PFAS the Next Frontier – An Industry Perspective

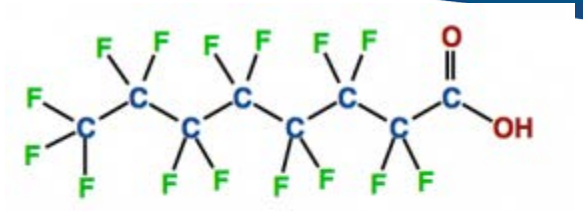
November 2020

Presentation Objectives

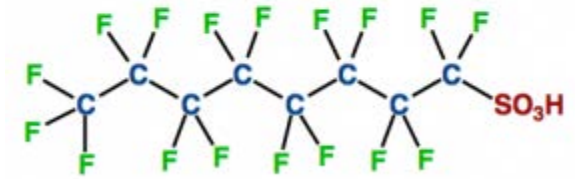
- Provide an industry perspective on PFAS emerging as a contaminant of concern
  - Understand the physical properties, toxicology, sources, fate and transport of the contaminant
  - Get to know the laboratory capabilities - sampling and analytical challenges for PFAS waste
  - Examine regulatory climate surrounding PFAS compounds – specifically at the State level
  - Review current technologies for PFAS management
  - Identify the current USE management capabilities for PFAS disposal

PFAS Introduction

- **PFAS** = per- and polyfluoroalkyl substances
- Complex family of more than 3,000 manmade fluorinated organic chemicals
- Unique physical and chemical properties
- Invented in the 1930s and used in a wide range of consumer and industrial products
- Extremely persistent

