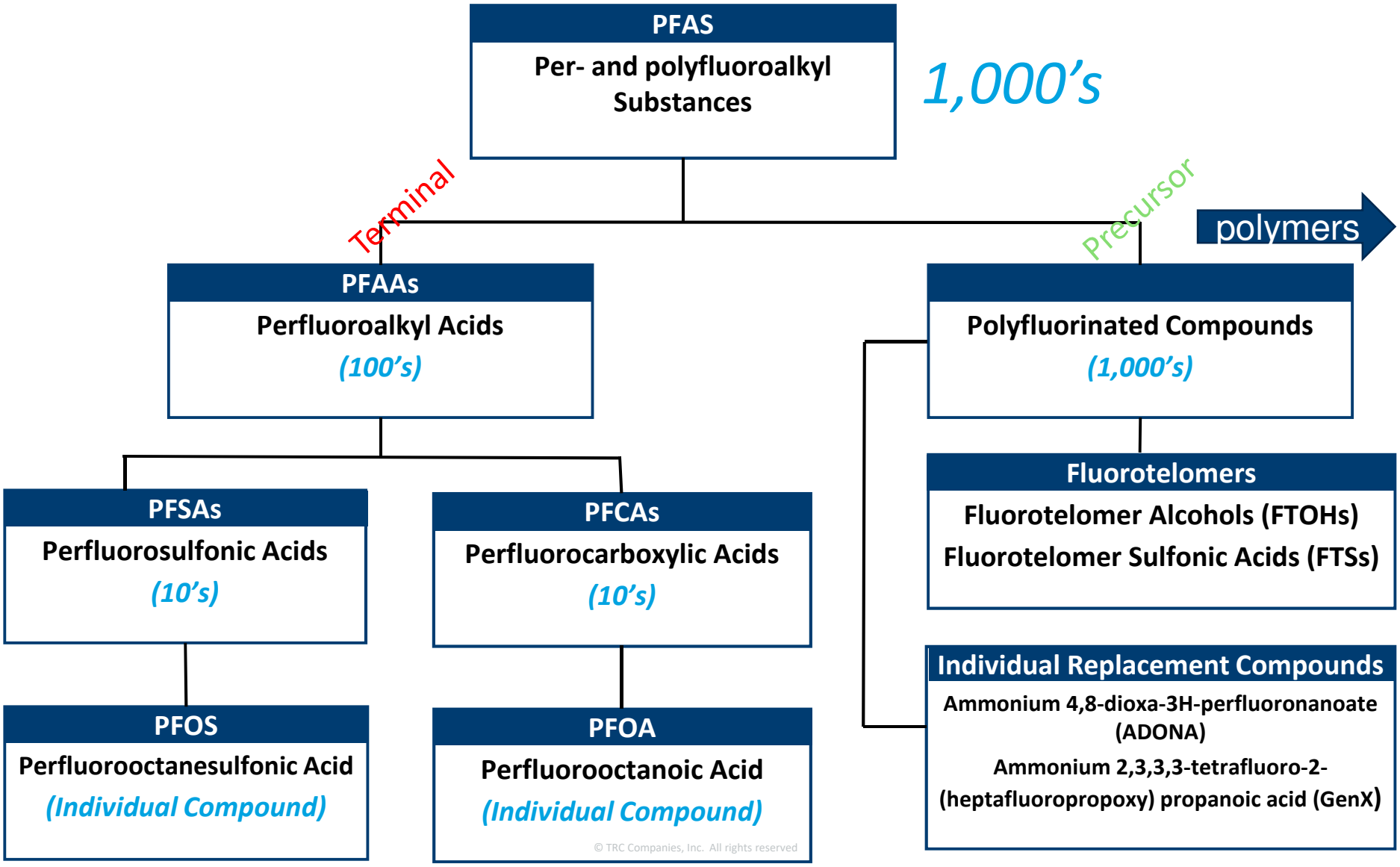
2006
- PFOA phased out
- EPA PFOA Stewardship Program

2009
- Stockholm Convention classifies PFOS as a persistent organic pollutant (POP)

