



## Foam Fractionation for PFAS Removal: *Leveraging the Properties of PFAS Against Itself*



Montrose Environmental Group

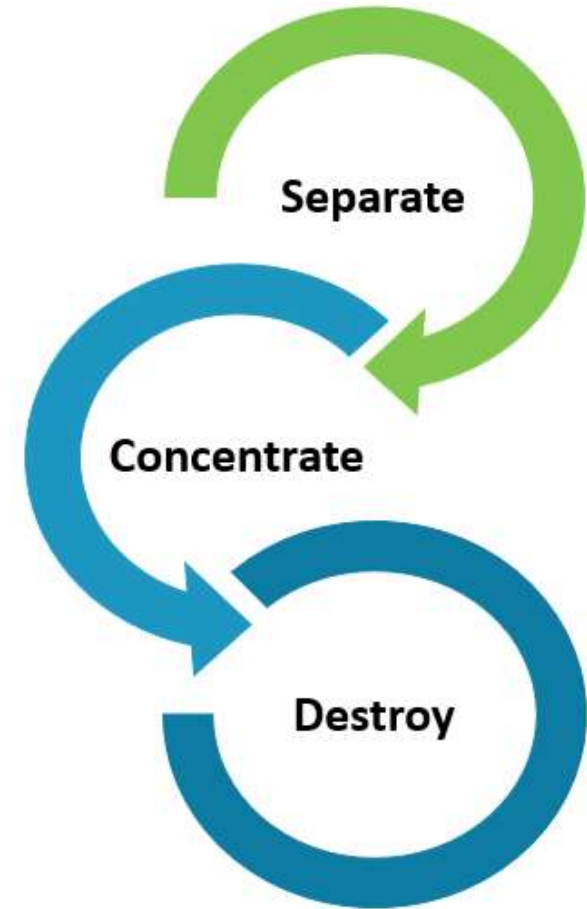
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AIR & WASTE MANAGEMENT  
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# Why Are We Discussing This?

- PFAS substances are an “everywhere” problem – right, Ralph?
- Difficult to remove and/or destroy
- Effective treatment technologies needed
- Foam Fractionation – a new spin on an older technology
  - Variety of liquid waste streams
  - Short- and long-chain PFAS removal
  - Simple
  - Potential for significant waste and liability reduction



# Presentation Outline

- Foam Fractionation (FF) – technology overview
- Key considerations
- Treatment train configuration
- Bench and pilot testing options
- Case studies – landfill leachate
- Q & A



# ECT2 PFAS Treatment Systems

ECT2 has the knowledge, data, and experience to solve PFAS challenges across multiple contamination types and treatment media.