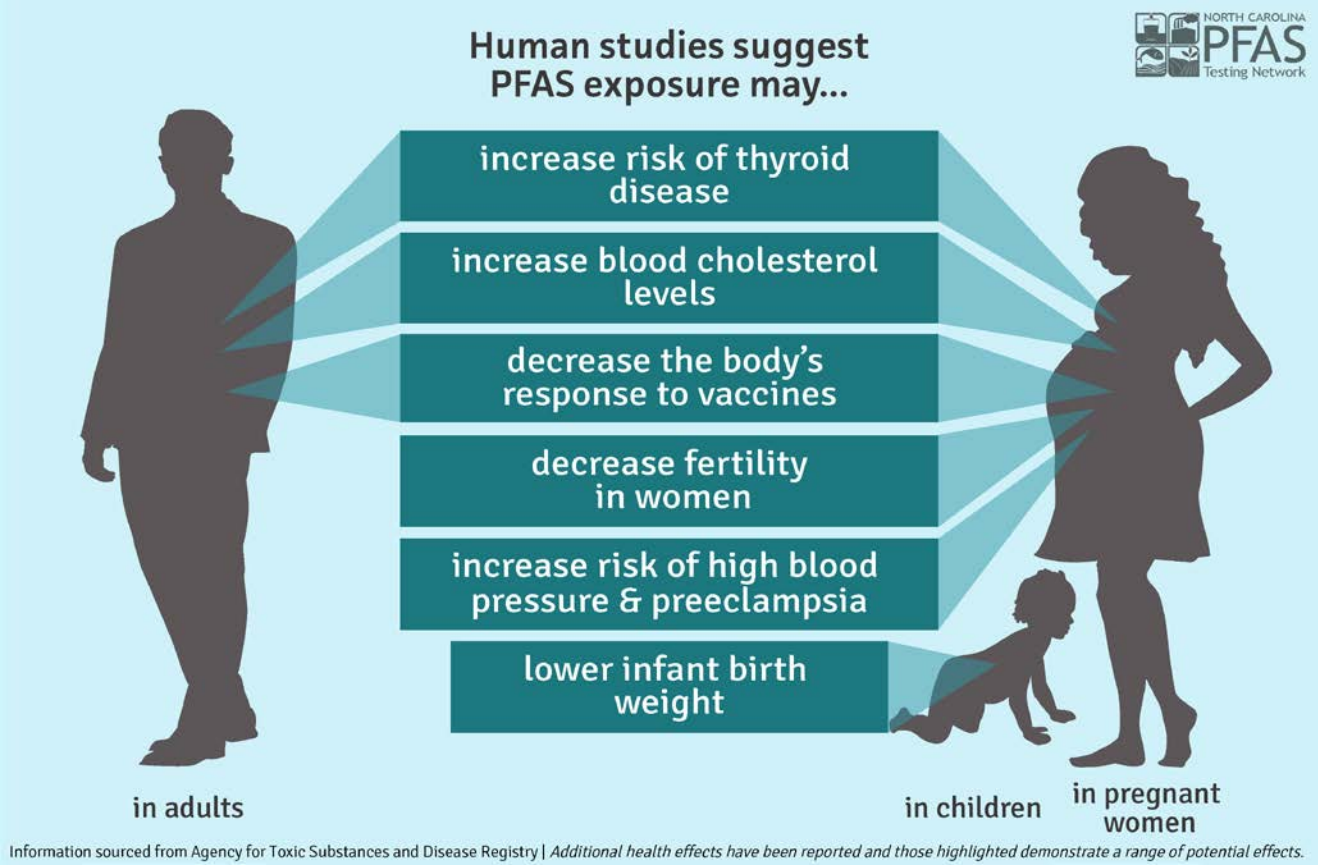


PFOA - perfluorooctanoic acid



PFOS - perfluorooctanesulfonic acid

PFAS Toxicology



PFAS Fate and Transport

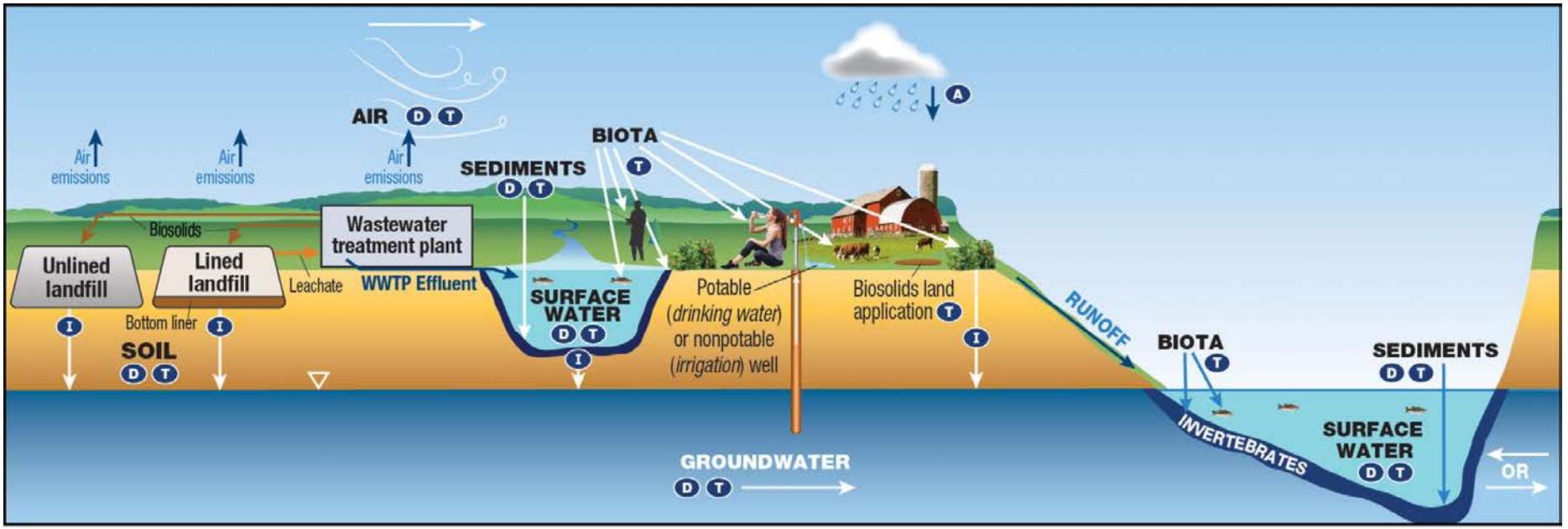
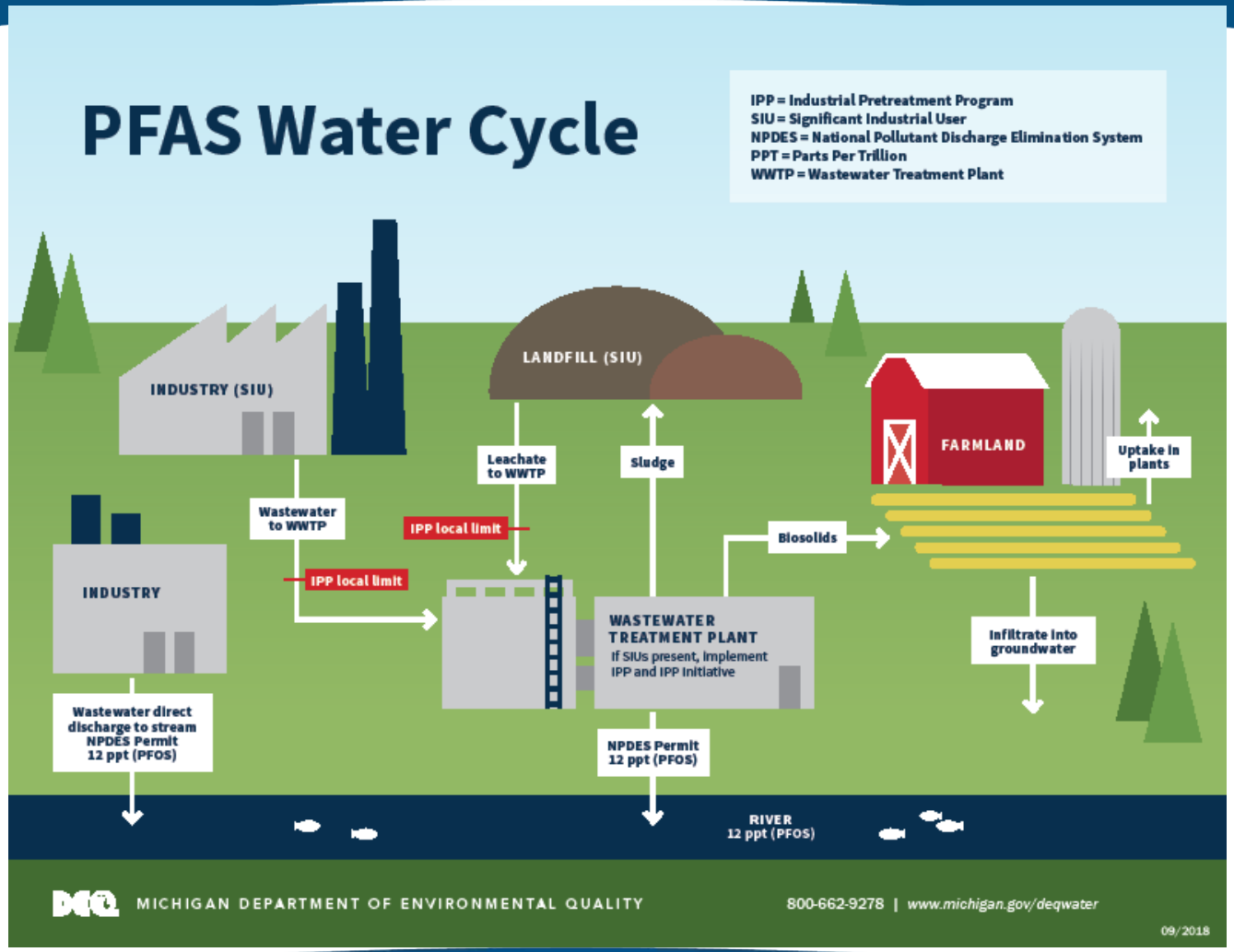


