PFAS Management – Breaking the Cycle

September 2021

Presentation Objectives

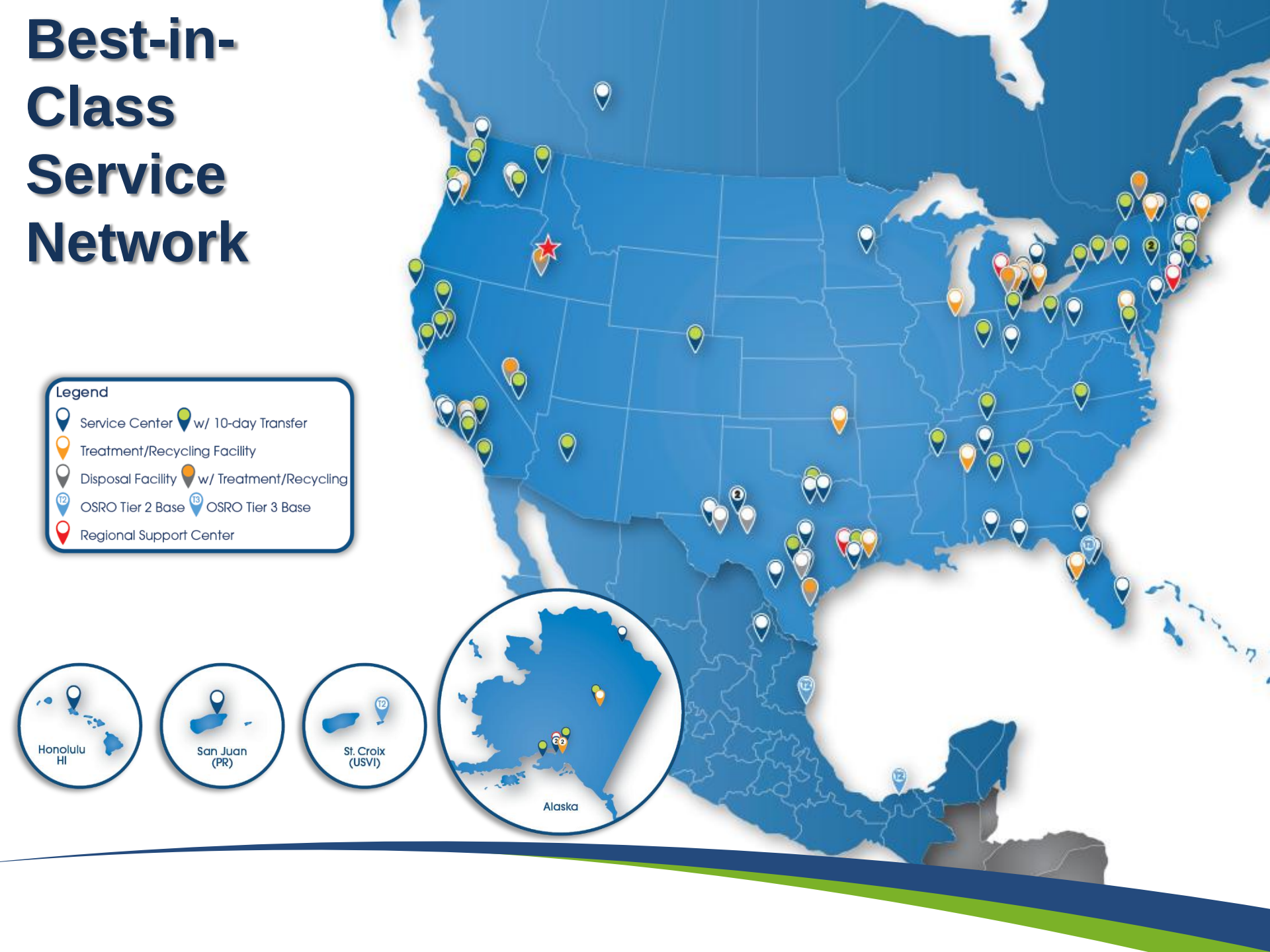
- Provide an industry perspective on the management of PFAS waste streams
  - Short Introduction to US Ecology
  - Examine regulatory climate surrounding PFAS compounds
  - Review current technologies for PFAS management
  - Identify the current USE management capabilities for PFAS disposal

US Ecology Industry Leadership

- Corporate HQ: Boise, Idaho
- NASDAQ: ECOL
- Established: 1952
- Approximately 3,200 environmental professionals
- Over 130 locations worldwide and over 115 US locations
- Offering comprehensive environmental services:

