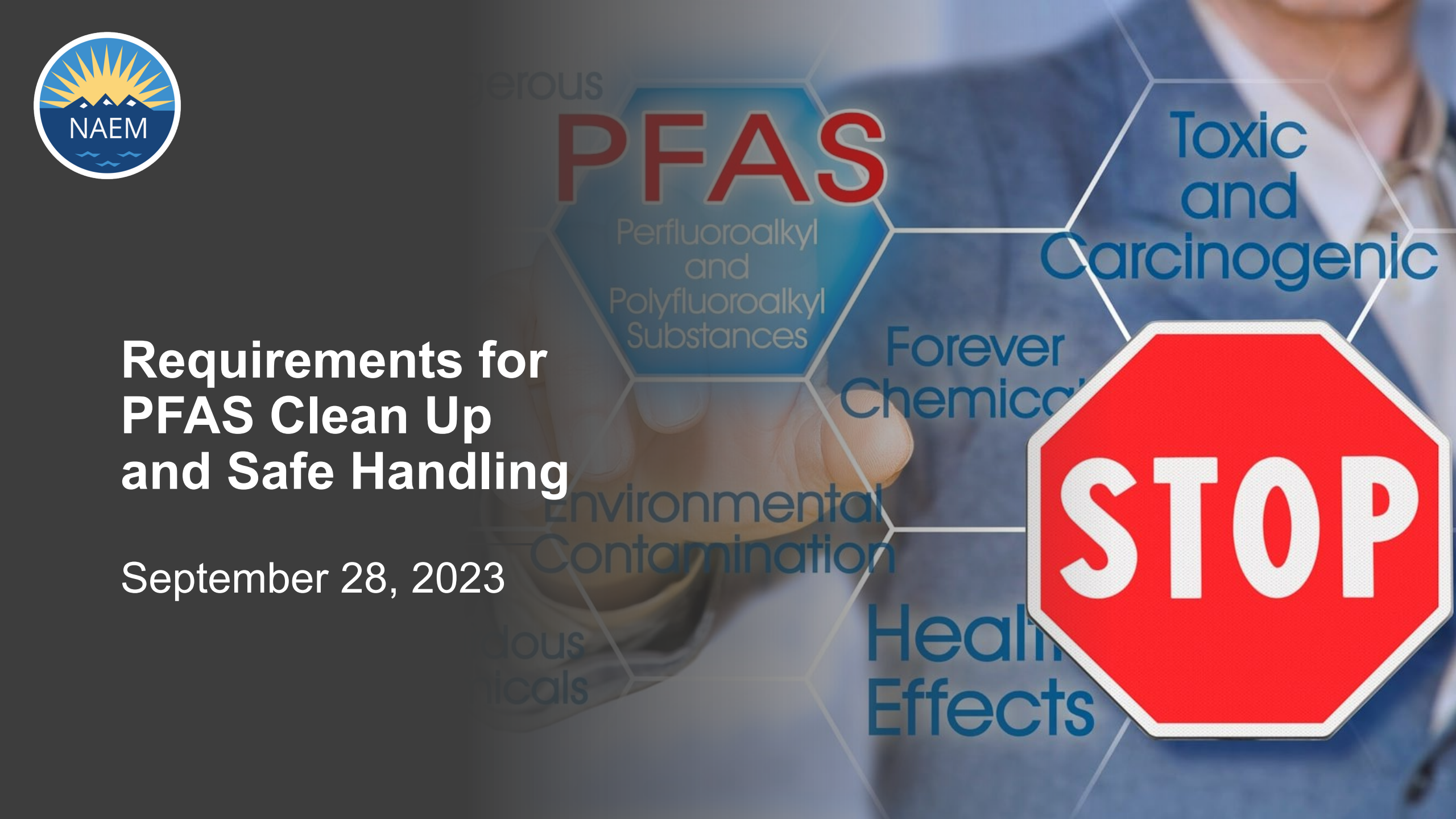
Requirements for PFAS Clean Up and Safe Handling

September 28, 2023



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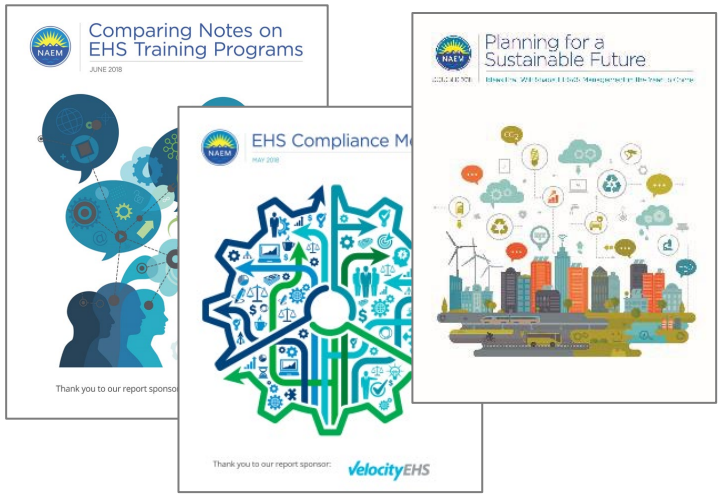

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September 28, 2023

Requirements for PFAS Clean Up and Safe Handling

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Nova Group, GBC

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Triumvirate Environmental

Nova Group

TRIUMVIRATE ENVIRONMENTAL

Agenda

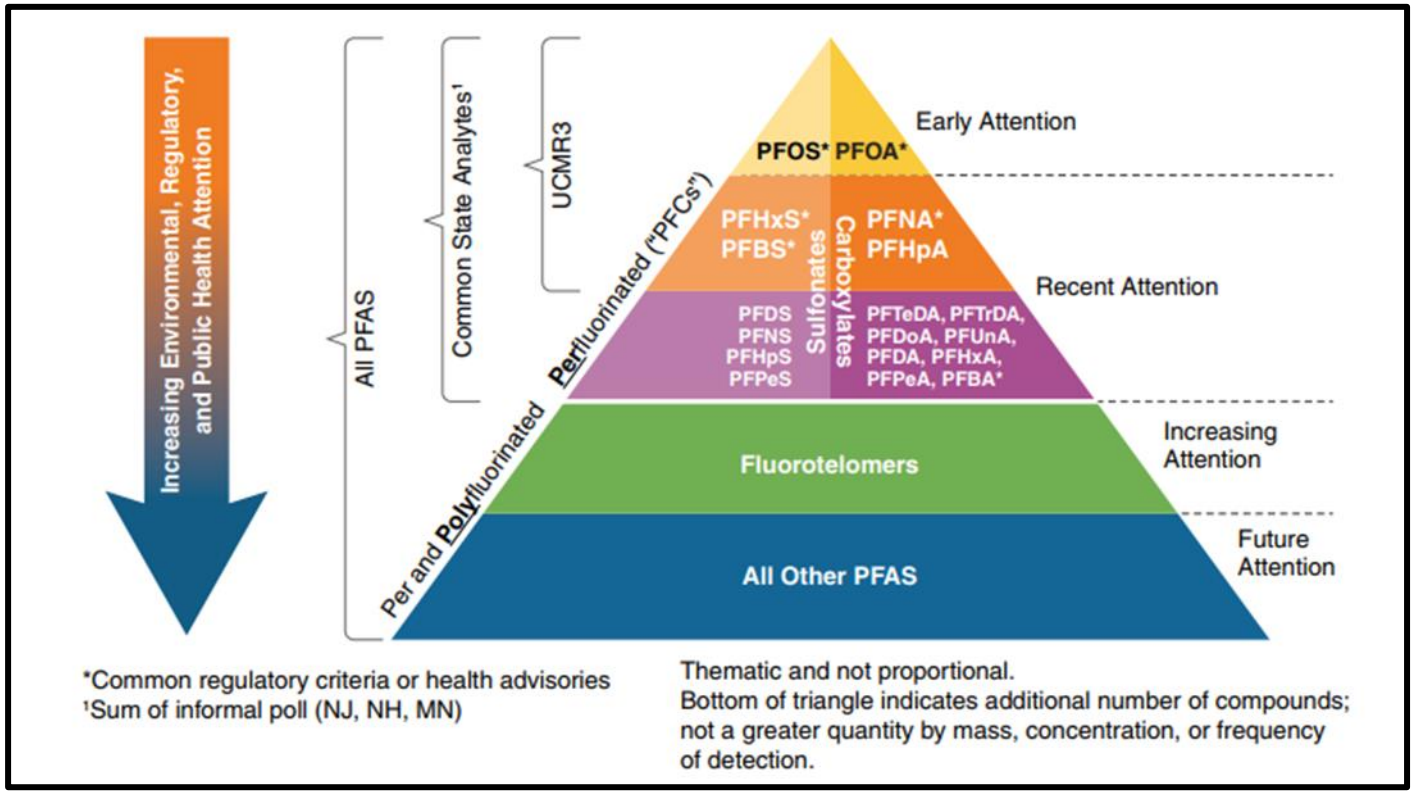
- **Introduction**
  - What Are PFAS?
  - History and Usage
  - Bioaccumulation and Prevalence
- **Remediation of PFAS Contaminated Sites**
  - Evaluation: Is Sampling Required at My Site?
  - Site Remediation Standards
  - Sampling and Site Characterization
  - Remediation Technologies
- **Disposal of PFAS Contaminated Material**
- **Case Studies**

