

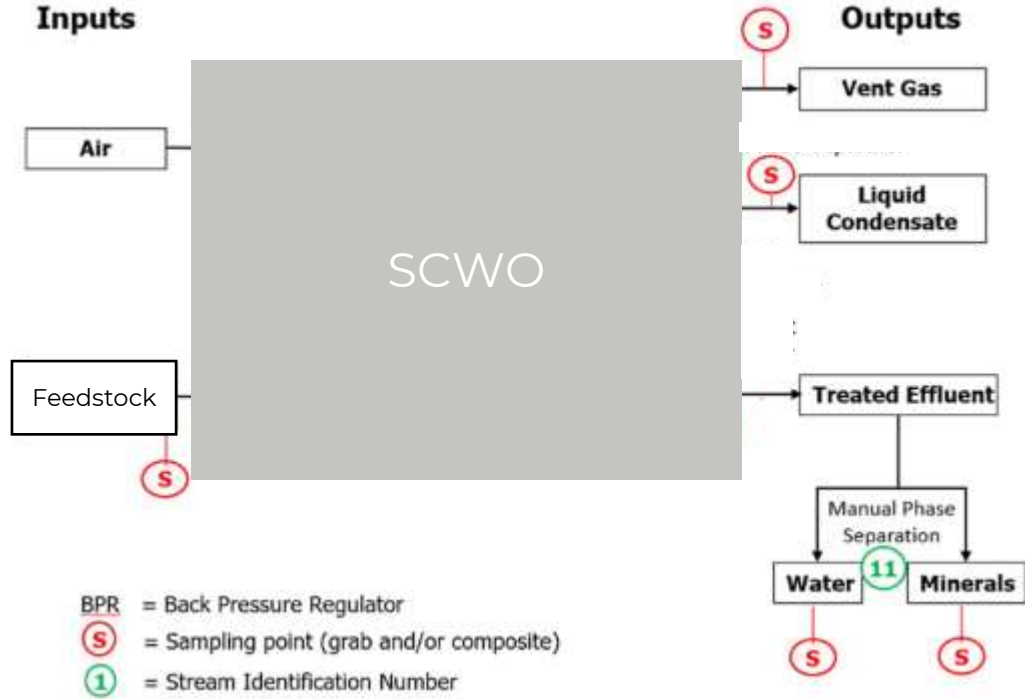
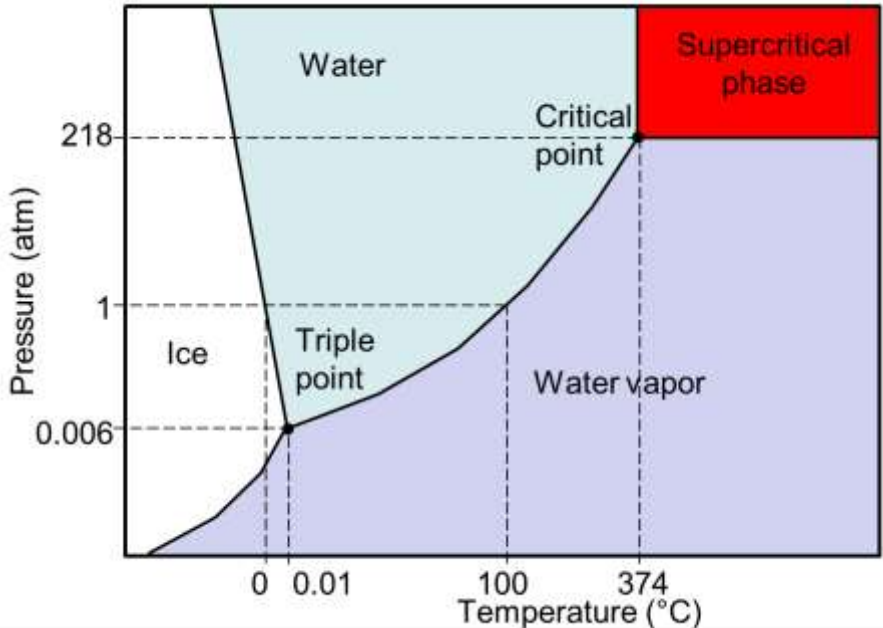
Supercritical Water Oxidation for PFAS Waste Destruction

Dora Chiang, Ph.D., P.E.
Atlanta, GA

April 4, 2024

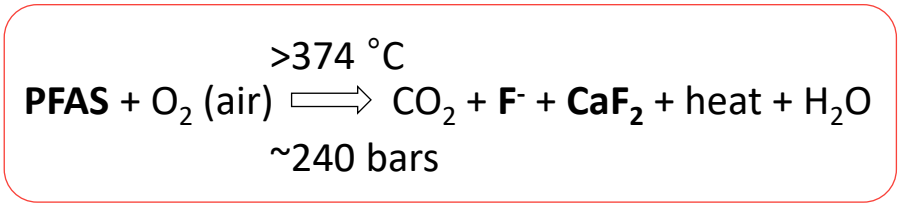


Supercritical Water Oxidation (SCWO)



