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Repelling the Repellent – PFAS Considerations for Water and Wastewater Utilities

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2020 NEWEA Conference
January 2020

Agenda

- PFAS Overview
- PFAS Management Strategies
  - ✓ Potable Water
  - ✓ Industrial
  - ✓ Wastewater
- State of Michigan Wastewater PFAS Study
- Emerging Treatment Technology – Electrochemical Oxidation

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PFAS Overview: Uses

Aerospace

Apparel

Building and Construction

Chemicals and Pharmaceuticals

Electronics

Oil & Gas

Energy

Healthcare and Hospitals

Aqueous Film Forming Foam

Semiconductors

PFAS Overview: Sources

Refineries

Emergency Response

Wastewater Treatment Plants

Biosolids Application

Metal Plating

Manufacturing

Landfills and Waste Disposal Areas

Airports

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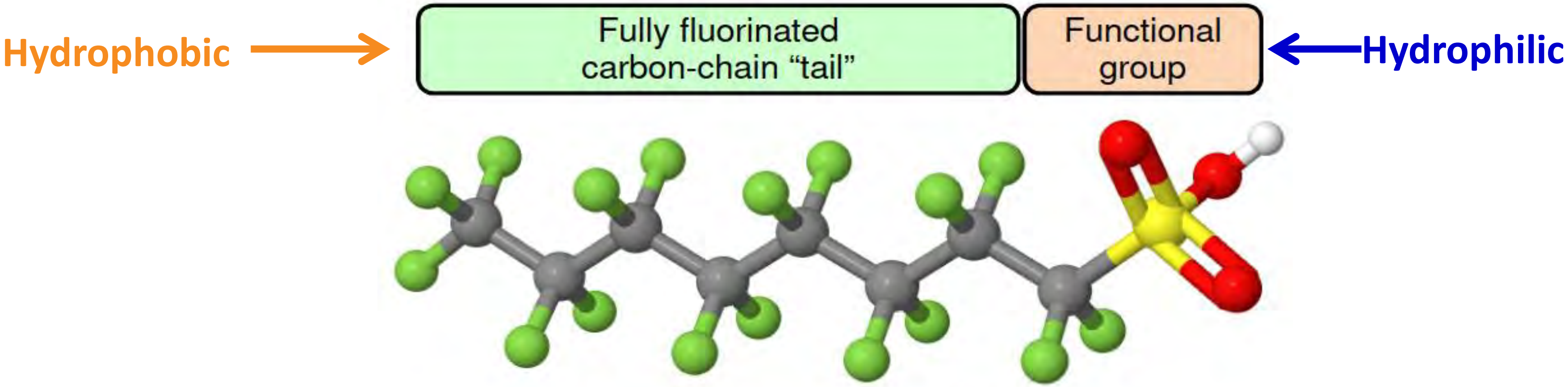
Fluorinated Chemistry Overview

Class of >6,000 synthetic compounds that are *persistent, bioaccumulative, and toxic* at very low concentrations

Carbon-fluorine bonds:

- Very strong (the strongest chemical bond), very soluble, not volatile
- Resists thermal, chemical, and biological degradation
- Surfactant, reduced surface tension
- Hydrophobic (repels water) *and* oleophobic (repels oil/fat/grease)

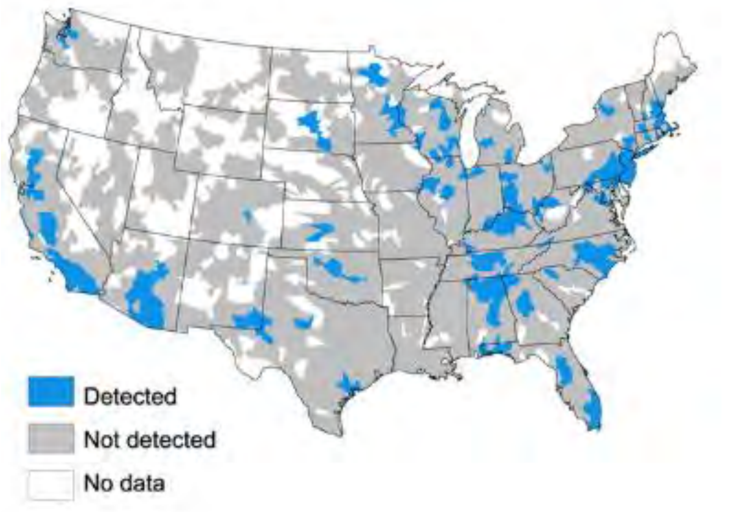


e.g. Per-fluorinated - PFOS

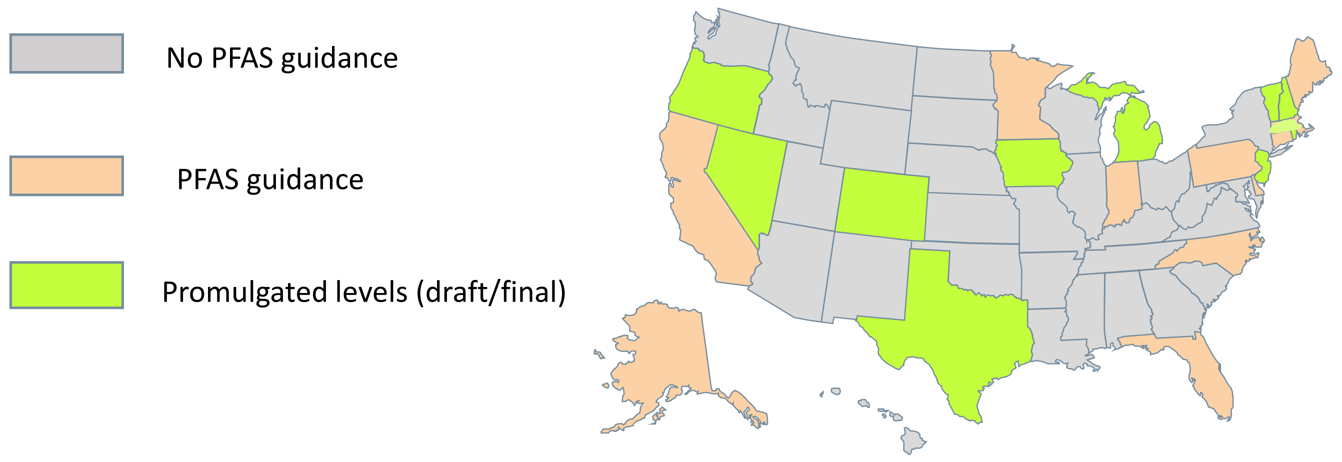
PFAS Overview: Occurrence and Regulation