2015
- PFOA phase-out complete
- Sampling of public drinking water wells for PFAS (EPA Unregulated Contaminant Monitoring Rule (UCMR3)

2016
- EPA Health Advisory announced for PFOA/PFOS (70 ppt, together and separately)

Nomenclature: Class at Glance



Precursor Transformations

Environmental Science & Technology

Article

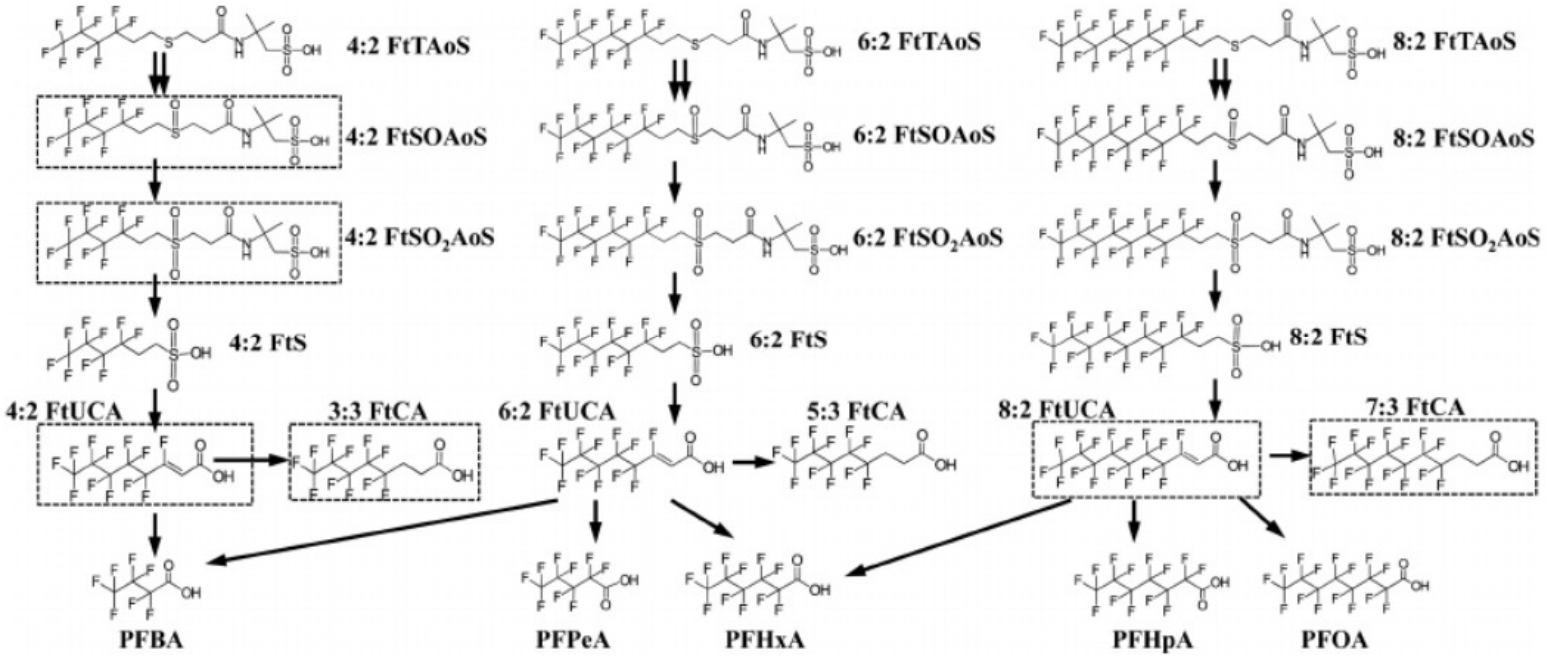


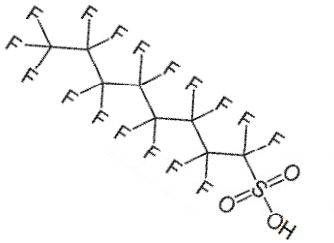
Figure 4. Proposed biotransformation pathways of 4:2, 6:2, and 8:2 FtTAoS by aerobic soil microcosms. Compounds in dashed boxes are proposed biotransformation intermediates and were not directly detected in microcosms. The double arrow indicates that the reaction occurs both biologically and abiotically.

