PFAS Remediation 101: Dealing with “Forever”

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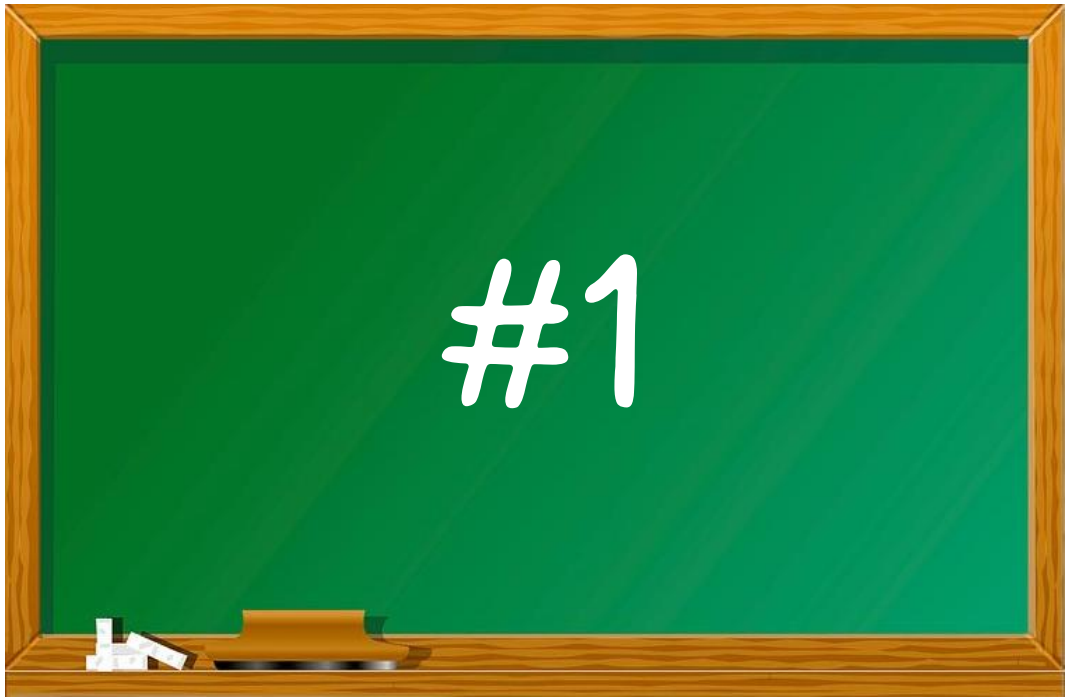


Some Quick PFAS Basics

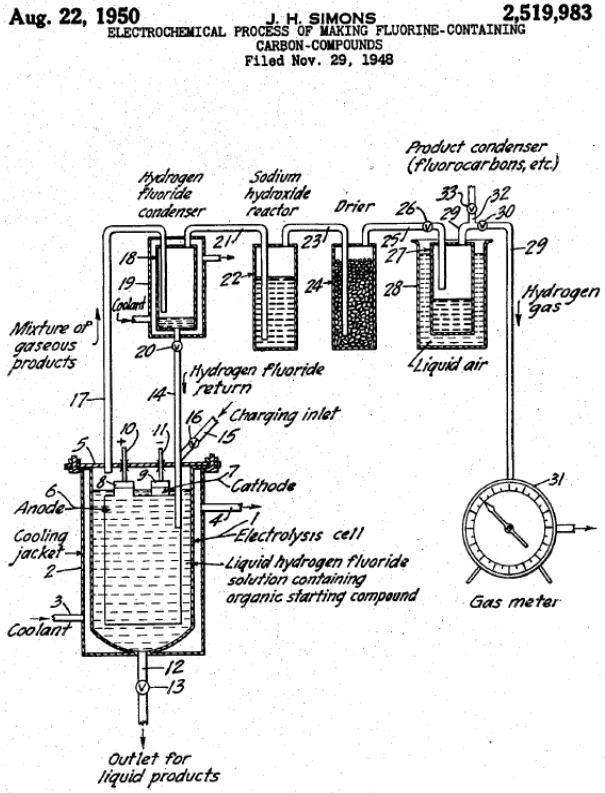
The Starting Point, Electrochemical Fluorination (ECF)