  - Transportation
  - **Waste Treatment**
  - **Waste Disposal**
  - **Wastewater Treatment**
  - Recycling
  - Industrial Cleaning & Maintenance
  - **Remediation**
  - Lab Pack Services
  - Total Waste Management
  - Technical Services
  - Emergency Response
  - Sustainable Solutions
  - Retail Solutions
  - Pharmaceutical Waste Management
  - Sewer Services
  - Household Hazardous Waste Collections

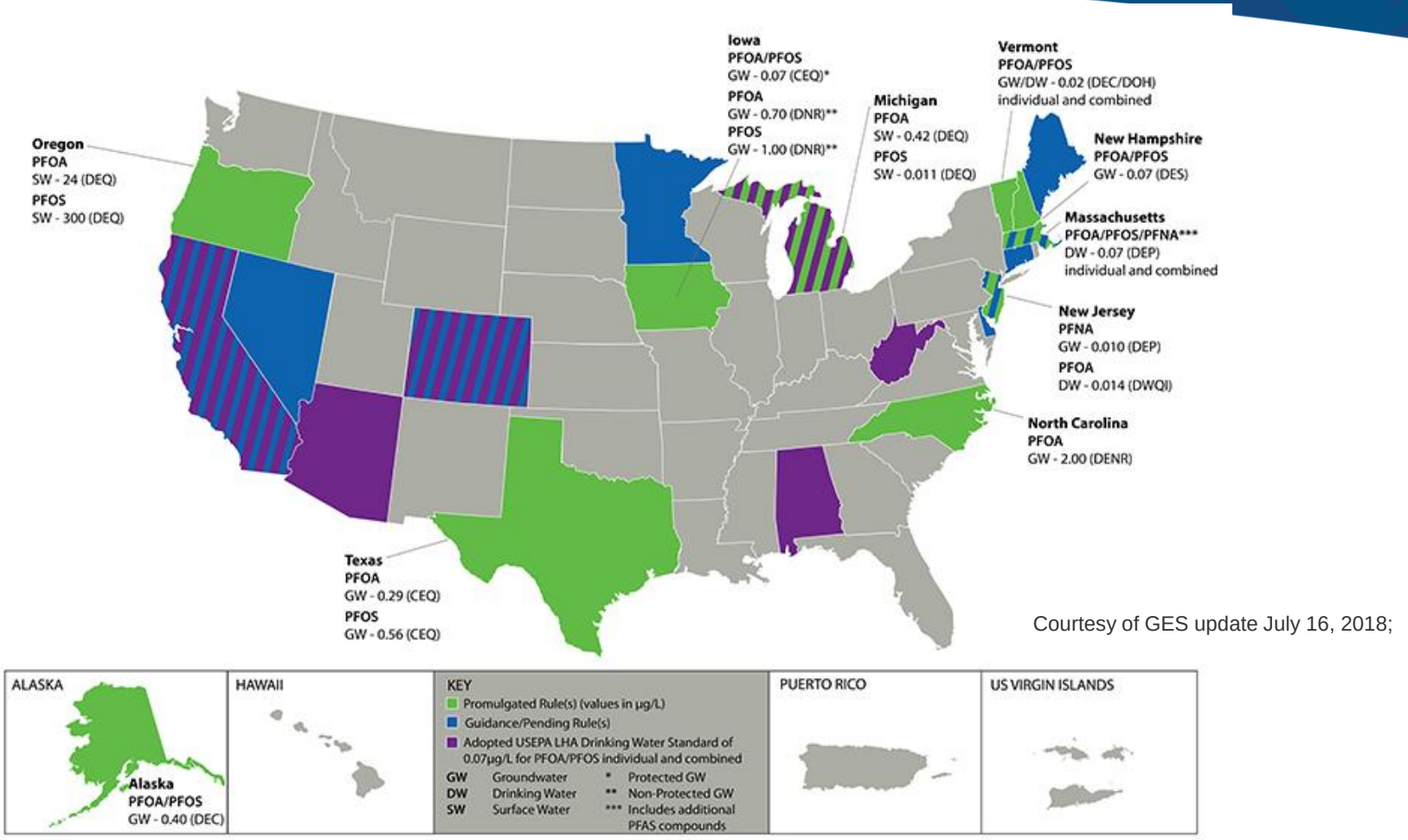
Best-in-Class Service Network



Overview by Regulatory Pathway

Regulation	Waste Volume	Timing	USE Current Capabilities	Notes
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 Regulations	↑↑ Soil, products, waste water	current	Permitted landfill, CWT & UIC	• Localize opportunities • Direct affect on our operations

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 incoming 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

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	

Subtitle C Landfills – Best Available Option

- Facilities Positioned throughout North America
  - Five Haz / Non-Haz Landfills (All Co-Located with Treatment)
- Broad Range of Permits and Acceptance Criteria
- Infrastructure to Support High Volume Transfer
- Extensive leak-detection and groundwater monitoring systems
- Leachate capture and management at all locations

