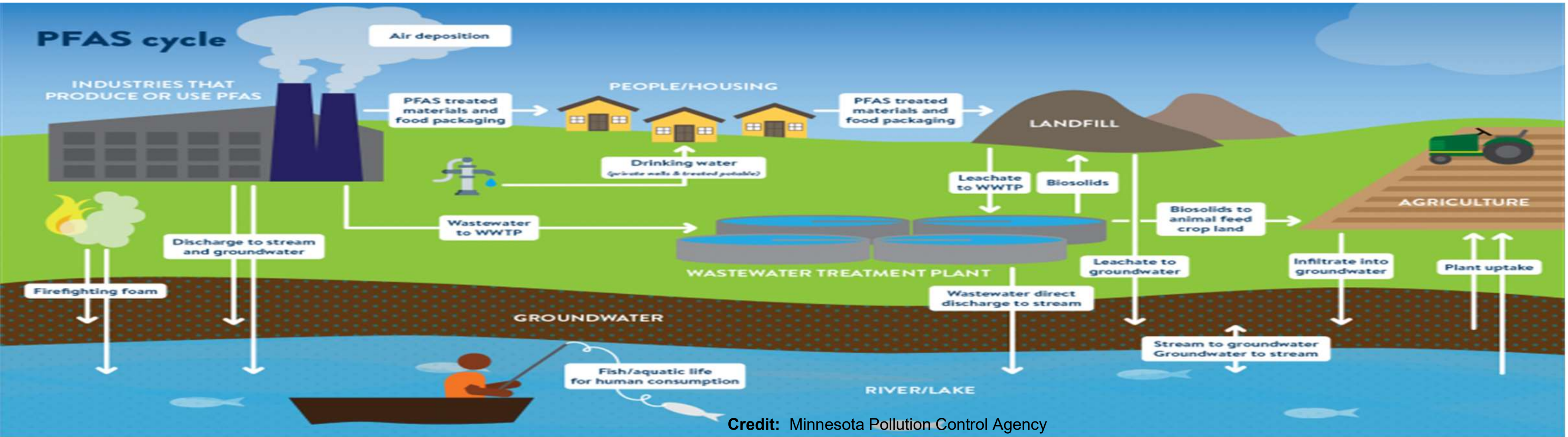


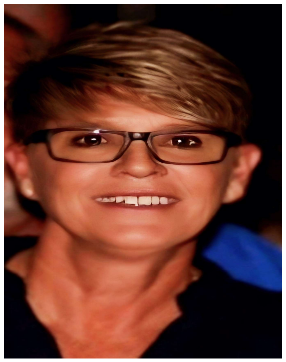
Credit: Minnesota Pollution Control Agency

PFAS Roundtable

ADEM Surface Water Conference, Tuesday October 15, 2024

ADEM Alabama Department of Environmental Management

Meet the Panelists



Jeaniece Slater
General Manager, West Morgan East Lawerence Water and Sewer Authority

Lindsay Boone, M.Sc.
Pace Analytical, Technical Specialist

Zia Klocke, P.E.
Research Engineer, Ovivo

Scotti Wells, EIT
PFAS Pilot Manager, Insite Engineering

Communicating PFAS

Customers want to Know

Introduction to PFAS

Regulatory Standards

BUT WAIT!!!!

The lawsuit filed by the American Water Works Association (AWWA) and the Association of Metropolitan Water Agencies (AMWA) against the EPA regarding PFAS regulations essentially means that these water industry groups are challenging the EPA's new PFAS standards, arguing that they are too stringent and not based on the best available science, potentially creating difficulties for water utilities in complying with the new regulations due to concerns about cost and feasibility, while still claiming to support public health protection.


PFAS
Per- and polyfluoroalkyl substanc

All Experts are challenged In today's world

Google Experts

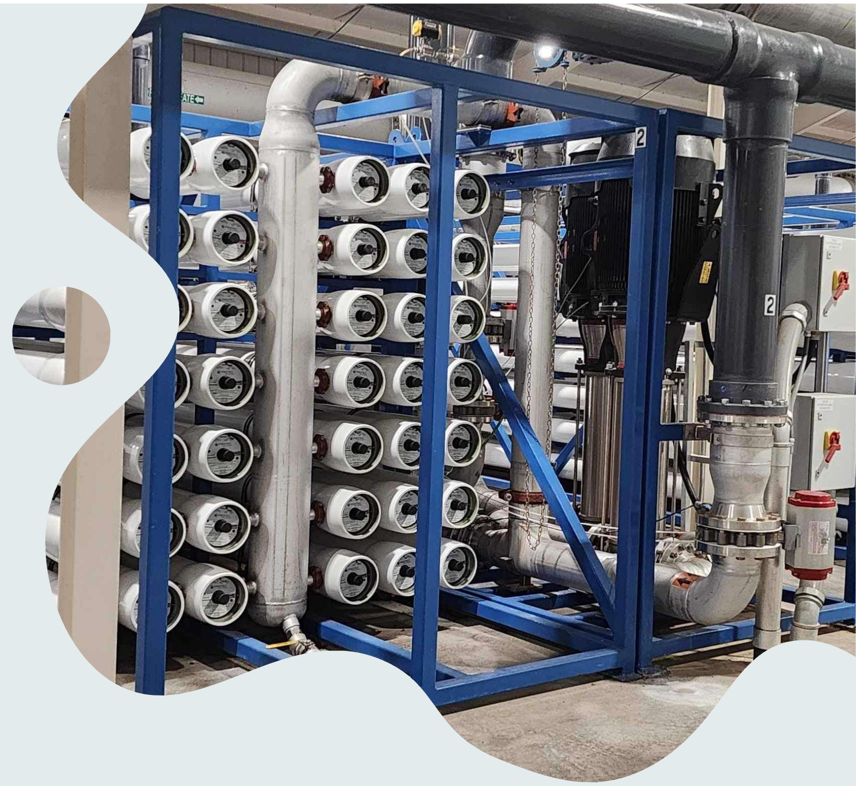
We Must Be First to Provide Information

Communication Strategies

- Transparency: We must be transparent with customers about PFAS
- Outreach: Social Media, newsletters, community meetings, and Q&A's
- Spokesperson
- Customers FAQ's
- Empathy and Reassurance

Work Hand and Hand With Your Community

Treatment Technologies



Have a Plan


STRATEGY
IDEAS
Progress
Process
MEETING
Business
Future
Innovation
Dialog
IDEAS
Forum
Discuss
Progress
Communication
Next
Communicate
Steps
SOLUTIONS
QUESTIONS
IDEAS
Connection
Session
INPUT
TALK
Creativity
BUSINESS
FUTURE
PROPOSAL
FORWARD
Strategy
Exploration


Thank you

INSITE ENGINEERING

IMPLEMENTING PFAS TECHNOLOGY

Tuesday, October 15, 2024

ADEM Alabama Department of Environmental Management

OUTLINE AND AGENDA

INSITE ENGINEERING
HOOVER | TUSCALOOSA

I. The New Maximum Contaminant Limit (MCL)
II. The Compliance Timeline
III. PFAS Treatment Options
IV. Q & A

WHAT SPECIFIC QUESTIONS WOULD YOU LIKE ADDRESSED?

EPA's MCLs

In this final rule, EPA is setting limits for five individual PFAS: PFOA, PFOS, PFNA, PFHxS, and HFPO-DA (known as GenX Chemicals). And EPA is also setting a hazard index level for two or more of four PFAS as a mixture: PFNA, PFHxS, HFPO-DA, and PFBS:

Chemical	Maximum Contaminant Level Goal (MCLG)	Maximum Contaminant Level (MCL)
PFOA	0	4.0 ppt
PFOS	0	4.0 ppt
PFNA	10 ppt	10 ppt
PFHxS	10 ppt	10 ppt
HFPO-DA (GenX chemicals)	10 ppt	10 ppt
Mixture of two or more: PFNA, PFHxS, HFPO-DA, and PFBS	Hazard Index of 1	Hazard Index of 1

Maximum Contaminant Level Goal (MCLG): The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

Hazard Index

Calculation

$$Hazard\ Index = \frac{PFHxS}{10\ ppt} + \frac{PFNA}{10.0\ ppt} + \frac{GenX}{10.0\ ppt} + \frac{PFBS}{2{,}000.0\ ppt}$$

Example Water Quality Results

$$PFHxS = ND$$

$$PFNA = ND$$

$$GenX = 6.0\ ppt \ll HAL$$

$$PFBS = 1{,}000\ ppt \ll HAL$$

Example Hazard Index

$$Hazard\ Index = \frac{0\ ppt}{10\ ppt} + \frac{0\ ppt}{10.0\ ppt} + \frac{6.0\ ppt}{10.0\ ppt} + \frac{1000\ ppt}{2{,}000.0\ ppt} = 1.1 > MCL$$

Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	1 (unitless) Hazard Index	1 (unitless) Hazard Index

What is EPA saying?

EPA'S PFAS Q&A FACT SHEET:

How many utilities does EPA estimate will be impacted by this proposal?

There are over 66,000 public water systems that are subject to the PFAS drinking water rule. Most of these systems will primarily have to conduct monitoring to confirm that they do not have PFAS at levels exceeding the regulatory standards. EPA estimates that between about 6% and 10% of the 66,000 public drinking water systems subject to this rule may have to take action to reduce PFAS to meet these new standards.

COMPLIANCE

General Requirements:

- *3 Years to Complete Initial Monitoring (2027) – Quarterly for 12 months (Twice per 12 months for small groundwater systems)*
- *Five Years to Implement Solutions (2029)*
- *Public Notification for Violations Begins in 2029*

PFAS TREATMENT OPTIONS

EVERY WATER SOURCE IS DIFFERENT

There is no one-size-fits-all solution for the removal of PFAS from drinking water.

"The Big 3"

What treatment options are most effective in removing PFAS from drinking water?

As part of the final PFAS National Primary Drinking Water Regulation (NPDWR), granular activated carbon, anion exchange, reverse osmosis, and nanofiltration were identified by the EPA as the "Best Available Technologies" (BATs) for meeting the PFAS Maximum Contaminant Levels (MCLs). This is based on six criteria: removal efficiency, historical full-scale operation, geographic applicability, compatibility with other treatment processes, ability to bring the entire water system into compliance, and a reasonable cost to large as well as medium sized systems. Water systems may use any technology or practice to meet the PFAS MCLs and are not limited to the BATs.

GAC

Ion Exchange

Reverse Osmosis

PFAS TREATMENT PROCESSES

There are so many options to consider:

RO: Reverse Osmosis

GAC: Granular Activated Carbon *EPA "BATs"*

IX: Ion Exchange

PAC: Powdered Activated Carbon

AOP: Advanced Oxidation Processes

SAFF: Surface Active Foam Fractionation

Ceramic Membranes with Adsorbent

Electrochemical Oxidation

Supercritical Water

Chemical Precipitation

Other Emerging Technologies

PFAS TREATMENT PROCESSES

PFAS TREATMENT PROCESSES

EVEN WITHIN THE SAME SYSTEM, IF THOSE WATER SOURCES ARE DIFFERENT THE TECHNOLOGY MAY RUN DIFFERENTLY

PFAS TREATMENT PROCESSES

How do you make a selection? What do you consider?

PFAS Removal Efficiencies

Capital Cost

Operational Cost

Ease of Operation

By-Products & Waste Stream Treatments

Media Regeneration / Disposal Costs

Other Local Issues….

WHAT'S THIS GOING TO COST?

Remember there are 2 parts:

CAPITAL + OPERATIONAL

What will the total costs look like 80 years from now?

CUSTOMER #1- 24MGD WATER TREATMENT PLANT

TECHNOLOGY	ANTICIPATED CAPITAL COST	ANTICIPATED ANNUAL OPERATIONAL COST	ANTICIPATED 80-YEAR LIFE CYCLE COST
MF + CCRO	$99.4M	$3.07M	$345M
UF + GAC	$82.4M	$3.86M	$391M

CUSTOMER #2- 3 MGD WATER TREATMENT PLANT

TECHNOLOGY	ANTICIPATED CAPITAL COST	ANTICIPATED ANNUAL OPERATIONAL COST	ANTICIPATED 80-YEAR LIFE CYCLE COST
RO	$40.3M	$1.79M	$109.2M
GAC	$21.8M	$1.86M	$94M

TODAY'S #1 TAKEAWAY:

YOUR WATER IS YOUR WATER

There is no one-size-fits-all solution for the removal of PFAS from drinking water.

Scotti Wells

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205-733-9696 – OFFICE/251-213-5716 - CELL

INSITE ENGINEERING

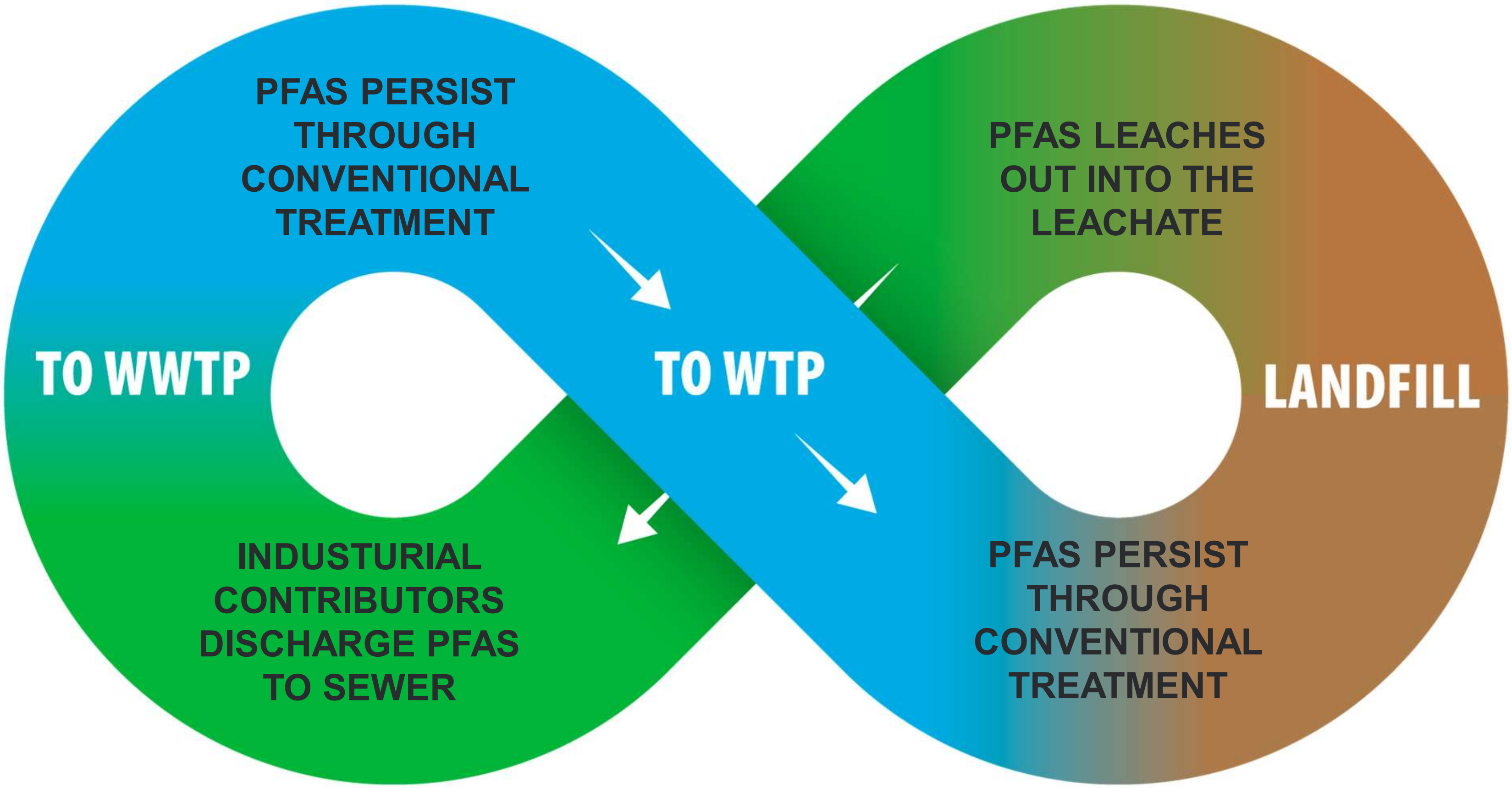
Alabama Georgia PFAS Working Group

Ovivo's Integrated Solution for Onsite PFAS Destruction: A Municipal Drinking Water Case Study

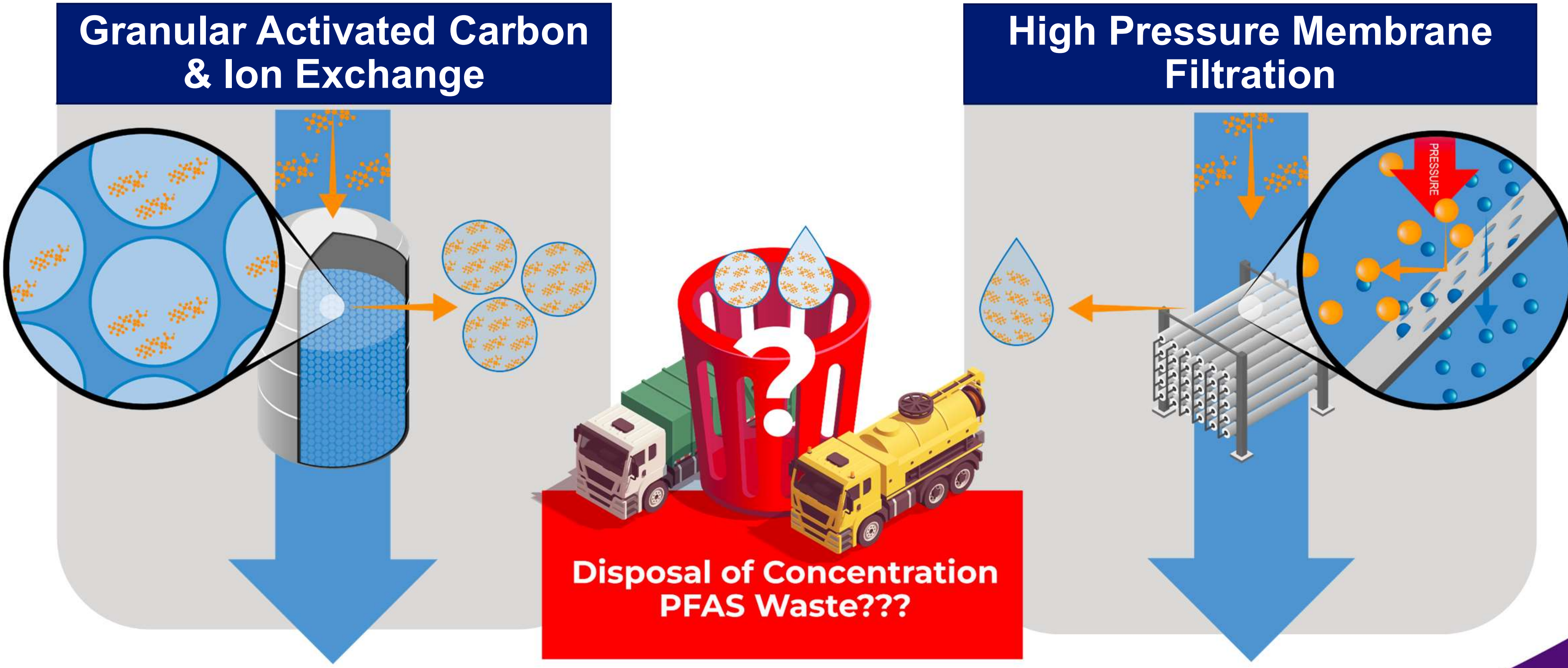
Zia Klocke, P.E.
Product Manager (Adsorption), PFAS Solutions
Alabama Surface Water Meeting 2024