11-29-1948 3M Application for Patent

"electrolyzing a liquid hydrogen fluoride(HF) solution containing a fluorinatable organic starting compound, at an electrolyzing potential which is insufficient to generate free fluorine under the existing conditions, but which is sufficient to cause the production of fluorine-containing carbon compound products at a useful rate"

https://patents.google.com/patent/US2519983A/en

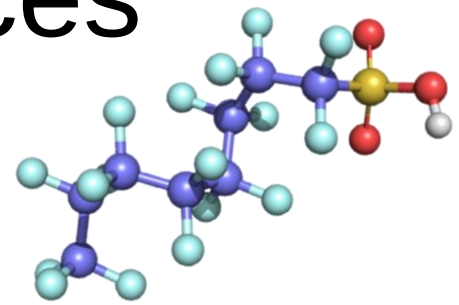
Patent US2519983



PFAS Chemistry

Anderson, 2017

Per- and Polyfluoroalkyl Substances (PFAS)



What are they?

- Strong Carbon-Fluorine Bonds
- Surfactants
- Highly Stable
- Repel Water, Oil, Fat, and Grease
- Began Developing in 1940s
- Thousands of Compounds Today

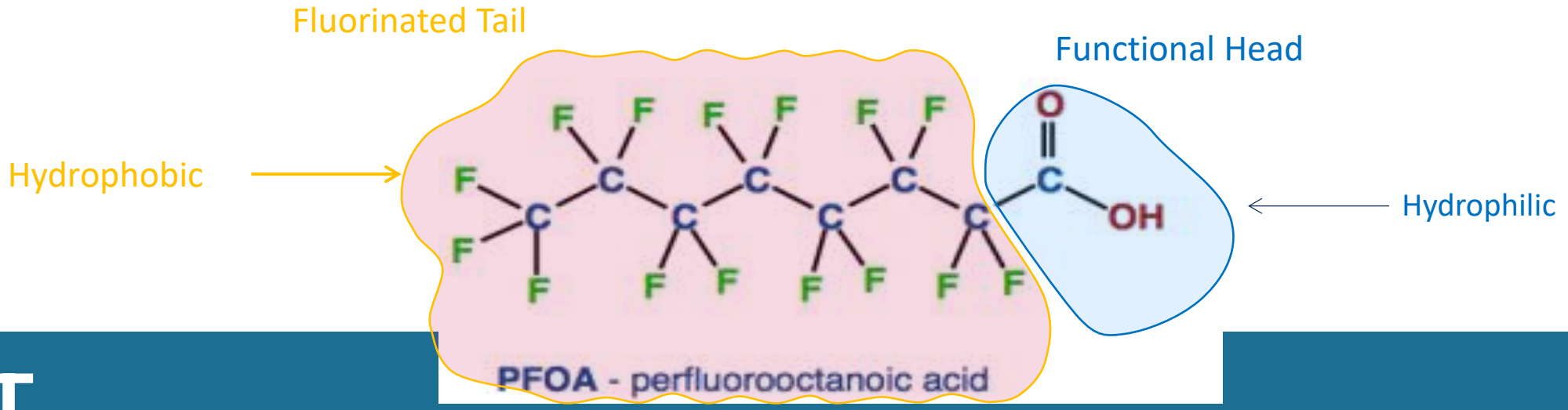
Why the concern?

- Widespread through the ecosystem
- Don’t Break Down Easily - Hard to Get Rid of
- Bioaccumulate – Build Up in Our Bodies
- Some PFAS May Affect Health
- Some emerging science/information
- Need for additional Federal Standards

Heads or Tails

Carbon-fluorine bonds:

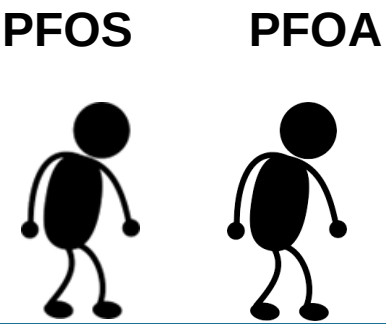
- The H is replaced with a F
- Very strong, inert
- Resists thermal, chemical, and biological degradation
- Surfactant, reduced surface tension
- Hydrophobic (repels water) *and* oleophobic (repels oil/fat/grease)