Source: 374Water

- Water >374°C and pressure of 221.1 bar is considered “supercritical”
- Under these conditions, certain chemical oxidation processes are accelerated



Supercritical Water Oxidation (Liquids and Solids)

Applications

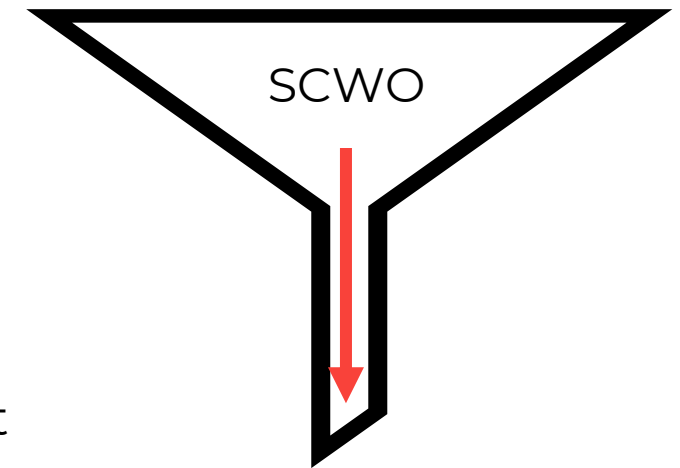
- Liquid: AFFF, AFFF firetruck wash wastewater, leachate, foam concentration,
- Solids: biosolids, sludge
- spent IX, spent GAC (Today's presentation)
- Centralized SCWO station approach

Market Ready

- 374Water AirSCWO™
- General Atomics iSCWO™
- Revive Annihilator™

- ✘ Soil
- ✘ Concrete
- ✘ Items that are not pumpable, or high salt content

Spent AC Spent IX
Leachates Microplastics
Ind. WW Biosolids
AFFF Food wastes
Liquid Conc



CO2 F-  



Supercritical Water Oxidation (Liquids and Solids)

Design Considerations

- Oxidation source (air, oxygen, hydrogen peroxide)
- Air flow rate, corrosion control, temperature profile to heat and cool down, calorific values, feedstock pumpability, GHG generation, energy consumption

Advantages

- SCWO technology is mature
- Complete destruction of PFAS and PFAS-laden solids/liquids
- Short reaction time (in seconds)
- No limit on treatable concentrations
- Work for other COCs

Limitations

- High capital cost for scale-up system
- Energy efficient only when running 24/7
- Inability to treat high salinity feedstock

Acceptance for PFAS destruction

- DOD funded to demonstrate
- Concern about PFAS mass balance and any fluorinated compounds in air emission, GHG generation

Spent PFAS-Laden Media Destruction

- Develop a new approach to effectively, safely and economically destroy PFAS-laden spent media on site without off-site disposal or incineration

Journal of Hazardous Materials 460 (2023) 132264



Contents lists available at [ScienceDirect](#)

Journal of Hazardous Materials

journal homepage: www.elsevier.com/locate/jhazmat



Research Paper

Supercritical water oxidation for the destruction of spent media wastes generated from PFAS treatment

Sheau-Yun Dora Chiang^{a,*}, Matthew Saba^{b,c}, Macon Leighton^{b,c}, David Ballenghien^b, Douglas Hatler^b, Justin Gal^a, Marc A. Deshusses^{b,c}