OVIVO
Worldwide Experts in Water Treatment

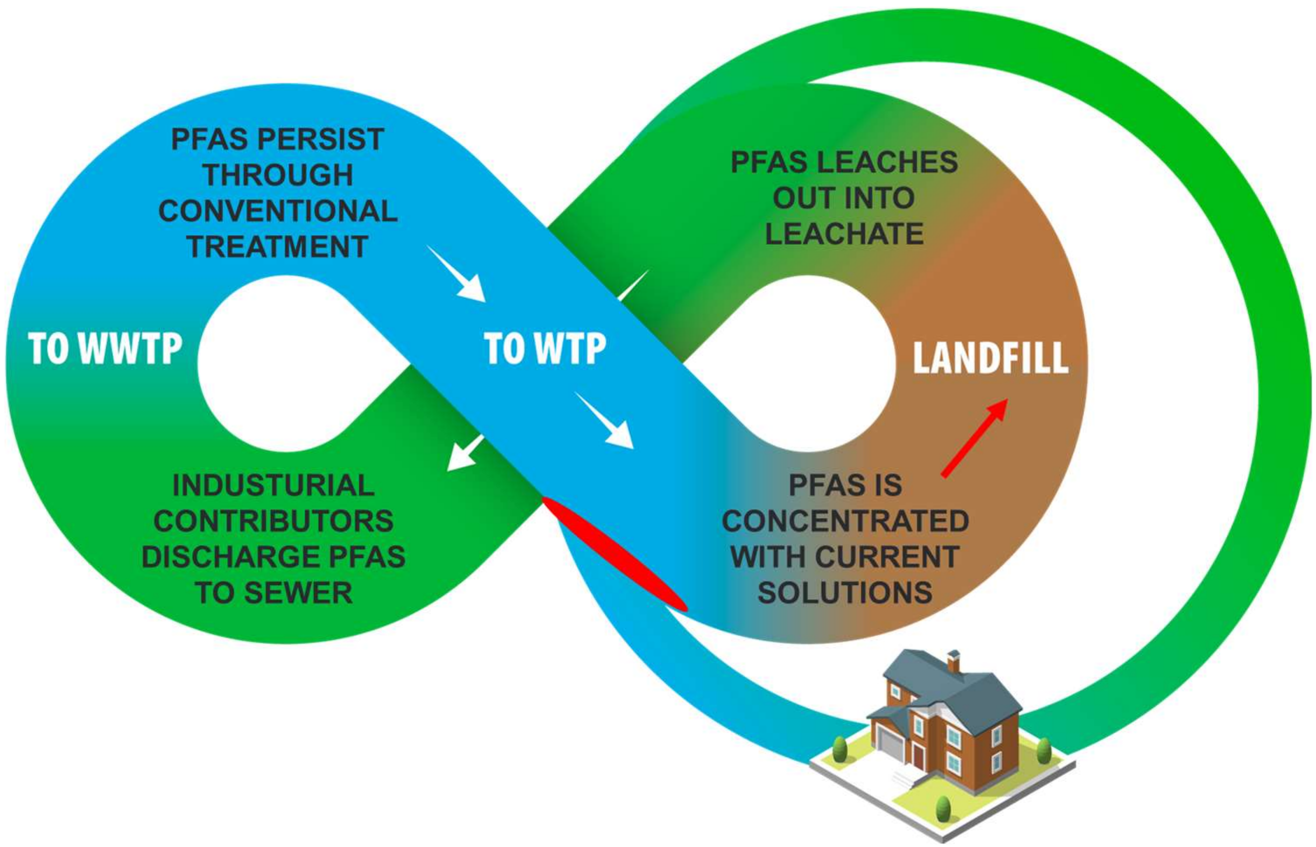
The Forever Chemical Cycle



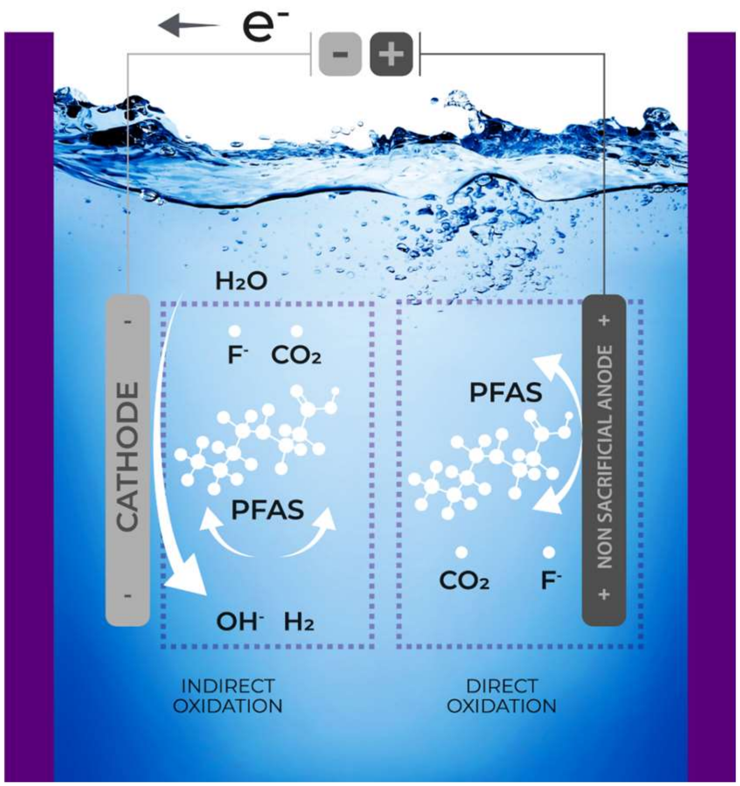
Current PFAS Water Treatment Methods



The Forever Chemical Cycle

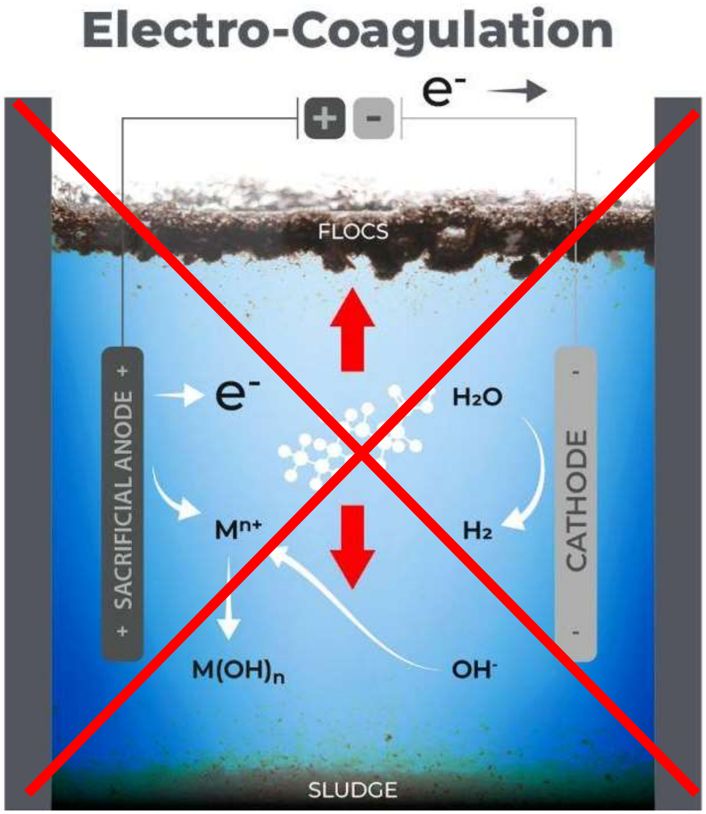


How Electro-Oxidation Destroys PFAS



- Pass an electrical current through the electrodes (anode and cathode)
  - Non-Sacrificial electrodes

How Electro-Oxidation Destroys PFAS

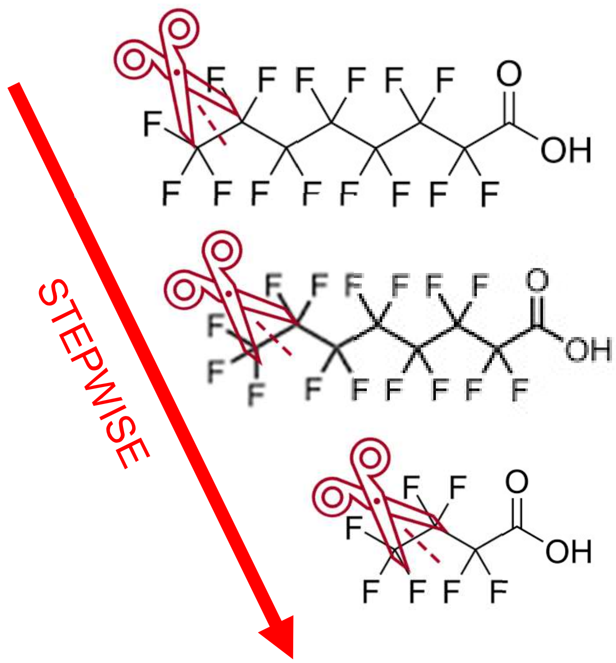


- Pass an electrical current through the electrodes (anode and cathode)
  - Non-Sacrificial electrodes

Two Approaches to PFAS Destruction

LOW INTENSITY

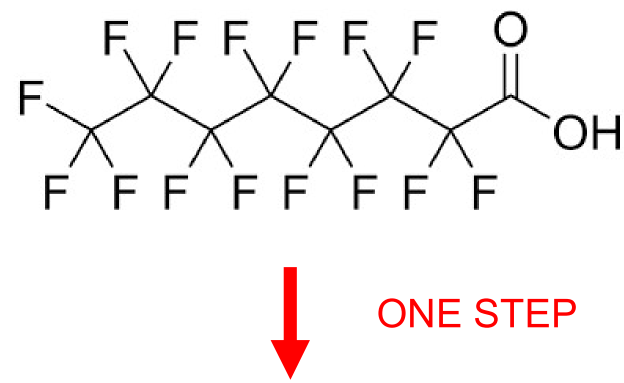
minutes-to-hours



CO_2 and F^-

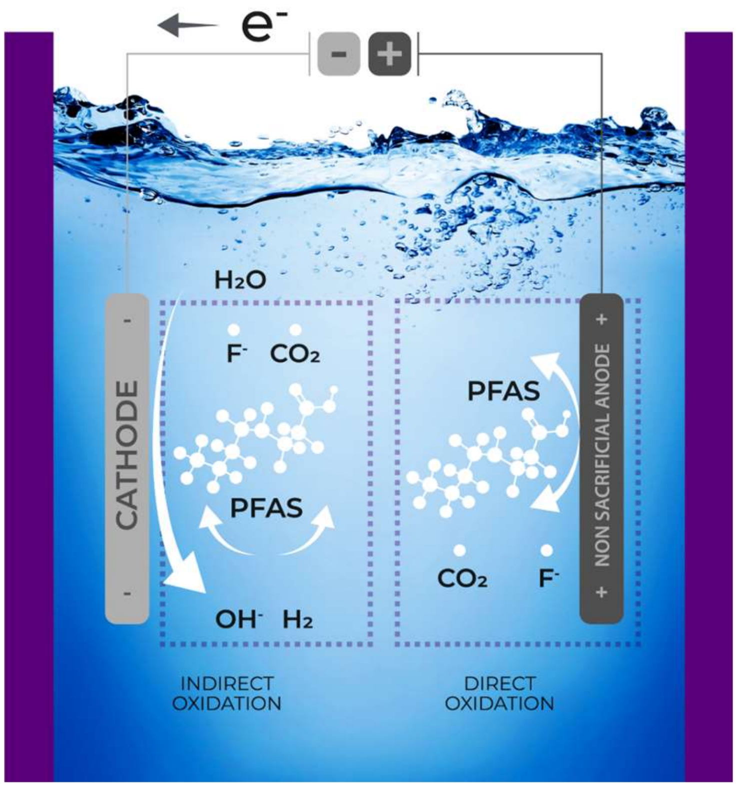
HIGH INTENSITY

seconds-minutes

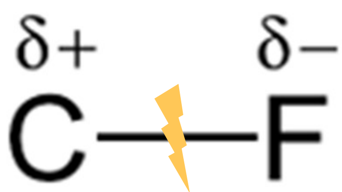


CO_2 and F^-

How Electro-Oxidation Destroys PFAS

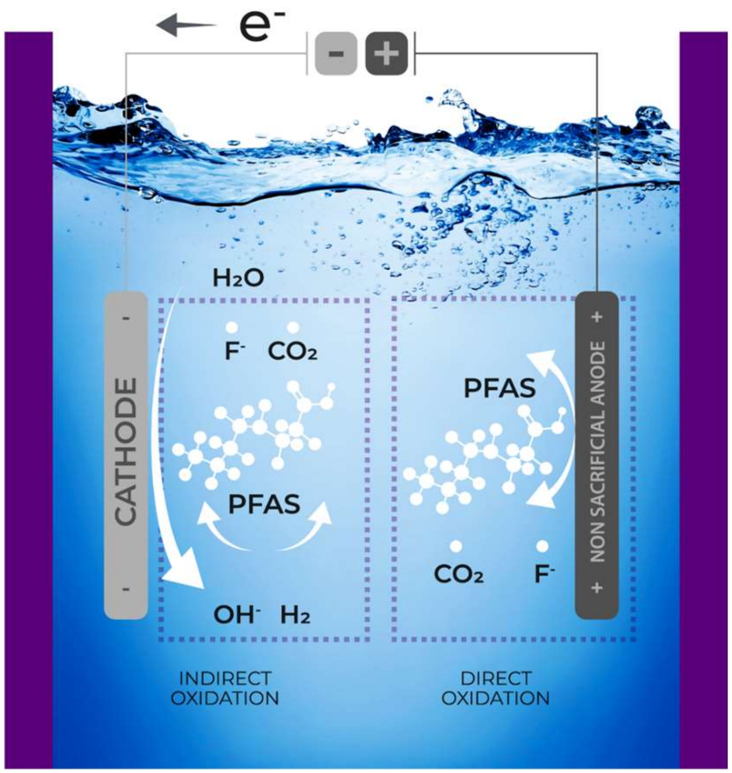


- Pass an electrical current through the electrodes (anode and cathode)
  - Non-Sacrificial electrodes
- **Direct oxidation** happens at the **surface of the anode** that cleaves the C-F bond.



- Indirect oxidation through other electrochemically-created oxidants also react with and break down PFAS in the bulk liquid.

How Electro-Oxidation Destroys PFAS



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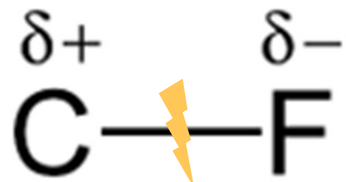


- Indirect oxidation through other electrochemically-created oxidants also react with and break down PFAS in the bulk liquid.
- Operates at ambient temps and low pressures

Integrated Solution

Onsite Destruction

CONCENTRATE

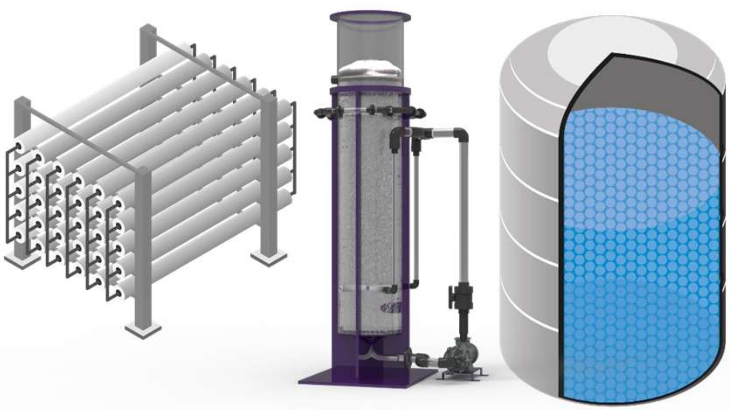
Reverse Osmosis
Foam Fractionation
Regenerable Ion Exchange

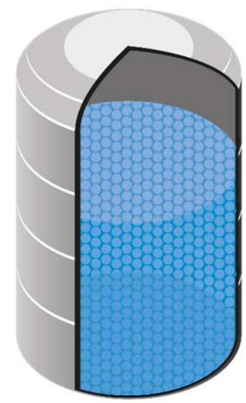
DESTROY

Ovivo Electrochemical Oxidation

POLISH

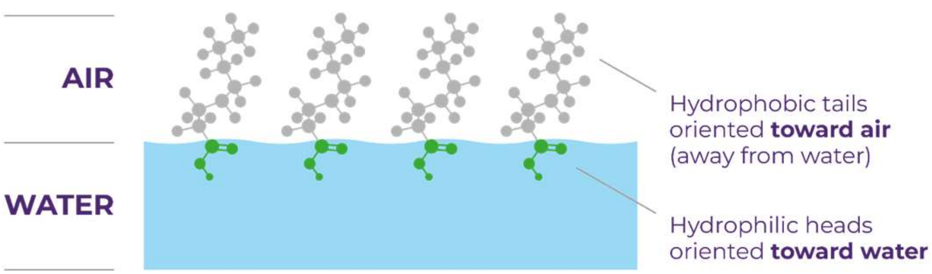
GAC
Ion Exchange





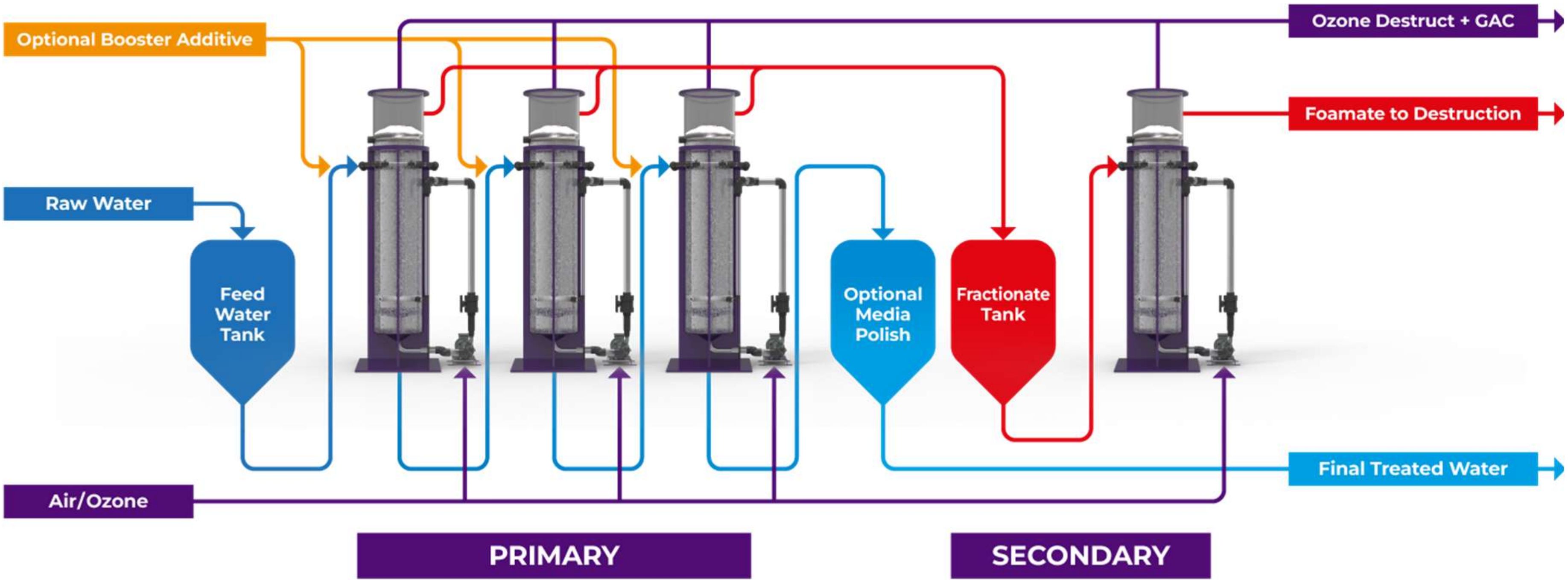
Foam Fractionation as a PFAS Separation Method

- Foam Fractionation utilizes PFAS attraction to the air water interface to remove and concentrate PFAS
- Foamate can be 1000X more concentrated and 1-10% the volume of the influent
- Ovivo's system selectively uses both ozone and air to create smaller bubbles with higher overall surface area and higher electrostatic charge compared to air-only systems, significantly boosting PFAS removal and concentration factors.