**>98%**

WATER TREATMENT SYSTEM UPTIME

**40+ PFAS**

SYSTEMS INSTALLED OR UNDER CONSTRUCTION WORLDWIDE SINCE 2016

**2,500,000,000+**

GALLONS OF REMEDIATION WATER TREATED IN THE LAST 6+ YEARS



PILOT SKID



SORBIX™ L SERIES



SORBIX™ H SERIES



SORBIX™ M SERIES MODULAR TREATMENT SYSTEMS



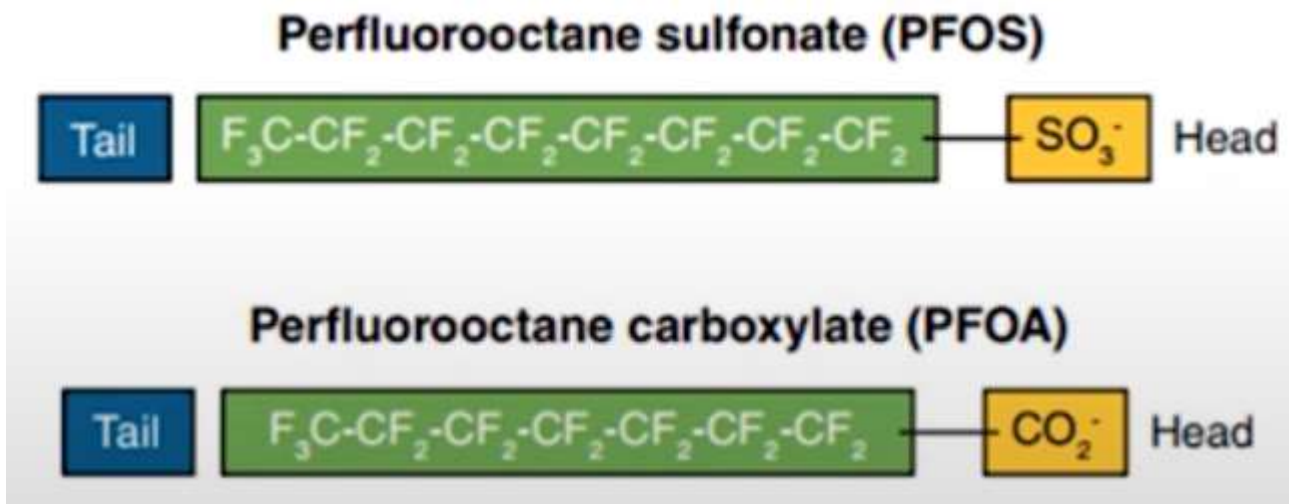
FOAM-X  
FOAM FRACTIONATION



SORBIX T™ SERIES



# Why It Works: Most PFAS are Surfactants



From ITRC



*Hydrophobic Tail*

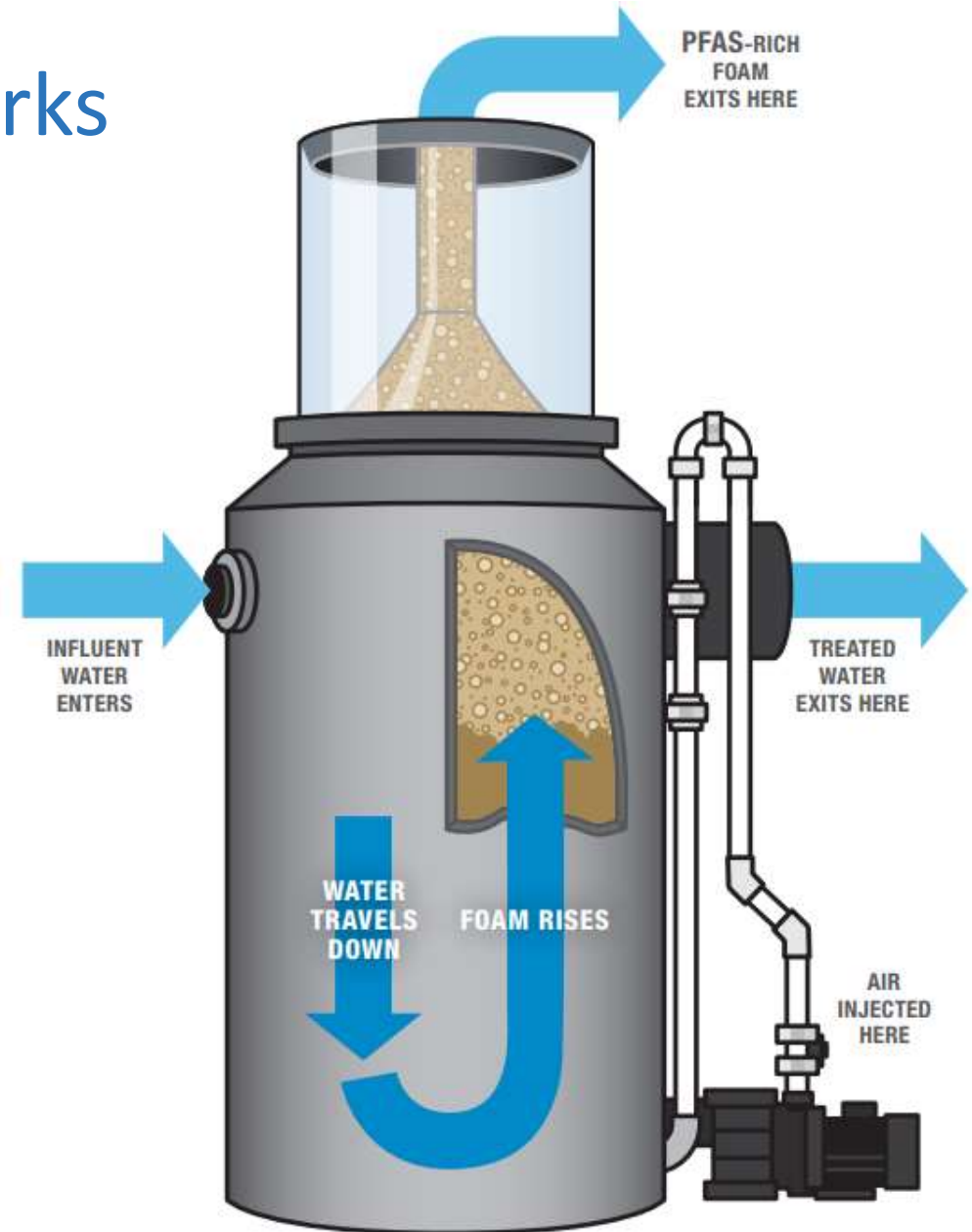


*Hydrophilic Head*



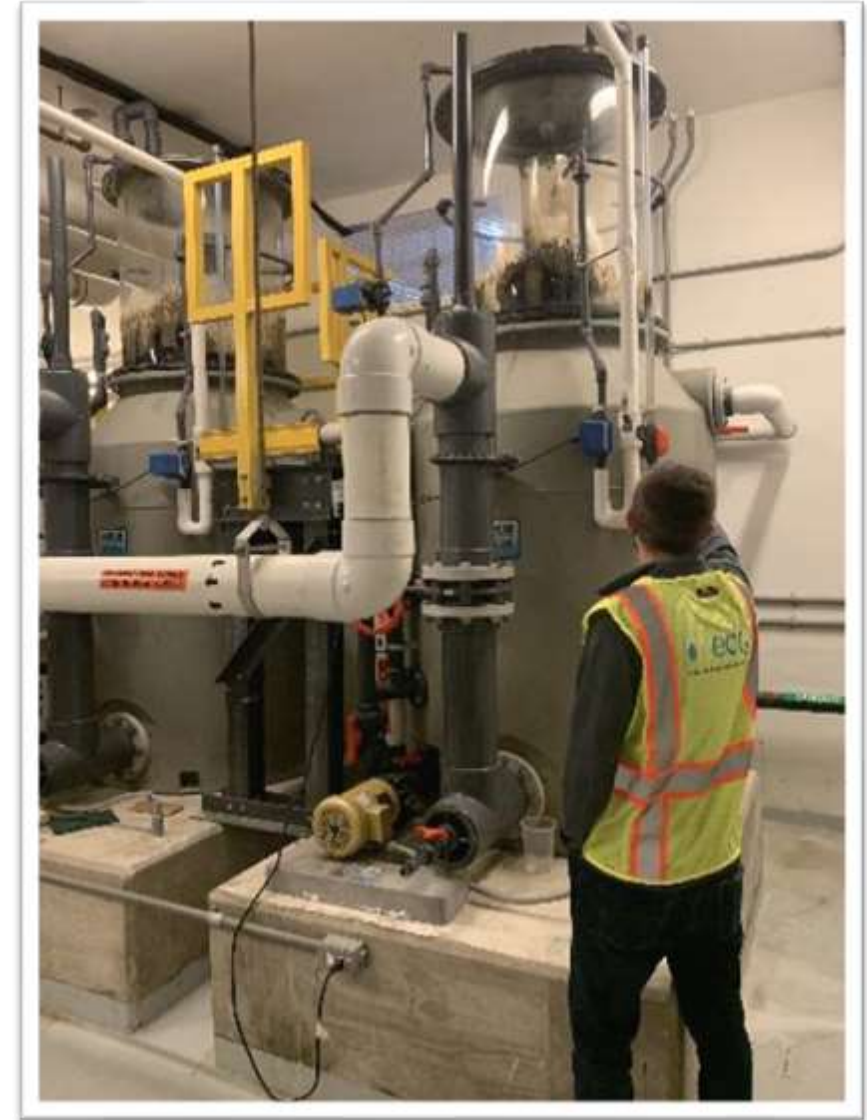
# How Foam Fractionation Works

- Agnostic to elevated TDS, NOM, etc.
- Simple operation, few moving parts
- Nothing to clog or build diff. pressure