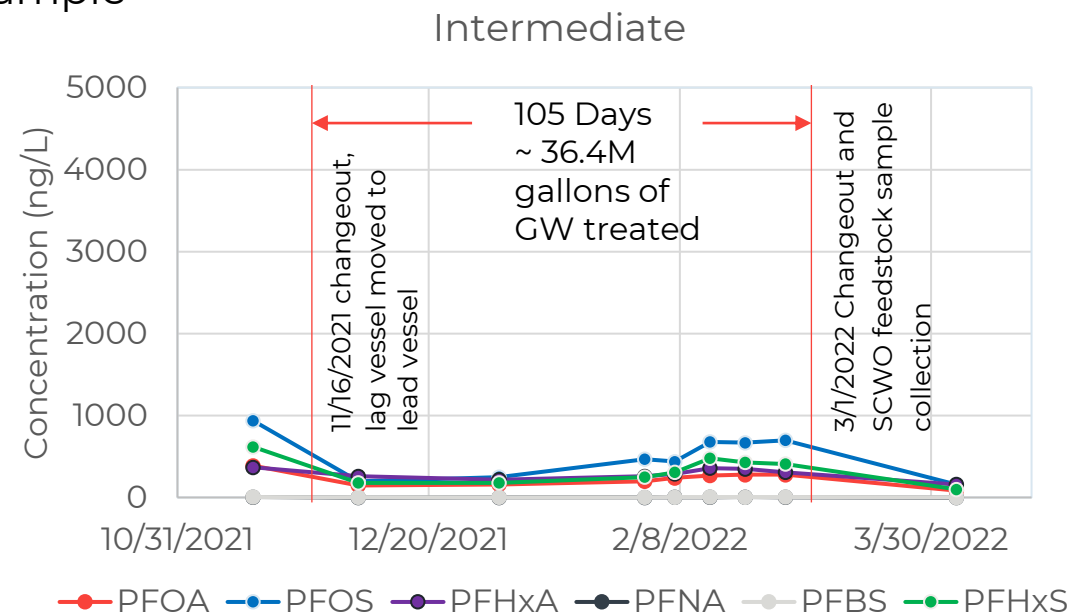
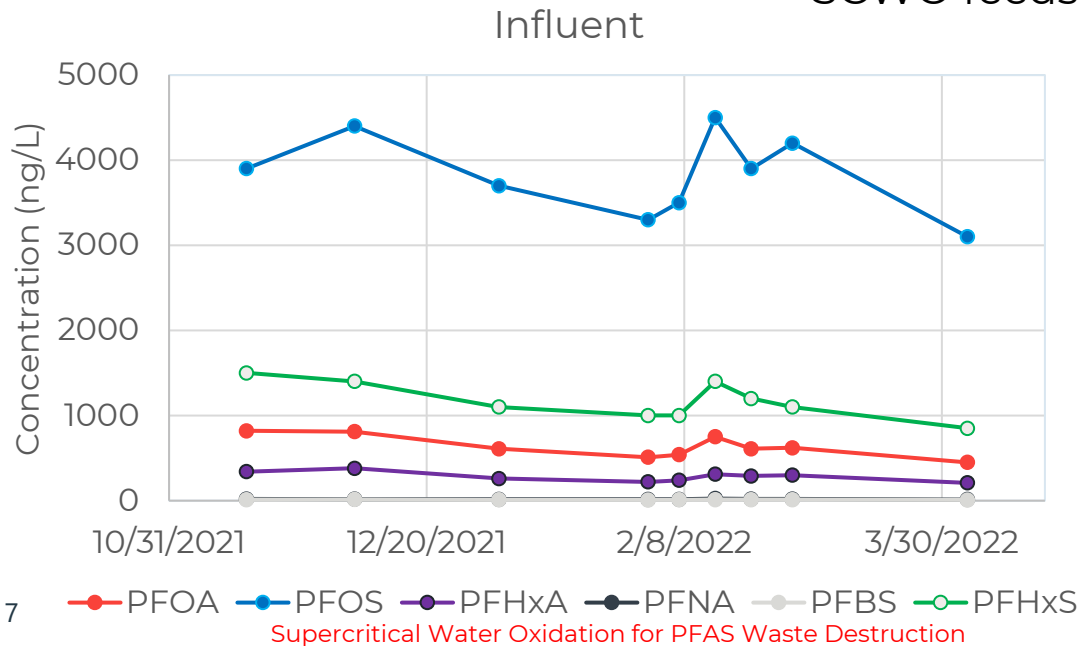
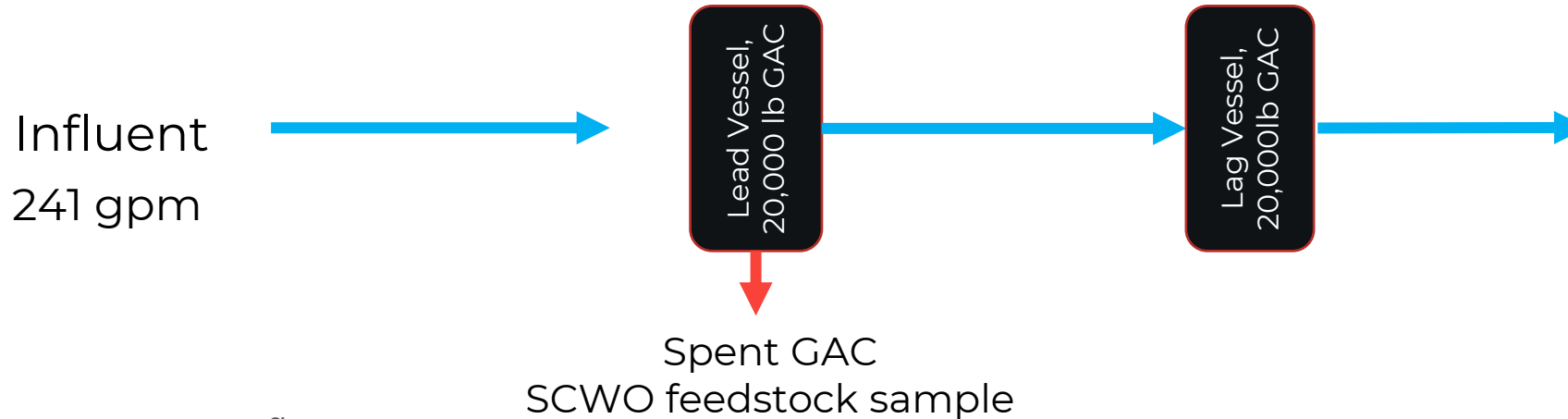
(Funded by WSP USA)