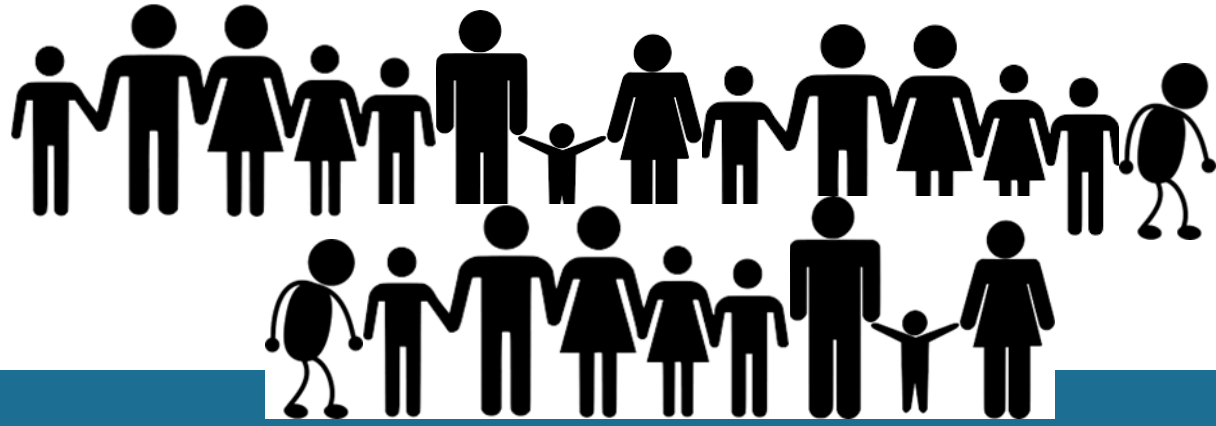
It’s all in the Name!