- Low energy, low pressure
- Low operating expense
- Can be very effective for difficult-to-treat waters:
  - Landfill leachate
  - Industrial wastewater
  - Groundwater hot spots
- Bench and pilot scale testing recommended



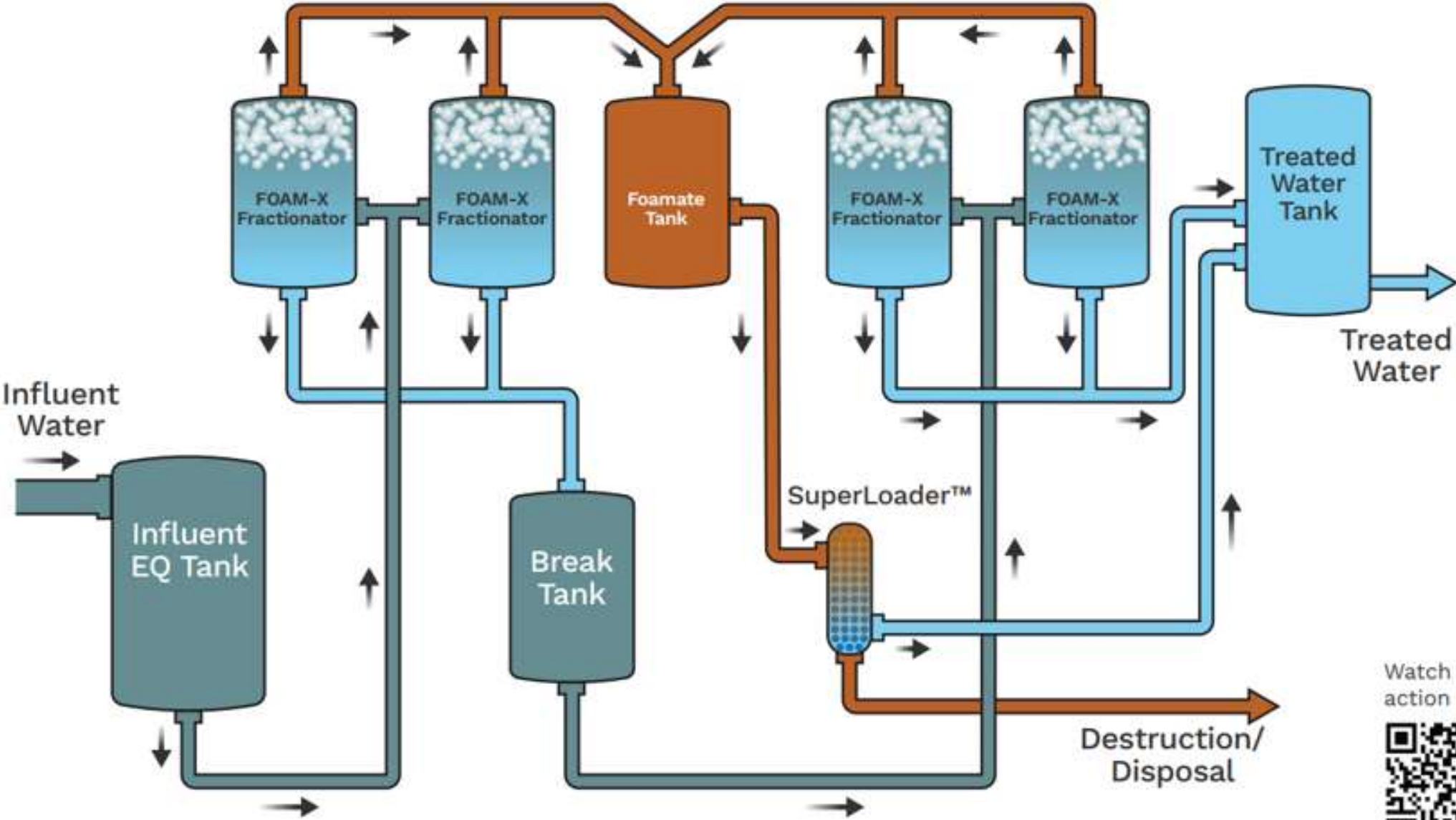
# Key Considerations

- Influent PFAS concentrations
- Co-contaminants present
- Short-chain vs. long-chain PFAS present
- Need for boosting agents (surfactants)
- Flow rate (Hydraulic Residence Time; HRT)
- Purpose: pretreatment vs. treatment
- Regulatory criteria – “percent removal” might not get you there
- Cost



# Treatment System Configuration

- Influent water
- Clean SuperLoader™ media
- PFAS
- Clean water



Watch it in action here!