SCWO Feedstock Sample Collection

- **Spent GAC** sample (FT-02) from a full-scale groundwater treatment system
- **Spent AIX** sample (Mission Street) from a full-scale groundwater treatment system
- **Spent AIX** sample (Miramar) from a mobile wastewater treatment system
- Estimated PFAS mass loading on the spent media based on the PFAS treatment system operation and monitoring data
- SCWO treatment using 374Water AirSCWO-1 system

FT-02 Spent GAC Sample

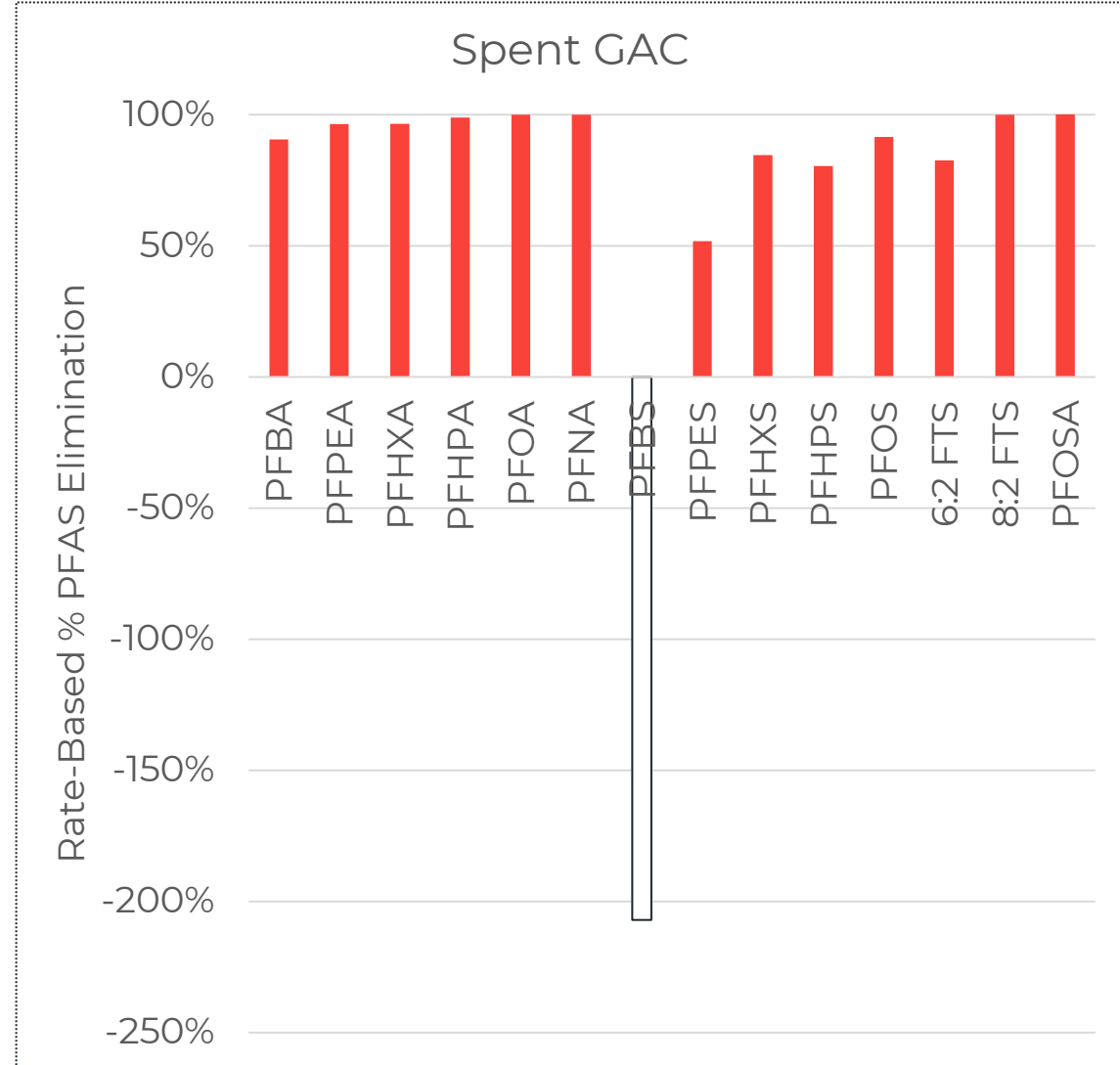
Full-scale PFAS treatment system operated since April 2015