PFAS: the *entire family* of chemicals

PFOS and **PFOA**: two members of the family



The whole PFAS family



PFAS Uses

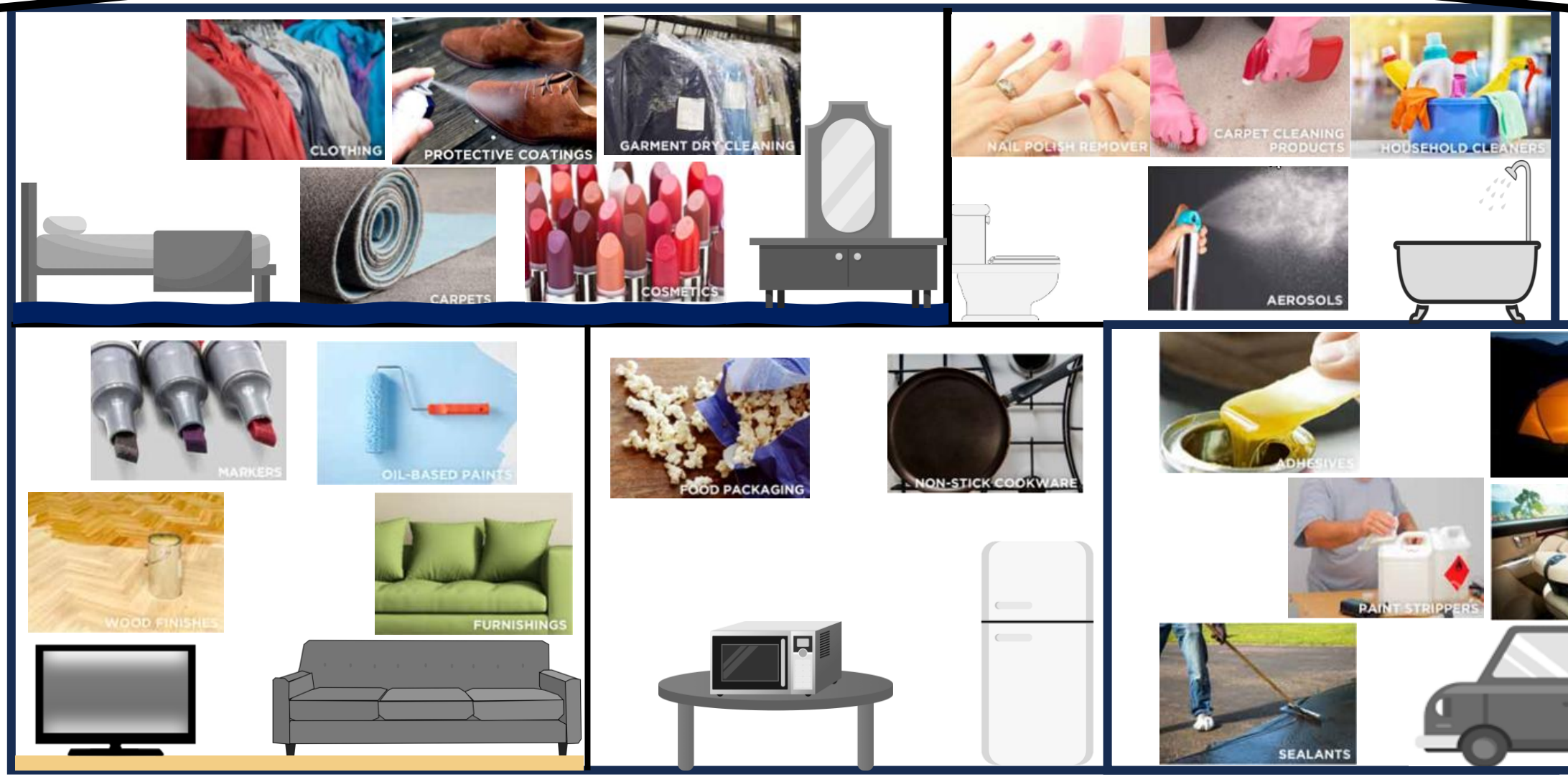
PFAS Timeline

PFAS[1]	Development Time Period							
	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s
PTFE	Invented	Non-Stick Coatings			Waterproof Fabrics			
PFOS		Initial Production	Stain & Water Resistant Products	Firefighting foam				U.S. Reduction of PFOS, PFOA, PFNA (and other select PFAS[2])
PFOA		Initial Production	Protective Coatings					
PFNA					Initial Production	Architectural Resins		
Fluoro-telomers					Initial Production	Firefighting Foams		Predominant form of firefighting foam
Dominant Process[3]		Electrochemical Fluorination (ECF)						Fluoro-telomerization (shorter chain ECF)
Pre-Invention of Chemistry /			Initial Chemical Synthesis / Production			Commercial Products Introduced and Used		

Notes:
1. This table includes fluoropolymers, PFAAs, and fluorotelomers. PTFE (polytetrafluoroethylene) is a fluoropolymer. PFOS, PFOA, and PFNA (perfluorononanoic acid) are PFAAs.
2. Refer to Section 3.4.
3. The dominant manufacturing process is shown in the table; note, however, that ECF and fluorotelomerization have both been, and continue to be, used for the production of select PFAS.

Sources: Prevedouros et al. 2006; Concawe 2016; Chemours 2017; Gore-Tex 2017; US Naval Research Academy 2017

History and Use of Per- and Polyfluoroalkyl Substances (PFAS). *Interstate Technology Regulatory Council* **November 2017**.