- Commercially deployed for PFAS in Australia since 2017

Ovivo's Ozone Foam Fractionation



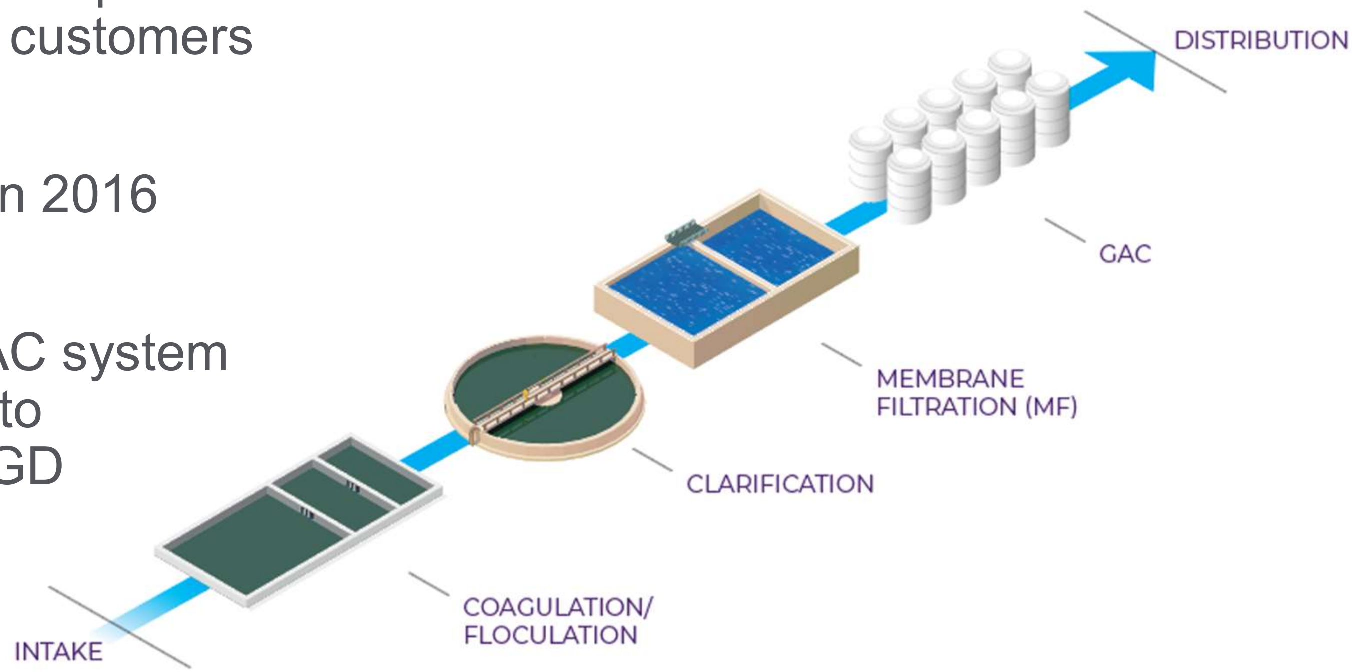
Case Study #1 Drinking Water Application

Reverse Osmosis Concentrate

Onsite since June 2022

West Morgan East Lawerence, AL
History

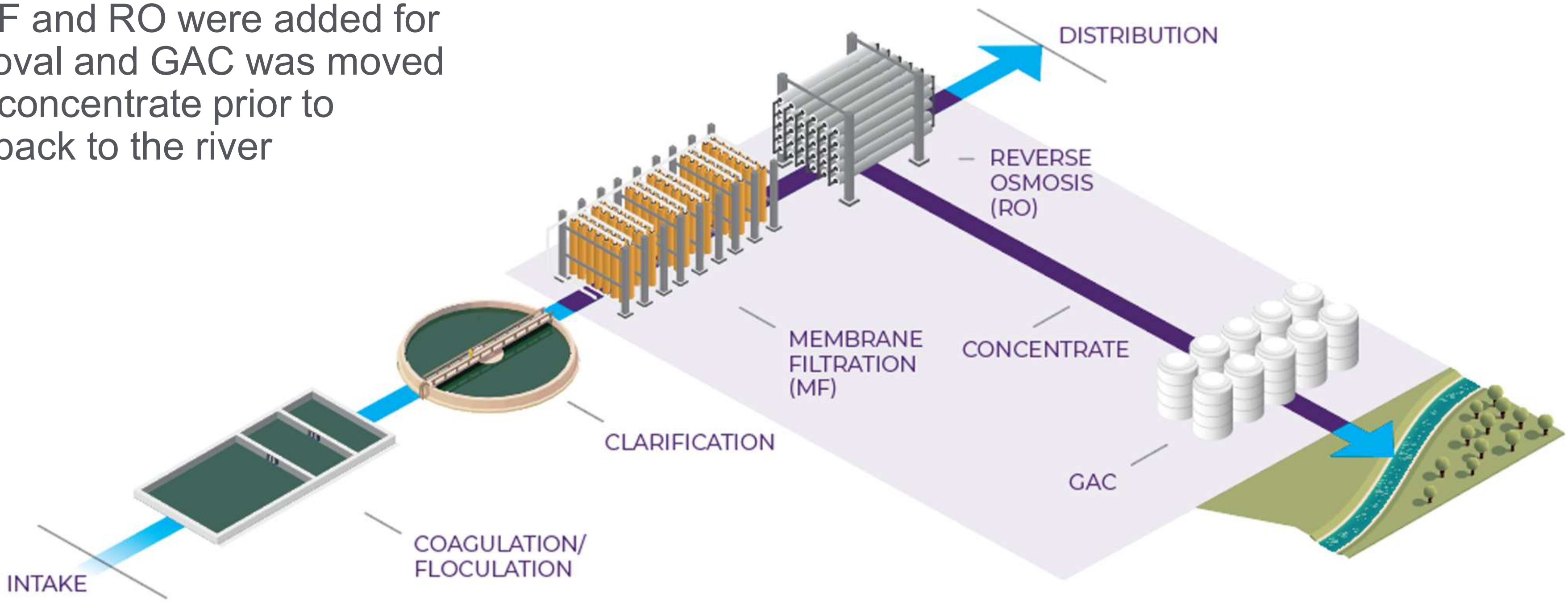
- 16 MGD water treatment plant serving over 100,000 customers
- First detected PFAS in 2016
- Emergency Ovivo GAC system installed in late 2016 to remove PFAS in 5 MGD



West Morgan East Lawerence, AL

History

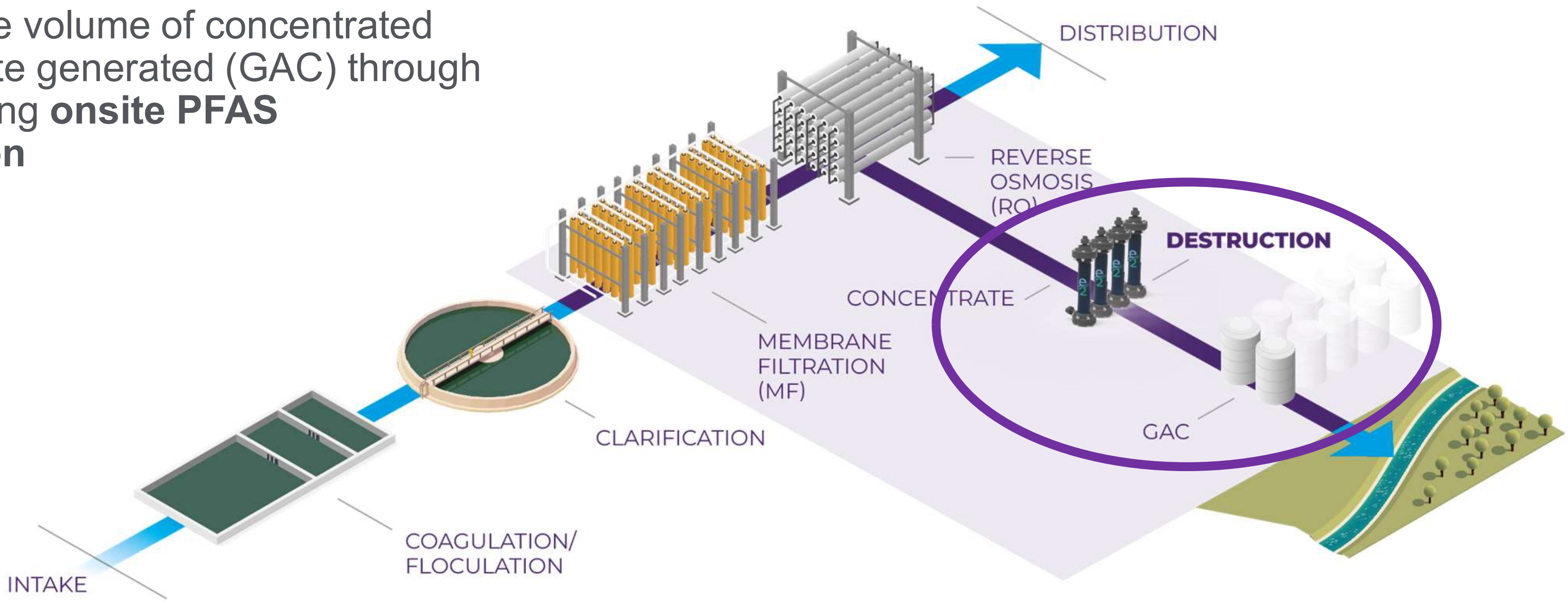
In 2021, MF and RO were added for PFAS removal and GAC was moved to treating concentrate prior to discharge back to the river



West Morgan East Lawerence, AL

Study Goal

Reduce the volume of concentrated PFAS waste generated (GAC) through incorporating **onsite PFAS destruction**



Evaluation of Electrochemical Oxidation (EO)

Compare Two Electrode Types:

- Multiple specialized electrodes that we can use to tailor to the water

Electrode #1

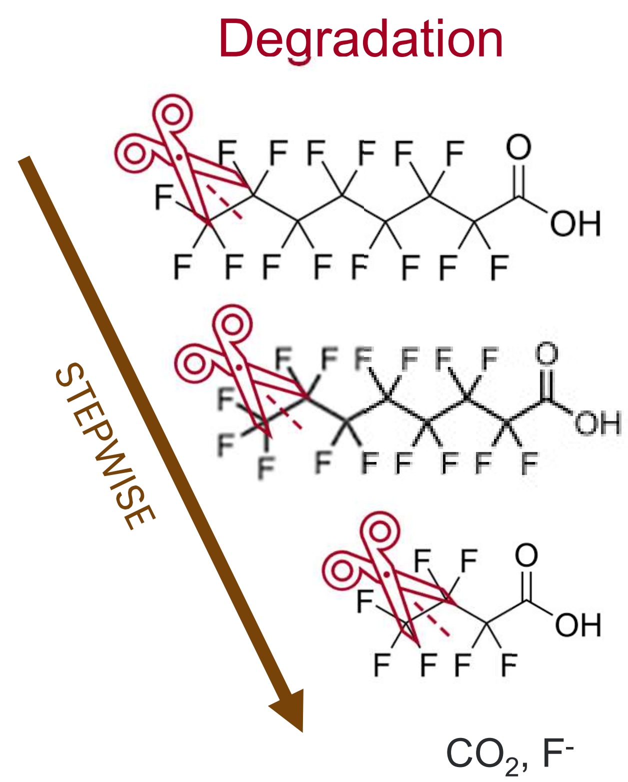
Electrode #2

Evaluation of Electrochemical Oxidation (EO)

Compare Two Electrode Types:

- Multiple specialized electrodes that we can use to tailor to the water

Electro degradation and generation of long- to short-chain PFAS compound



Evaluation of Electrochemical Oxidation (EO)

Compare Two Electrode Types:

- Multiple specialized electrodes that we can use to tailor to the water

Electro degradation and generation of long- to short-chain PFAS

Generation of Perchlorates

Chloride Oxidized to Perchlorate

$$Cl^- \rightarrow ClO_4^-$$

Evaluation of Electrochemical Oxidation (EO)

Compare Two Electrode Types:

- Multiple specialized electrodes that we can use to tailor to the water

Electro degradation and generation of long- to short-chain PFAS compound

Generation of Perchlorates

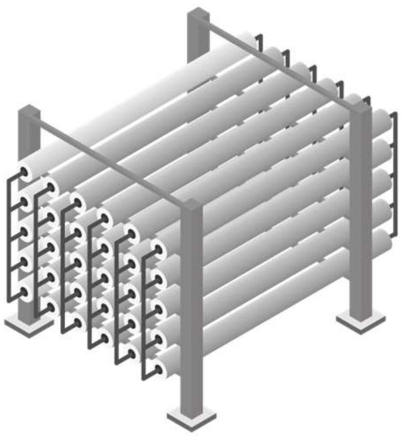
Energy Consumption

- Energy vs. Total PFAS Reduction

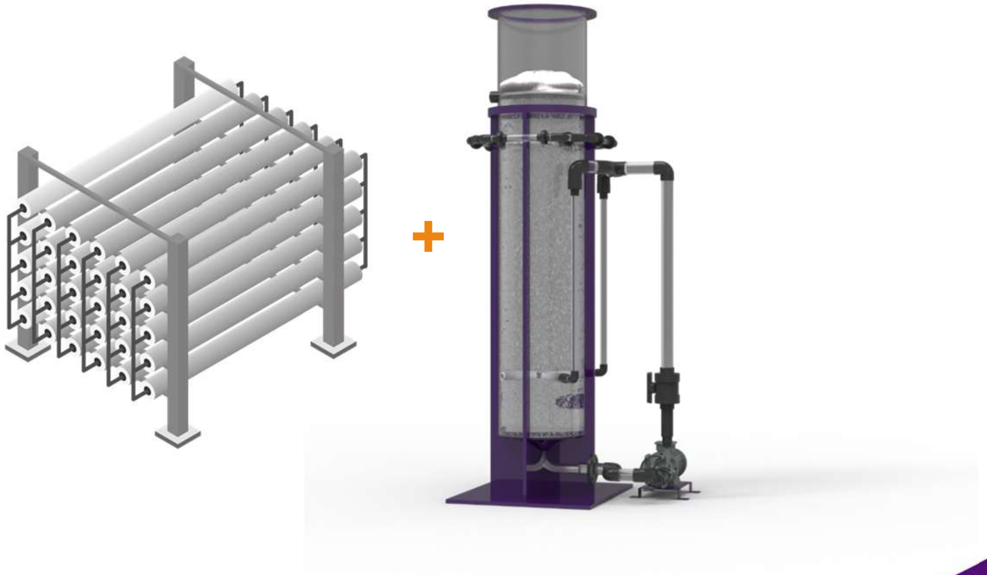
Integrated Solution Updates

Concentration Options

Reverse Osmosis



Reverse Osmosis + Foam Fractionation



Reverse Osmosis Treatment Train

Concentration
Reverse Osmosis

Destruction
Electrochemical Oxidation

Polishing
Ion Exchange

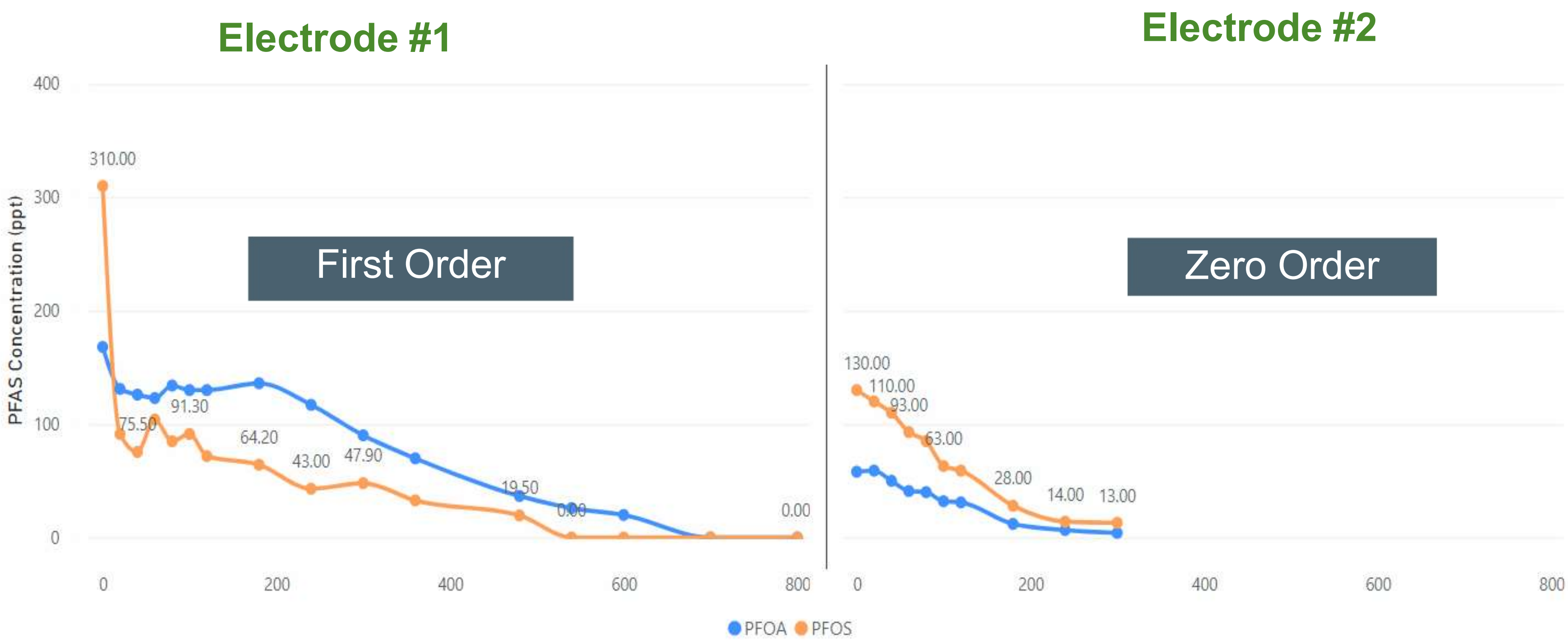
Pilot Testing Performed with 300 liters

Method: 537 Modified (PACE ENV-SOP-MIN4-0179)

Reverse Osmosis Concentrate

EO Destruction

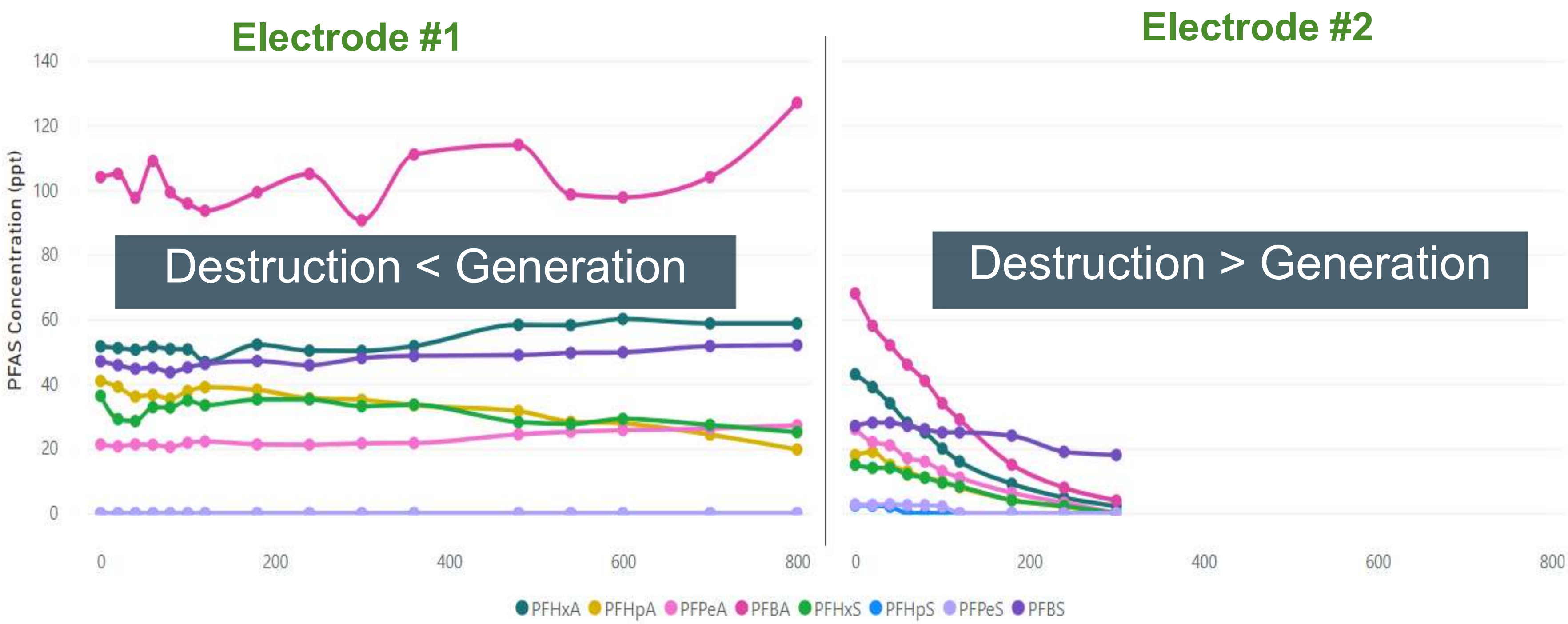
Reverse Osmosis Concentrate
EO Long-Chain Destruction



Method: 537 Modified (PACE ENV-SOP-MIN4-0179)

Reverse Osmosis Concentrate

EO Short-Chain Destruction



Method: 537 Modified (PACE ENV-SOP-MIN4-0179)