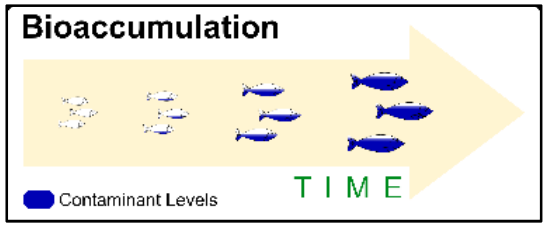
Shaw, et. al., Degradation and defluorination of 6:2 fluorotelomer sulfonamidoalkyl betaine and 6:2 fluorotelomer sulfonate by Gordonia sp. strain NB4-1Y under sulfur-limiting conditions, Science of The Total Environment, Volume 647,2019.

PFAS Appear to be Toxic

Safe levels are unknown for most PFAS

- Limited toxicity studies on humans (C8 study), but several animal studies
- Immunotoxicity and liver toxicity reported in humans and animals
- Carcinogenic tumors reported (PFOA): testicular, kidney, liver, and pancreatic
- EPA and the National Toxicology Program (NTP) are collaborating on toxicity studies for 75 PFAS as of January 2019
- ATSDR Report released June 2018 – 14 compounds
- CDC/ATSDR Multi-Site Health Study (9/23/19)
- Current Integrated Risk Information System (IRIS) assessment for five additional PFAS – PFDA, PFNA, PFHxA, PFHxS, PFBA





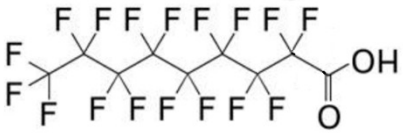
Exposure Assessment

PFAS in the U.S. Population

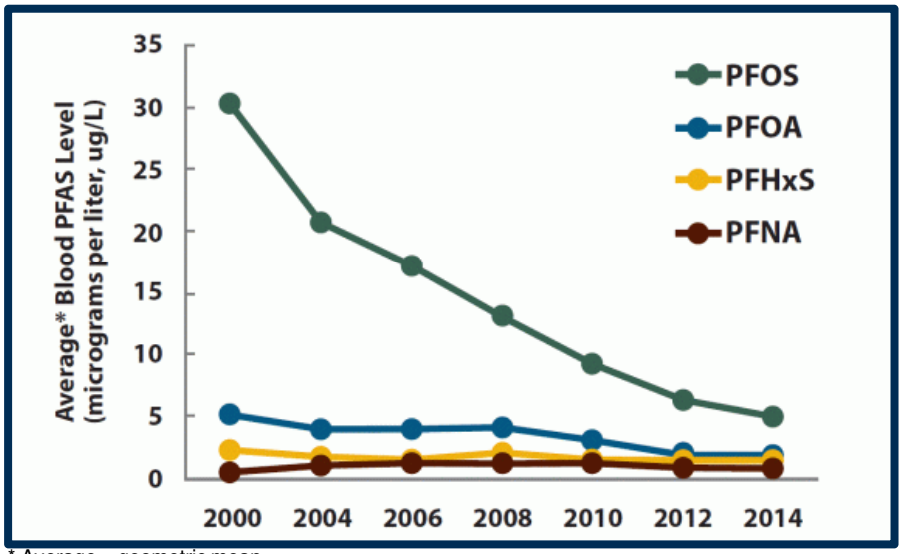
The major sources of exposure to PFAS are contaminated food and drinking water.

Industrial releases of perfluoroalkyls into ambient air or surface water may also be a source of exposure for the general population.

The general population may also be exposed to PFOS from carpets that have been mill treated to resist stains and to PFOA from migration from paper packaging and wrapping into food and inhalation from impregnated clothes.