Nova Group

TRIUMVIRATE ENVIRONMENTAL

Introduction

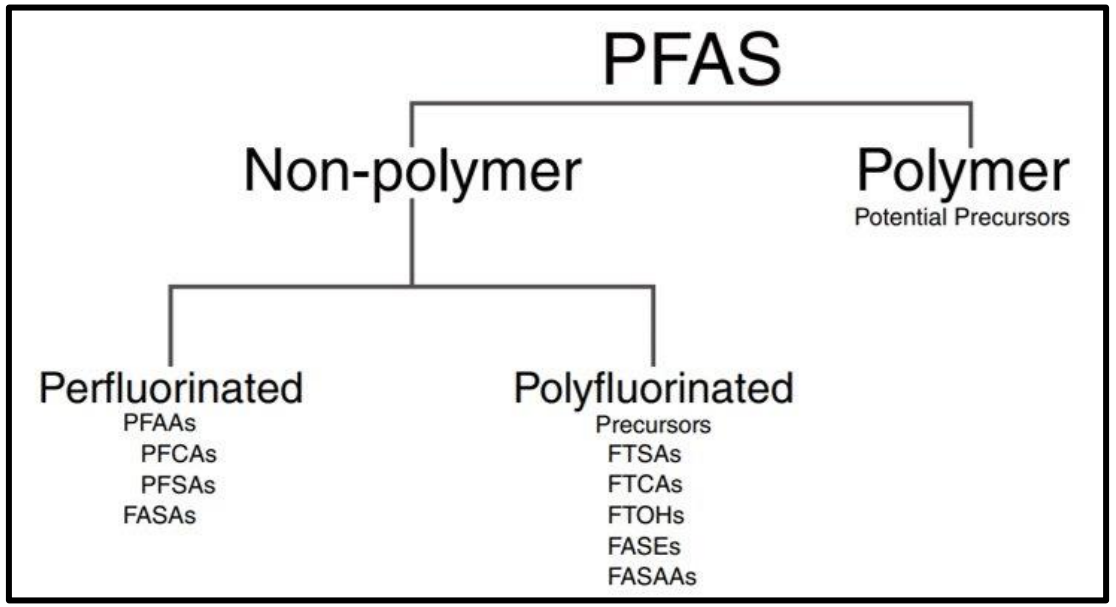
- PFAS stands for **per- and polyfluoroalkyl substances.**
- Complex family of more than 3,000 man-made fluorinated organic chemicals.
- Unique ability to repel oil and water; used in nonstick cookware, Tyvek, and aqueous film-forming foam (AFFF) to fight fires.



Source: https://pfas-1.itrcweb.org/wp-content/uploads/2017/11/pfas_fact_sheet_history_and_use__11_13_17.pdf

Physical/Chemical Properties

- PFAS molecules have a chain of linked carbon and fluorine atoms. Because the carbon-fluorine bond is one of the strongest, these chemicals do not degrade easily in the environment.
- PFAS are either polymer or non-polymer; the ones of interest are non-polymer because they are more dangerous.
- PFAS are encountered in *gases, liquids, and high molecular weight solids*.



Source: https://pfas-1.itrcweb.org/wp-content/uploads/2018/03/pfas_fact_sheet_naming_conventions__3_16_18.pdf

History of PFAS

- **1938** - DuPont discovered PTFE while working on fluorocarbons for refrigerants.
- **1945** - DuPont commercialized PTFE as Teflon.
- **1950s** - 3M started manufacturing PFAS.
- **1960s** - 3M and the US Navy began research on AFFF and in 1967, the US Navy patented AFFF.
- **1970s** - First studies identified PFAS in human blood and fish.
- **1998** - EPA issued first alert of potential danger of PFAS.
- **2000** - Study by American Chemical Society indicated PFOS was widespread in the environment and can bioaccumulate.
- **2002** - 3M ceased production of PFOS.
- **2015** - DuPont ceased production of PFOA.
- **2016** - EPA issued Lifetime Health Advisory for two of the most widely detected PFAAs (PFOA and PFOS) at 70 ppt.
- **2021** - EPA announced strategic roadmap for PFAS regulations.

History of Use

While PFOA and PFOS have been phased out from their use in commercial products, they are still found in the environment from historical uses.

PFAS can be found in everyday products, such as:

- Fire-fighting foam
- Cleaning products
- Water-resistant fabrics, such as rain jackets, umbrellas, and tents
- Grease-resistant paper
- Nonstick cookware
- Personal care products, like shampoo, dental floss, nail polish, and eye makeup
- Stain-resistant coatings used on carpets, upholstery, and other fabrics

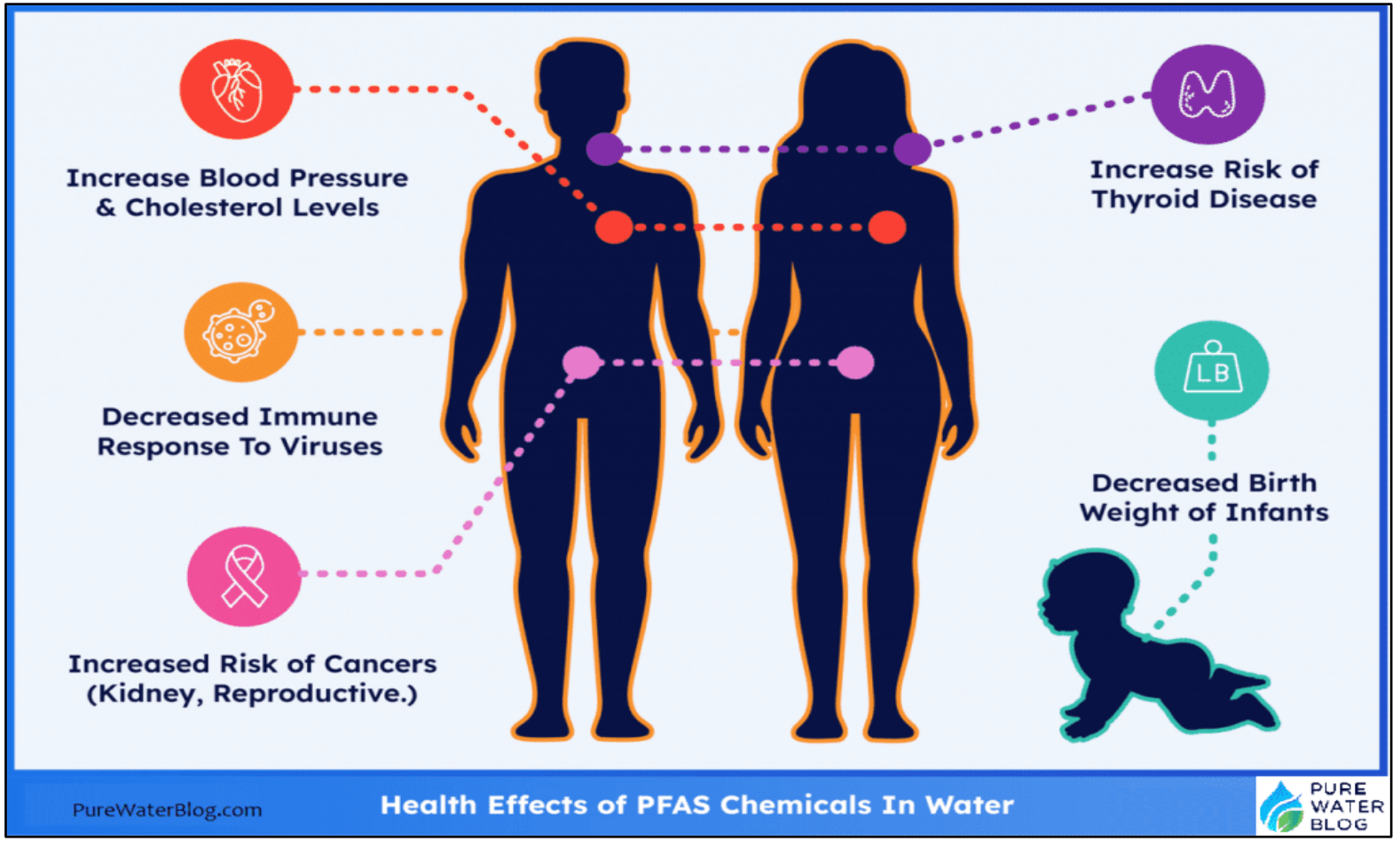
Bioaccumulation & Prevalence

Many PFAS, including perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), are a concern because they:

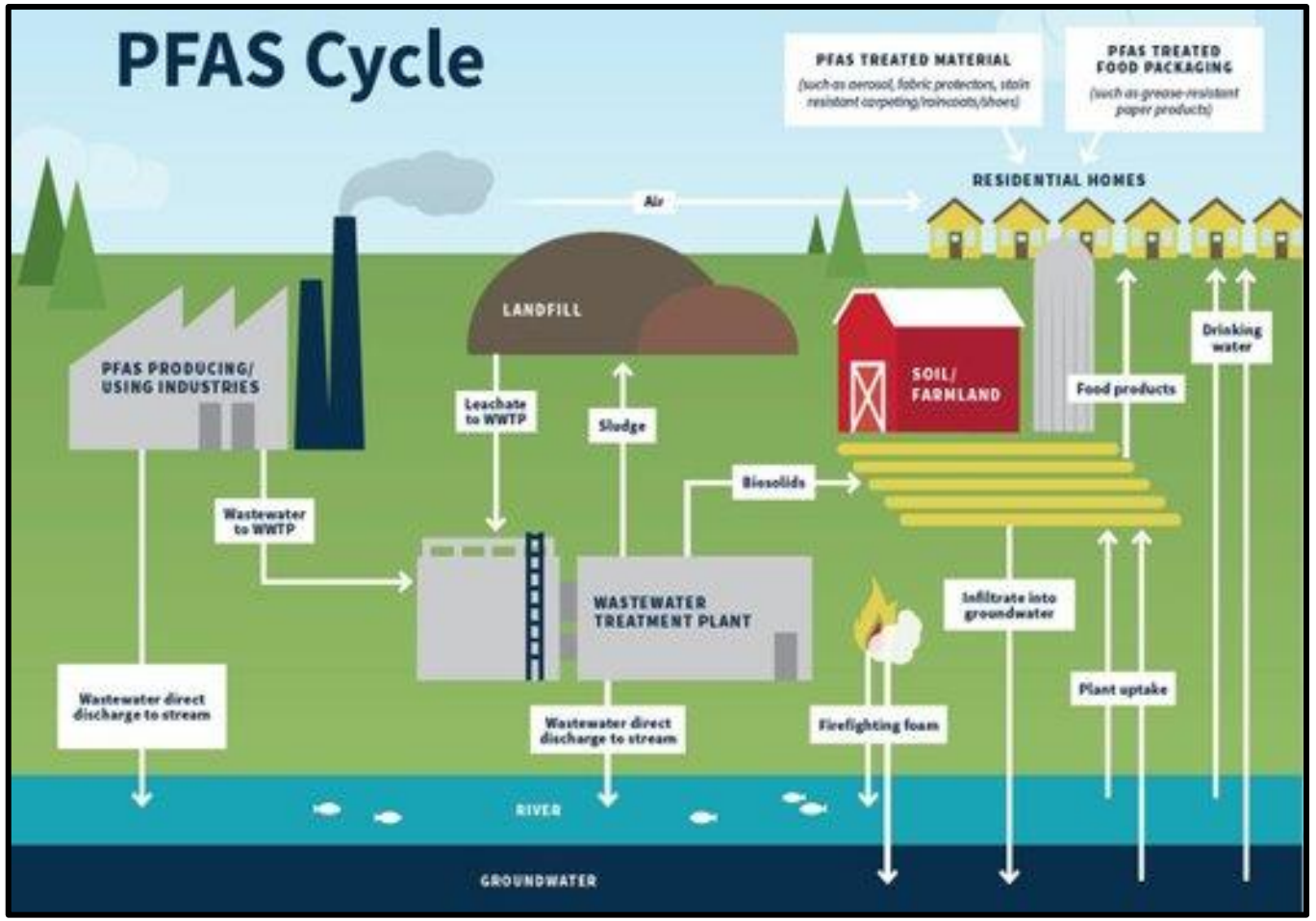
- Do not break down in the environment
- Can move through soils and contaminate drinking water sources
- Build up (bioaccumulate) in fish and wildlife
- Persist in the environment and exposure in people can occur by consuming PFAS-contaminated water or food; exposure may happen by using products that contain PFAS

Because PFAS are highly persistent in the environment and do not break down easily, PFAS have become widespread contaminants, including in drinking water sources. The health risks and impacts of PFAS exposure and bioaccumulation are a growing concern.

Health Effects of PFAS Exposure



PFAS Cycle



Source: https://www.whmi.com/news/article/pfas-presentation-huron-river-watershed-councilr

- PFAS are a complex family of more than 3,000 man-made fluorinated organic chemicals
- The PFAS cycle shows how PFAS enter our environment and how humans are affected.
- PFAS are important to understand because they're contaminants of emerging concern and their regulatory standards are continuing to evolve due to new science.

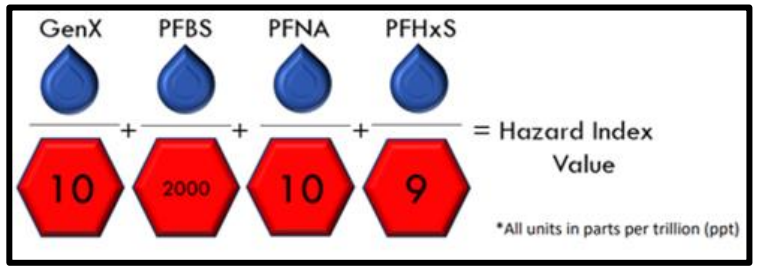
Regulations & Guidance

Federal Regulations and Standards

- EPA's PFAS Strategic Roadmap originally proposed drinking water Maximum Contaminant Levels (MCLs) for PFAS and POAS.
- March 2023: EPA proposes PFAS National Primary Drinking Water Regulation, proposing standards for 6 PFAS compounds.
- May 4, 2023: Public hearing was conducted.

Compound	Proposed MCLG	Proposed MCL
PFOA	0 ppt	4.0 ppt
PFOS	0 ppt	4.0 ppt
PFNA	1.0 (unitless) Hazard Index	1.0 (unitless) Hazard Index
PFHxS		
PFBS		
HFPO-DA (GenX)		

Hazard Index is utilized to evaluate the potential risk from a mixture of chemicals.