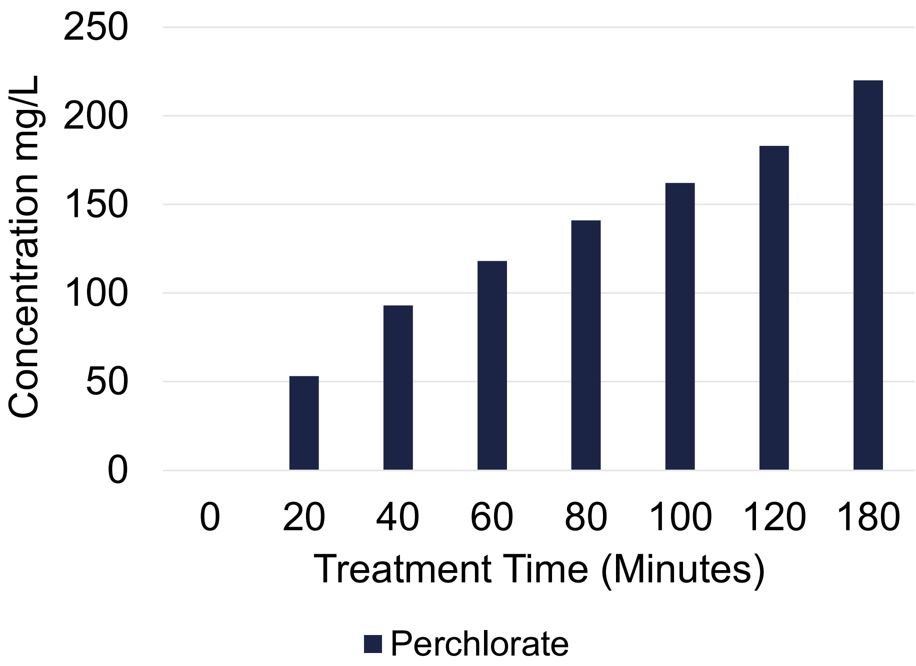
Reverse Osmosis Concentrate
Perchlorate Evaluation

Electrode #1

No Perchlorate Generated

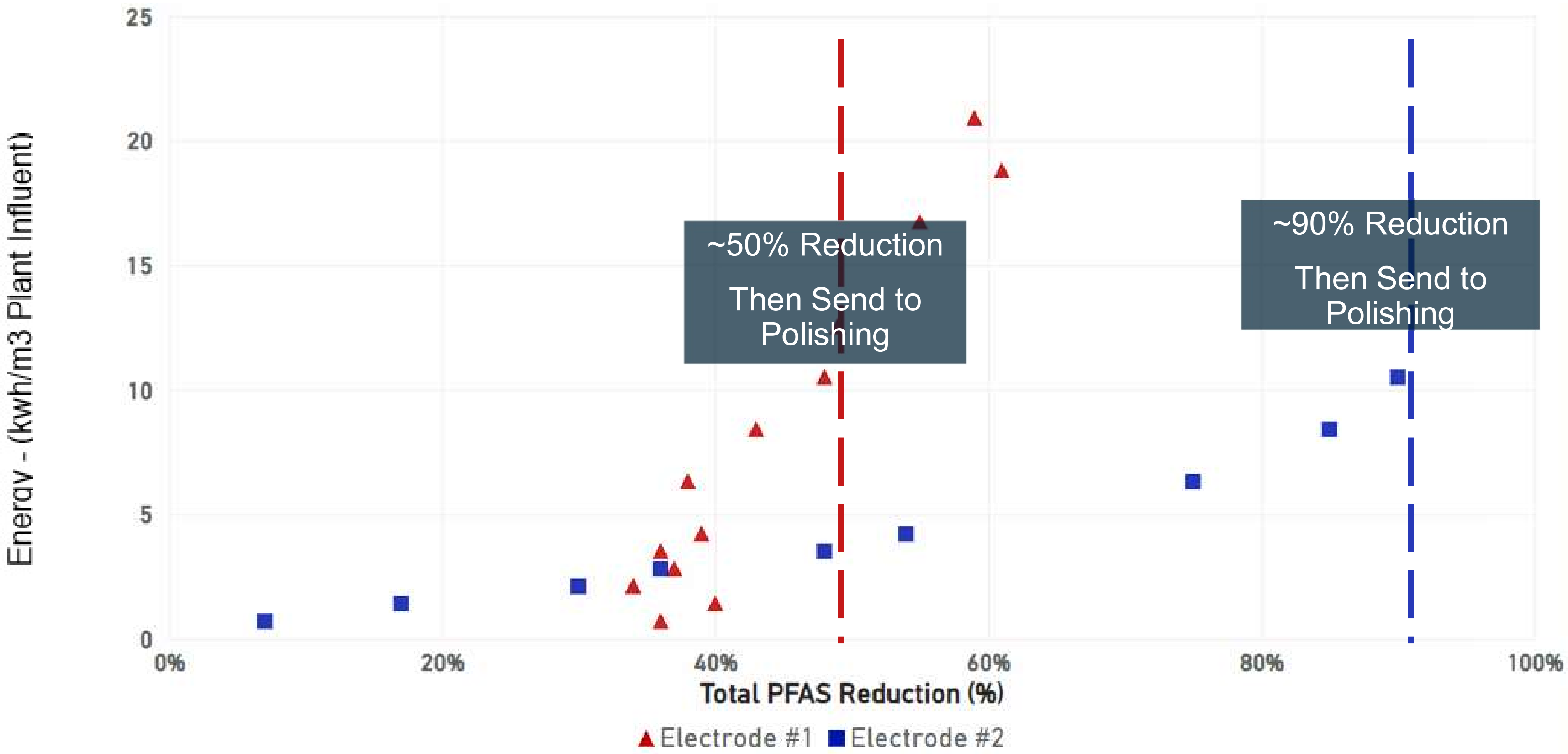
Maximum Contaminant Level (MCL) for the perchlorate in CA is at 0.006 mg/L

Electrode #2



Method: EPA 314

Reverse Osmosis Concentrate
Energy Evaluation

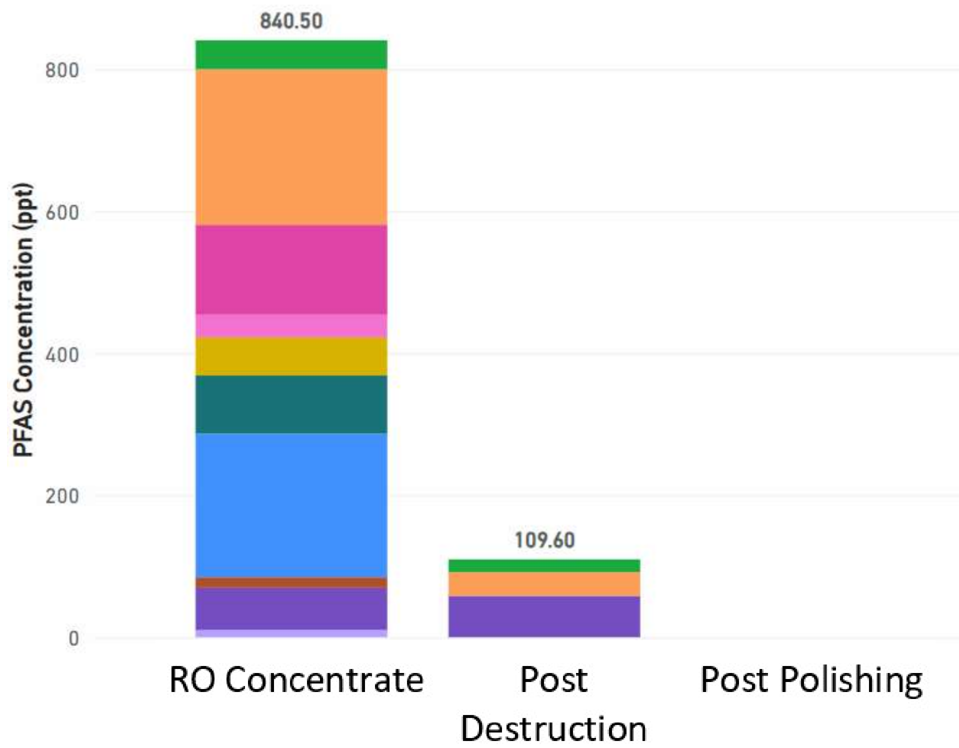


Reverse Osmosis Concentrate

Integrated Solution Summary

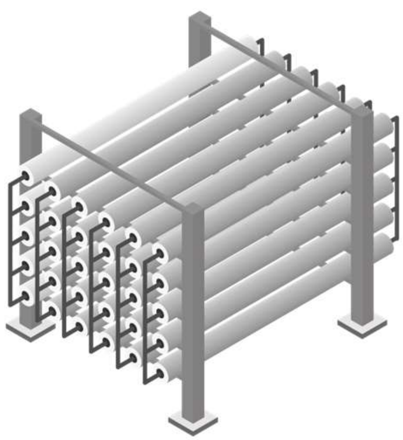
PFAS Compound	Units	RO Concentrate	Post Destruction	Post Polish
PFOS	**ng/L**	**219**	**33**	**ND**
PFOA	**ng/L**	**202**	**ND**	**ND**
PFNA	**ng/L**	**ND**	**ND**	**ND**
PFHxS	**ng/L**	**41**	**18**	**ND**
PFBS	**ng/L**	**60**	**58**	**ND**
PFBA	ng/L	127	ND	ND
PFPeA	ng/L	32	ND	ND
PFHxA	ng/L	82	ND	ND
PFPeS	ng/L	10	ND	ND
PFHpA	ng/L	54	ND	ND
6:2 FTS	ng/L	ND	ND	ND
PFHpS	ng/L	ND	ND	ND
PFOSAm	ng/L	ND	ND	ND
PFDA	ng/L	ND	ND	ND
NMeFOSAA	ng/L	15	ND	ND
NEtFOSAA	ng/L	ND	ND	ND

Polishing Removed Perchlorate to ND

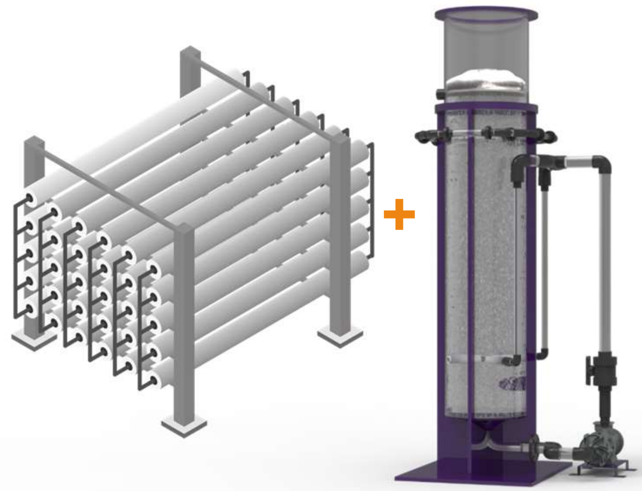


Integrated Solution Updates
Concentration Options

Reverse Osmosis



Reverse Osmosis + Foam Fractionation

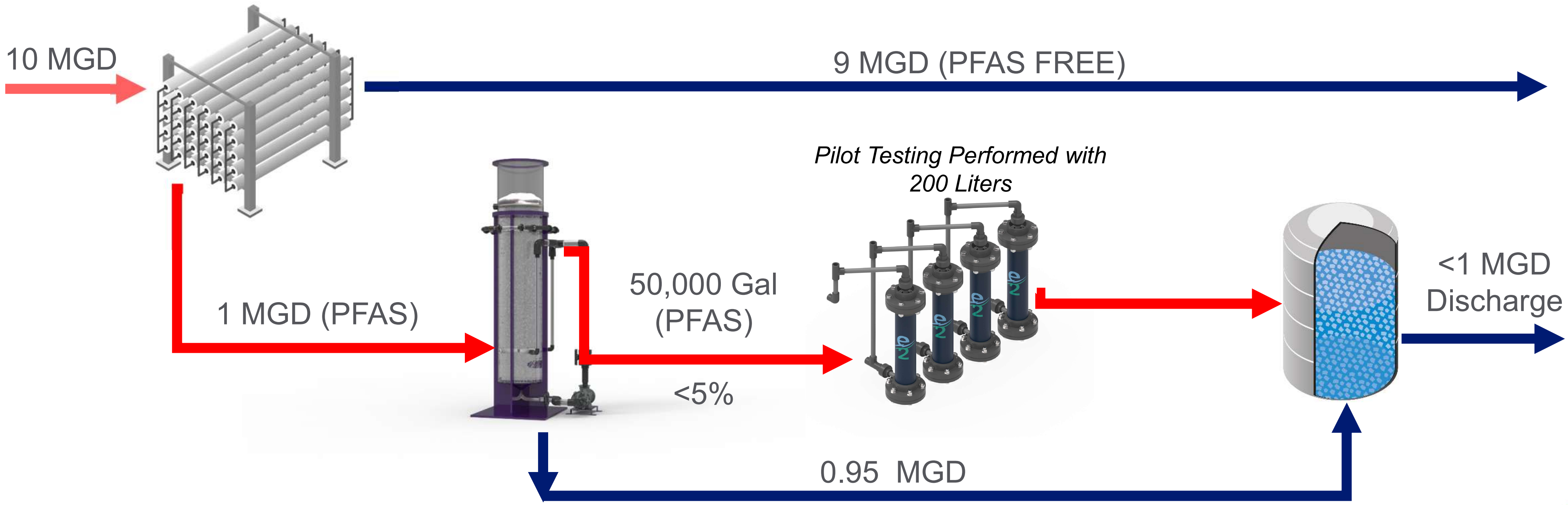


Foam Fractionation Treatment Train

Concentration
Reverse Osmosis Followed by Foam Fractionation

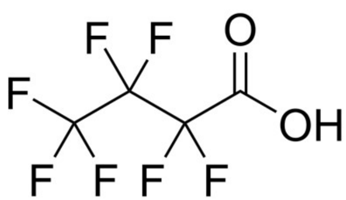
Destruction
Electrochemical Oxidation

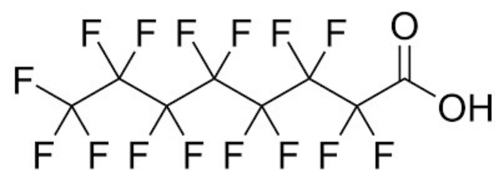
Polishing
IX or GAC



Foam Fractionation as a PFAS Separation Method

Short-Chain PFAS	**Long-Chain PFAS**
Lower Removal	High Removal
High Water Solubility	Low Water Solubility
PFBA/PFBS	PFOA/PFOS





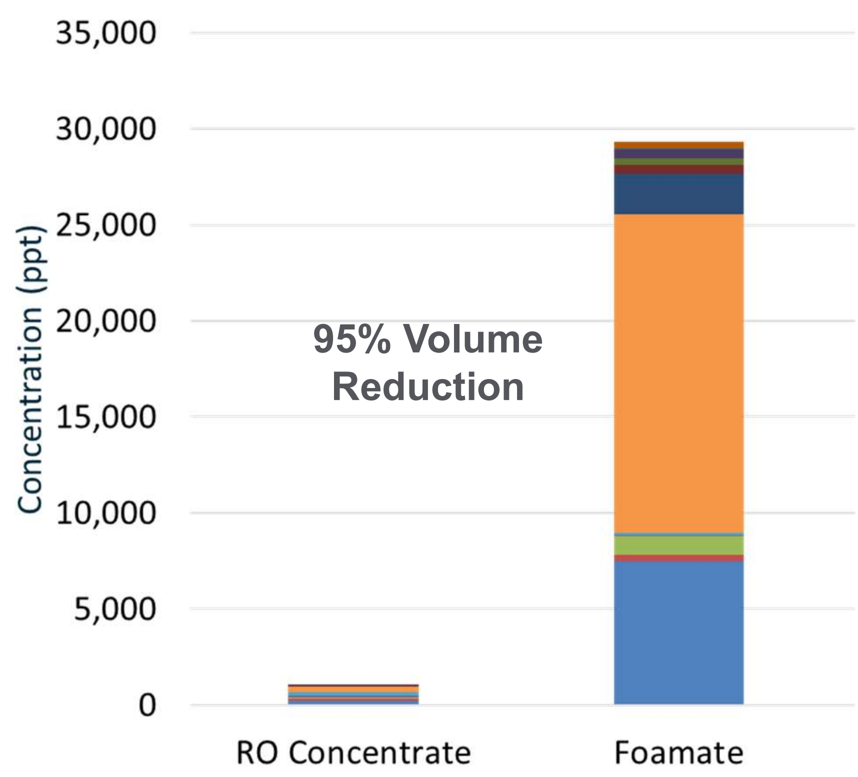
Number of Carbons	4	5	6	7	8	9	10	11	12
PFCAs	Short-Chain PFCAs				Long-Chain PFCAs				
	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDoA
MCLs					4.0 ppt	HI			
PFSAs	Short-Chain PFSAs		Long-Chain PFSAs						
	PFBS	PFPeS	PFHxS	PFHpS	PFOS	PFNS	PFDS	PFUnS	PFDoS
MCLs	HI		HI		4.0 ppt				

HI = Hazard Index. GenX is not shown on this table but part of the Hazard Index.

Concentration by Foam Fractionation (Air only)

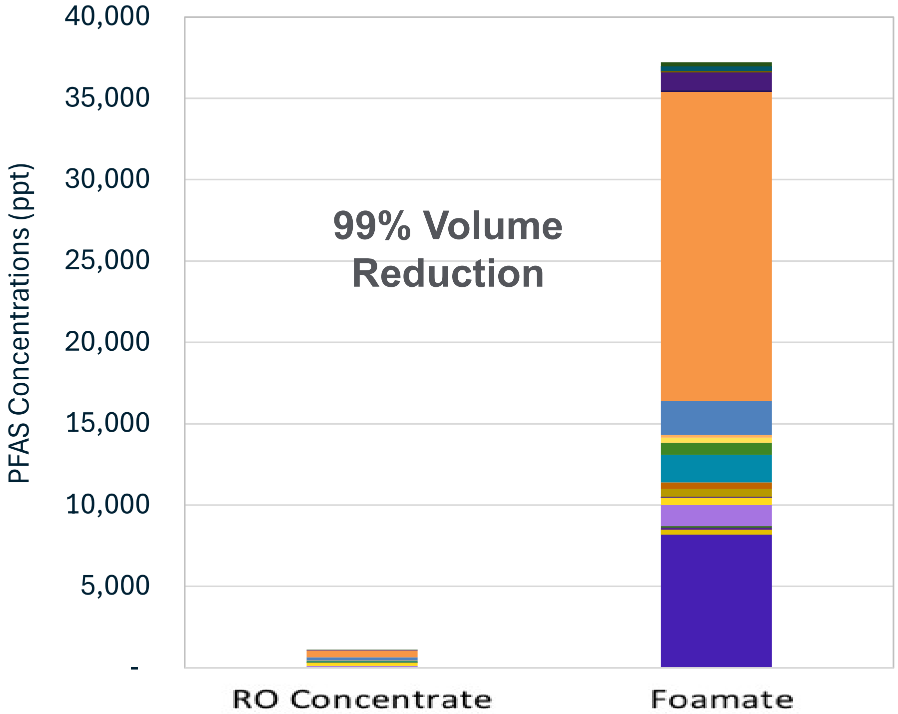
PFAS Compound	Units	RO	Foamate
PFBA	ng/L	143	113
PFPeA	ng/L	48.9	56.2
PFBS	**ng/L**	**55.1**	**500**
PFHxA	ng/L	81.2	324
PFPeS	ng/L	9.6	301
PFHpA	ng/L	56.4	976
PFHxS	**ng/L**	**50.1**	**2,110**
PFOA	**ng/L**	**224**	**7,480**
6:2 FTS	ng/L	ND	27.1
PFHpS	ng/L	7.1	476
PFNA	**ng/L**	**ND**	**106**
PFOSAm	ng/L	ND	352
PFOS	**ng/L**	**288**	**16,600**
PFDA	ng/L	ND	44.4
NMeFOSAA	ng/L	13.7	554
NEtFOSAA	ng/L	23.6	801

Method: 537 Modified (PACE ENV-SOP-MIN4-0179)