Blood Levels of the Most Common PFAS



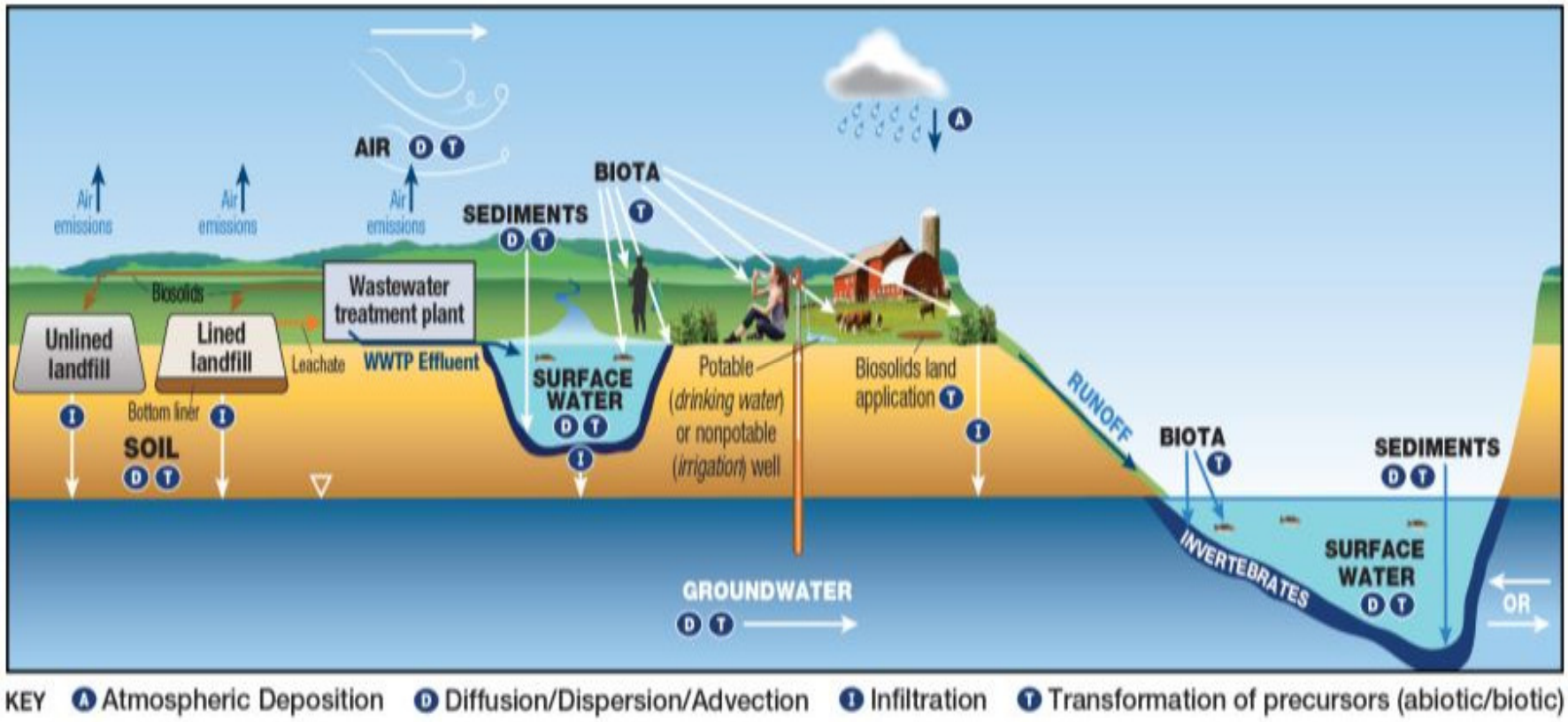
* Average = geometric mean

Data Source: Centers for Disease Control and Prevention. Fourth Report on Human Exposure to Environmental Chemicals, Updated Tables, (January 2017). Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.

What Types of Sites Can Be Sources of PFAS?