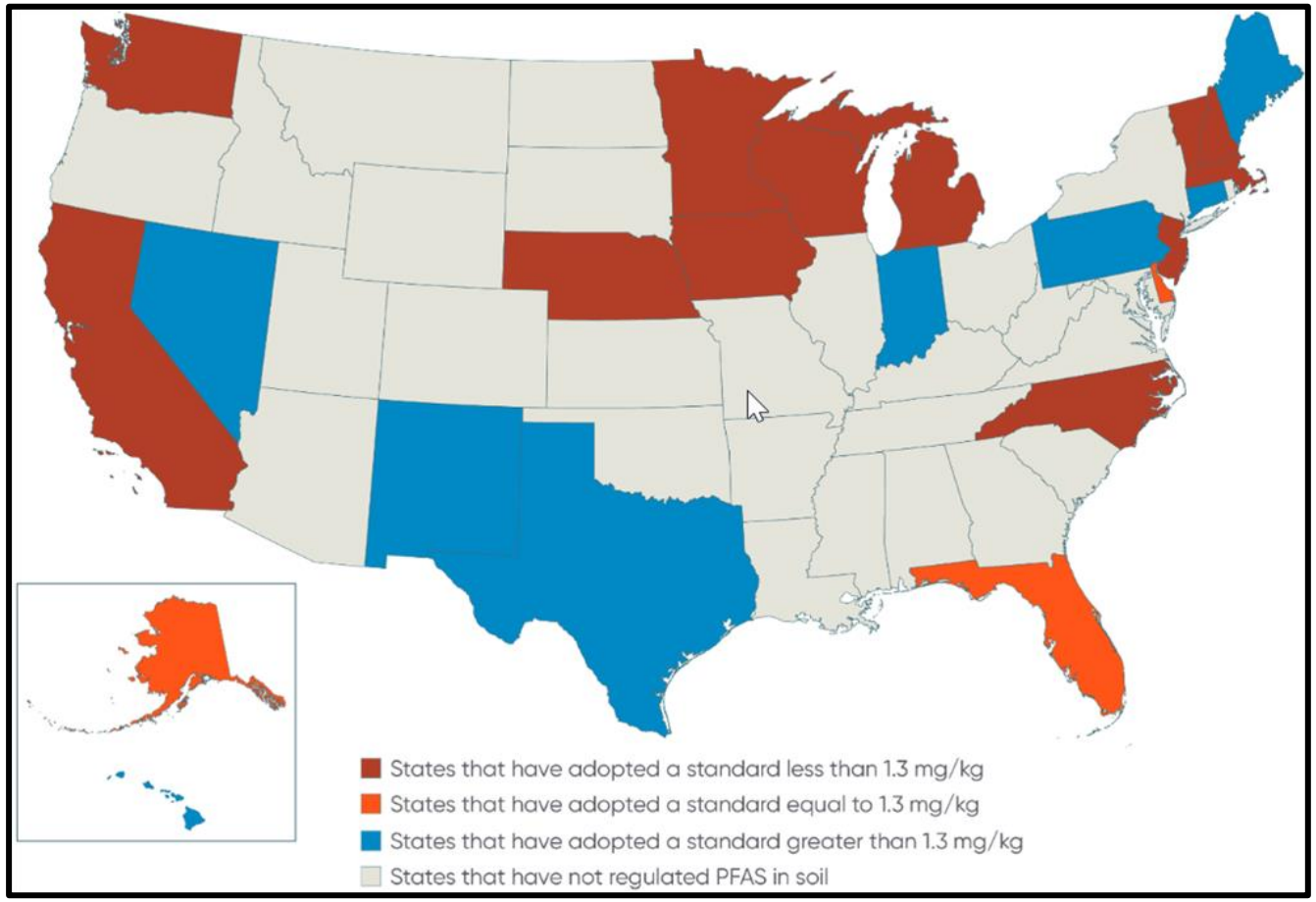


TRIUMVIRATE ENVIRONMENTAL

Regulations & Guidance

State Regulations and Standards

- 21 states have soil and/or groundwater standards (as of July 2023)



Source: https://www.bclplaw.com/en-US/events-insights-news/pfas-update-state-soil-concentration-regulations-july-2023.html

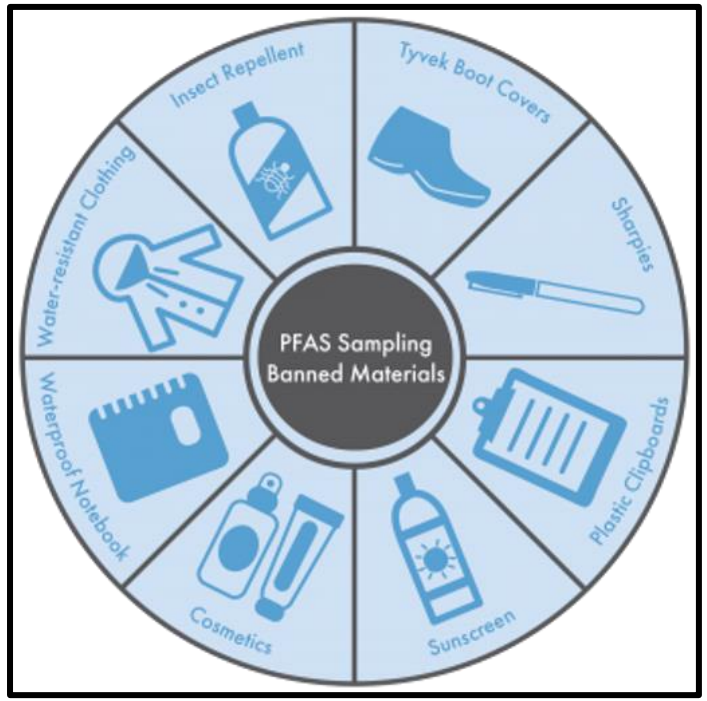
Site Characterization, Sampling & Lab Considerations

When to sample?

- State regulations may trigger an environmental investigation.
- Before sampling conduct an evaluation:
  - Review current and historic chemical inventories.
  - Review operations and operational areas – compare operations to list of known PFAS industries (Interstate Technology Regulatory Council (ITRC) or some states have created lists).
  - Review history of known releases at the site.
- If the evaluation concludes that PFAS was not used on site or there was no release of PFAS, that will likely conclude the investigation.

Site Characterization, Sampling & Lab Considerations

- Sample for PFAS first and store in separately sealed plastic bags away from other sample parameters.
- Sampling personnel shouldn't wear PPE containing PFAS, including Gore-Tex, Tyvek, or water/stain resistant materials.
- Need thorough QA/QC program for sampling; not all PFAS are hydrophilic so some may sorb to sampling equipment.
- Containers should be specified in analytical method and provided by the lab and certified PFAS-free, typically polypropylene or high-density polyethylene bottles.