Image credit: ITRC Fate and Transport - Landfills

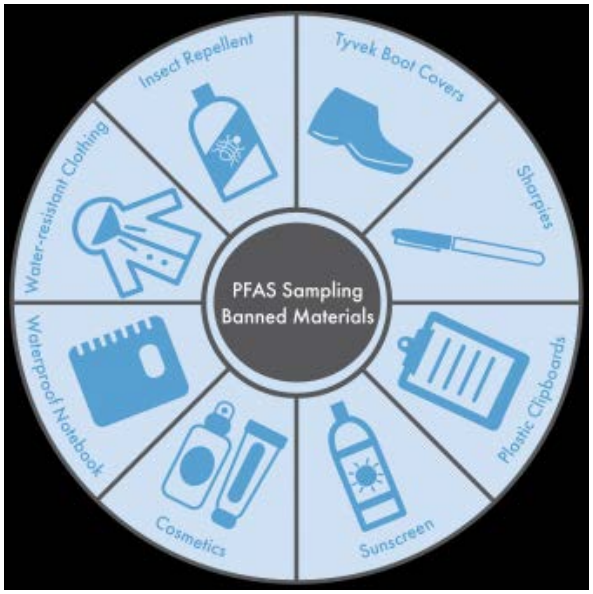
- Extremely stable
- Low volatility
- Readily transported in ground water
- Atmospheric disposition around industrial sites

PFAS Waste Streams



- Consumer products
- Industrial by-products
  - Sludge
  - Filter cake
  - Residuals
- Household waste
- Landfill leachate
- Biosolids
- Remediation soils and debris

Sampling and Analytical Methods



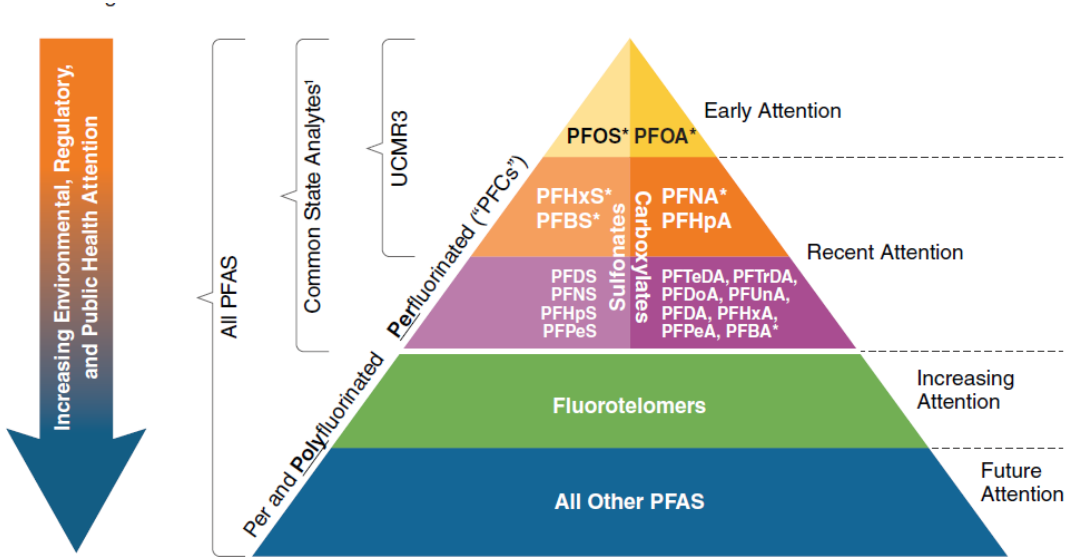
Laboratory Analytical Methods

- EPA Methods 533 and 537.1 for drinking water
- EPA SW-846 Method 8327 for non- potable water
- EPA Method 537 Modified Isotope Dilution (all aqueous and solid matrices, including soil), ISO 25101, ASTM D7979, and total oxidizable precursors (TOP) analysis are also available.
- An EPA-validated method for PFAS air- emission sampling and analysis has not yet been developed; modifications of existing air methods are currently being used.

https://www.epa.gov/water-research/pfas-analytical-methods-development-and-sampling-research

PFAS Emerging Awareness

- Early focus on long-chain compounds
- Long-chain compounds phased out of US in 2015
- Federal and State regulatory agencies actively investigating compounds