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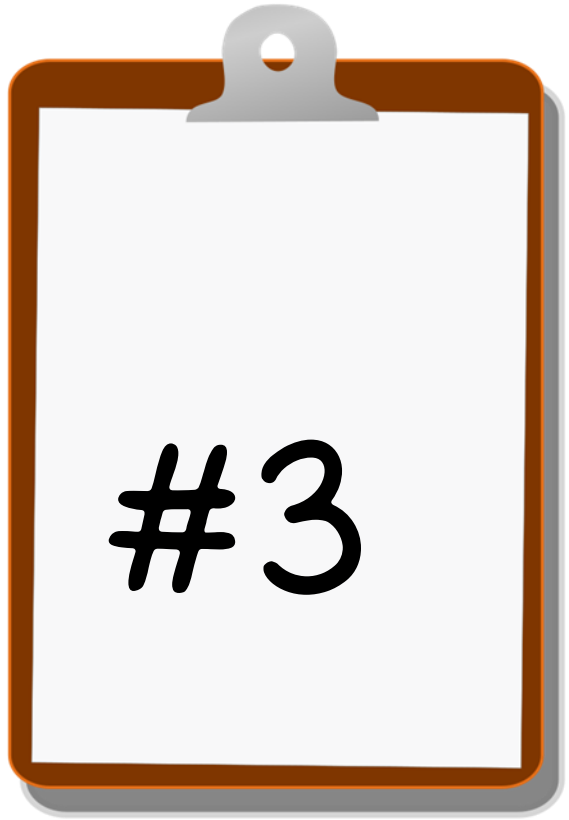
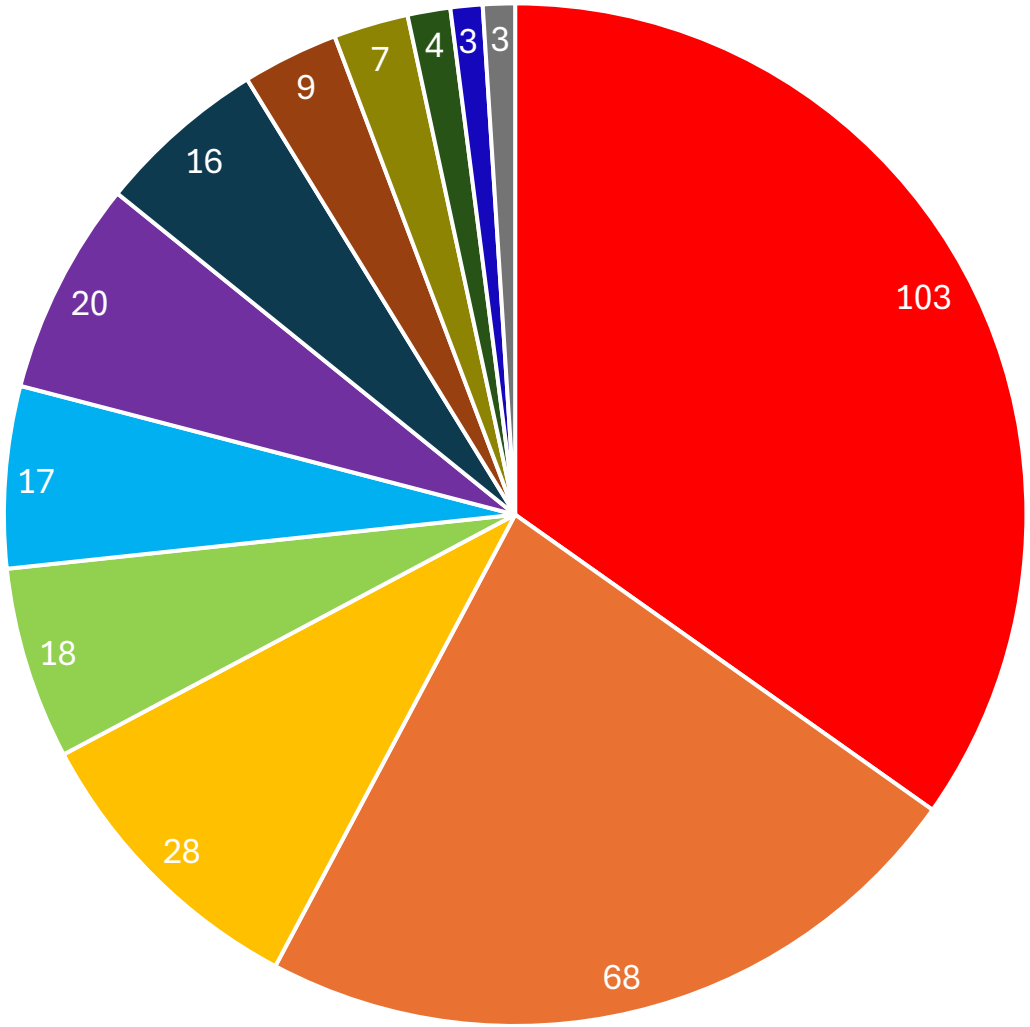


PFAS Contamination by Type of Site

296 PFAS Sites by Type



- Landfill
- Industrial (transportation-related, chemical, and other manufacturing)
- Plating
- Airport
- Military
- Wastewater (wastewater treatment plants and a car wash)
- Fire Related
- Laundromat/Dry Cleaner
- Paper Manufacturing
- Tannery
- Refinery
- Unknown

Remediation and Interim Responses

Water Remediation Technologies

- Treatment technologies are still advancing, water is “easier”
- Pump and Treat with GAC-Granular Activated Carbon, not so good on short chain
- Ion Exchange
- Reverse Osmosis, “goo” on the filter to deal with, may have high energy and maintenance needs
- Surface Active Foam Fractionation (SAFF), bubble air through the water and collect resulting foam for destruction, handles a wide range of concentrations
- Super Critical Water Oxidation (SCWO, 374ºC and 3200 psi), in use on AFFF and landfill leachate, currently one site in Michigan