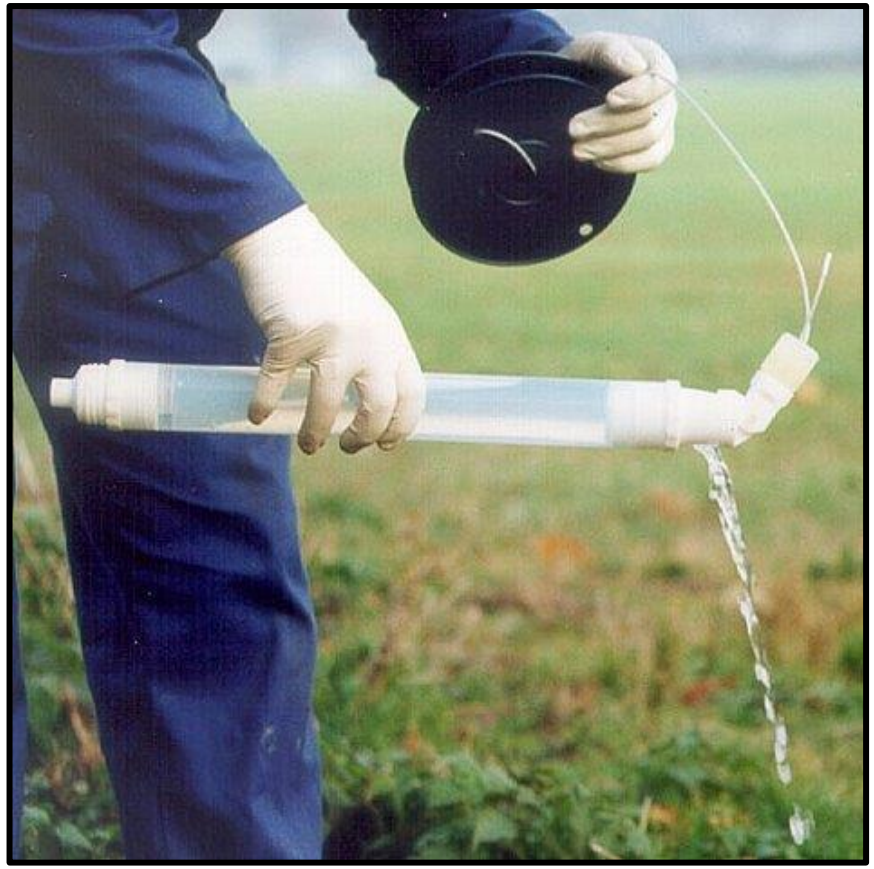


Source: https://www.limno.com/sampling-for-pfas-requires-caution/

Source: https://www.limno.com/pfas-emerging-but-not-new

Site Characterization, Sampling & Lab Considerations

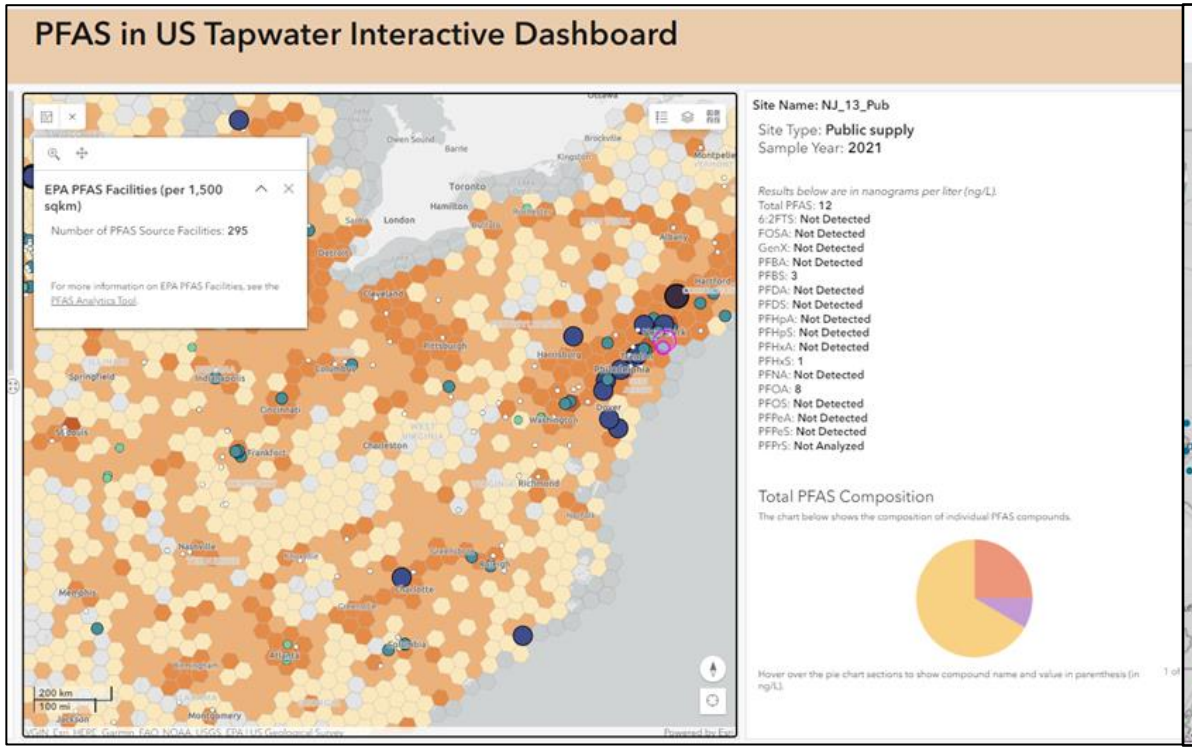
- Analytical detection method preferred is LC/MS/MS (liquid chromatography mass spectrometry mass spectrometry), but GC/MS (gas chromatography mass spectrometry) can also be used.
- EPA Method 537 Version 1.1 for lab analysis is when the USDOD attempted to standardize these lab modifications.
- Draft EPA Method 1633 is replacing Method 537 for soil and groundwater.
- Low flow sampling with bladder pump with polyethylene bladder and tubing. Grab sampling (bailer, passive diffusion).



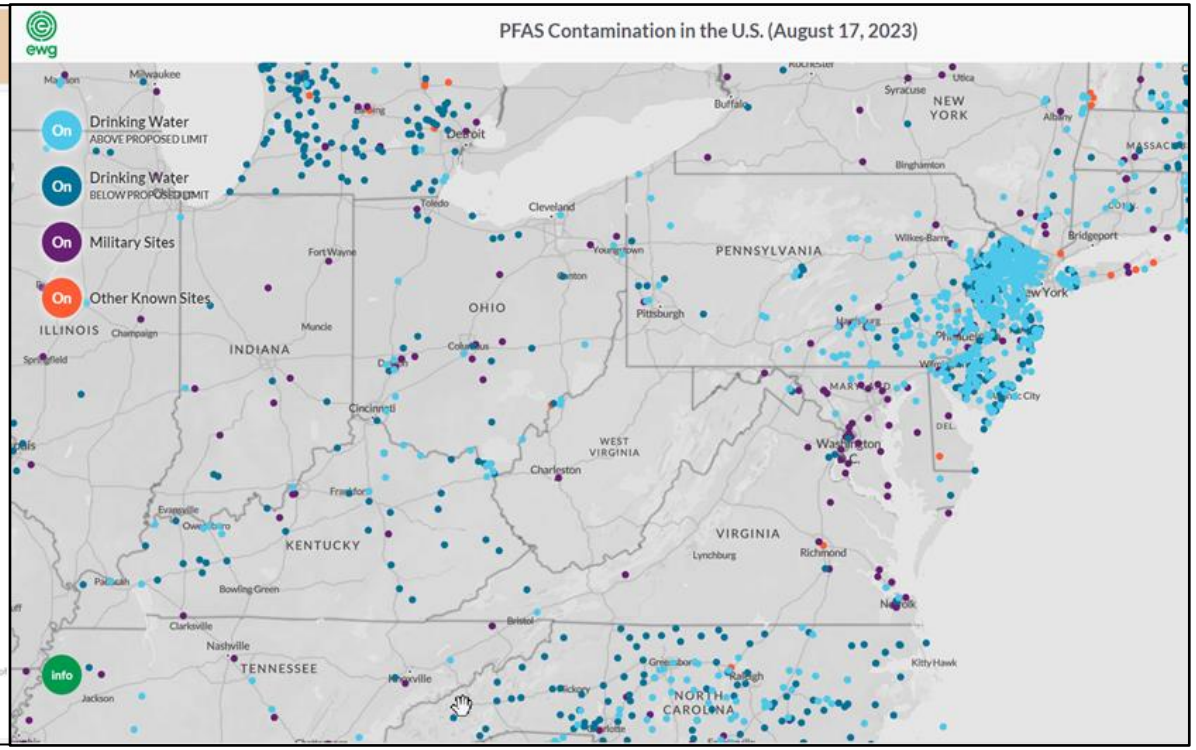
Source: http://www.mgs.co.uk/pumps-groundwater/sampling/138/bailers.html

Site Characterization, Sampling & Lab Considerations

Reviewing Potential Background Sources:



Source: https://geonarrative.usgs.gov/pfasustapwater/



Source: https://www.ewg.org/interactive-maps/pfas_contamination/map/

Site Characterization, Sampling & Lab Considerations

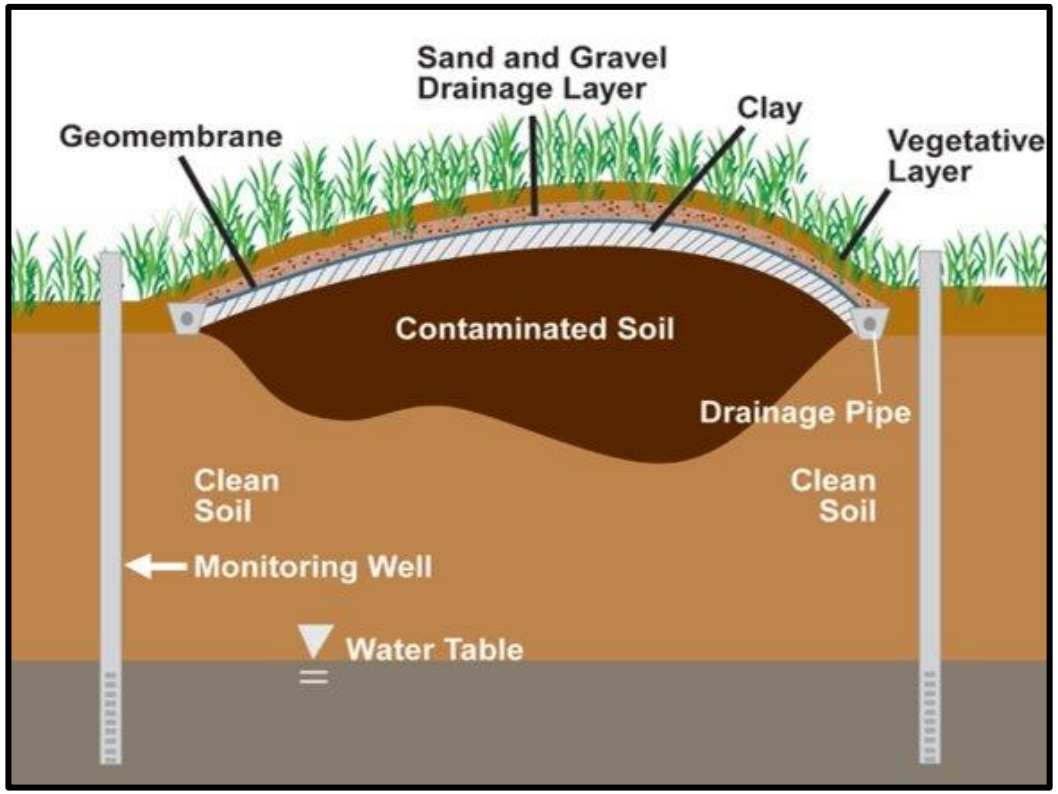
- Data validation
  - Confirm QAQC procedures during sampling.
- Evaluate conceptual site model
  - Does plume geometry match expected groundwater flow direction and velocity?
  - Does core of plume align with potential areas of concern?
- Evaluate potential regional impact in groundwater