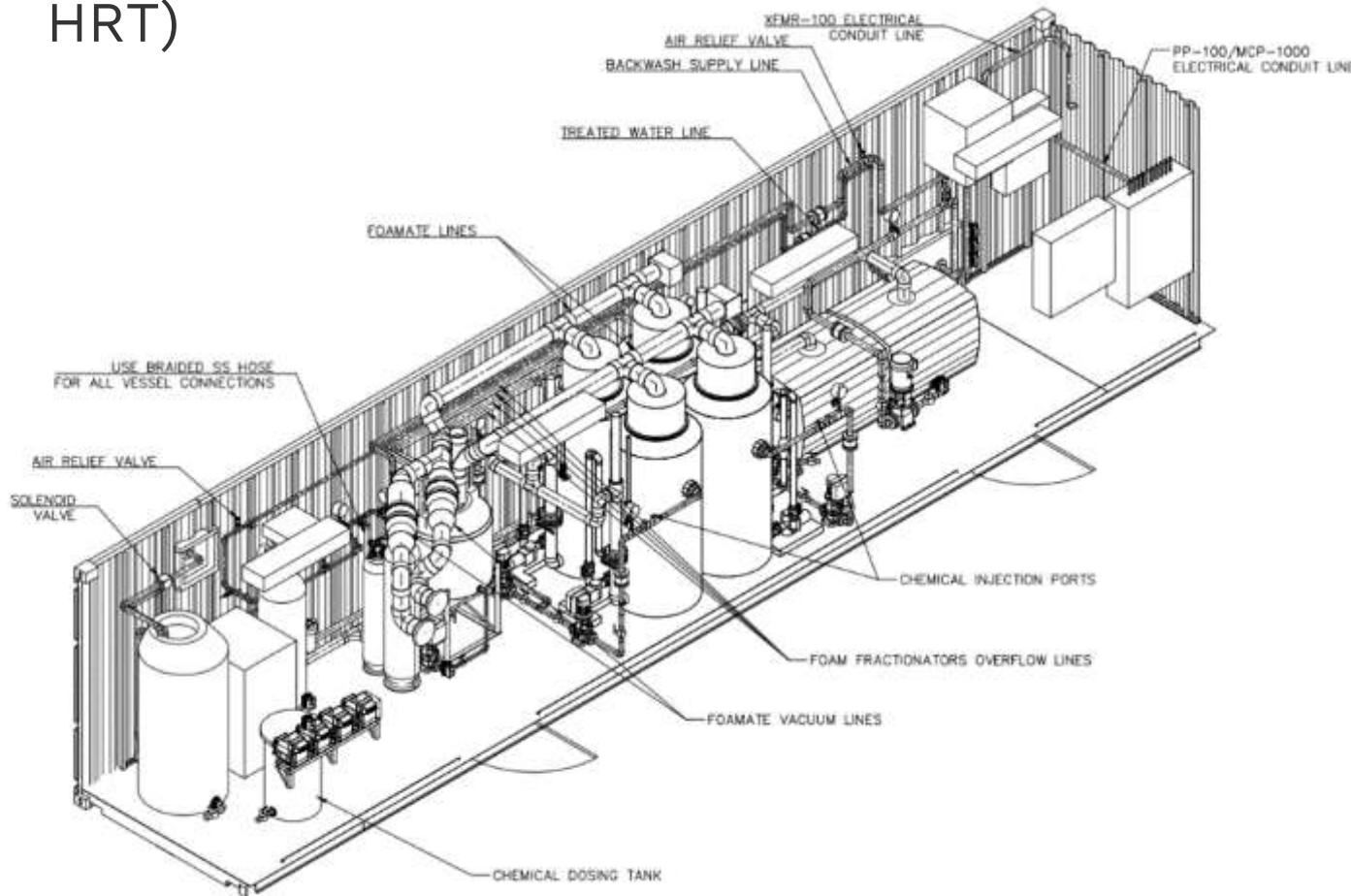




# Full-Scale Containerized System

## Manufacturing facility - Alabama

- 50 gpm design flowrate (20 min HRT)





# Bench and Pilot Testing Approaches

# Bench Testing

## R&D Facility – Fuquay-Varina, NC

- Evaluate removal efficiencies, need for surfactants to enhance short-chain removal
- 5-10 gallon batch treatability testing



# Pilot Testing

## R&D North Facility – ME

- Containerized system with 1-5 gpm flow rate
- Can be operated in parallel or in series



# Pilot Testing Asset

- Automated containerized weatherproof system
- 4+ Modes of operation
  - Operation independently, series, parallel
- 2 foam fractionators
- 5 – 30 gpm