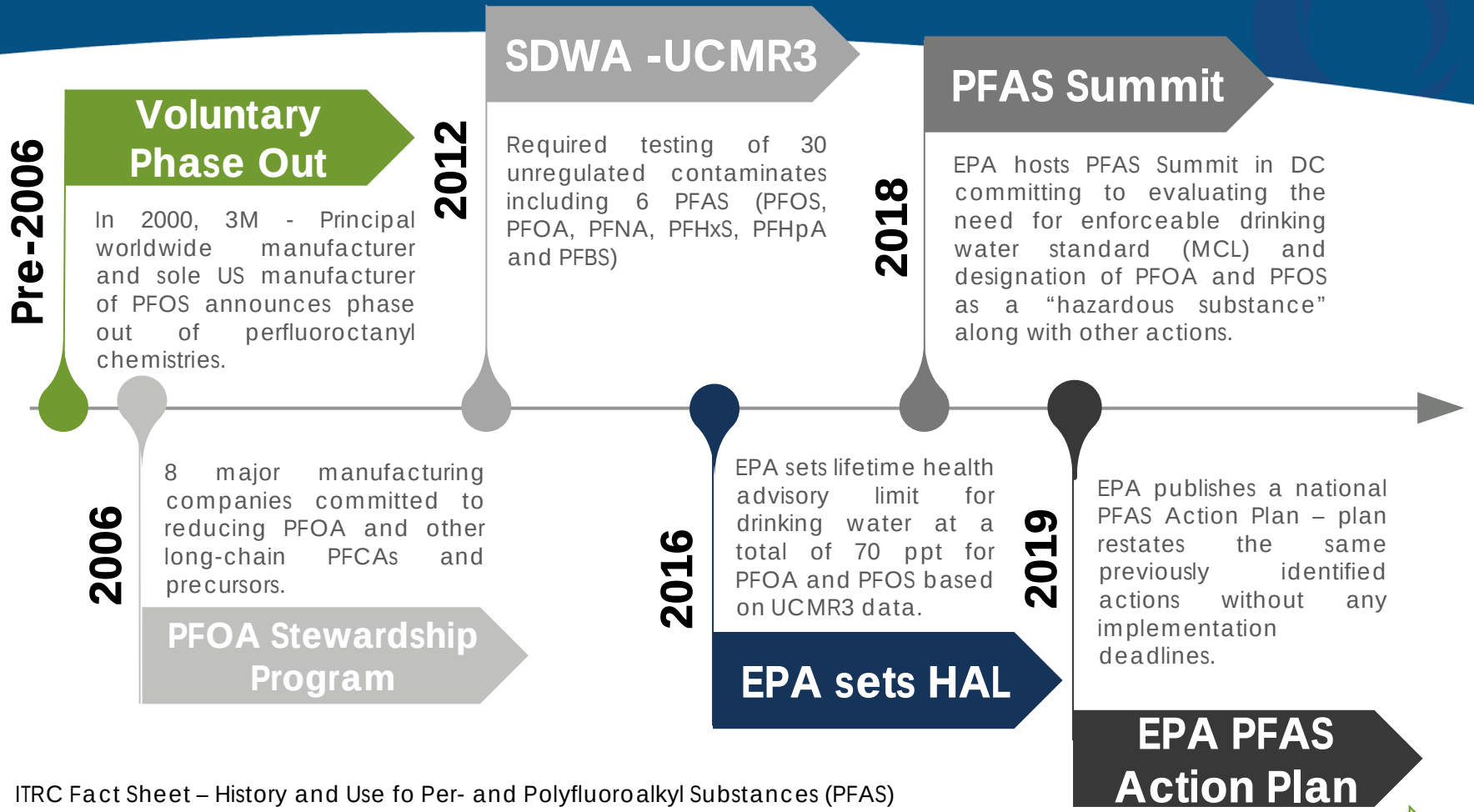


*Common regulatory criteria or health advisories
[1]Sum of informal poll (NJ, NH, MN)

Thematic and not proportional.
Bottom of triangle indicates additional number of compounds; not a greater quantity by mass, concentration, or frequency of detection.

ITRC Fact Sheet – History and Use fo Per- and Polyfluoroalkyl Substances (PFAS)

Federal Regulatory Climate



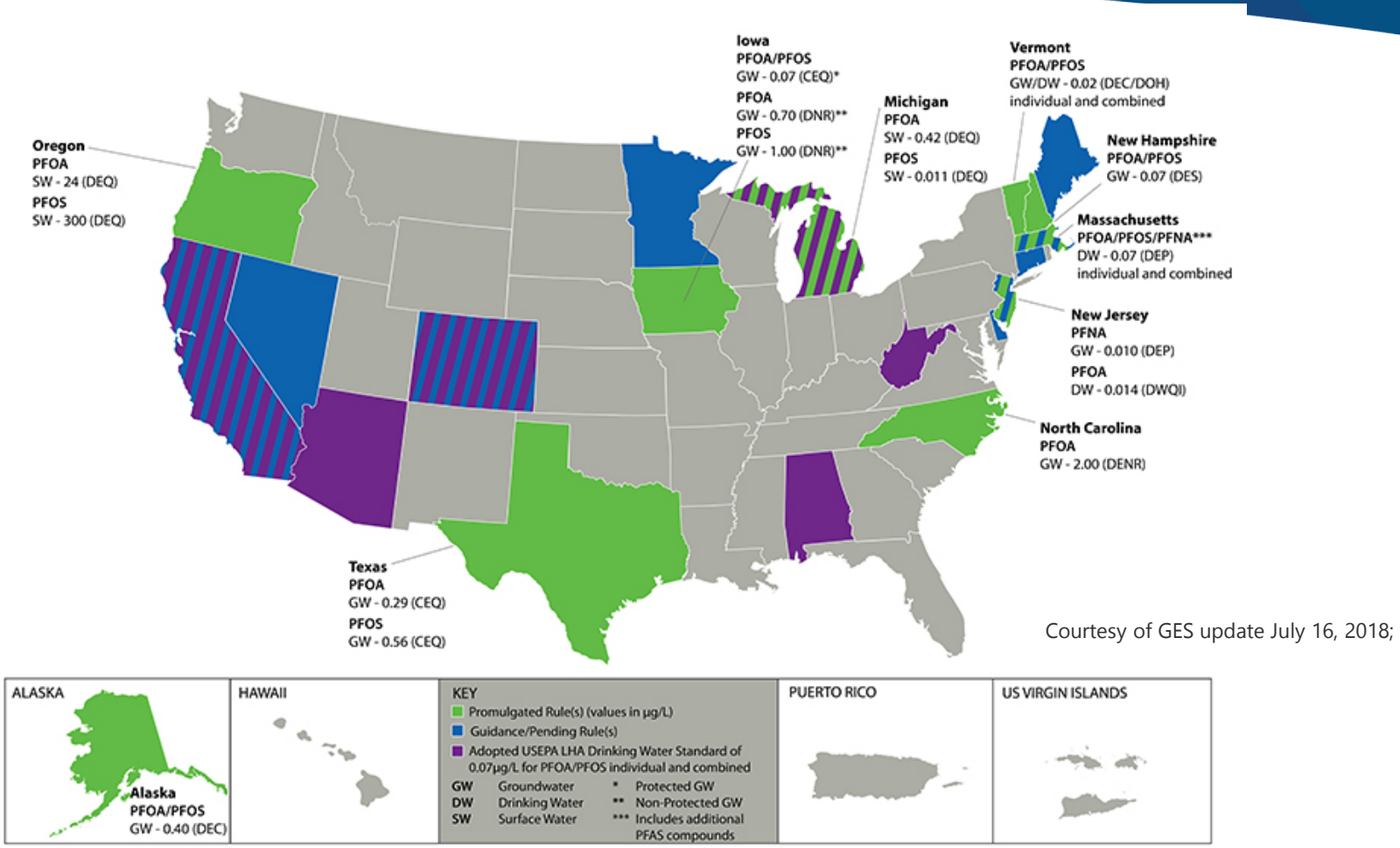
ITRC Fact Sheet – History and Use fo Per- and Polyfluoroalkyl Substances (PFAS)