Area of concern Sample Identifier Laboratory Identifier Sample Date Top of Casing (fmsl) Depth to Water (feet below inner casing) Depth to Product (feet below inner casing) Ground Water Elevation (fsml)	NJDEP Ground Water Quality Standard[1]	SB-35/TWP-6 L2137872-01 7/14/2021			EB-20210714 L2137872-02 7/14/2021		
		Result	Q	RL	Result	Q	RL
1,4-Dioxane	0.4	-	-	-	-		-
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	NS	ND		0.00186	ND		0.00216
1H,1H,2H,2H-Perfluorohexanesulfonic Acid (4:2FTS)	NS	ND		0.00186	ND		0.00216
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	NS	ND		0.00186	ND		0.00216
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	NS	ND		0.00186	ND		0.00216
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	NS	ND		0.00186	ND		0.00216
Perfluorobutanesulfonic Acid (PFBS)	NS	0.00256		0.00186	ND		0.00216
Perfluorobutanoic Acid (PFBA)	NS	0.0239		0.00186	0.29		0.00216
Perfluorodecanesulfonic Acid (PFDS)	NS	ND		0.00186	ND		0.00216
Perfluorodecanoic Acid (PFDA)	NS	0.0063		0.00186	0.011		0.00216
Perfluorododecanoic Acid (PFDoA)	NS	0.0019		0.00186	0.0102		0.00216
Perfluoroheptanesulfonic Acid (PFHpS)	NS	ND		0.00186	ND		0.00216
Perfluoroheptanoic Acid (PFHpA)	NS	0.00796		0.00186	0.0471		0.00216
Perfluorohexanesulfonic Acid (PFHxS)	NS	0.00197		0.00186	ND		0.00216
Perfluorohexanoic Acid (PFHxA)	NS	0.0183		0.00186	0.036		0.00216
Perfluorononanesulfonic Acid (PFNS)	NS	ND		0.00186	ND		0.00216
Perfluorononanoic Acid (PFNA)	0.013	0.00492		0.00186	0.0217		0.00216
Perfluorooctanesulfonamide (FOSA)	NS	ND		0.00179	ND		0.00216
Perfluorooctanesulfonic Acid (PFOS)	0.013	0.0121		0.00186	ND		0.00216
Perfluorooctanoic Acid (PFOA)	0.014	0.0232		0.00186	0.0152		0.00216
Perfluoropentanesulfonic Acid (PFPeS)	NS	ND		0.00186	ND		0.00216
Perfluoropentanoic Acid (PFPeA)	NS	0.0276		0.00186	0.344		0.00216
Perfluorotetradecanoic Acid (PFTA)	NS	0.00085	J	0.00186	0.00657		0.00216
Perfluorotridecanoic Acid (PFTrDA)	NS	0.00177	J	0.00186	0.0123		0.00216
Perfluoroundecanoic Acid (PFUnA)	NS	0.00422		0.00186	0.0207		0.00216

Note: Sample collected with a Teflon bailer.

Remediation Technologies/Methods

- Factors affecting remedy selection include characteristics of PFAS, changes in PFAS properties, and community acceptance.
- Remediation technologies are described as either demonstrated technologies, partially demonstrated technologies, or promising technologies.
- Demonstrated technologies for soil remediation:
  - Excavation and disposal
  - Engineering controls – capping
  - Thermal Conduction Heating treatment has been demonstrated by a few technology vendors



Source: https://www.epa.gov/sites/production/files/2015-04/documents/a_citizens_guide_to_capping.pdf

Remediation Technologies/Methods

Ex situ groundwater remediation technologies:

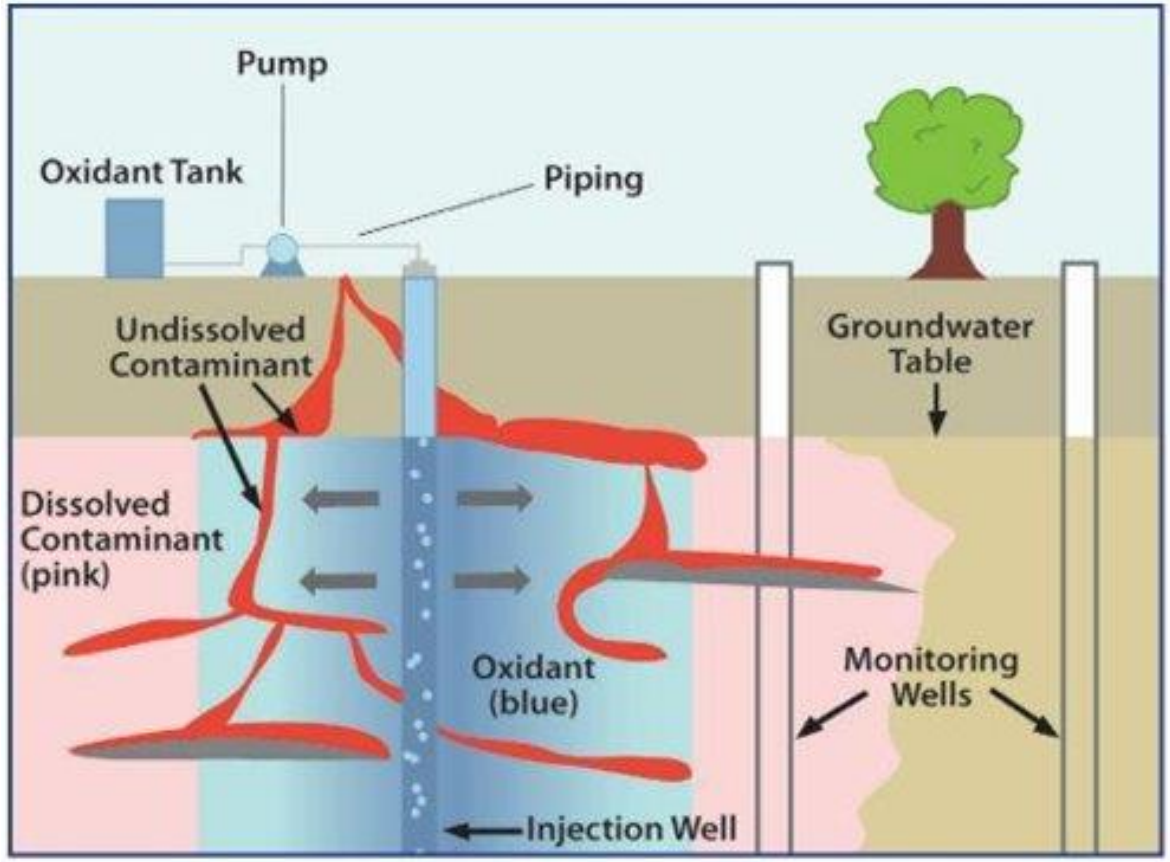
- Activated carbon media
- Coagulation/flocculation
- Membrane filtration (nanofiltration)
- Reverse osmosis
- Ion exchange
- Clay minerals
- Polymer-coated sand
- Biochar

Source: http://www.h2ktech.com/carbon-vessels/liquid-phase-carbon-vessels.html

Remediation Technologies/Methods

In situ remediation technologies (promising technologies):

- ❖ Colloidal activated carbon
- ❖ Chemical oxidation
  - Ozone and hydrogen peroxide injections
  - Catalyzed hydrogen peroxide
  - Activated persulfate
- ❖ Solidification/Stabilization
- ❖ Sonochemical oxidation



Source: https://theenergycollective.com/smithwillas/2386972/5-green-technologies-to-accomplish-environmental-remediation

Disposal of PFAS Material Regulations & Guidance

- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) doesn't list PFAS as hazardous substances; instead addressed as pollutants/contaminants.
- PFAS are not currently regulated under the Resource Conservation and Recovery Act (RCRA), the Clean Water Act, or the Clean Air Act.
- PFAS disposal is not regulated by TSCA.