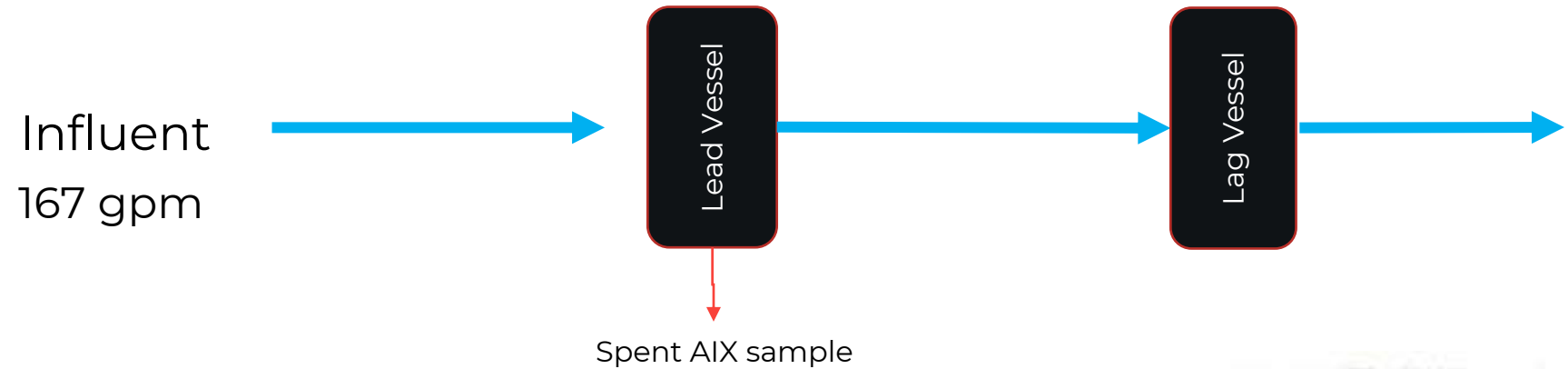
SCWO Treatment Results



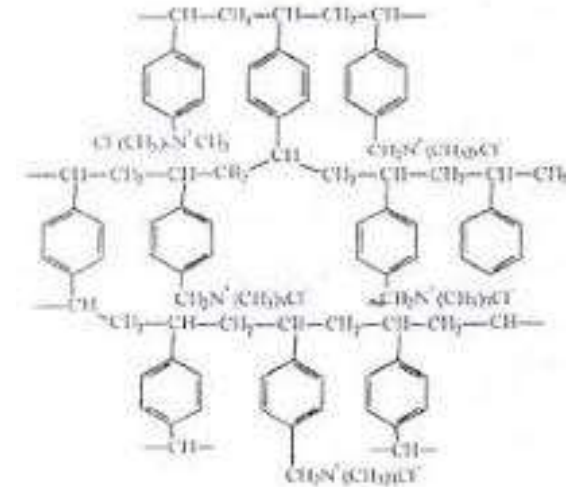
FT-02 Spent GAC	Feedstock (Measured)	Effluent
	ng/kg	ng/L
PFBA	15,035.78	42.6
PFPEA	25,196.78	25.7
PFHXA	33,506.26	28.7
PFHPA	3,364.94	1.14
PFOA	13,059.03	1.1
PFNA	288.82	ND
PFBS	689.62	41.3
PFPEs	514.4	5.09
PFHXS	17,737.03	50.9
PFHPS	928.44	4.62
PFOS	83,935.60	243
6:2 FTS	12,611.81	98.7
8:2 FTS	4,321.11	ND
PFOSA	3,164.58	5.07
Total PFCA	90,451.61	99.24
Total PFSA	103,805.09	344.91
Precursors	20,097.50	103.77
Short chain (C<6)	41,436.58	114.69
Total	214,354.20	547.92



Mission Street Spent AIX Sample



- The lead vessel was operated for 264 days
- 63.4 M gallons of groundwater was treated
- The spent AIX is drained and disposed of at hazardous landfill