Increased public awareness and pressure to act

Overview by Regulatory Pathway

Regulation	Waste Volume	Timing	USE Current Capabilities	Notes
State Regulations	↑ Soil, products, waste water	current	Permitted landfill, CWT & UIC	• Localize opportunities • Direct affect on our operations
CWA	↑↑ Biosolids, waste water	current	Permitted landfill, CWT & UIC	• Biosolid regulations • Could push to waters to UIC program
SDWA	↑ Filtration media, GAC, IX resin	1-5 yrs	N/A	• Currently primary focus (Federal and State) • MCL generation
CERCLA	↑↑ Soil	2 yrs	Permitted landfill	• Long-term liability protection • RQ development
TSCA	↑↑ Soil, products, waste water	5 yrs	Permitted landfill, CWT & UIC	• SNUR* • Section 6 - concentration dependent, disposal must include landfill
CAA	↑ Soil, products	5 yrs	Permitted landfill	• Could limit competition, remediation solutions
RCRA	↑↑ Products, soil, waste water	Unlikely	Permitted landfill and CWT	• LDR/treatment standard required • Not likely due to regulatory implications

State Regulatory Climate



Courtesy of GES update July 16, 2018;

Regulatory Implications

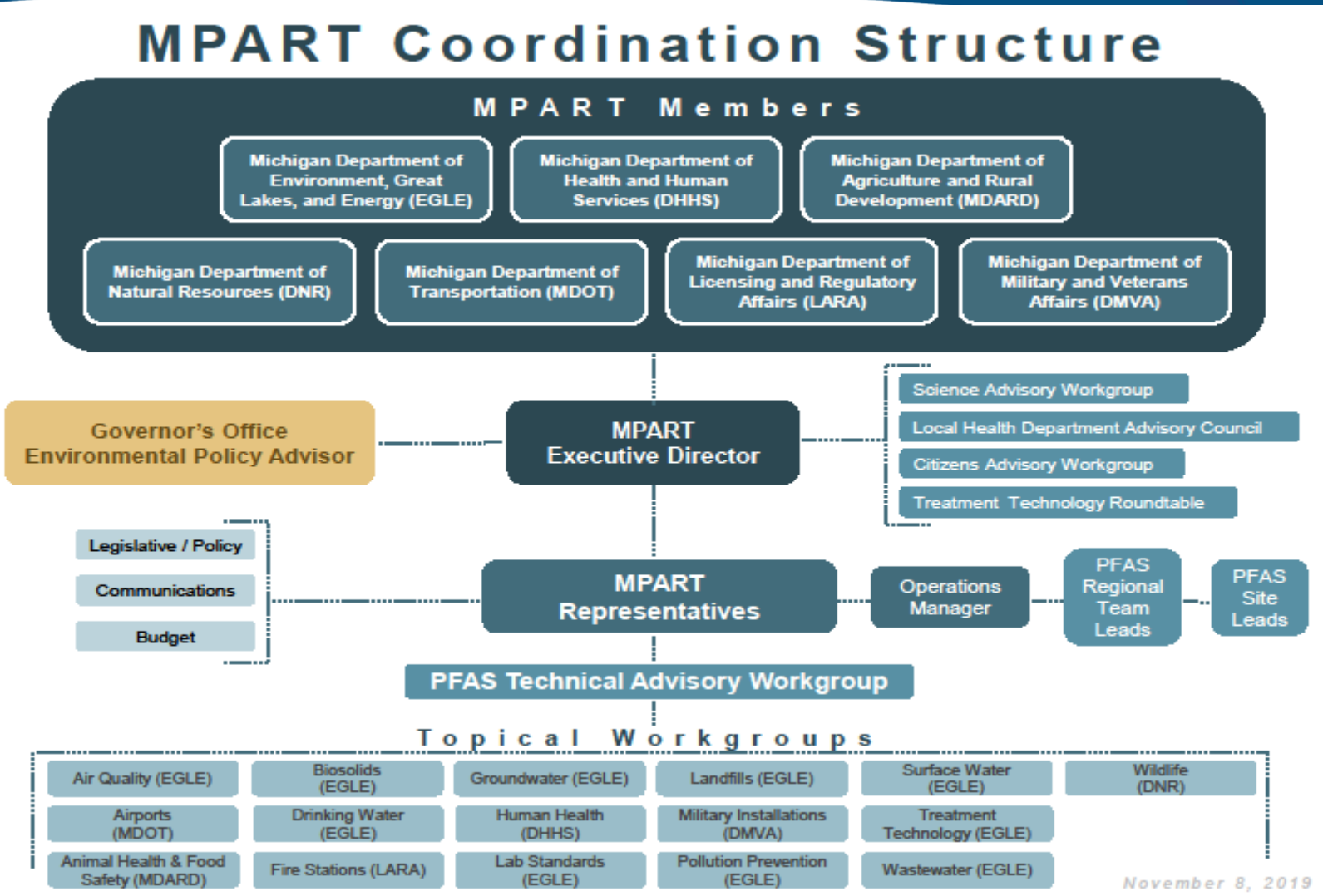
Local authorities having jurisdiction requiring load monitoring, source identification and treatment options:

- Required to sample discharge and track PFAS concentrations over time
- Evaluate in coming waste streams to identify contributors
- Evaluate treatment technologies for PFAS removal

Commercial challenges:

- Process/infrastructure limitations
- Sampling and analytical methods
- Customer response – non regulated, analytical not required
- Regional competition

Michigan PFAS Action Response Team



Soil/Solids Technology

Technology	Considerations	Feasibility
Incineration	Technically acceptable approach; destructive. High cost, subject to capacity	Highly feasible- Accepted and preferred method – 1100°C required, fluorine mass balance lacking, emissions scrubbing required
Landfill	Acceptable approach; non-destructive. Long-term maintenance	Highly feasible- Requires lined landfill with leachate management
Thermal Desorption with off-gas treatment	Mobile option, technically acceptable approach; destructive. Subject to efficiency testing. Potential lower cost and lower barrier to entry than incineration.	Feasible- Mass balance to understand destructive mechanism; document air treatment emission, 1100°C required, emission scrubbing for HF
Stabilization/ Sequestration	In Situ or Ex Situ; carbon and mineral/organo-clay based.	Feasible- More R&D on long term stability and potential for desorption
Vapor Energy Generator (VEG)	Ex Situ applications; current full-scale applications for oils, PCBs, PAH, pesticides. Closed loop process with little to no vapor emissions	Likely Feasible- More R&D on PFAS soils. Assessment of PFAS fate through the system
Reactive Media	In Situ and Ex Situ applications	Feasible- More R&D on long term stability and potential for desorption, site specific feasibility
Other: advanced oxidation, other thermal-based treatments, reductive defluorination	More regulatory clarity and R&D required	

Water Technology

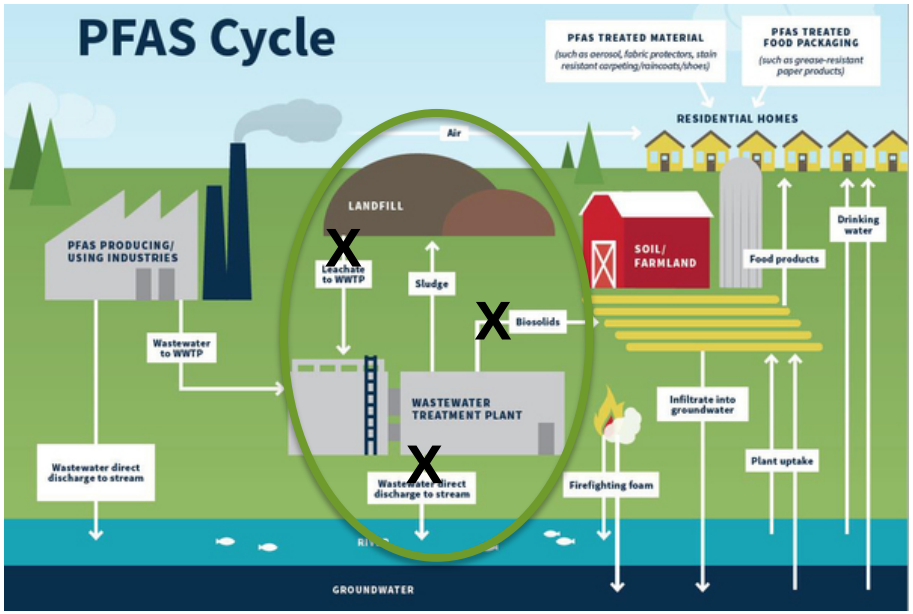
Technology	Considerations	Feasibility
Granular Activated Carbon	Conventional technology; Effective long chain PFAS removal, short chain breakthrough first. Competitive adsorption with other species.	Highly feasible- Multiple vendors. Reactivation available. Other non-PFAS organics can consume carbon and may require pre-treatment.
Ion Exchange Resin	Higher load capacities compared to GAC. Disposal of spent resin or potential regeneration.	Highly feasible- Higher media costs, less replacement; Cost benefit is stream dependent.
UIC – Deep Well Injection	Conventional technology; currently in use. Class 1 acceptability, Class 2 in question	Highly feasible- Limited Class 1 capacity and locations. Class 2 wells are numerous. Public perception and long-term viability still unknown.
Traditional Filtration – RO, Nanofiltration	Established technology, but not for PFAS at full-scale. Flux and recovery limited by fouling. High volume of concentrate generated	Feasible- Cost effectiveness to be determined.
Other Specialty filtration; Zeolites, minerals	Conventional water treatment process. Off-site disposal of solids/filter media required.	Feasible- More research required.
Specialty coagulants	Conventional water treatment process. Requires solids dewatering and disposal. Upstream treatment option, not for polishing	Feasible- Use as part of a treatment train. Limited data outside lab and bench scale
Activated persulfate	Limited effectiveness on PFOS. Incomplete reactions may produce PFAAs	Not feasible- Limited effectiveness
Other: Sonolysis, Ozonfractionation, Photolysis, Electrochemical Oxidation	More R&D required	

PFAS Treatment and Disposal Solutions

Solids/Soils

Highly engineered Subtitle C permitted hazardous waste landfills with leachate management systems