# Mobile Pilot System in Action





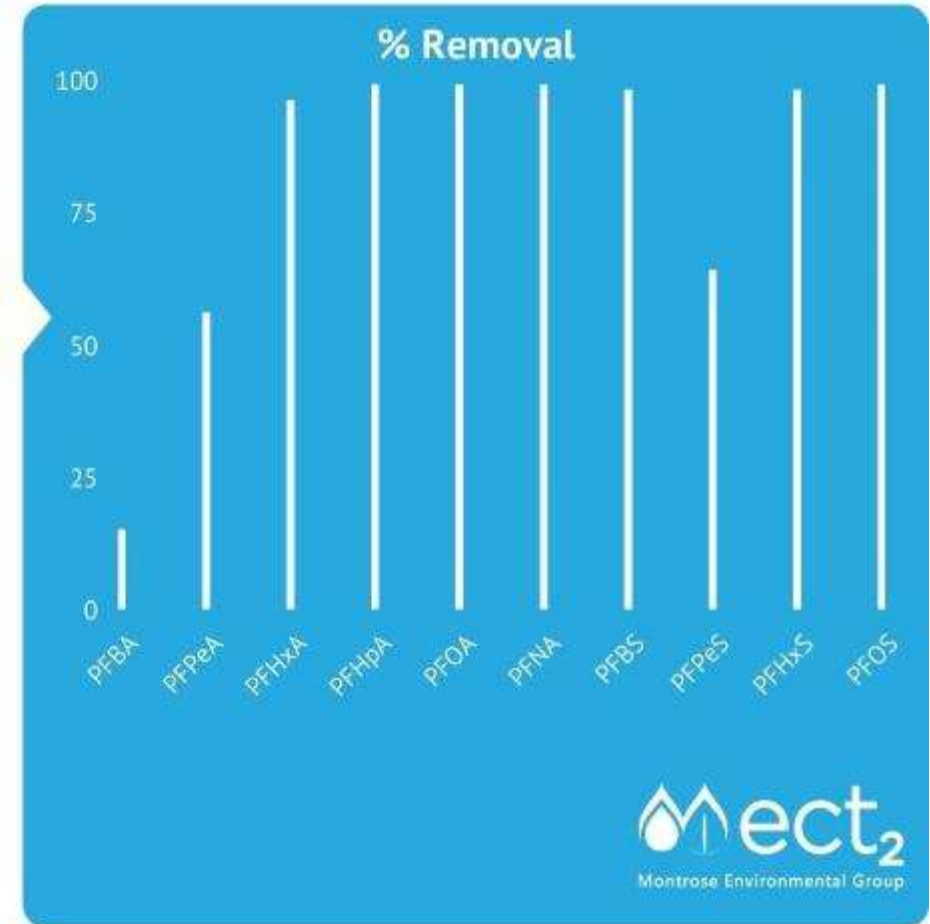
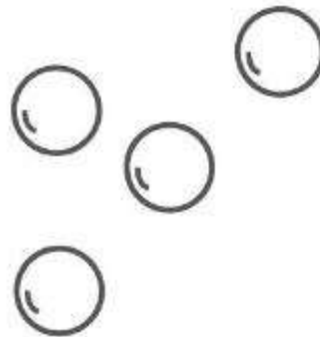
Bench and Pilot Testing Results

# Foam Fractionation Bench Test – New England Landfill Leachate



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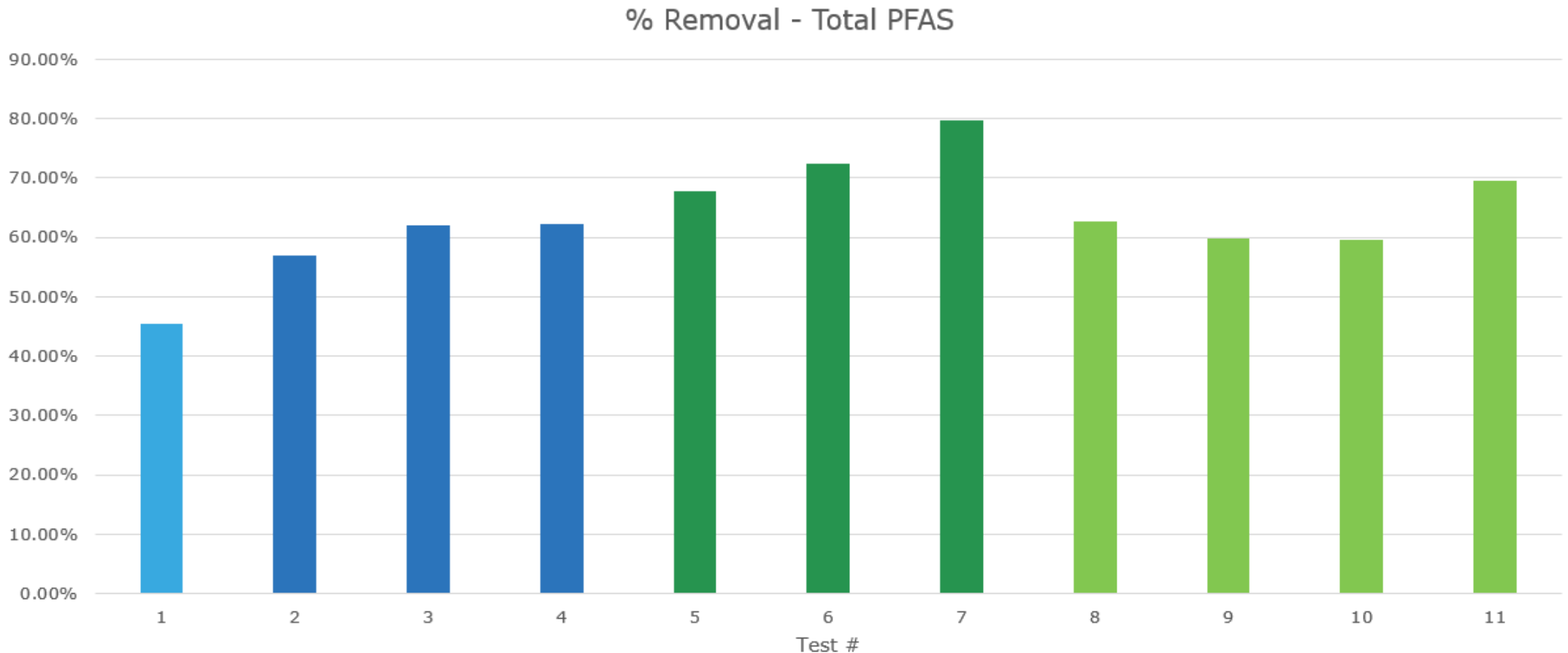
Effluent on the regulated New England 6 compounds with Foam Fractionation alone





# Impacts of Boosting Agents

- Each test # indicated different conditions, each color notates a different boosting agent
- Test 1 has no chemical addition



# More Details Regarding Boosting Agents

Analyte	Influent (ng/L)	Without FF-1 Boost	Percent Removal	With FF-1 Boost	Percent Removal
PFHxA	387	271	30%	< 13	97%
PMPA	8,961	3.325	64%	< 63	99%
PolyF - 1	3,037	397	87%	< 65	98%
PolyF - 2	11,296	8,960	21%	< 63	99%
PFOA	828	117	86%	< 63	92%