- Fire training facilities
- Fire stations
- Refineries
- DoD sites/Military bases
- Commercial and private airports
- Biosolids land application
- Rail yards
- Chemical facilities
- Plating facilities
- Textile/carpet manufacturers
- Residential areas with septic systems
- **Wastewater Treatment Plants (receiver)**
- Landfills (leaching from industrial and consumer products)

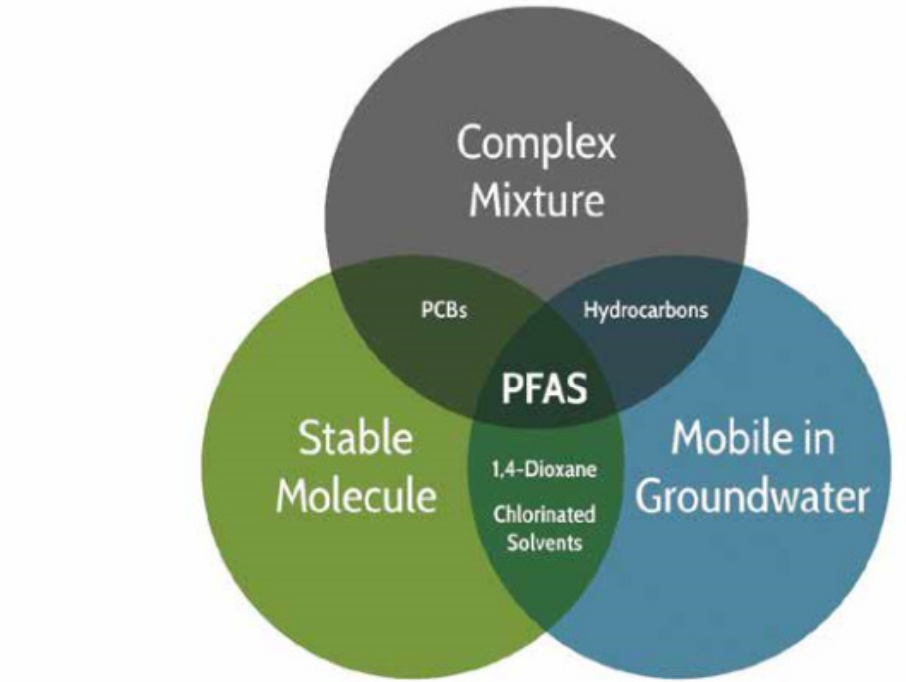
Fate and Transport of PFAS
Landfill / WWTP / Biosolids



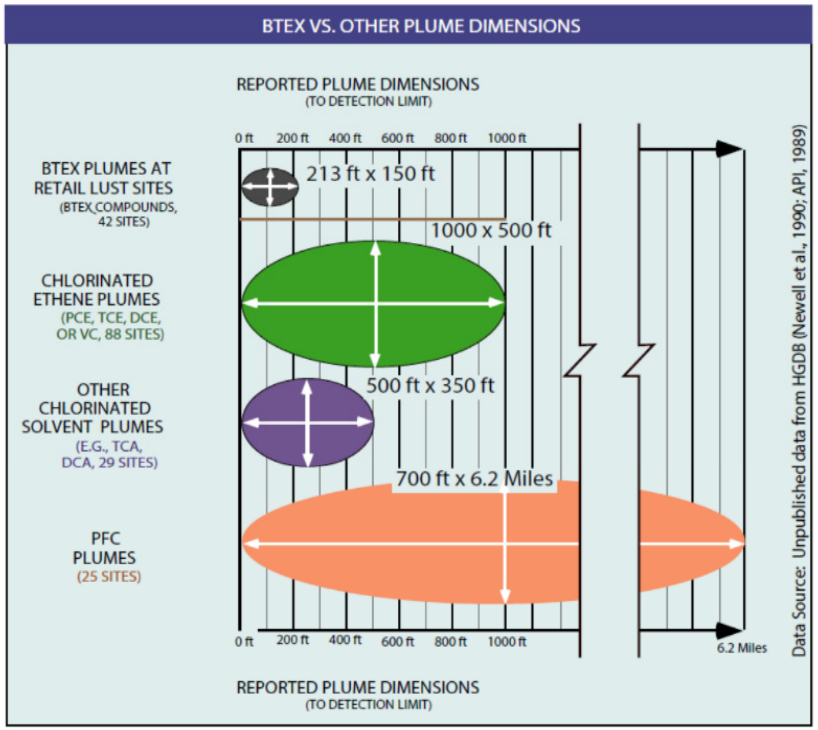
Source: Interstate Technology & Regulatory Council (ITRC), Adapted from L. Trozzolo, TRC, used with permission