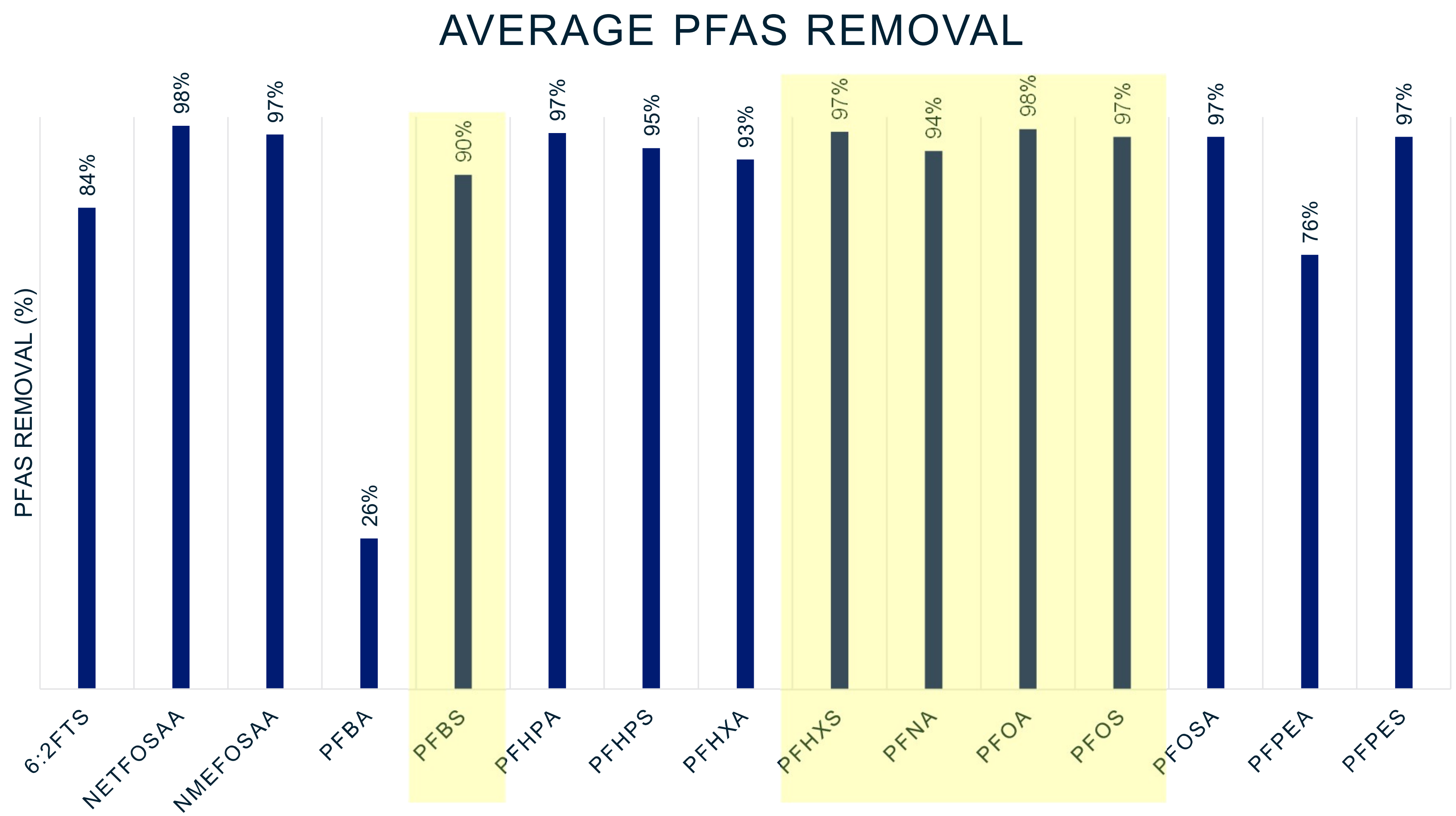


Concentration by Foam Fractionation (Air + Ozone)

PFAS Compound	Units	RO	Super Concentrate
PFBA	ng/L	72	1 ,300
PFPeA	ng/L	26	1,100
PFBS	**ng/L**	**160**	**450**
PFHxA	ng/L	57	1,700
PFPeS	ng/L	-	87
PFHpA	ng/L	42	490
PFHxS	**ng/L**	**39**	**1,700**
PFOA	**ng/L**	**210**	**2,100**
6:2 FTS	ng/L	16	8,200
PFHpS	ng/L	10	400
PFNA	**ng/L**	**6**	**310**
PFOSAm	ng/L	9	120
PFOS	**ng/L**	**410**	**19,000**
PFDA	ng/L	2	24
NMeFOSAA	ng/L	12	93
NEtFOSAA	ng/L	23	130



PFAS Removal by Foam Fractionation (Air + Ozone)

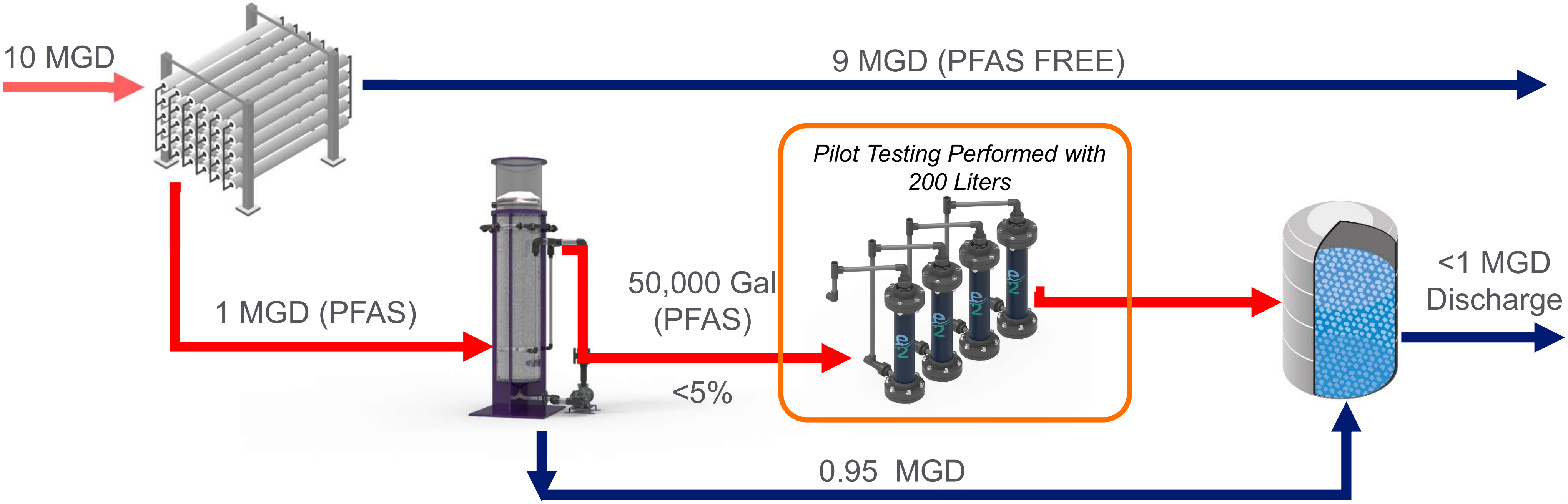


Foam Fractionation Treatment Train

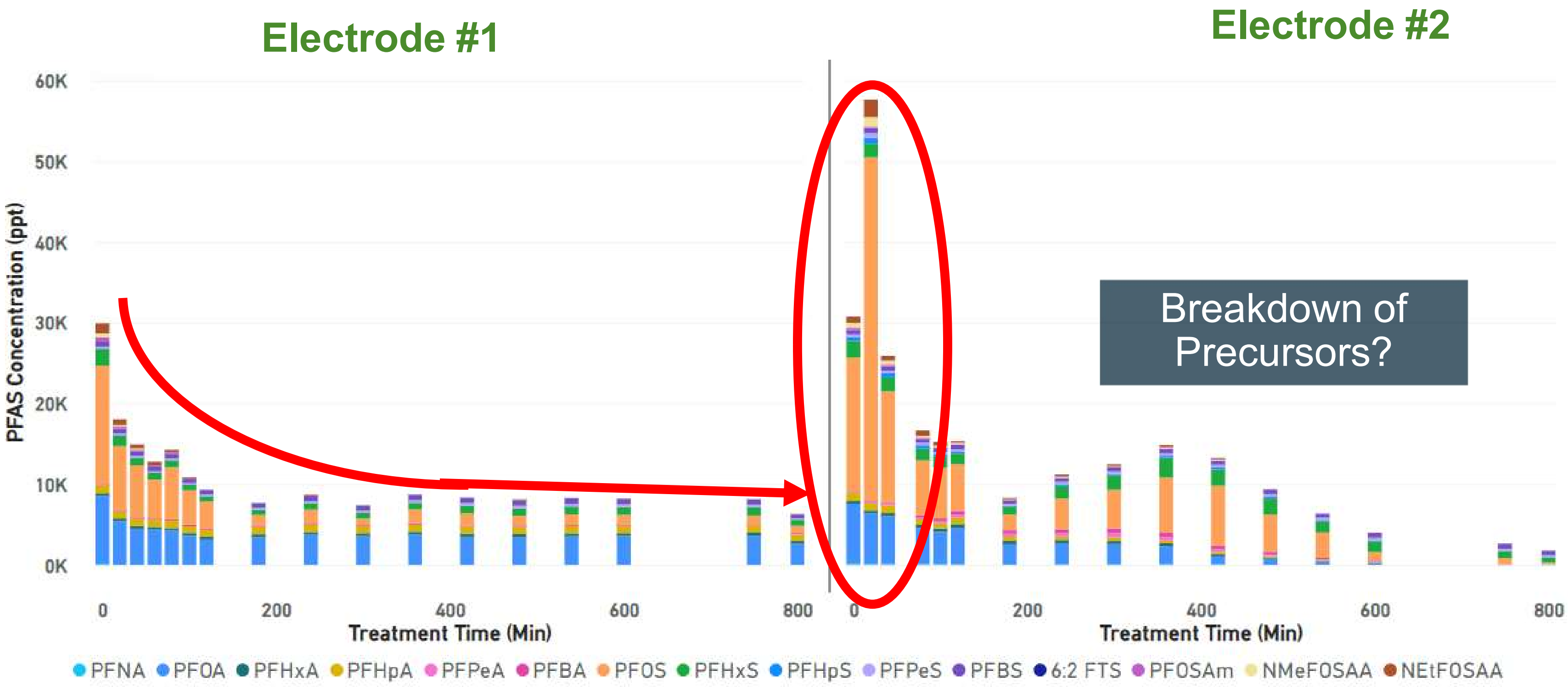
Concentration
Reverse Osmosis Followed by Foam Fractionation

Destruction
Electrochemical Oxidation

Polishing
IX or GAC

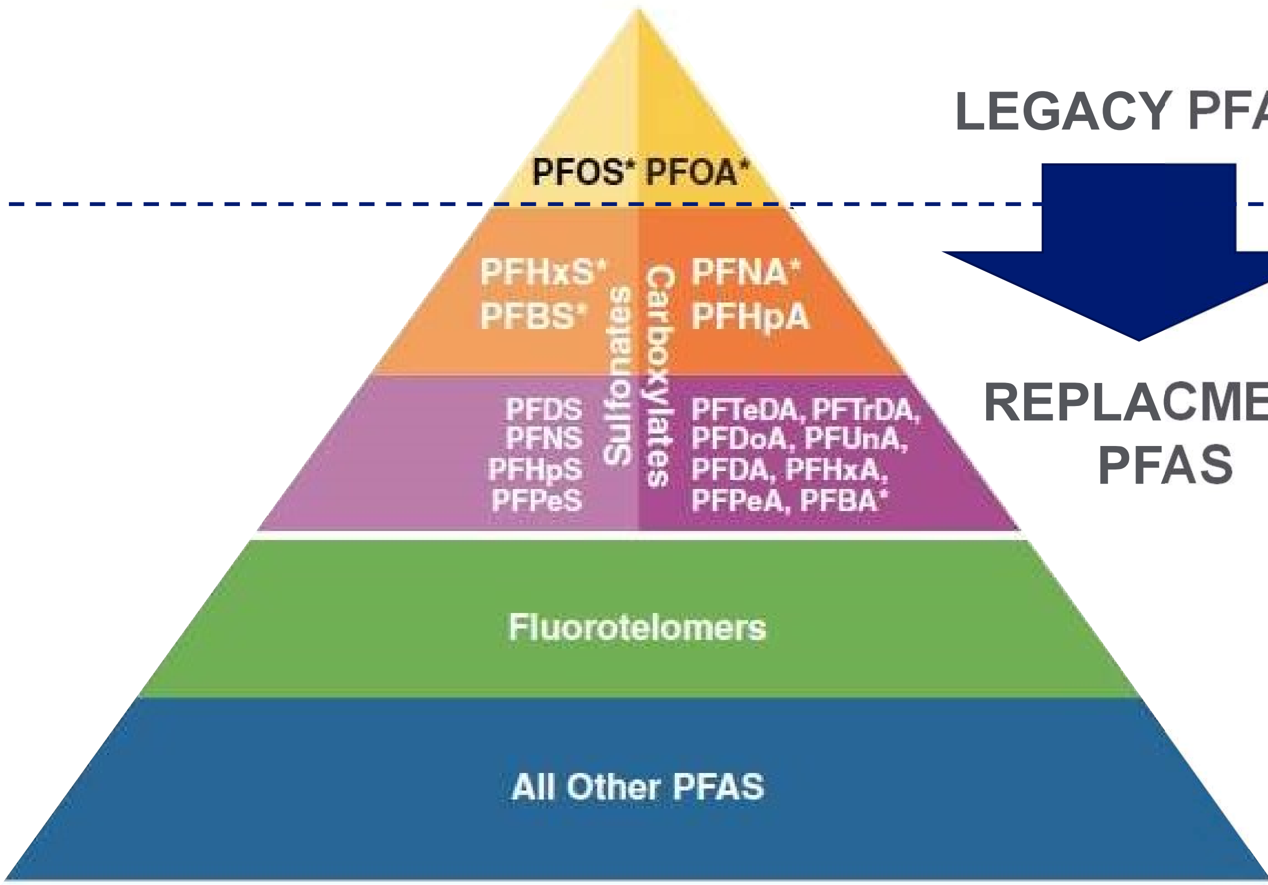


Foam Fractionation (Foamate)
EO Destruction



Method: 537 Modified (PACE ENV-SOP-MIN4-0179)

Precursor Compounds



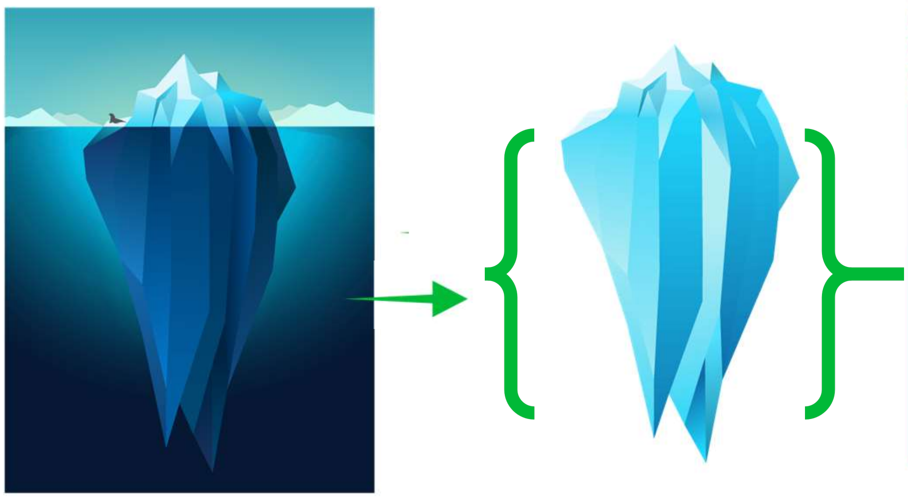
Source: J. Hale, Kleinfelder. PFAS-1, Figure 2-16.

LEGACY PFAS

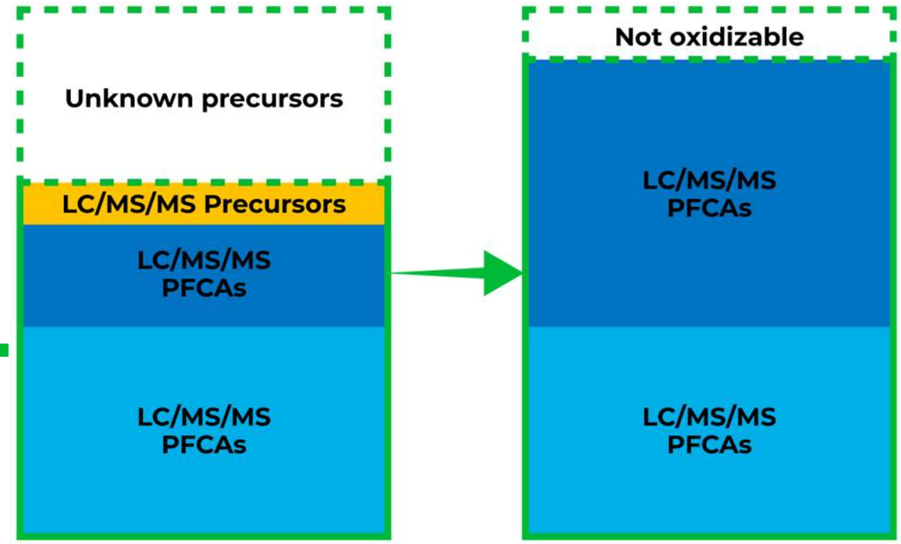
REPLACMENT PFAS

Total Oxidizable Precursor Assay (TOP)
Explained

TOP Assay is a measurement of oxidizable PFAS precursors. Useful tool to understand the "actual" presence of PFAS.



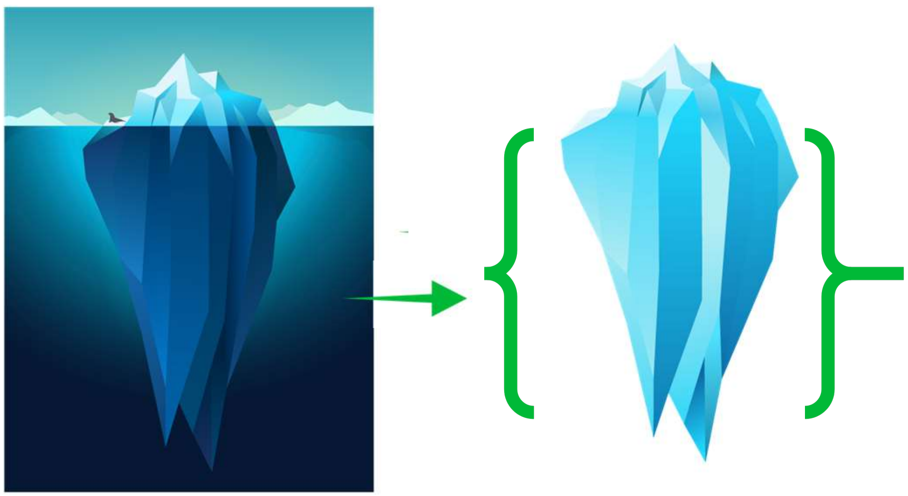
PRE POST



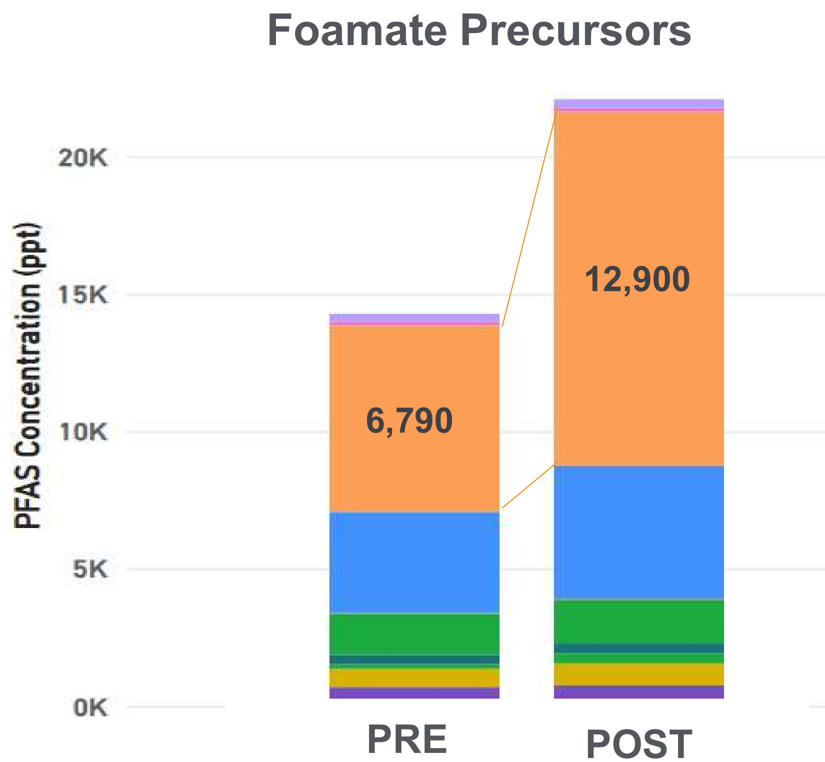
PRE POST

Total Oxidizable Precursor Assay (TOP)
Foamate

TOP Assay is a measurement of oxidizable PFAS precursors. Useful tool to understand the "actual" presence of PFAS.