Idaho (Grand View)

Nevada (Beatty)

Texas (Robstown)

Michigan (Belleville)

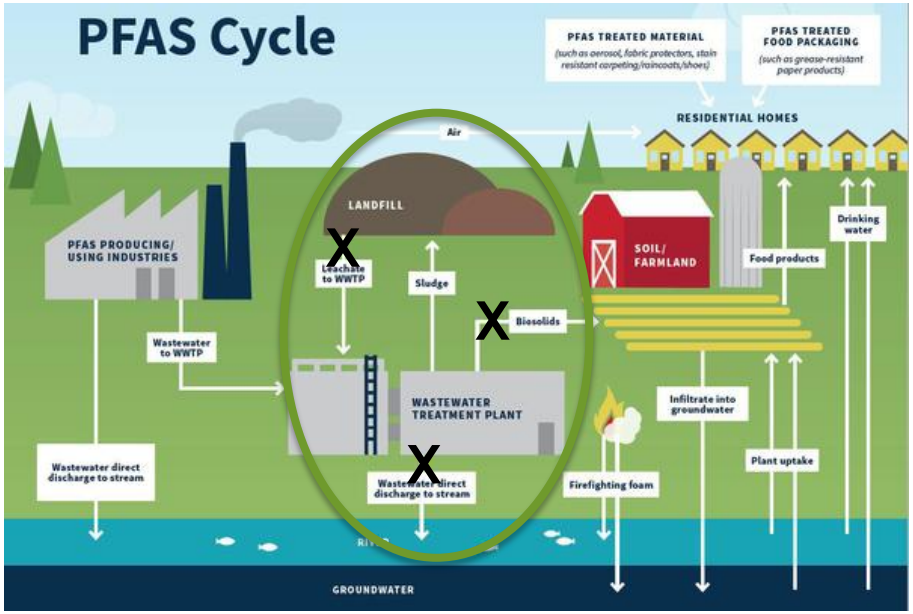
Stablex (Blainville, QC)

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



PFAS Waste Streams

Types of PFAS waste streams USE is handling for disposal:

- AFFF concentrate
- AFFF waters from fire events
- AFFF tank wash waters
- AFFF soils/sludge
- PFAS contaminated IDW
- Spent media – ion exchange resin/GAC
- Hazardous waste with PFAS contamination
  - Metal plating sludge
  - Soil

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	

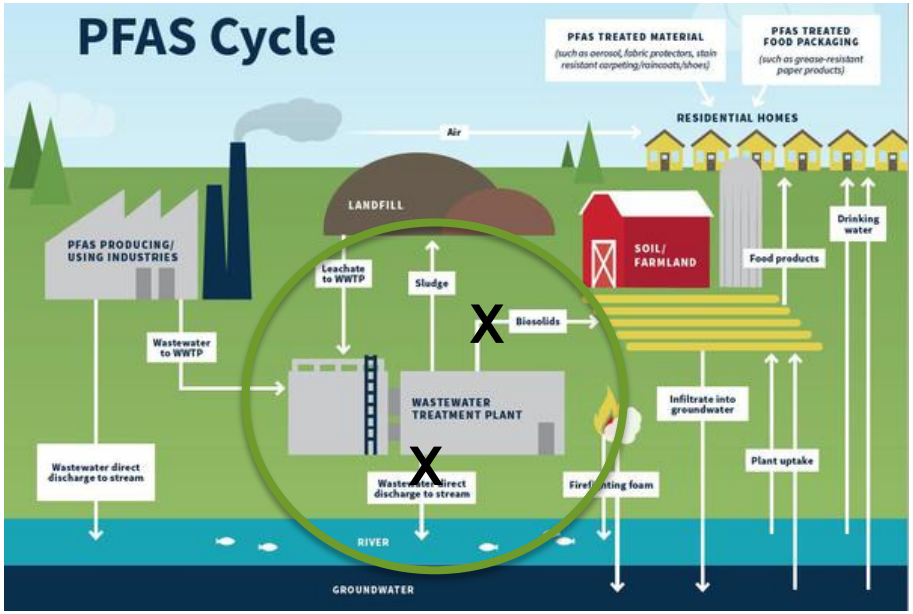
Wastewater Treatment

- 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

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**



Targeting the Source of Contamination

EGLE Contacts Permits Online Services Programs Locations MI.gov

EGLE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

Search

ABOUT EGLE | AIR | LAND | WASTE | WATER | SUSTAINABILITY

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.

###

Contact for Additional Info / Pricing

Mike Cate, MS Chemistry
Senior Account Executive (Michigan)
Mike.Cate@usecology.com
P: 313-930-1805

Livonia Regional Office
17740 College Parkway
Livonia, MI 48152

Emergency Response: 800-839-3975