Water Remediation Technologies, Continued

- HALT (hydrothermal alkaline treatment, 350 C with NaOH)
- Electrochemical Oxidation, electrodes and water
- Plasma (cold), ionized gas
- Colloidal Carbon, “barrier wall”
- Sonication (ultrasound), creation of microbubbles
- UV, moving on from chlorinated solvents
- Cyclodextrin, made from starch, “traps” PFAS in matrix
- Clays and Minerals, many brands

Water Remediation Technologies, Continued

- Solidification of liquids and landfilling
- Deep Well Injection, out of sight, out of mind?
- Incineration, not 100% efficient and what is coming out of the stack and how do you measure it?
- Air Stripping, if it worked, do we want PFAS deposited downgradient or around the area?

What About Soil and Solids?

Soil Remediation Technologies

- Treatment technologies are advancing slowly and lag behind water, limited and expensive. Haven't I used/seen these before?
- Excavation (dig and haul), landfill limitations due to leachate
- Capping, keep it from leaching to groundwater
- Ball Milling, think pulverizing coal
- Stabilization-Biochar and colloidal carbon, adsorption, long term monitoring
- Soil Thermal Treatment (high temperature, both in-situ and ex-situ, 350-400+ C) off gases to treat
- Soil Washing, media transfer, better for coarse materials, need water and power
- Biotech, many studies being conducted
- Phytoremediation, trees and shrubs, hemp

Soil Remediation Technologies, Continued

- Incineration, Cement Kiln, potential emissions issues, how to measure stack emissions
- Biotech
- Smoldering Combustion

PFAS Resources

Michigan PFAS Action Response Team

Michigan.gov/PFASResponse

Health | Resources for Residents | Drinking Water & Wells | Investigations & Sites | Fish & Wildlife | Public Engagement | FAQs | About

Michigan PFAS Action Response Team (MPART)