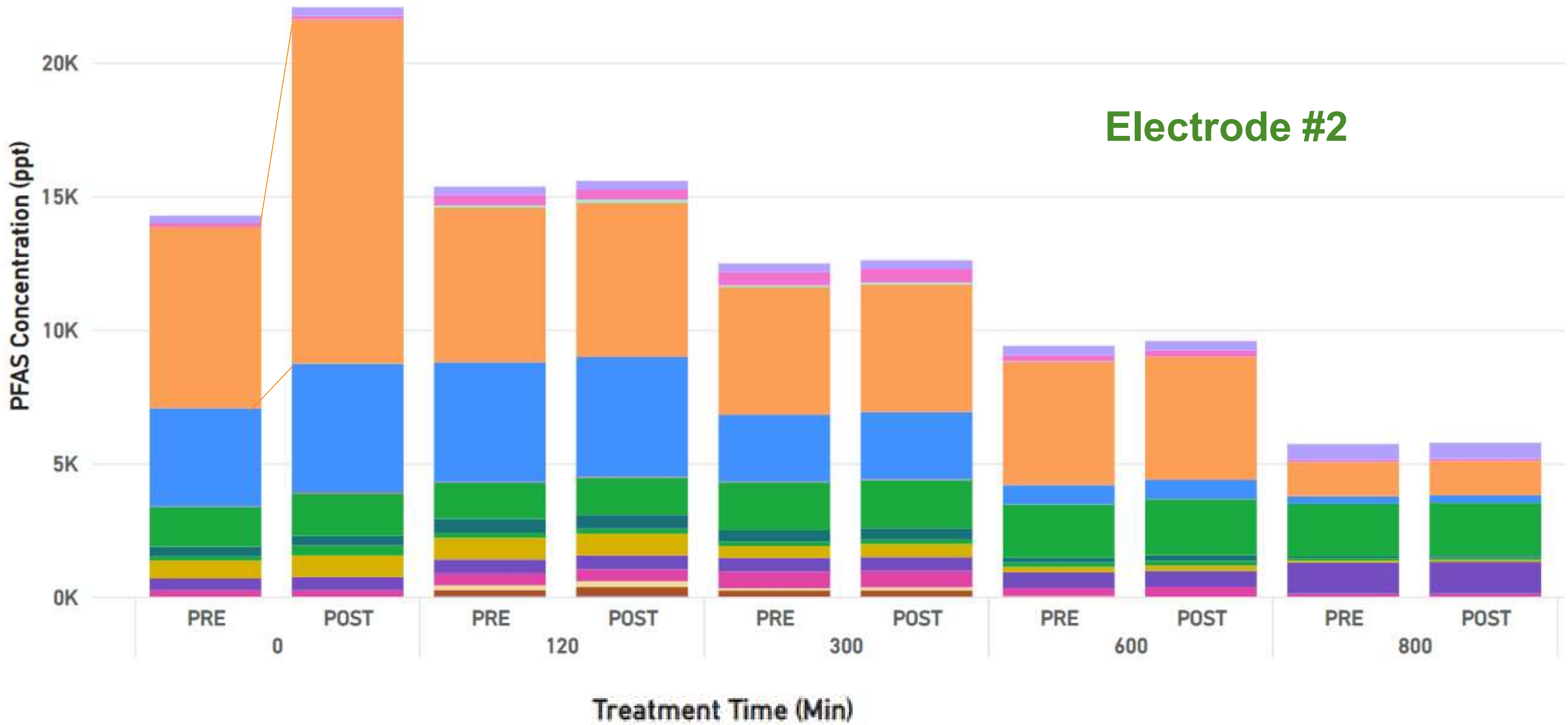


PRE **POST**



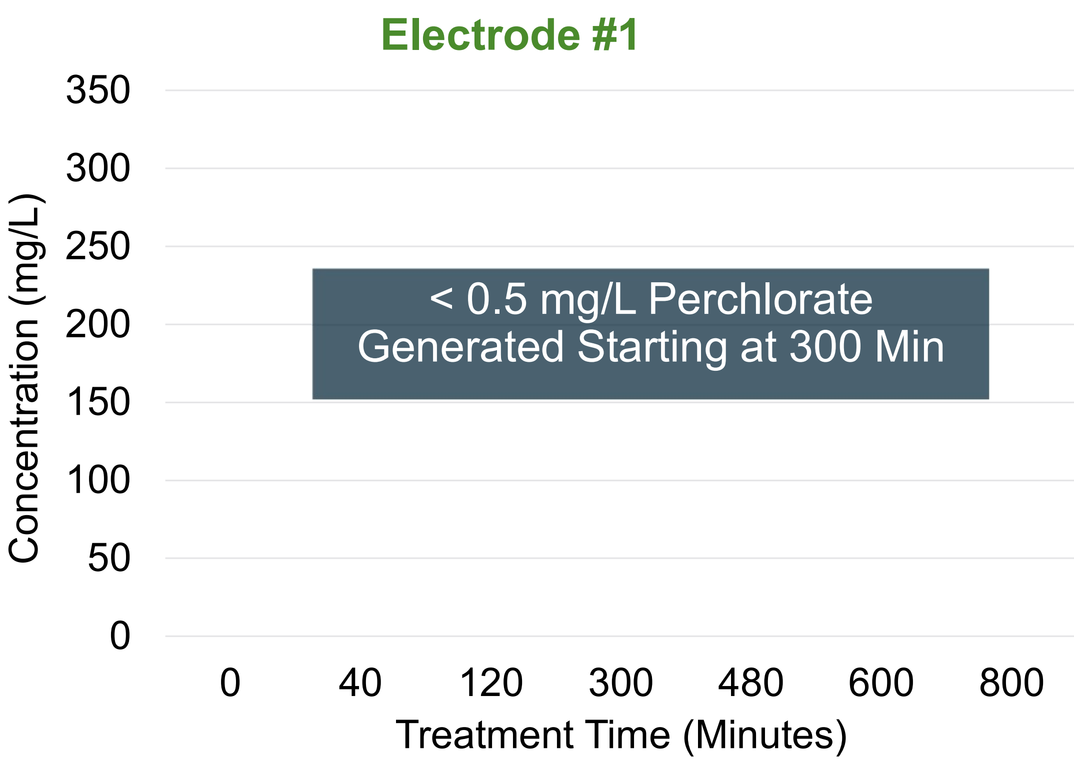
Total Oxidizable Precursor Assay (TOP)

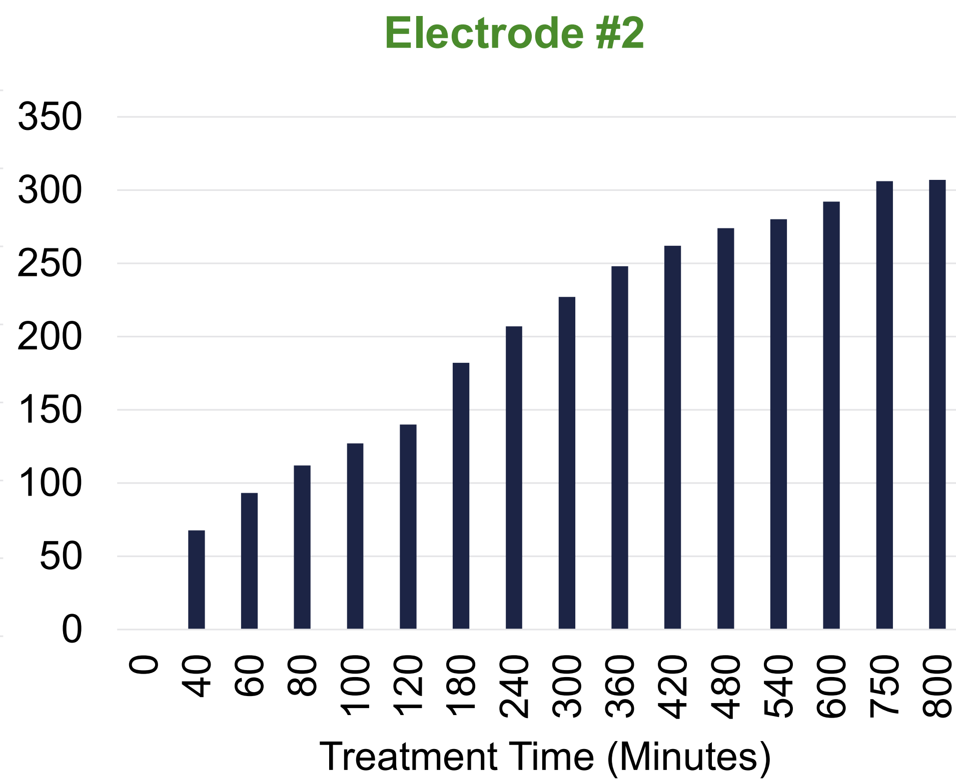
Foamate EO Destruction



Foam Fractionation (Foamate)

Perchlorate Generation

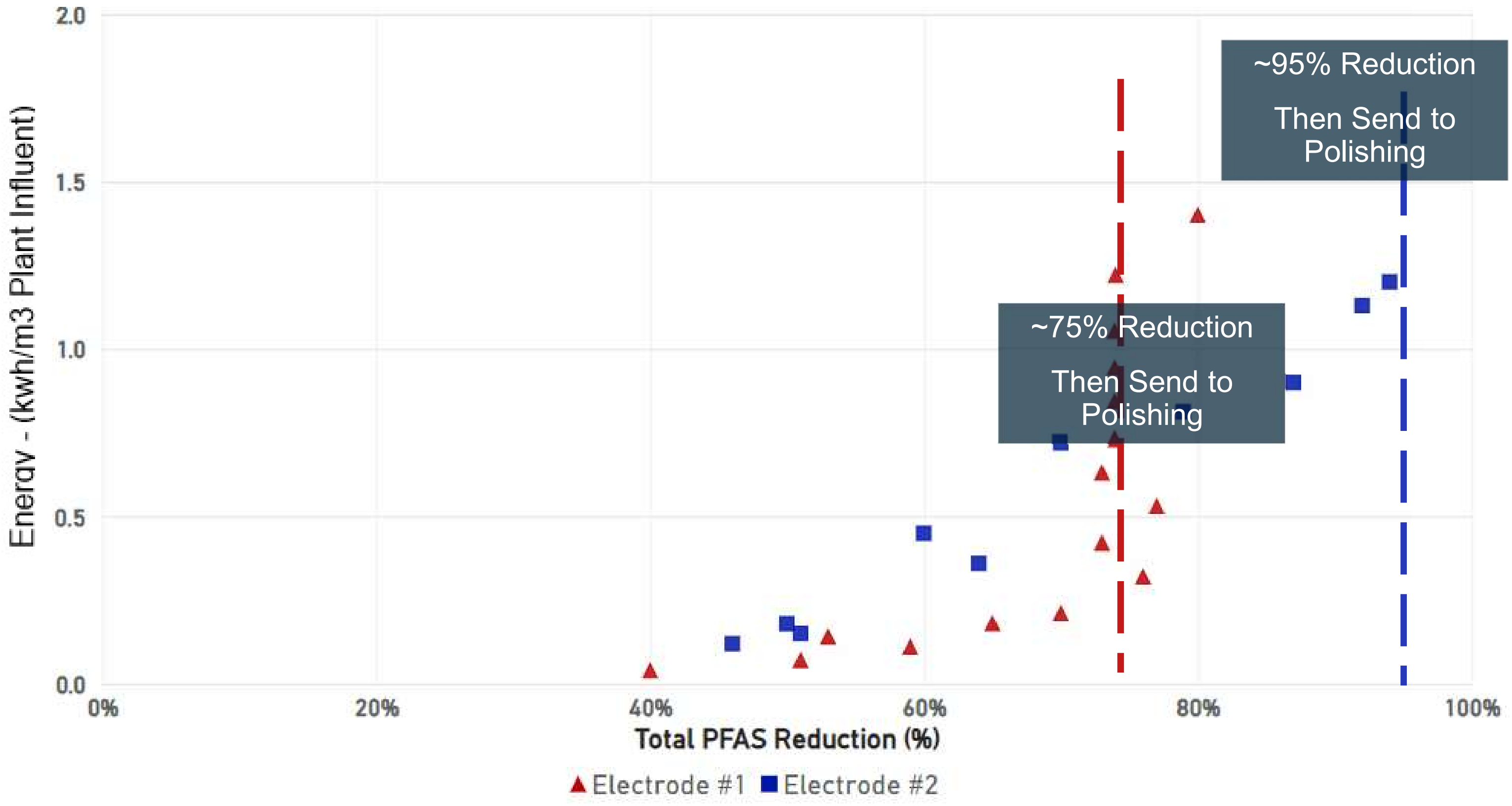




Method: EPA 314

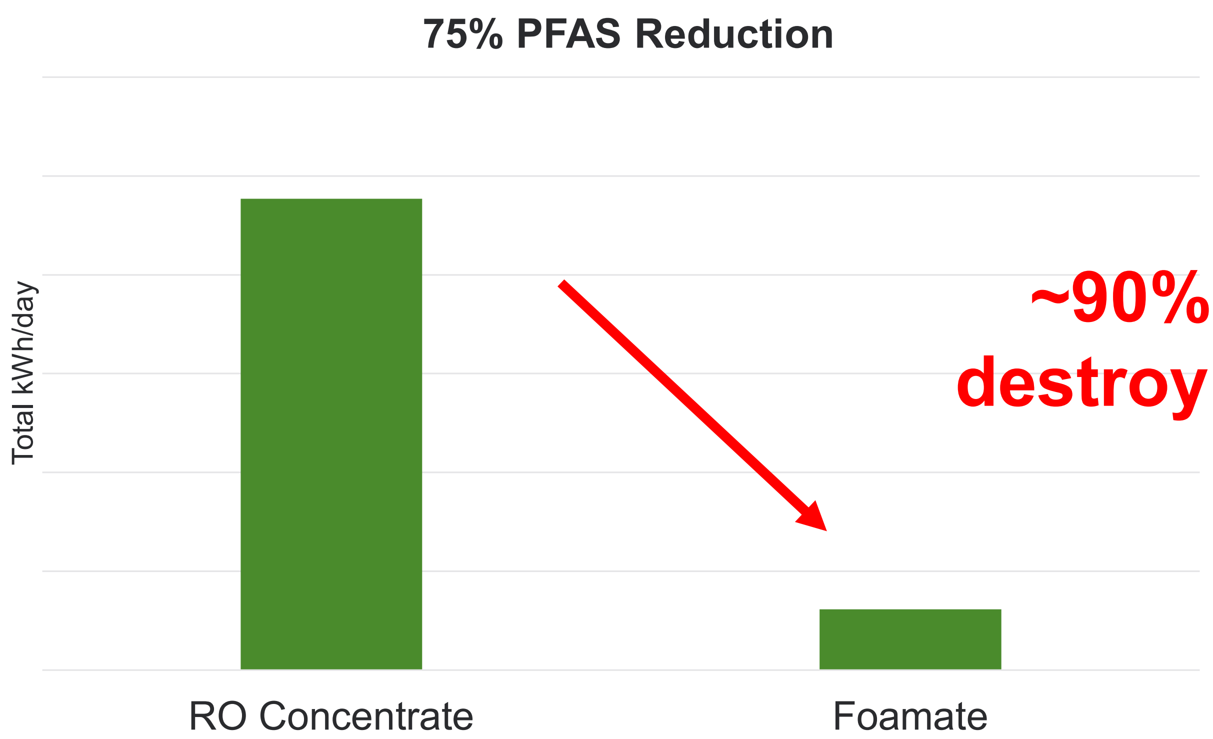
Foam Fractionation (Foamate)

Energy Evaluation



Foam Fractionation (Foamate)

Energy Evaluation



~90% less energy to destroy the same 75% of PFAS

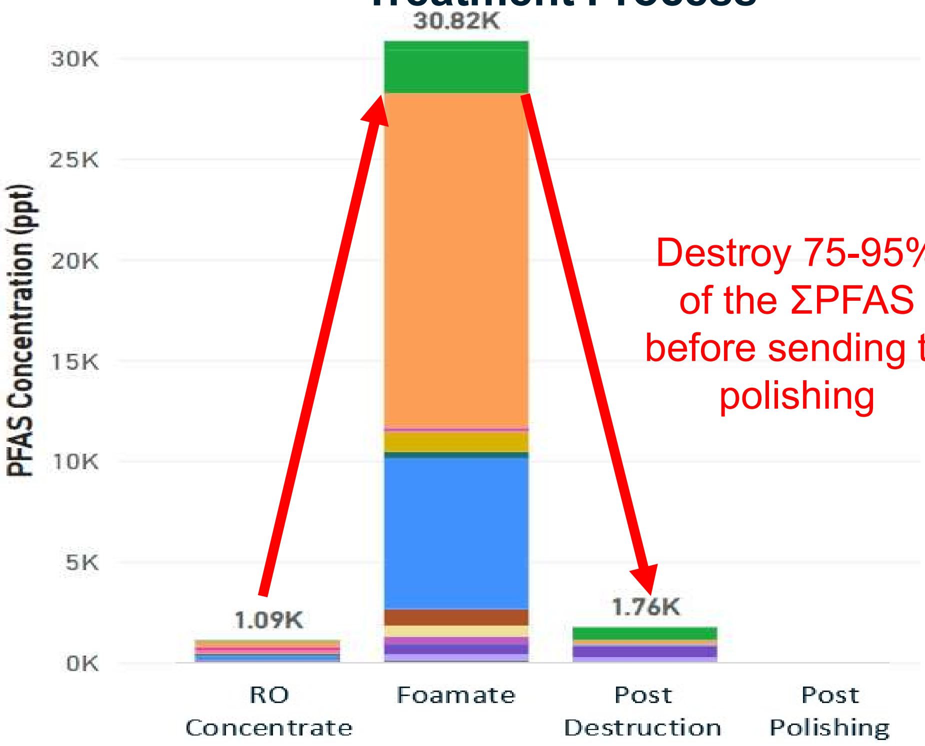
Foam Fractionation (Foamate)

Integrated Solution Summary

PFAS Compound	Units	RO Concentrate	Foamate	Post Destruction	Post Polish
PFOS	**ng/L**	**288**	**16,600**	**191**	**ND**
PFOA	**ng/L**	**224**	**7,480**	**50.6**	**ND**
PFNA	**ng/L**	**ND**	**106**	**ND**	**ND**
PFHxS	**ng/L**	**50.1**	**2,110**	**635**	**ND**
PFBS	**ng/L**	**55.1**	**500**	**565**	**ND**
PFBA	ng/L	143	113	11.1	ND
PFPeA	ng/L	48.9	56.2	5.97	ND
PFBS	ng/L	55.1	500	565	ND
PFHxA	ng/L	81.2	324	8.11	ND
PFPeS	ng/L	9.6	301	265	ND
PFHpA	ng/L	56.4	976	12.3	ND
6:2 FTS	ng/L	ND	27.1	ND	ND
PFHpS	ng/L	7.1	476	14.1	ND
PFOSAm	ng/L	ND	352	1.36	ND
PFDA	ng/L	ND	44.4	ND	ND
NMeFOSAA	ng/L	13.7	554	ND	ND
NEtFOSAA	ng/L	23.6	801	ND	ND