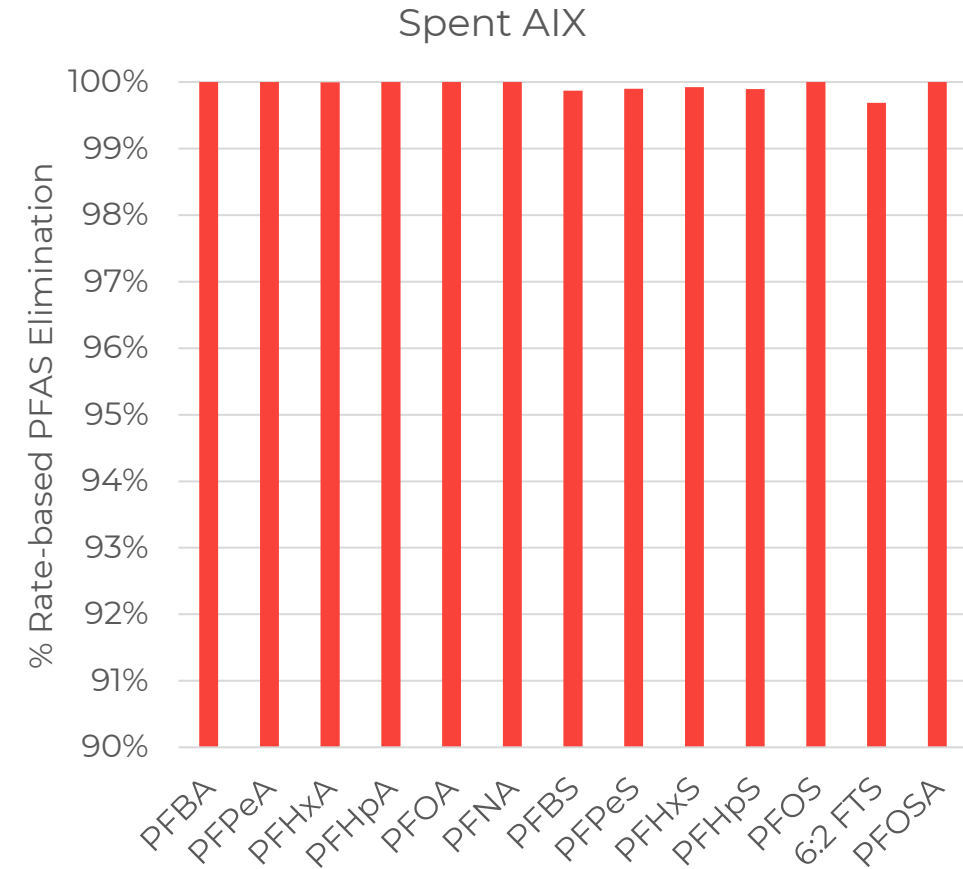


Example of AIX structure

SCWO Treatment Results



Mission Street Spent AIX	Feedstock	Effluent
	ng/kg	ng/L, ppt
PFBA	2,645.65	ND
PFPeA	17,841.45	ND
PFHxA	87,831.90	1.04
PFHpA	31,155.68	ND
PFOA	120,057.31	ND
PFNA	686.53	ND
PFBS	27,153.77	0.47
PFPeS	36,743.08	0.5
PFHxS	555,873.93	6.45
PFHpS	50,687.68	0.71
PFOS	421,776.50	62.7
6:2 FTS	33,256.92	1.39
PFOSA*	182.426	3.74
Total PFCA	260,218.52	1.04
Total PFSA	1,092,234.96	70.83
Precursors	33,256.92	5.13
Short chain (C<6)	84,383.95	0.97
Total	1,385,892.83	77