Without boosting agent 21 – 87% removal

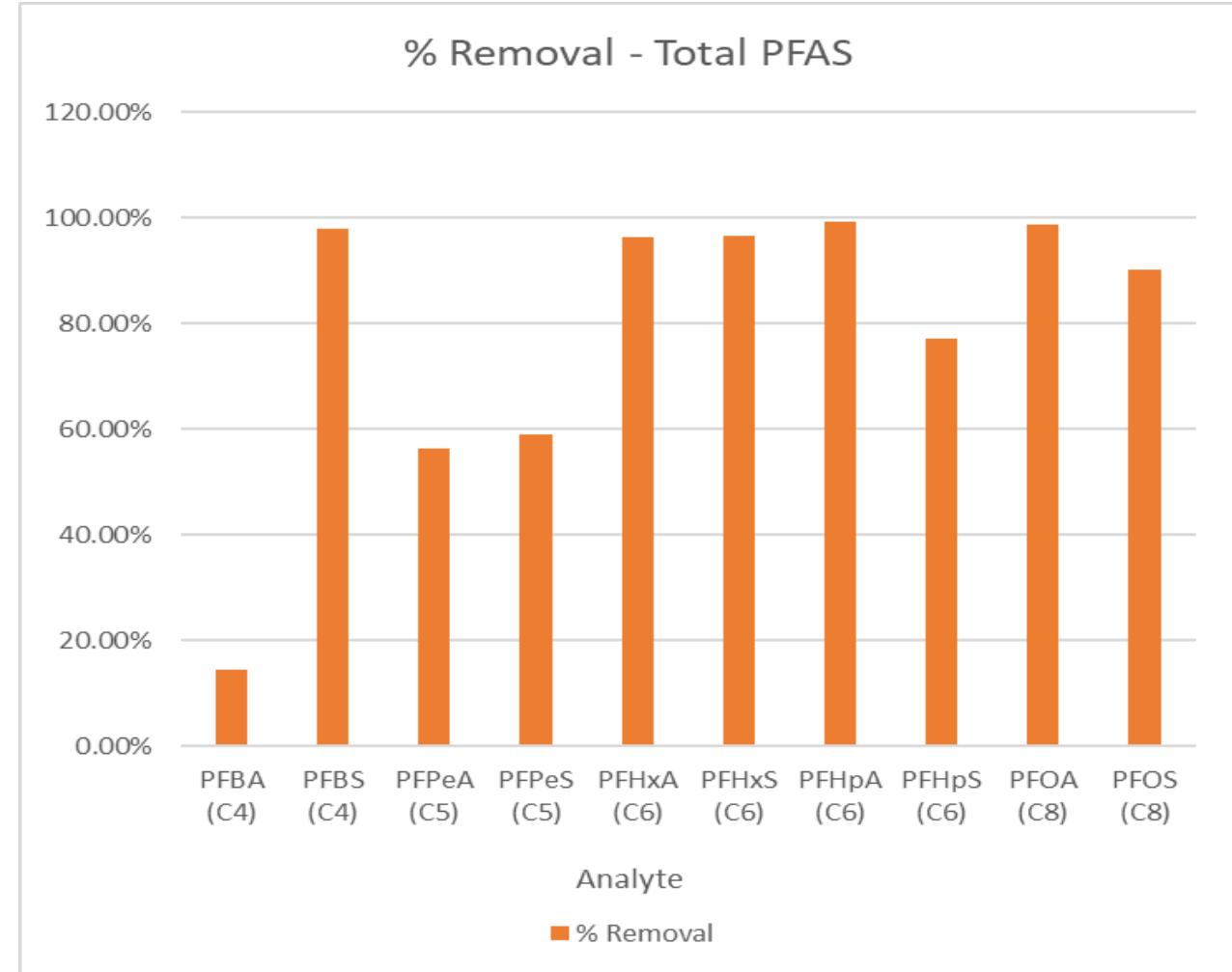
With boosting agent 92 – 99% removal

*Short- and long-chain removal enhancement*



# Field Foam Fractionation Pilot Test - Landfill Leachate

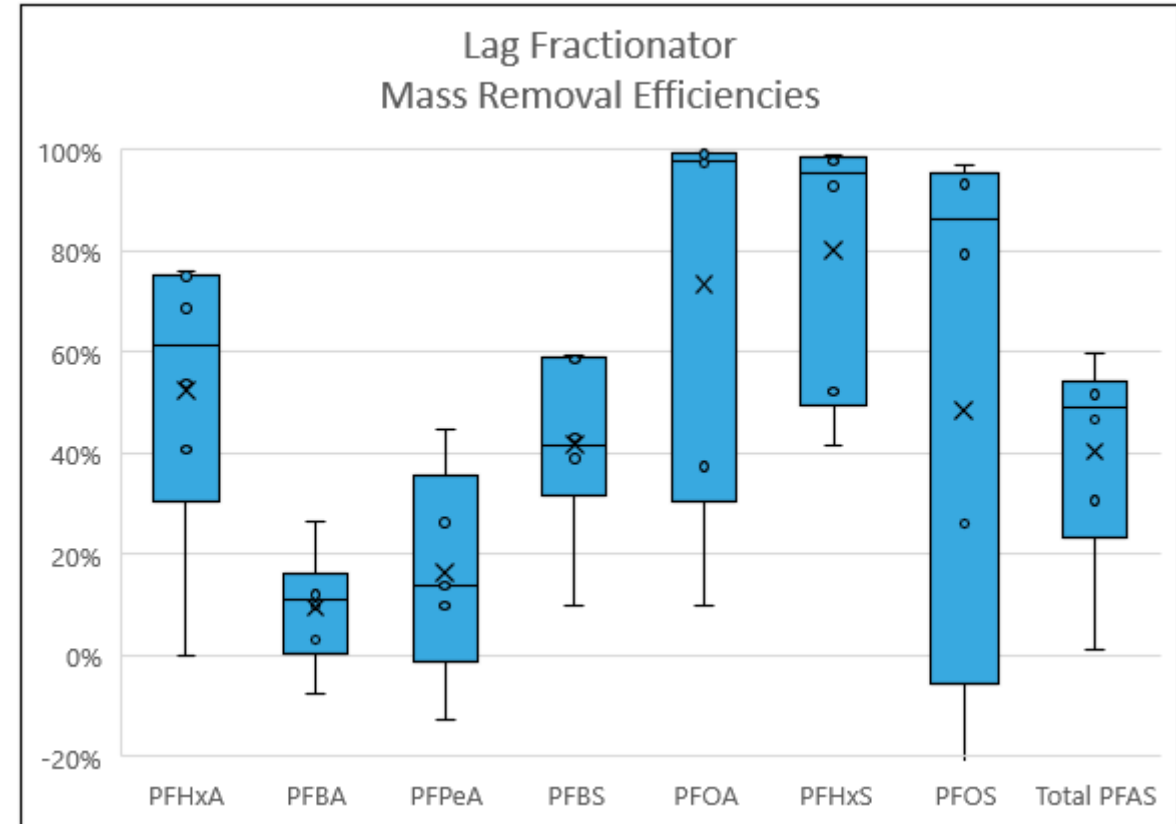
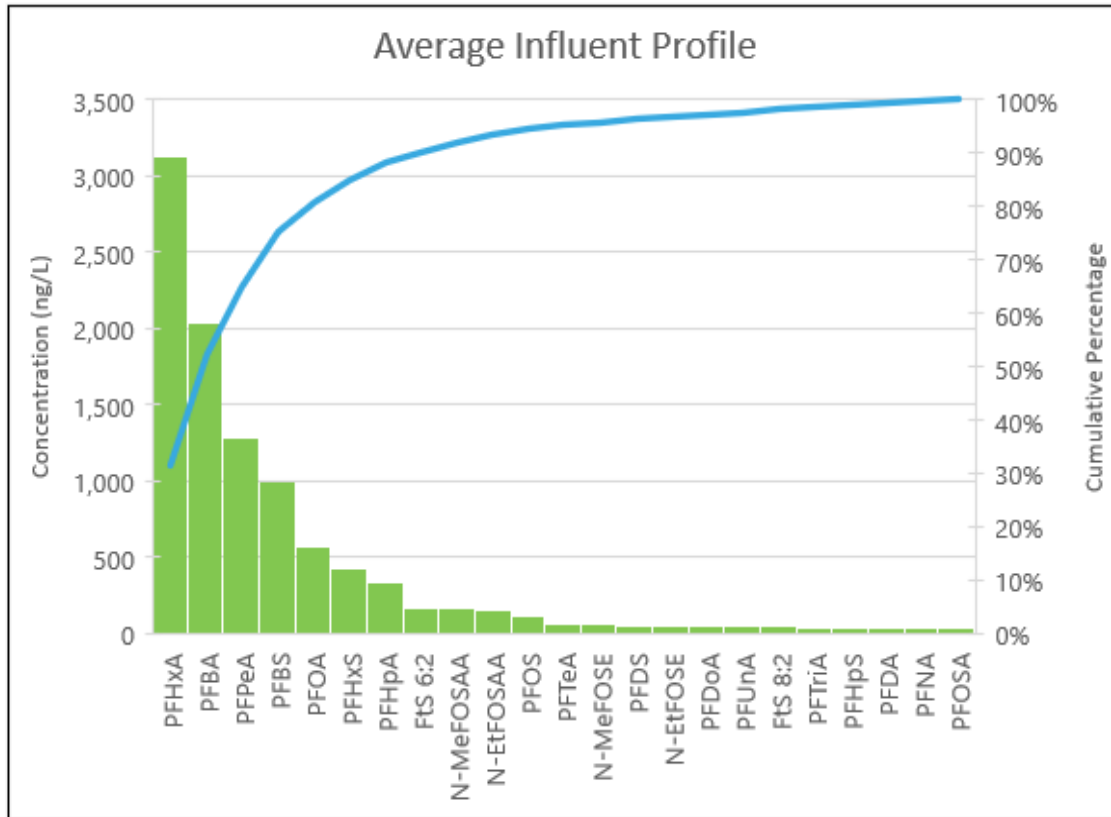
Analyte	Influent (ng/L)	Effluent (ng/L)	Percent Removal
PFBA (C4)	1,503	1,285	14%
PFBS (C4)	1,944	40	98%
PFPeA (C5)	1,507	660	56%
PFPeS (C5)	62	25	59%
PFHxA (C6)	2,735	102	96%
PFHxS (C6)	337	11	97%
PFHpA (C6)	723	4.9	99%
PFHpS (C6)	4	0.8	77%
PFOA (C8)	1,166	16	99%
PFOS (C8)	115	11	90%