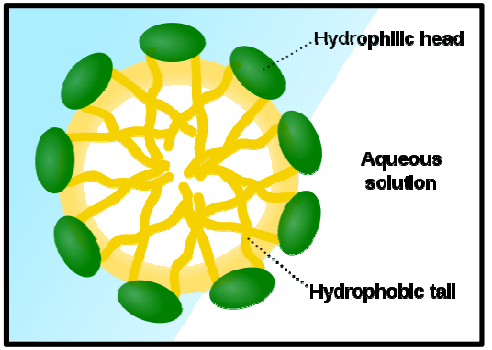
Fate and Transport of PFAS

Figure 4.2. PFAS comparison to other contaminant classes.



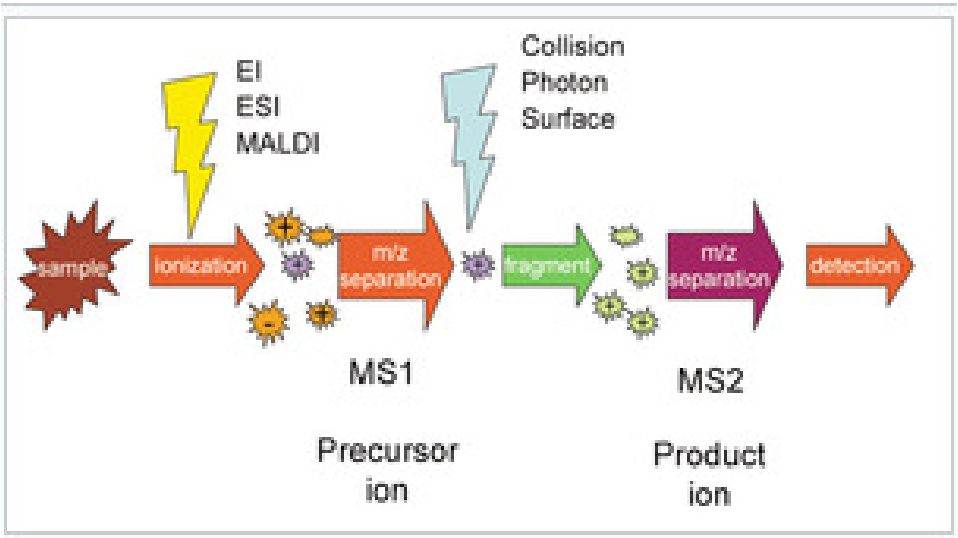
NGWA Groundwater and PFAS: State of Knowledge and Practice, 2017





PFAS Sampling and Analysis

- Discrete PFAS Analysis by Liquid Chromatography-tandem mass spectrometry (LC-MS/MS)
- Screening Analyses for total organic fluorine, total fluorine



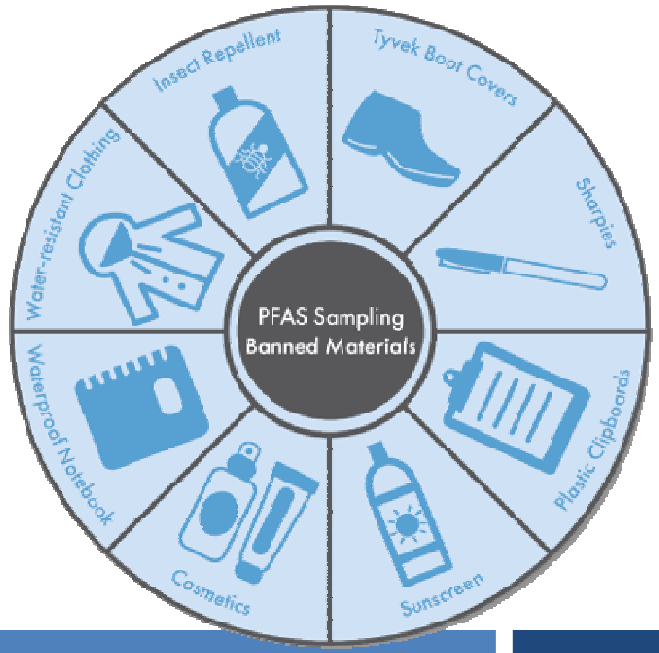
PFAS Analytical Methods and Method Criteria