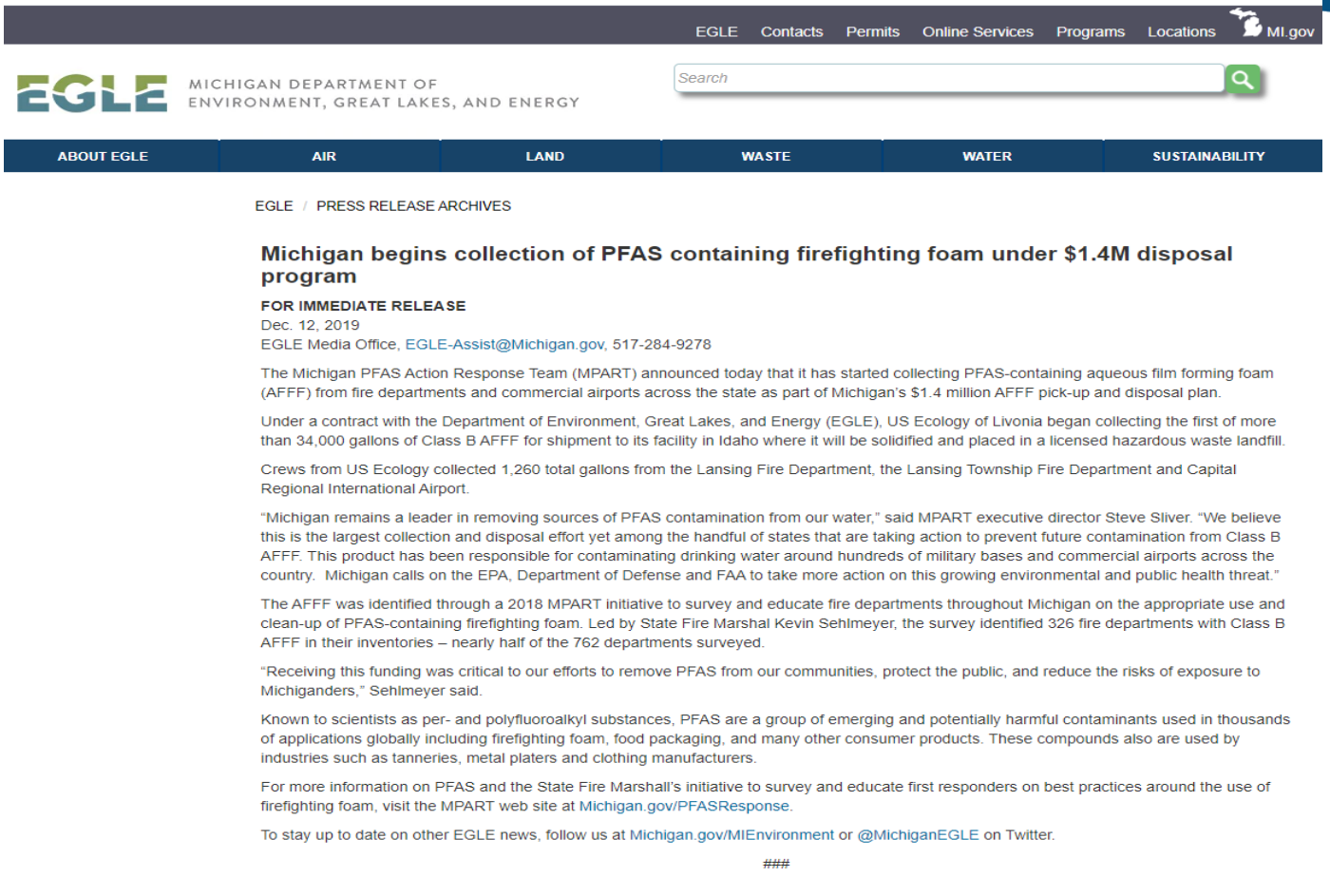
- **Isolate PFAS within landfill cell, limit exposure to leachate**
- **Leachate managed on-site**



Subtitle C Landfills – Best Available Option

- 5 Haz landfills
- RCRA, TSCA, NORM/TENORM permitted
- Accepts hundreds of waste codes
- Extensive leak-detection and groundwater monitoring systems
- Leachate capture and management at all locations

Targeting the Source of Contamination



EGLE Contacts Permits Online Services Programs Locations MI.gov

EGLE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

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EGLE / PRESS RELEASE ARCHIVES

Michigan begins collection of PFAS containing firefighting foam under $1.4M disposal program

FOR IMMEDIATE RELEASE
Dec. 12, 2019
EGLE Media Office, EGLE-Assist@Michigan.gov, 517-284-9278

The Michigan PFAS Action Response Team (MPART) announced today that it has started collecting PFAS-containing aqueous film forming foam (AFFF) from fire departments and commercial airports across the state as part of Michigan's $1.4 million AFFF pick-up and disposal plan.

Under a contract with the Department of Environment, Great Lakes, and Energy (EGLE), US Ecology of Livonia began collecting the first of more than 34,000 gallons of Class B AFFF for shipment to its facility in Idaho where it will be solidified and placed in a licensed hazardous waste landfill.

Crews from US Ecology collected 1,260 total gallons from the Lansing Fire Department, the Lansing Township Fire Department and Capital Regional International Airport.

"Michigan remains a leader in removing sources of PFAS contamination from our water," said MPART executive director Steve Sliver. "We believe this is the largest collection and disposal effort yet among the handful of states that are taking action to prevent future contamination from Class B AFFF. This product has been responsible for contaminating drinking water around hundreds of military bases and commercial airports across the country. Michigan calls on the EPA, Department of Defense and FAA to take more action on this growing environmental and public health threat."

The AFFF was identified through a 2018 MPART initiative to survey and educate fire departments throughout Michigan on the appropriate use and clean-up of PFAS-containing firefighting foam. Led by State Fire Marshal Kevin Sehlmeyer, the survey identified 326 fire departments with Class B AFFF in their inventories – nearly half of the 762 departments surveyed.

"Receiving this funding was critical to our efforts to remove PFAS from our communities, protect the public, and reduce the risks of exposure to Michiganders," Sehlmeyer said.