Miramar Spent AIX Sample

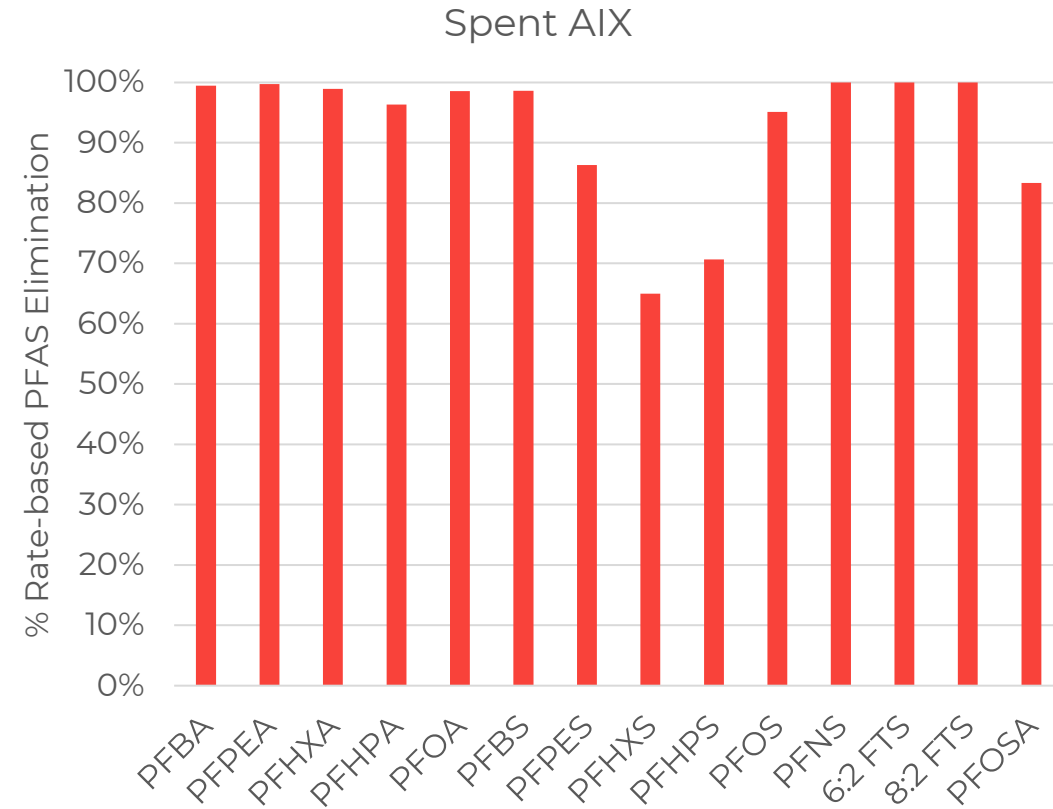
- Wastewater treatment using WSP trailer to reduce PFAS from 8 mg/L to low ng/L for discharge
- Treatment train : organoclay (pre-treatment), GAC (primary treatment), and AIX (polishing treatment).
- COCs: PFAS, metals, TPH, VOC
- Two independent treatment trains of the same configuration
- Maximum operational flow rate of 10 gpm, and total EBCT of 50 minutes
- AIX treated approximately 0.36 M gallons of PFAS-contaminated wastewater



SCWO Treatment Results



Miramar Spent AIX	Feedstock	Effluent
	ng/kg	ng/L, ppt
PFBA	85,907.81	7.82
PFPEA	102,163.69	4.74
PFHXA	33,979.30	7.08
PFHPA	1,641.58	1.01
PFOA	7,515.52	1.82
PFBS	41,279.40	9.55
PFPEs	4,724.37	10.8
PFHXS	33,659.45	198
PFHPS	8,056.44	39.5
PFOS	491,251.18	501
PFNS	180.53	ND
6:2 FTS	77,441.20	ND
8:2 FTS	3,875.82	ND
PFOSA	3,492.94	14.7
Total PFCA	231,207.90	22.47
Total PFSA	579,151.37	758.85
Precursors	84,809.96	14.70
Short chain (C<6)	234,075.27	32.91
Total	895,169.23	796.02