Source: https://www.lion.com/lion-news/april-2016/ceo-convicted-for-superfund-superfraud

Disposal of PFAS Material

There aren't federal regulations on PFAS disposal— yet. In the meantime, and with regulations on the horizon, there are sound business reasons to move toward best practices as quickly as possible, to be ready for regulations when they arrive.

The EPA recommends three methods for PFAS-contaminated material as follows:

- **Incineration**
- **Landfill**
- **Deep well injection**

Incineration

PFAS destruction through high-temperature breakdown via incineration

- Utilize a RCRA Licensed Hazardous Waste Incinerator that operates at a minimum of 2012°F with significant air pollution control equipment, such as exhaust gas scrubbers
- Can be used for both liquid and solid material
- Excellent PFAS destruction and lower liability for generators
- Typically, high cost

Landfill

PFAS disposal via placement into a landfill

- Utilize a RCRA Part B permitted controlled landfill that protects against leaching into the environment
- Can be used only for solid material
- Not a PFAS destruction process, so a higher liability for generators
- Typically, lower cost

Deep Well Injection

PFAS disposal via placement into a deep well

- Use a facility that operates under the existing federal protocols for hazardous substance disposal in deep wells, which include stipulations to ensure the chemicals cannot migrate from the geological formation used for disposal
- Can be used only for liquid material
- Not a PFAS destruction process, but an excellent system to minimize the discharge of PFAS chemicals; this a moderate liability for generators
- Typically, lower cost

Proposed PFAS Regulations

EPA's PFAS Roadmap – 2021

- Review existing PFAS under TSCA to ensure existing PFAS are being used in ways that do not present concerns, and to prevent resumed production of legacy PFAS or their use in new ways.
- Propose to designate certain PFAS as CERCLA hazardous substances to require reporting of PFOA and PFAS releases, enhance the availability of data, and ensure agencies can recover cleanup costs.
- Initiate two rulemakings under RCRA to address PFAS.

Case Study 1: Remediation Site in New Jersey

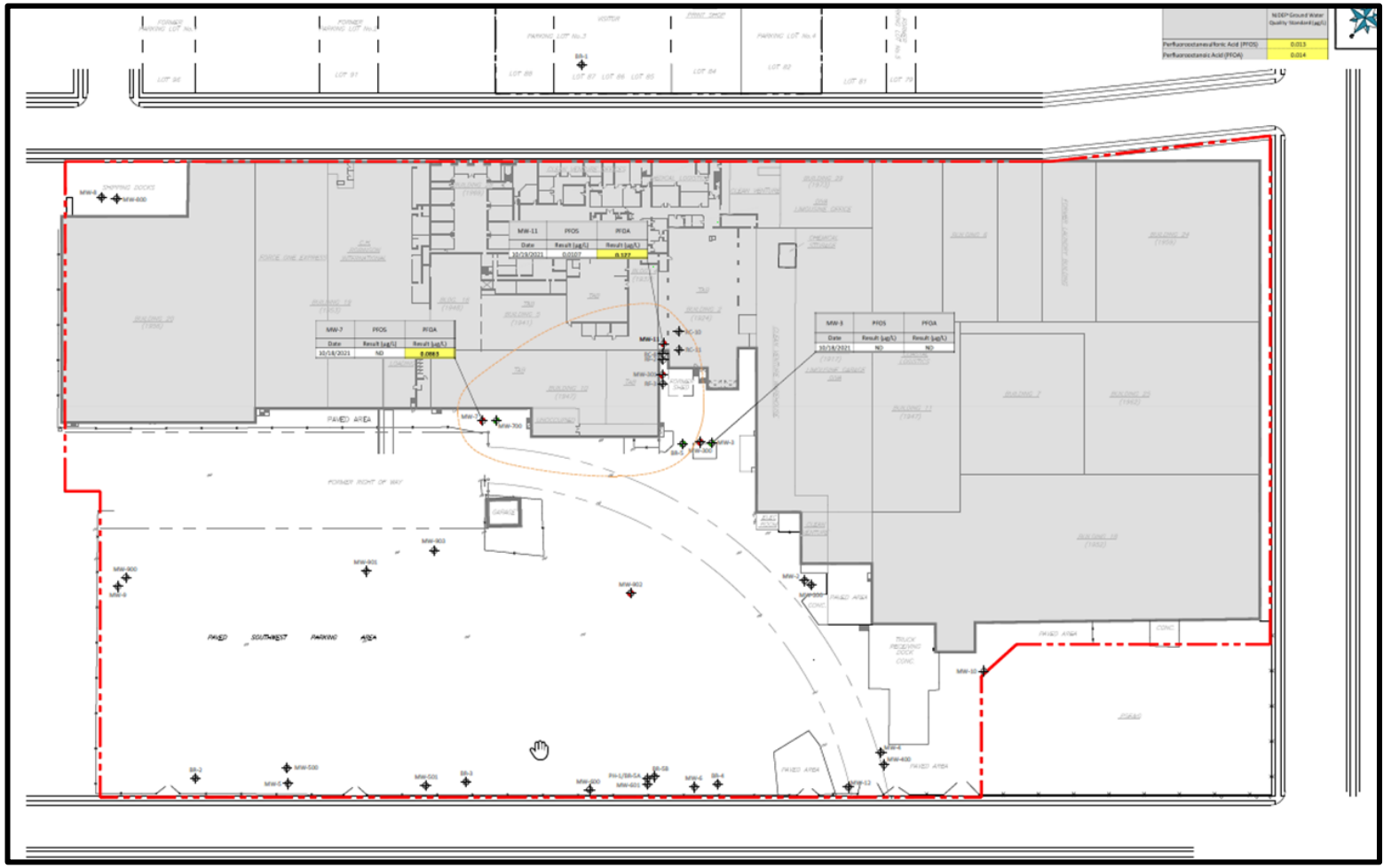
- Large industrial site with 20-year history of investigation and remediation for CVOC, metals, EPH, and PBCs.
- In 2020, NJDEP published PFAS standards and investigation was required.
- Conducted an PFAS evaluation:
  - Historic metal plating operation potentially utilized PFAS, no confirmed documentation of PFAS usage
  - Trenching associated with plating operations had a documented release

Case Study 1: Remediation Site in New Jersey

- Based on the evaluation, sampling was required.
- Sampling was conducted in the potential source area and impact was identified in groundwater (only a GW standard at the time).
- Reviewed CSM and potential background sources and a background investigation was recommended and implemented.
- Upgradient monitoring wells confirmed CSM and an unknown upgradient plume was identified.