Known to scientists as per- and polyfluoroalkyl substances, PFAS are a group of emerging and potentially harmful contaminants used in thousands of applications globally including firefighting foam, food packaging, and many other consumer products. These compounds also are used by industries such as tanneries, metal platers and clothing manufacturers.

For more information on PFAS and the State Fire Marshall's initiative to survey and educate first responders on best practices around the use of firefighting foam, visit the MPART web site at Michigan.gov/PFASResponse.

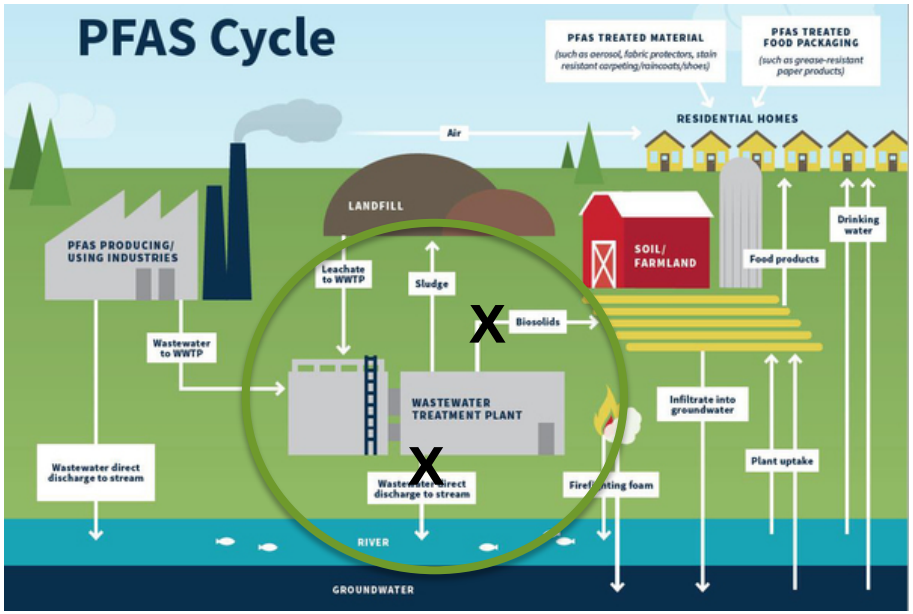
To stay up to date on other EGLE news, follow us at Michigan.gov/MIEnvironment or @MichiganEGLE on Twitter.

###

PFAS Treatment and Disposal Solutions

Wastewater

- **Permitted Part B Commercial Wastewater Treatment facilities discharging to local Publically Owned Treatment Works (POTWs)**
- **Underground Injection Control (UIC) permitted operation, deep well injection**



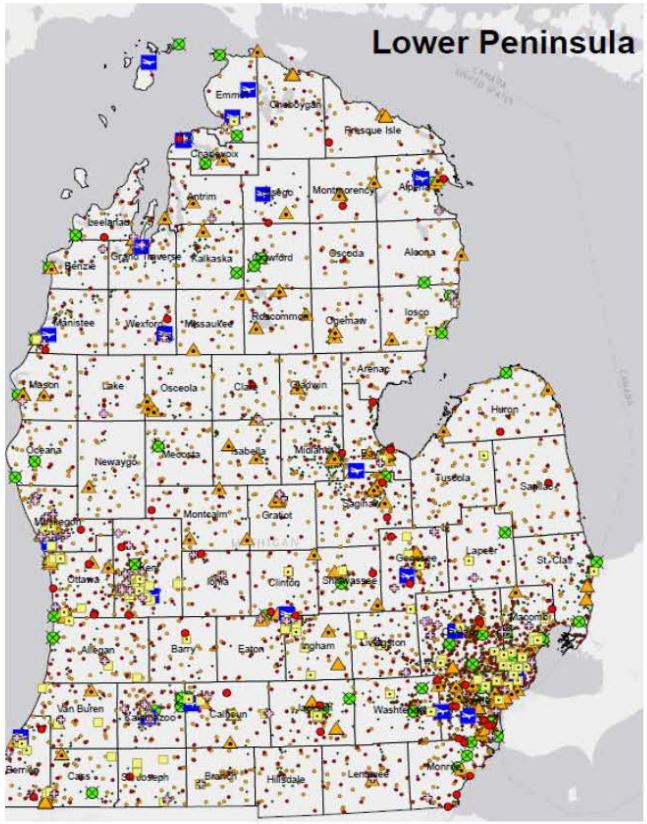
Wastewater Treatment

- 6 commercial and 1 non-commercial wastewater treatment operations in the Midwest, Northeast and Southern regions
- Multiple treatment services
  - Physical, chemical, biological treatment
  - Oil-water separation
  - Metals precipitation and recovery
  - Valuable metals recovery
- Underground Injection Control (UIC) operation - deepwell

If you look for PFAS you will find PFAS

MDEQ - 11,000 Potential PFAS Sites

- Active Landfills
- Superfund Sites
- Electroplaters
- Plating and Polishing Sites
- Airports
- Petroleum Terminals
- Petroleum Bulk Stations
- Military Sites
- Fire Stations
- Historic Landfills
- Environmental Contamination Sites



Michigan Chemistry Council 2018 Annual Conference

AECOM

<u>26,000</u> contaminated sites estimated for entire country affecting 6 million residents *(EPA, 2018)*

Additional Resources

https://www.itrcweb.org/Team/Public?teamID=78

https://www.eurofinsus.com/environment-testing/testing-services/pfas-analysis/

https://www.epa.gov/pfas

https://www.defense.gov/Explore/Spotlight/pfas/

https://www.ncsl.org/research/environment-and-natural-resources/per-and-polyfluoroalkyl-substances-pfas-state-laws.aspx

https://www.michigan.gov/pfasresponse/

Media

Netflix – The Devil We Know

Darker Water – 2019 (motion picture)

Exposure – book by Robert Bilott

Questions?

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