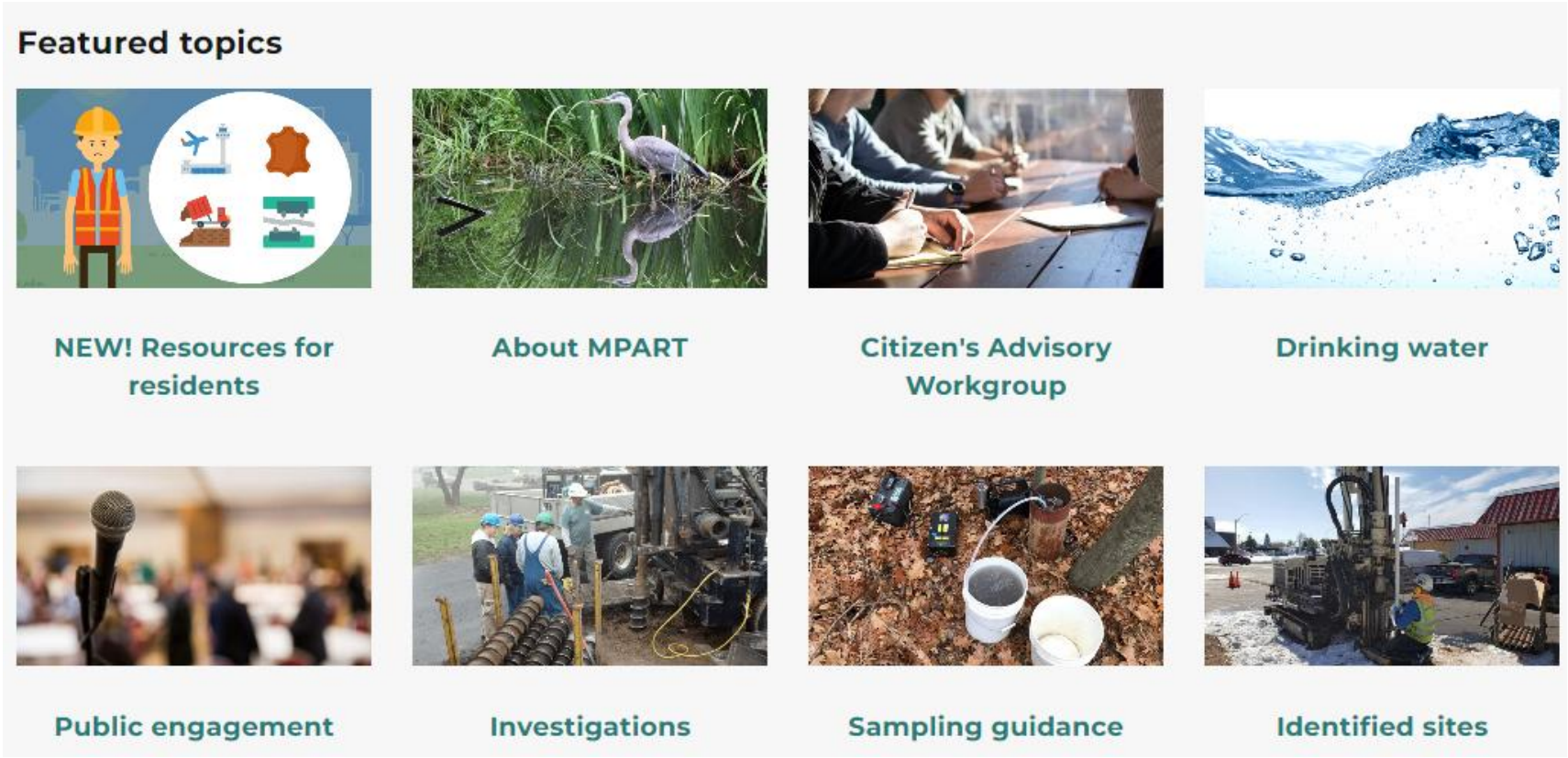
What's new

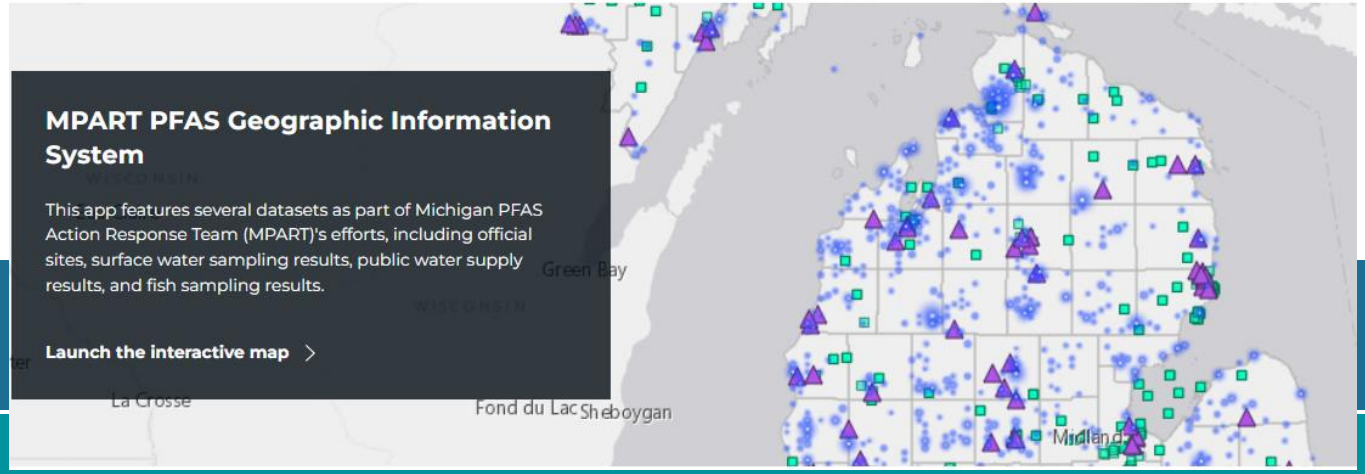
- **3/14 - New site in Washtenaw County:** 253 Dino Drive
- **3/3 - New site in Allegan County:** Former Plainwell Mill Operable Unit 7 (OU7)
- **3/3 - New site in Kalamazoo County:** Roto-Finish Co., Inc.
- **1/15 - New site in Wayne County:** Nankin Township Landfill

MPART FY24 Fast Facts

Find a recap of MPART's activities throughout fiscal year 2024

- PFAS 101
- FAQs
- Site investigation summaries
- Sampling guidance
- Public meeting calendar





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ITRC Website - https://pfas-1.itrcweb.org/

Michigan PFAS Action Response Team (MPART)

www.Michigan.gov/PfasResponse

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MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

Michigan Department of Agriculture & Rural Development

Department of Natural Resources DNR Michigan

MDOT Michigan Department of Transportation

Department of Military and Veterans Affairs Michigan

MDHHS Michigan Department of Health & Human Services

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