Extractable PFAS from Spent Media using Draft Method 1633

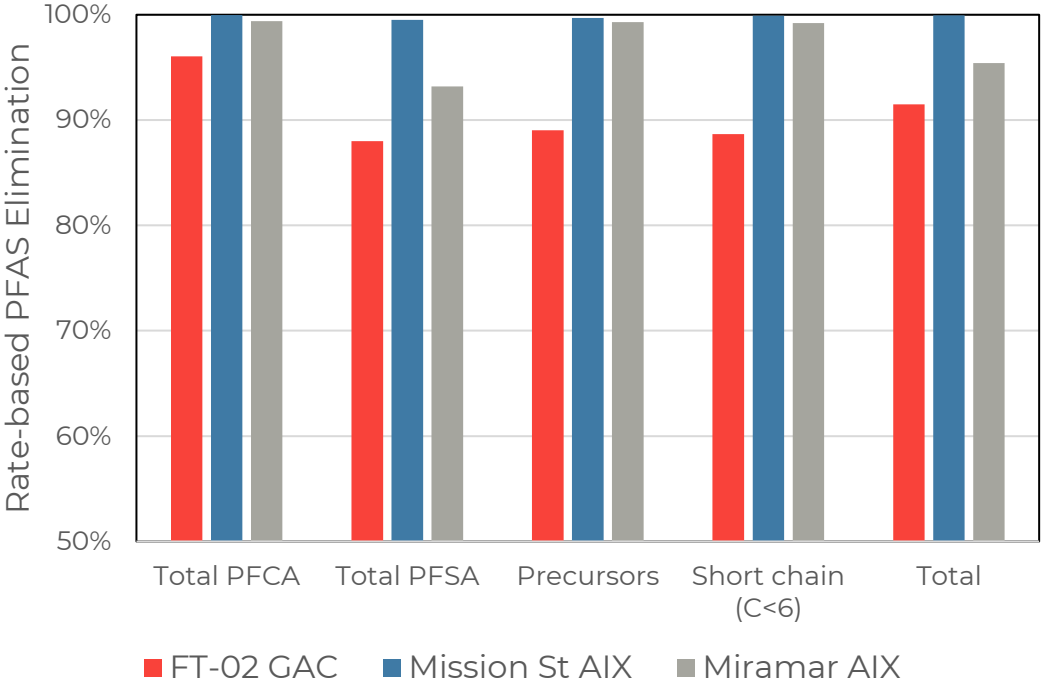
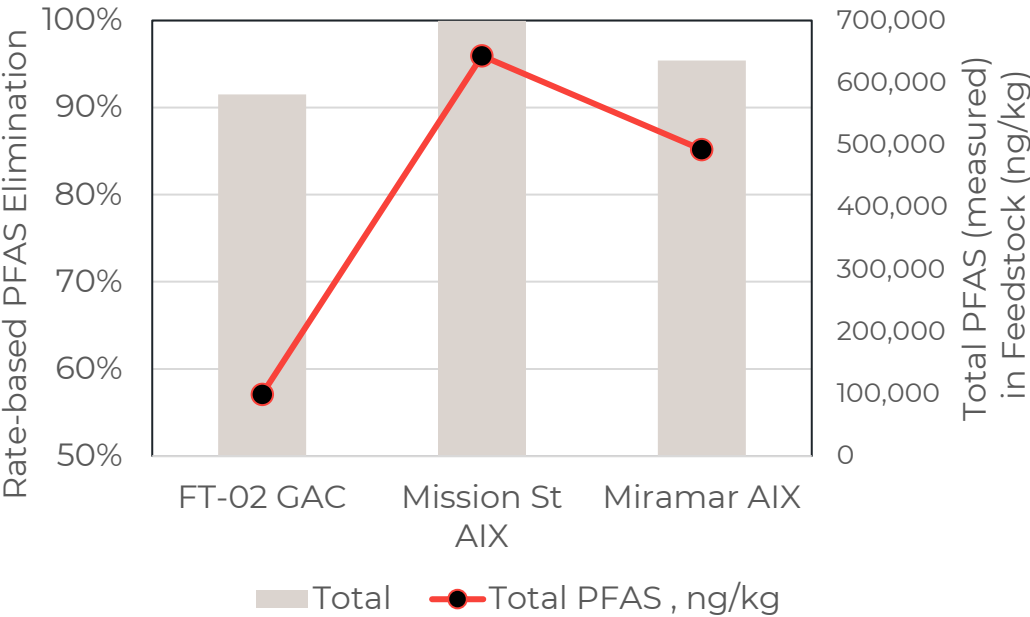
- Low PFAS recovery from spent GAC and AIX
- PFAS elimination %, DRE and fluorine mass balance are not reliable

Mass loading	Calculated in spent GAC	EPA 1633 measured	Measured/Calculated
PFOA, ng/kg	11,045,123	13,059	0.12%
PFOS, ng/kg	59,622,929	83,936	0.14%

Mass loading	Calculated in spent AIX	EPA 1633 measured	Measured/Calculated
PFOA, ng/kg	1,658,988,799	120,057	0.007%
PFOS, ng/kg	13,863,759,680	421,776	0.003%

Summary

- The study proves the concept that SCWO can destroy spent PFAS-laden GAC and AIX



- Measured PFAS concentrations in feedstock may be underestimated

Next Steps

- Lab scale testing Q2 2024
 - *PFAS destruction*
 - *F mass balance*
 - *Factors governing PFAS destruction*
 - SCWO reaction time
 - Sorbent media structures
 - Feedstock composition
 - Energy consumption
- Field Demonstrations Q4 2024-Q4 2025
 - *Full-scale AIX vessel*
 - *Full-scale GAC vessel*
- Life cycle cost and sustainability assessment
- Develop robust PFAS performance monitoring program



Acknowledgement

WSP Team

Justin Gal
Kevin Olness
Nathan Hagelin

374WATER^o

Marc Deshusses, Ph.D.

SGS/AXYS Laboratory



Thank You

Dora Chiang, Ph.D., P.E. | dora.chiang@wsp.com | Atlanta, GA