*Short-chain PFAS removal more challenging than long-chain PFAS*



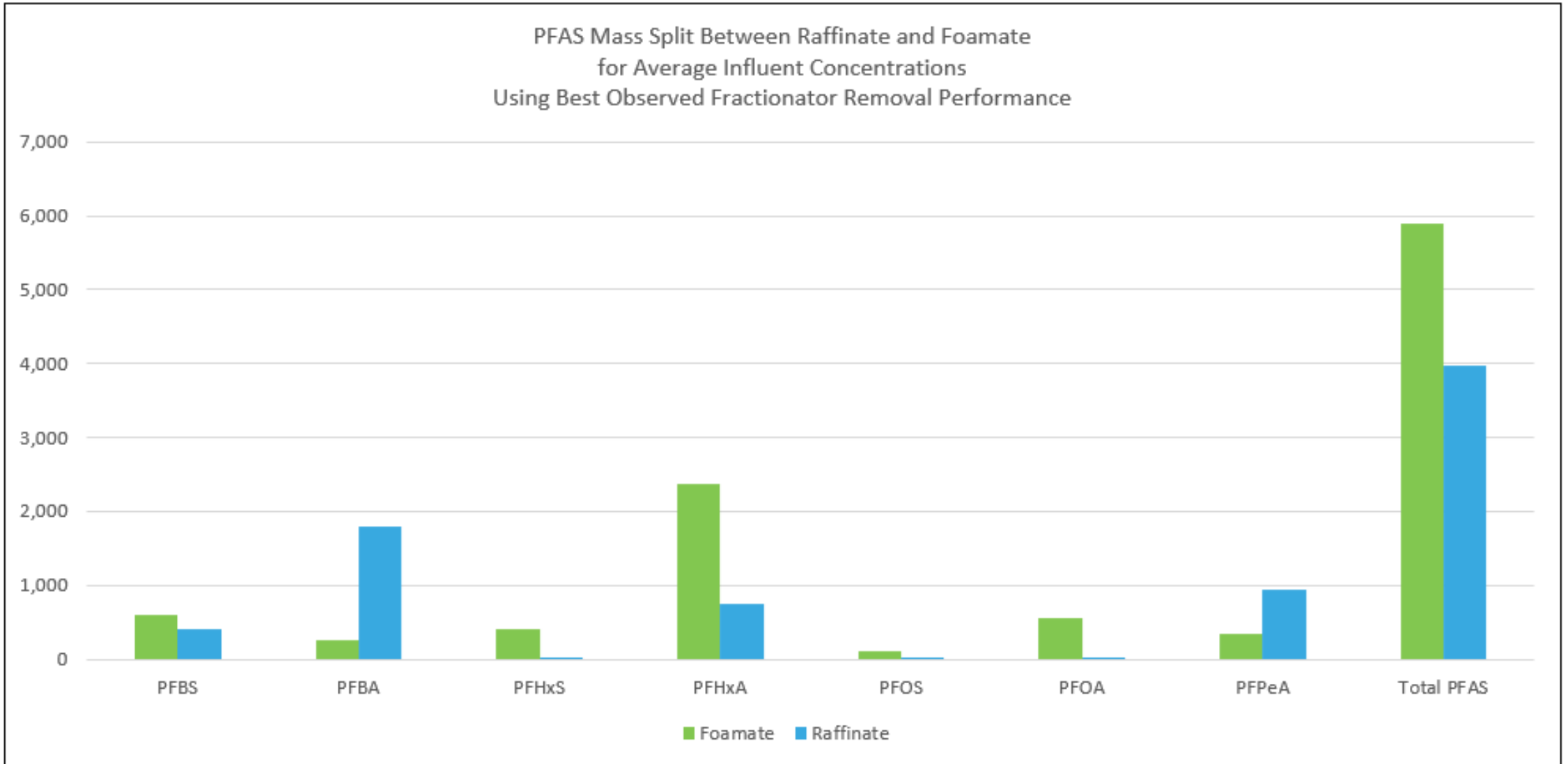
# Field Foam Fractionation Pilot Test – MSW Landfill Leachate



*Short-chain PFAS removal more challenging than long-chain PFAS*

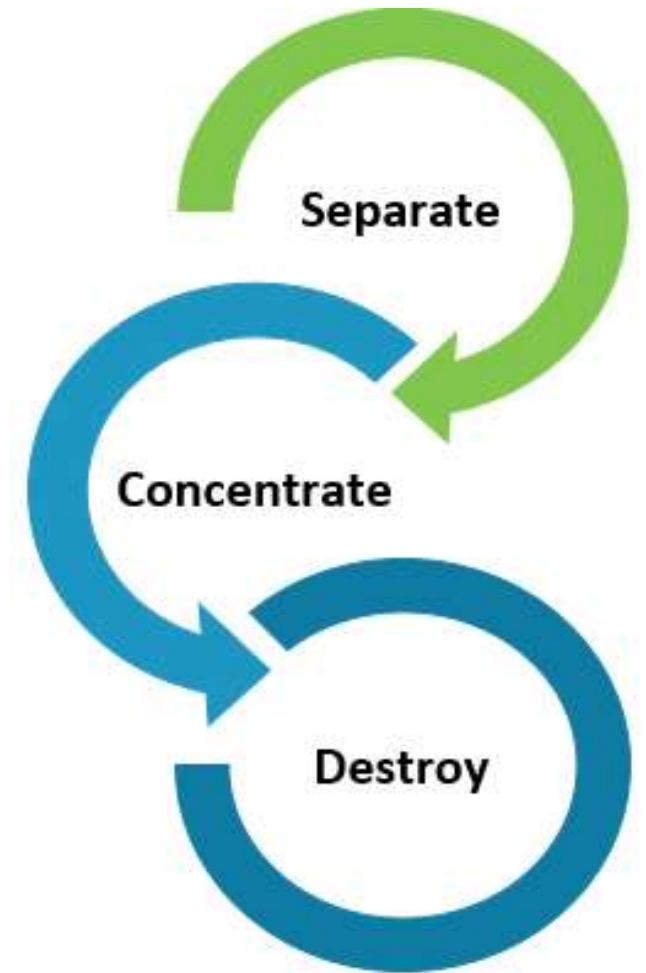


# PFAS Removal Optimized – MSW Landfill Leachate



# Summary

- You can't destroy PFAS without concentrating it
- Foam fractionation can be a cost-effective means to remove and concentrate PFAS waste
- Not a silver bullet – depends upon objectives and water characteristics
- Significant work underway to refine process and meet stringent cleanup goals
- Q&A





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