Polishing Removed Perchlorate to ND

PFAS Concentration at The End of Each Treatment Process

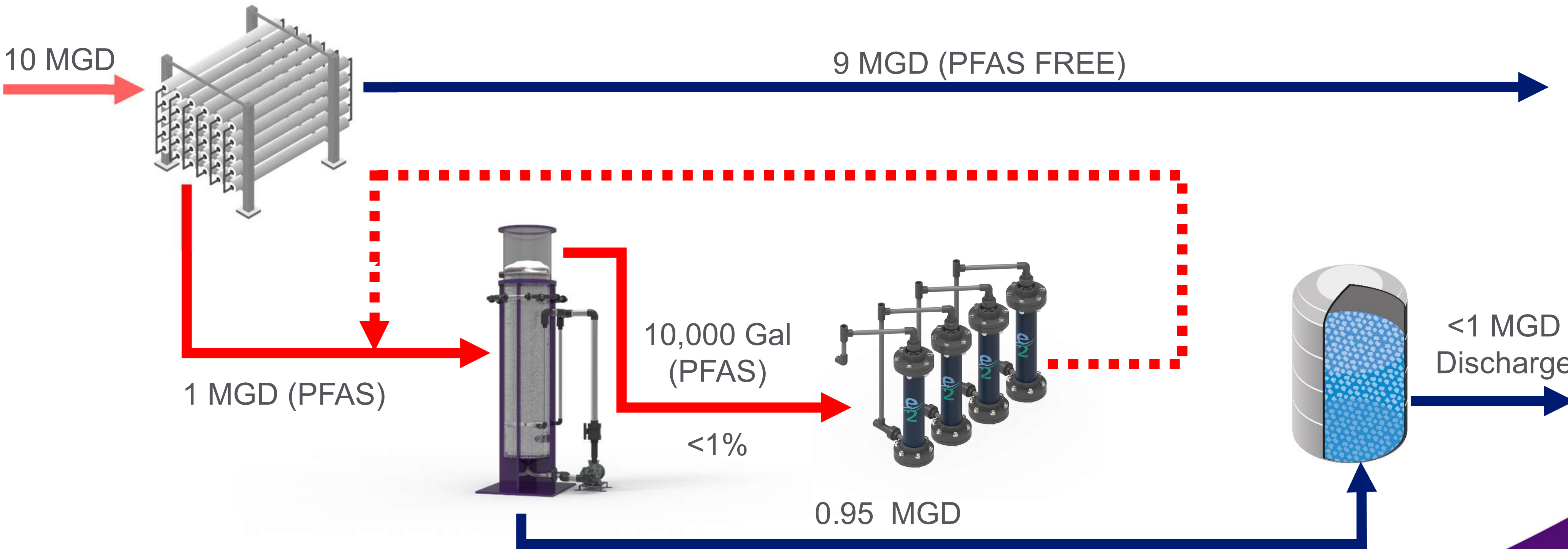


Foam Fractionation Treatment Train (Recycle)

Concentration
Reverse Osmosis Followed by
Foam Fractionation

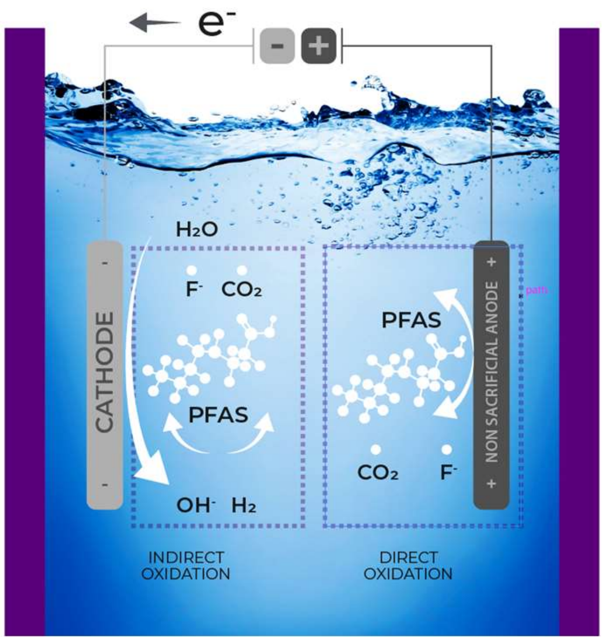
Destruction
Electrochemical Oxidation

Polishing
IX or GAC



Destruction Takeaways

- Electrochemical Oxidation is designed for safe operation onsite by water treatment operators making it well positioned for municipal application in comparison to other energy intensive PFAS destruction technologies.
- When coupled with upstream concentration, destruction is more energy efficient and cost effective.
- A toolbox of solutions both with combining different upstream and downstream removal technologies is needed for large flows and dilute concentrations.
- A team of experts at Ovivo to customize the best approach to meet your treatment goals and objectives.



Overall Solution Takeaways

EVERY WATER IS DIFFERENT

- There will be no one-size fits all solutions for PFAS removal and destruction!

Piloting Testing is Required

- There are so many unknowns with each water type that we all learn a lot through testing

Things to Consider Beyond Removal Efficiencies and Capital Costs

- Safety and ease of operation
- Future availability (demand of media and disposal options)
- Complete lifecycle cost + operating costs
    - Byproduct treatment, disposal costs, transportation, chemicals, media replacement, power, end of life disposal, ect.

THANK YOU!

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Tom Whitton – Business Development Manager

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PEOPLE ADVANCING SCIENCE

PFAS Panel – Analytical

Lindsay Boone, M.Sc.
Technical Specialist, PFAS

Pace®

ADEM Alabama Department of Environmental Management

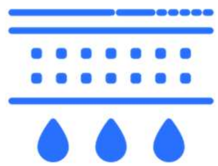
PFAS OVERVIEW

- **Speciated PFAS Test Methods**
- **Organic Fluorine**

MATRICES

CHOOSING THE RIGHT TEST METHODS

Drinking water

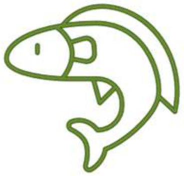


Groundwater, surface water, & leachate

Wastewater, sludge & biosolids

AFFF – concentrate & diluted

Soil, sediment, solid waste & other solids



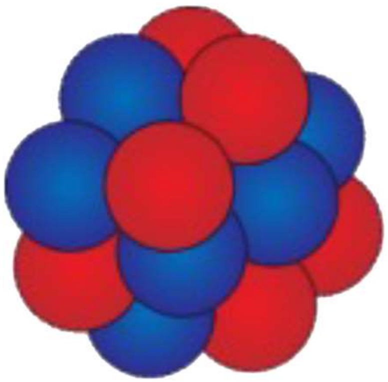
Biota – plant & animal tissue

Consumer & Industrial Products

TEST METHODS DRINKING WATER

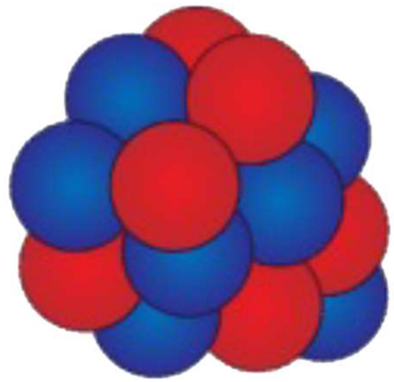
METHOD	EPA 537.1	EPA 533
MATRIX	Drinking Water	Drinking Water
COMPOUNDS	18	25
HOLDING TIMES, DAYS	14/28	28/28
EXTRACTION	Solid Phase (SPE)	Solid Phase (SPE)
QUANTIFICATION	Internal Standard (IS)	Isotope Dilution (ID)
NOTES		Developed for UCMR 5 and additional PFAS. **Does not replace 537.1.**

Isotopes of Carbon



Carbon-12
98.9%
6 protons
6 neutrons

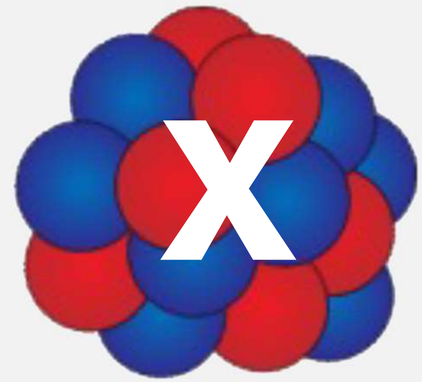
Atomic weight:
12 Da exactly



Carbon-13
1.1%
6 protons
7 neutrons

Atomic weight:
13.00335483521(23) Da

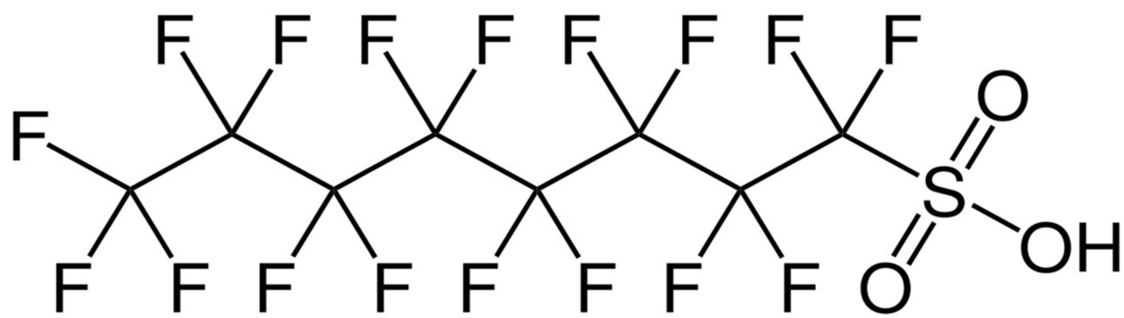
UNSTABLE



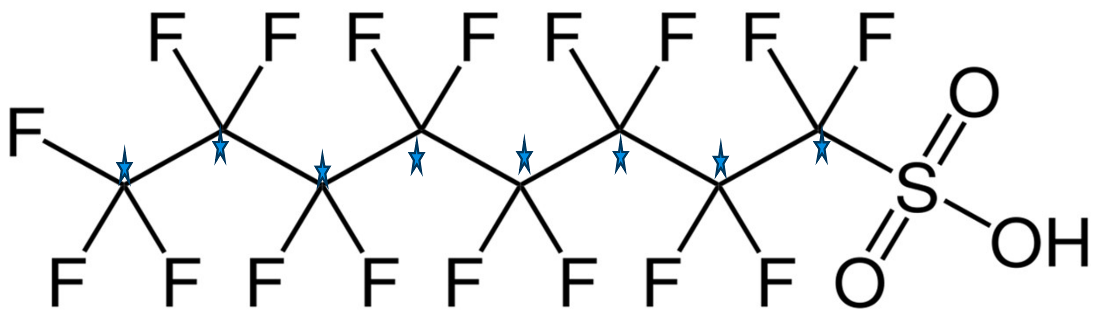
Carbon-14
<0.1%
6 protons
8 neutrons

Atomic weight:
14.003241988(4) Da

The Difference is the molecular weight!



PFOS with ^{12}C
molecular weight 499.937 g/mol



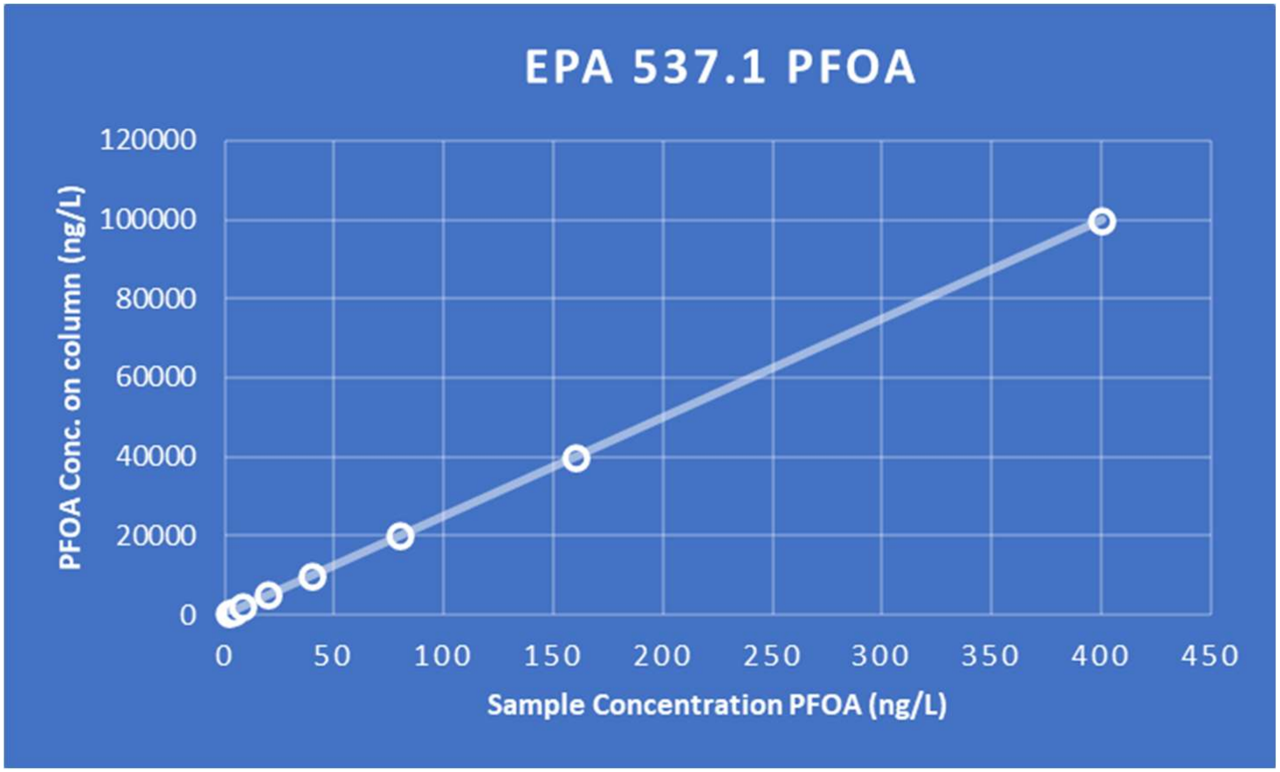
PFOS with ^{13}C
molecular weight 508.205 g/mol

Isotopically labelled PFOS is spiked in your sample and the percentage of labelled analyte not recovered is mathematically accounted for when reporting your native (C12) PFOS

EPA Finalized National Primary Drinking Water Regulations for Six PFAS

Compound	Final MCLG	Final MCL (enforceable levels)
PFOA	Zero	4.0 parts per trillion (ppt) (also expressed as ng/L)
PFOS	Zero	4.0 ppt
PFHxS	10 ppt	10 ppt
PFNA	10 ppt	10 ppt
HFPO-DA (commonly known as GenX Chemicals)	10 ppt	10 ppt
Mixtures containing two or more of PFHxS, PFNA, HFPO-DA, and PFBS	1 (unitless) Hazard Index	1 (unitless) Hazard Index

Calibration Curve of 4.0 ppt for PFOA EPA 537.1



TEST METHODS

DRINKING WATER

- US EPA reports 25 compounds from EPA 533 and 4 that don't overlap from EPA 537.1
- Note: All 29 PFAS in EPA's UCMR 5 for its survey of the nation's public water systems are included in EPA Method 1633

ANALYTE	537.1	533
PFEESA		•
HFPOA-DA/Gen X	•	•
NFDHA		•
PFOS	•	•
PFUdA	•	•
N-MeFOSAA	•	
PFPeA		•
PFPeS		•
6:2 FTS		•
N-EtFOSAA	•	
PFHxA	•	•
PFDoA	•	•
PFOA	•	•
PFDA	•	•
PFHxS	•	•
PFBA		•
PFBS	•	•
PFHpA	•	•
PFHpS		•
PFNA	•	•
PFTeDA	•	
PFMOPrA		•
8:2 FTS		•
PFTrDA	•	
9Cl-PF3PONS	•	•
4:2 FTS		•
11Cl-PF3OUdS	•	•
PFMOBA		•
ADONA	•	•

UCMR 5 Update July 2024 for Regulated Contaminants

Regulated PFAS	MCL (ng/L)[1]	Total number of PWSs with location(s) with a full set of results	Number of PWSs with average(s) greater than MCL	% of PWSs with average(s) greater than MCL
PFOS	4	3,459	316	9.1%
PFOA	4	3,460	246	7.1%
HFPO-DA (GenX chemicals)	10	3,462	1	0.0%
PFHxS	10	3,460	29	0.8%
PFNA	10	3,462	3	0.1%
Hazard Index (HFPO-DA, PFHxS, PFNA, PFBS)	1 (unitless)	3,455	33	1.0%
Total number of unique PWSs with one or more averages greater than MCL = 393 of 3,463 (11%)				

UCMR 5 Update July 2024 for Unregulated Contaminants

Contaminant	UCMR MRL[2] (i.tg/L)	% of total results ≥MRL	Total number of PWSs with results	Number of PWSs with results ≥MRL
lithium	9000	28.1%	6,520	2,248
PFBA	5	8.4%	6,401	1,101
PFHxA	3	9.5%	6,403	1,040
PFDA	3	0.1%	6,403	6
11Cl-PF3OUdS	5	0.0%	6,402	0
8:2 FTS	5	0.0%	6,402	5
4:2 FTS	3	0.0%	6,402	2
6:2 FTS	5	0.5%	6,402	111
ADONA	3	0.0%	6,402	2
9Cl-PF3ONS	2	0.0%	6,402	1
NFDHA	20	0.0%	6,402	3
PFEESA	3	0.0%	6,403	0
PFMPA	4	0.0%	6,403	2
PFMBA	3	0.0%	6,403	1
PFDoA	3	0.0%	6,403	2
PFHpS	3	0.0%	6,403	2
PFHpA	3	2.4%	6,403	311
PFPeS	4	0.2%	6,403	34
PFPeA	3	10.7%	6,403	1,148
PFUnA	2	0.0%	6,403	2
NEtFOSAA	5	0.0%	6,490	1
NMeFOSAA	6	0.0%	6,490	0
PFTA	8	0.0%	6,490	0
PFTrDA	7	0.0%	6,490	0

TEST METHODS

NON-POTABLE WATER & LEACHATE

SOIL & OTHER SOLIDS

BIOTA – PLANT & ANIMAL TISSUE

CWA Analytical Methods for Per- and Polyfluorinated Alkyl Substances (PFAS)

The EPA developed two new analytical methods to test for PFAS compounds in wastewater, as well as other environmental media.

On this page:

- Background
- NEW Method 1633 for 40 PFAS Compounds
- NEW Method 1621 for Adsorbable Organic Fluorine
- NEW Documents
- Related Information

https://www.epa.gov/cwa-methods/cwa-analytical-methods-and-polyfluorinated-alkyl-substances-pfas

TEST METHODS

NON-POTABLE WATER & LEACHATE

SOIL & OTHER SOLIDS

BIOTA – PLANT & ANIMAL TISSUE

EPA 1633

- Valid for 8 matrices - wastewater, surface water, groundwater, soils, biosolids, landfill leachate, biota, and sediment
- Joint EPA/DOD development
- Method is now final
- This method will eventually eliminate the use of “modified” methods/lab-specific SOPs
- There are several important differences between the “modified” method and 1633

EPA 1633 - Features

- Sample Volume Needed varies by matrix
- TSS limitations on aqueous matrices
- Prep restrictions
- Method modifications needed to water samples >100mg/L TSS
- Centrifuge/sub sample/multiple cartridges
- Moisture Content on solids-dry weight reporting
- Biosolid/Sludge limitations

EPA 1633 - Containers

1633 Aqueous Containers

537M/PFAS by ID
(Historical Containers)

Solids Container

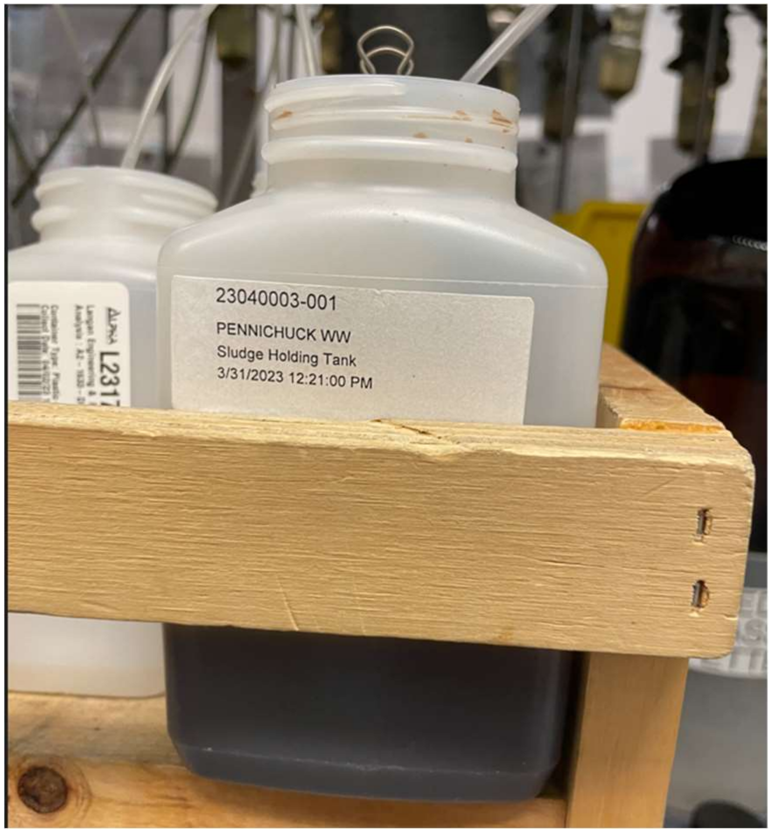
TEST METHODS

NON-POTABLE WATER & LEACHATE

SOIL & OTHER SOLIDS

BIOTA – PLANT & ANIMAL TISSUE

EPA 1633



EPA 1633 - TSS Impacts – something to think about…

Analyte	Liquid ng/L	Solid ug/kg
PFBA	53000	43
PFPeA	86000	96
PFHxA	130000	210
PFHpA	15000	34
PFOA	32000	79
PFNA	1700	3.8
PFDA	1300	3.1
PFUnA	<500	0.32
PFDoA	<500	0.53
PFTrDA	<500	<0.17
PFTeDA	<500	0.26
PFBS	180000	430
PFPeS	<500	1.3
PFHxS	19000	49
PFHpS	<500	0.47
PFOS	5400	14
PFNS	<500	<0.17
PFDS	<500	<0.17
PFDoS	<500	<0.17
4:2FTS	<2000	<0.69
6:2FTS	4800	7.8
8:2FTS	<2000	2.6
PFOSA	<500	<0.17

Analyte	Liquid ng/L	Solid ug/kg
NMeFOSA	<500	<0.17
NEtFOSA	<500	<0.17
N-MeFOSAA	5900	14
N-EtFOSAA	3400	8
NMeFOSE	<5000	4.2
NEtFOSE	<5000	4.9
HFPO-DA	<2000	<0.69
ADONA	<2000	<0.69
9Cl-PF3ONS	<2000	<0.69
11Cl-PF3OUdS	<2000	<0.69
3:3 FTCA	<5000	<1.7
5:3 FTCA	220000	140
7:3 FTCA	32000	28
PFEESA	<1000	<0.35
PFMPA	<1000	<0.35
PFMBA	<1000	<0.35
NFDHA	<1000	<0.35

TEST METHODS

NON-POTABLE WATER & LEACHATE

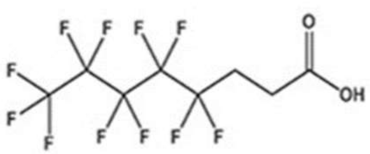
SOIL & OTHER SOLIDS

BIOTA – PLANT & ANIMAL TISSUE

EPA 1633 – 40 PFAS Compounds

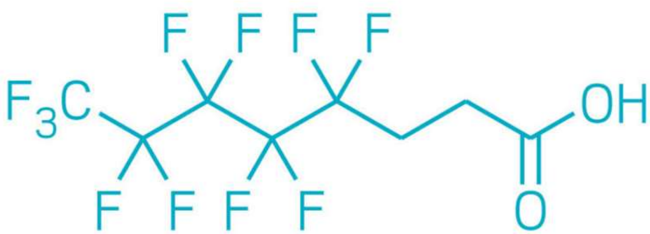
- Addition of Precursors will be insightful these can degrade to terminal PFAS like PFBA
- 5:3 fluorotelomer carboxylic acid (FTCA) is a common and often dominant constituent of PFAS found in landfills and is released from carpet in model anaerobic landfill reactors. This compound could prove to be an indicator of PFAS in the environment originating from landfills (Land et al. 2017, 2016).