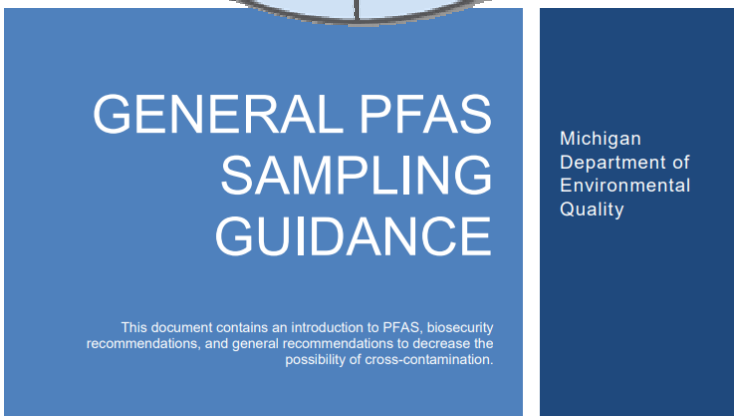
Method	Year	Applicable Matrices	# PFAS Analytes
EPA 537.1	2018	Drinking Water	18 analytes
EPA 533	2019	Drinking Water	25 analytes
EPA 537 “Modified”	Current	All	70+ analytes
ASTM D7979-17	2017	Water, Wastewater	21 analytes
ASTM D7968-17	2017	Soil	21 analytes
ISO 25101	2009	Aqueous	PFOA/PFOS
ISO 21675	2019	Aqueous	30 analytes
FDA C-010.01	2019	Bread, Lettuce, Milk, Fish	16 analytes
SW-846 8327	2019	Solid & Aqueous	24 analytes
Developing CWA/ SW-846	Single Lab Validation	Solid & Aqueous	40 analytes
DoD QSM 5.1	2017	Solid & Aqueous	24+ analytes
DoD QSM 5.2/5.3	2018/2019	Solid & Aqueous	24+ analytes
WI Criteria*	2019	All	33 analytes

*Wisconsin PFAS Aqueous (Non-Potable Water) and Non-Aqueous Matrices Method Expectations

PFAS Sampling – High Risk of Cross-Contamination

- Due to sensitive detection limits and environmental presence of PFAS, special care is required to prevent cross contamination
- Accomplished by exclusion of specific sampling equipment
- Include equipment and field blanks in sampling event
- Consider split sampling for effluent samples collected for compliance purposes





TRC Publication: Per- and polyfluoroalkyl substances in environmental sampling products: Fact or Fiction?

PFAS Treatment and Remediation

Ineffective | Developing | Established

Sequestration Technologies & Techniques	Media
Granular Activated Carbon (GAC)	Aqueous
Ion Exchange Resin (IX)	Aqueous
Reverse Osmosis (RO)	Aqueous
Air Stripping	Aqueous
Surface Active Foam Fractionation (SAFF)	Aqueous
Sorption Amendments	Soil and Sediment
Excavation	Soil and Sediment
Colloidal Activated Carbon (CAC)	Aqueous
Coagulation	Aqueous
Nanofiltration	Aqueous
Deep Well Injection	Aqueous
Isolation in Place	All
Solidification	All

Destructive Technologies	Media
Incineration	All
Pyrolysis	All
Plasma Arcing	Aqueous
Thermal Oxidizer[1]	Air
Sonolysis	Aqueous
Hydrodynamic and Acoustic Cavitation	Aqueous
Advanced Oxidation Processes (AOP)	Aqueous
Bioremediation	Aqueous
Photolysis	Aqueous
Advanced Reductive Processes (ARP)	Aqueous
Ozonolysis	Aqueous

Research!

1 - Thermal Oxidizer Performance Test Report Chemours Company Fayetteville Works

https://www.epa.gov/pfas/interim-guidance-destroying-and-disposing-certain-pfas-and-pfas-containing-materials-are-not

Thank You

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