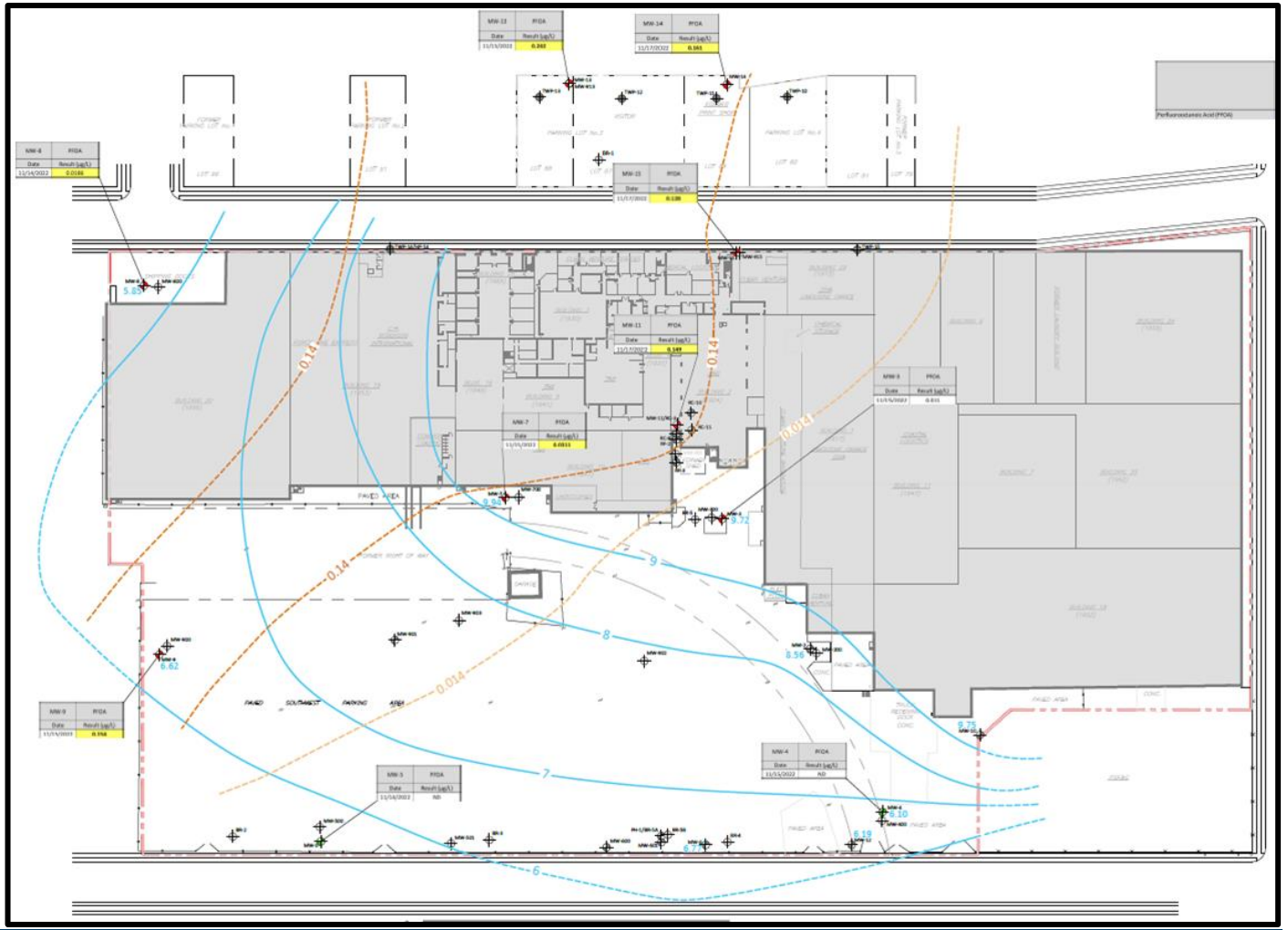
Case Study 1: Remediation Site in New Jersey

Initial Investigation



Case Study 1: Remediation Site in New Jersey

Background Investigation



Case Study 2: Fair Lawn Well Field Superfund Site

- In 1983, EPA identifies Westmoreland well field as NPL Superfund Site.
- Impact on well field associated with volatile organic compounds.
- Area consists of 15 square miles.
- PFAS were sampled at the wells (April 2021) and PFAS were identified as a contaminant of concern.
- Nova's client is within the footprint of the Superfund Site and an investigation is required.

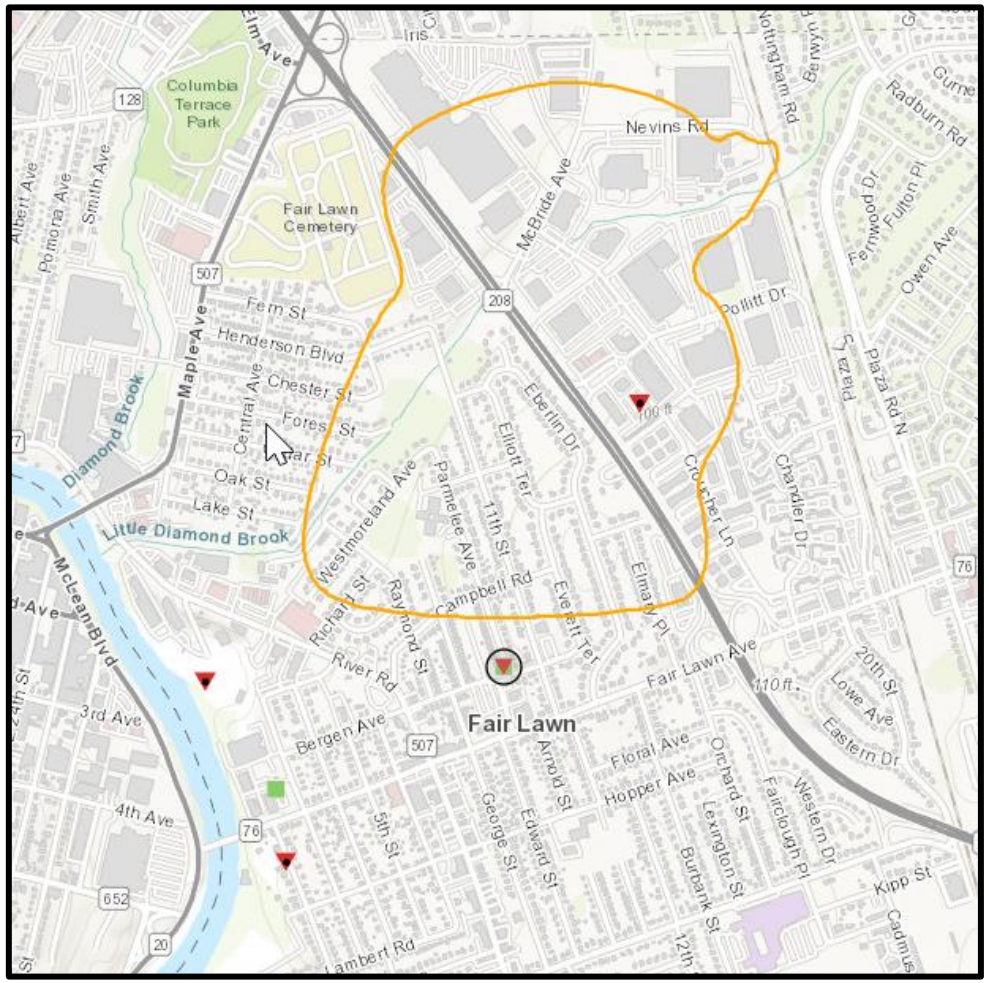
Case Study 2: Fair Lawn Well Field Superfund Site

- Nova conducted an initial PFAS evaluation
  - Potential PFAS use during former operation
  - Known areas of historic releases, predominantly VOCs
  - Sampling was recommended
- Development of sampling plan
  - Identify areas of concern that potentially contained PFAS
  - Review historic remediation conducted and redevelopment of the site
  - Conduct soil investigation to determine if PFAS is a contaminant of concern

Case Study 2: Fair Lawn Well Field Superfund Site

Conclusions

- For sites with multiple responsible parties, understanding your potential contribution is critical.
- Narrow your investigation to specific AOCs that potentially contain PFAS.



Thank you!

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TRIUMVIRATE ENVIRONMENTAL

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VALUABLE PEER LEARNING

Climate & Sustainability Mgmt.	Driving Transparency & Accountability	EHS&S Innovations & Emerging Issues	Leadership & Talent Development
Developing a Credible Net Zero Roadmap	Running Effective Audit and Corrective Action Programs	Taking an Expanded View of Worker Health to Drive Safety Culture	Effective Presentation Skills for Your Senior Executives & Board
Water & Biodiversity: Addressing Critical Issues	Leveraging Data Visualization to Enable Change	The Latest In Fleet Safety & Sustainability	Strategies for Creating Successful Partnerships with Consultants
Establishing A Supply Chain Sustainability Program	Preparing your company for new ESG Reporting Requirements	Innovations in PPE to Drive Improved Safety in Different Work Environments	Developing EHS skills in Non-EHS Professionals
Climate Risk Assessments & Scenario Planning	Ethics and Transparency in ESG	Critical Information On Emerging Chemical Risks and Regulations	Designing Organizations to address ESG, Sustainability and EHS
Corporate Action on Environmental Social Justice			

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Our Next Drop-in for 2023

November 16th

Q1: Sustainability Updates & Takeaways from COP27

Q2: Advancing Zero-Waste and the Circular Economy Efforts

Q3: Tools and Strategies to Accelerate your Climate Action Plan

Q4: Preparing for 2024 ESG-Sustainability Reporting
December 7th

- **Offering Session as a Hybrid!**

Contact Programs@naem.org if you'd like to host a Regional IMPACT event

Upcoming Research

- 2024 EHS&S Staffing, Structure and Budget
  - To begin fielding this year in Q4

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Have a safe, healthy and environmentally friendly day!