5:3 FTCA

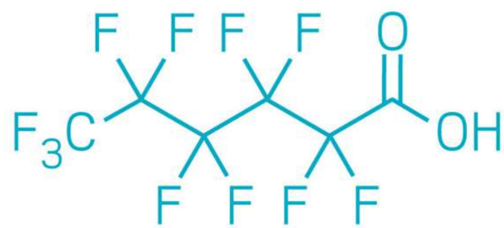


Analyte	Analyte
PFBA	8:2 FTS
PFPeA	PFOSA
PFHxA	N-MeFOSAA
PFHpA	N-EtFOSAA
PFOA	HFPO-DA
PFNA	PFMOPrA
PFDA	ADONA
PFUnDA	9Cl-PF3ONS
PFDoDA	11Cl-PF3OUdS
PFTrDA	**3:3 FTCA**
PFTeDA	**5:3 FTCA**
PFBS	**7:3 FTCA**
PFPeS	N-EtFOSA
PFHxS	N-EtFOSE
PFHpS	NFDHA
PFOS	N-MeFOSA
PFNS	N-MeFOSE
PFDS	PFDoS
4:2 FTS	PFEESA
6:2 FTS	PFMOBA

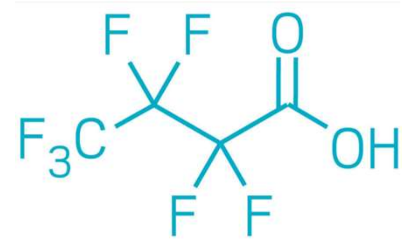
5:3 FTCA has several potential degradation pathways



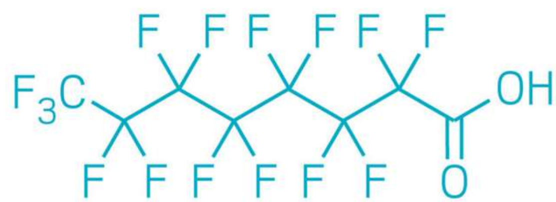
5:3
FTCA



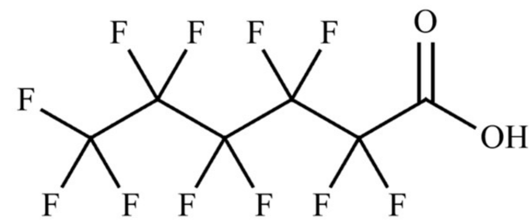
PFHxA



PFBA



PFOA



PFPEA

EPA 1633 – Lower Detection Limits

	Water, ng/L		Solids, µg/kg	
Acronym	LOQ	DL	LOQ	DL
PFBA	4	0.55	0.8	0.14
PFPeA	2	0.29	0.4	0.06
PFHxA	1	0.12	0.2	0.08
PFHpA	1	0.16	0.2	0.03
PFOA	1	0.16	0.2	0.04
PFNA	1	0.17	0.2	0.04
PFDA	1	0.18	0.2	0.04
PFUnA	1	0.18	0.2	0.03
PFDoA	1	0.17	0.2	0.04
PFTrDA	1	0.20	0.2	0.03
PFTeDA	1	0.17	0.2	0.03
PFBS	1	0.10	0.2	0.03
PFPeS	1	0.12	0.2	0.03
PFHxS	1	0.17	0.2	0.03
PFHpS	1	0.11	0.2	0.02
PFOS	1	0.26	0.2	0.05
PFNS	1	0.22	0.2	0.04
PFDS	1	0.15	0.2	0.03
PFDoS	1	0.34	0.2	0.03
PFOSA	1	0.15	0.2	0.05

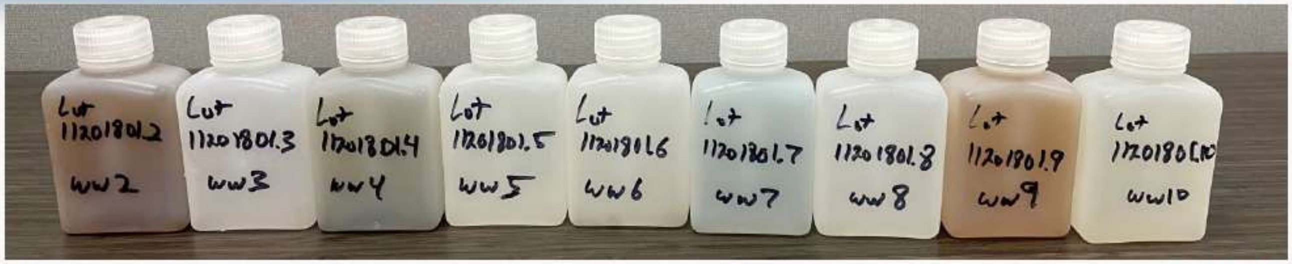
	Water, ng/L		Solids, µg/kg	
Acronym	LOQ	DL	LOQ	DL
NEtFOSA	1	0.14	0.2	0.06
NMeFOSA	1	0.15	0.2	0.03
NEtFOSE	10	2.36	2.0	0.44
NMeFOSE	10	1.52	2.0	0.40
NEtFOSAA	1	0.28	0.2	0.03
NMeFOSAA	1	0.19	0.2	0.05
4:2 FTS	4	0.63	0.8	0.15
6:2 FTS	4	0.95	0.8	0.14
8:2 FTS	4	0.54	0.8	0.13
PFMPA	2	0.32	0.4	0.04
PFMBA	2	0.30	0.4	0.04
HFPO-DA	4	0.89	0.8	0.10
NFDHA	2	0.49	0.4	0.06
ADONA	4	0.57	0.8	0.10
PFEESA	2	0.48	0.4	0.05
9Cl-PF3ONS	4	0.73	0.8	0.08
11Cl-PF3OUdS	4	0.94	0.8	0.11
3:3FTCA	5	1.48	1.0	0.21
5:3FTCA	25	1.88	5.0	1.11
7:3FTCA	25	2.56	5.0	1.00

Note: Detection limits for Leachate are 5× and Biosolids are 10×

P*FAST*®
EPA 8327/ASTM D8421/D8535

- LOQ ~10 ppt
- Pricing is a plus
- Faster on average TAT
- All MCL PFAS included
- All 40 PFAS in EPA 1633
- 44 PFAS Useful for pilot studies, bench scale remediation technologies, destruction technologies
- SW-846 8327 and ASTM D8421 needs vary by regulatory agency

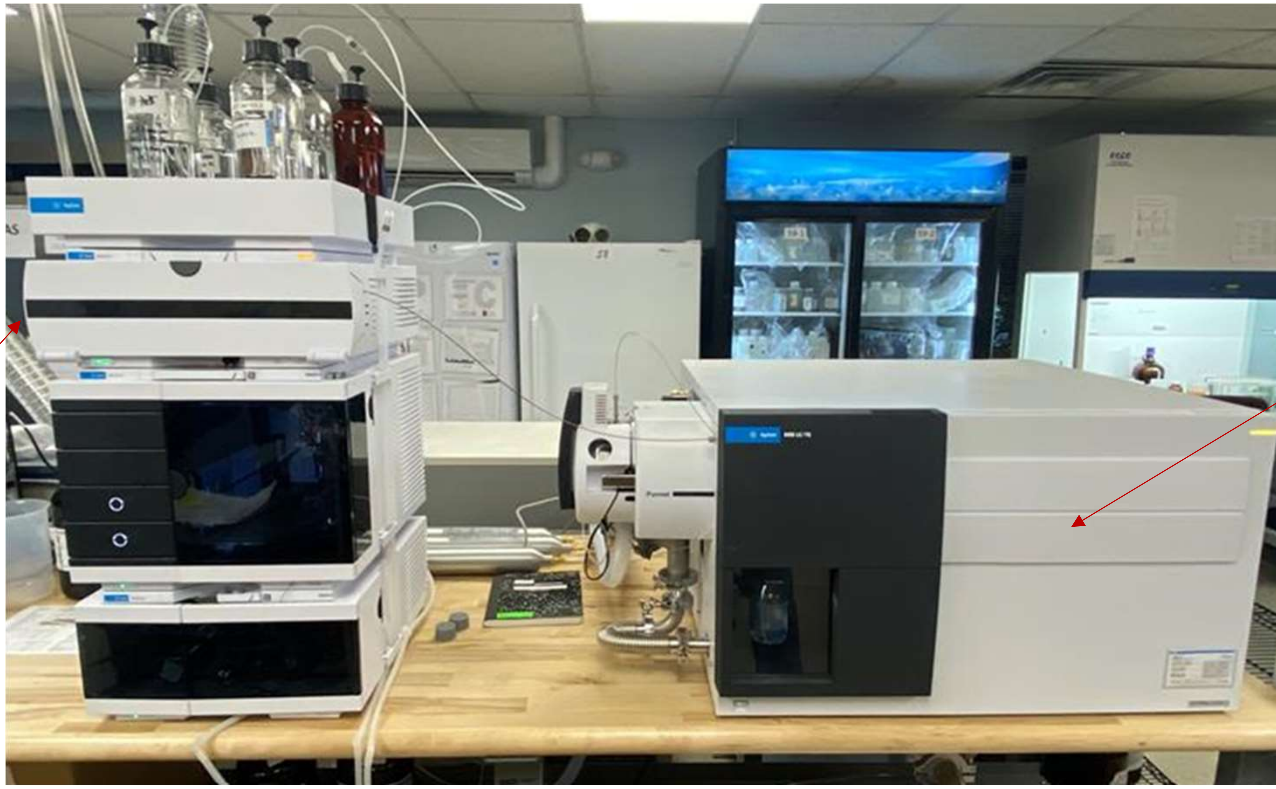
Eleven Matrices



Nine sources supplied by OW/OST/EAD

- Landfill Leachate
- Metal Finisher
- POTW Effluent 1
- Hospital
- POTW Influent
- Bus Washing Station
- Powerplant
- Pulp and Paper
- POTW Effluent 2
- Ground Water
- Surface Water

LC-MS/MS Analysis Instrumentation for Speciated PFAS
Liquid Chromatography Tandem Mass Spectrometry



MS/MS

Mass Spectrometry Detector (Quadrupole)

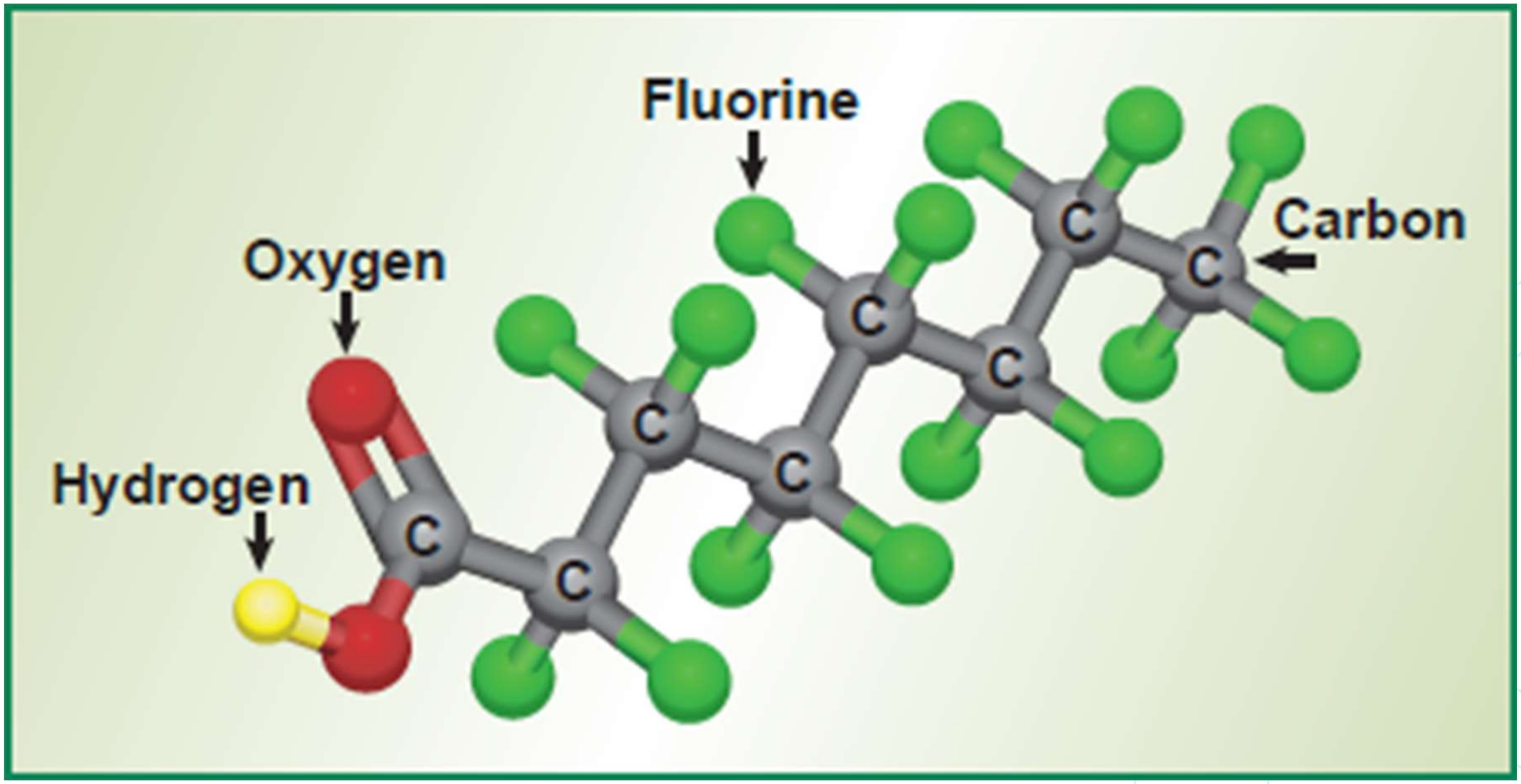
LC

Traditional Liquid Chromatography

PFAS OVERVIEW

- **Speciated PFAS Test Methods**
- **Organic Fluorine**

What is Organic Fluorine?



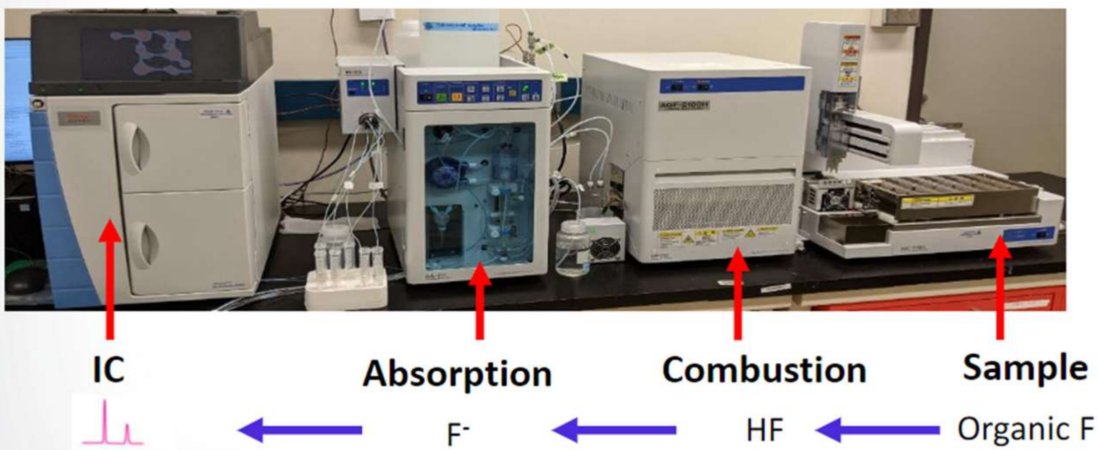
Adsorbable Organic Fluorine (AOF) EPA 1621

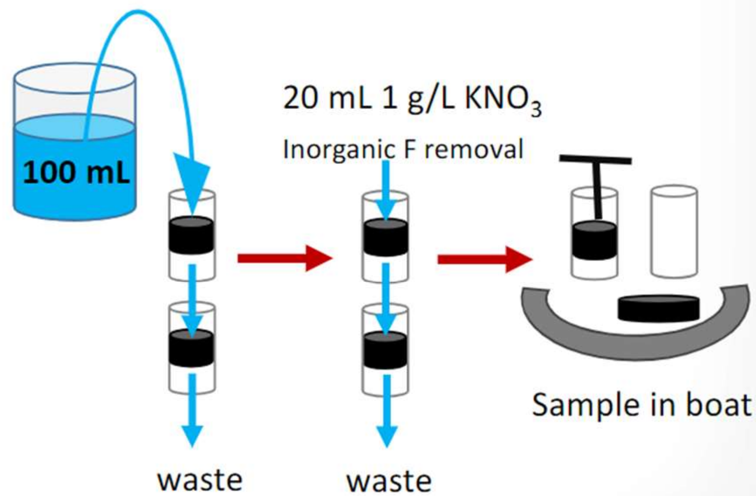
- SCREENING METHOD
- *Method 1621* Screening Method for the Determination of Adsorbable Organic Fluorine (AOF) in Aqueous Matrices by Combustion Ion Chromatography (CIC)
  - "Estimates the concentration of AOF"
  - "…numerical results generated not expected to be as accurate or precise as those from targeted methods for PFAS."
- **Screening data** can support an intermediate or preliminary decision but should eventually be supported by definitive data before a project is complete.
- **Definitive data** should be suitable for final decision-making (of the appropriate level of sensitivity, precision and accuracy, as well as legally defensible).

Approach – AOF/CIC

How:

- Screening method adsorbs contaminants onto granular activated carbon, removal of inorganic fluoride with nitrate solution, followed by combustion of the carbon
- Organofluorine compounds are converted to fluoride in the combustion process and measured by ion chromatography





Method Detection Limit: 1.4 - 2.2 µg/L


PEOPLE ADVANCING SCIENCE
QUESTIONS?
THANK YOU
Additional resources:
• PFAS.com
• PACELABS.COM | Search: PFAS
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Pace®