- US Department of Defense (DoD) and industrial manufacturers proactively investigating PFAS liability and potential response actions
- Federal drinking water Health Advisory (HA) of 70 parts per trillion (ppt); 19 states have independent standards
- Massachusetts – Draft MCL (December 2019) for 20 ppt (Total of PFOA, PFOS, PFNA, PFHpA, PFHxS, PFDA)

Hydrological units with detectable PFAS[1]



PFAS Regulations

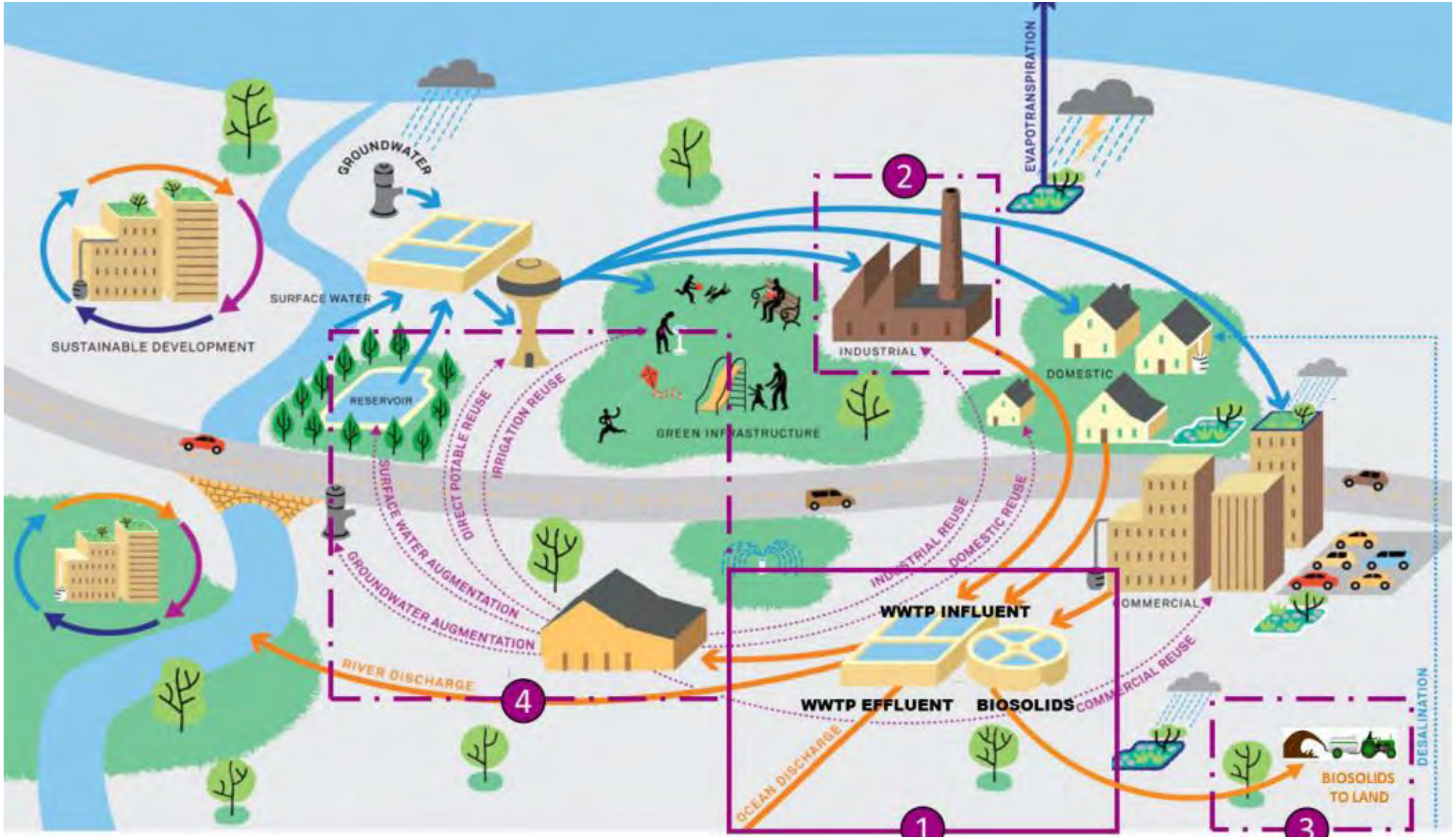


*CDC, Federal, CA, MN, VT are advisories, MI, NH, MA, NY, NJ are proposals.

1:*Hu XC et al., Environmental Science & Technology Letters, 2016.*
2: Barclays research, NHPR

PFAS Management Strategies

One Water Perspective: PFAS in Water Cycle



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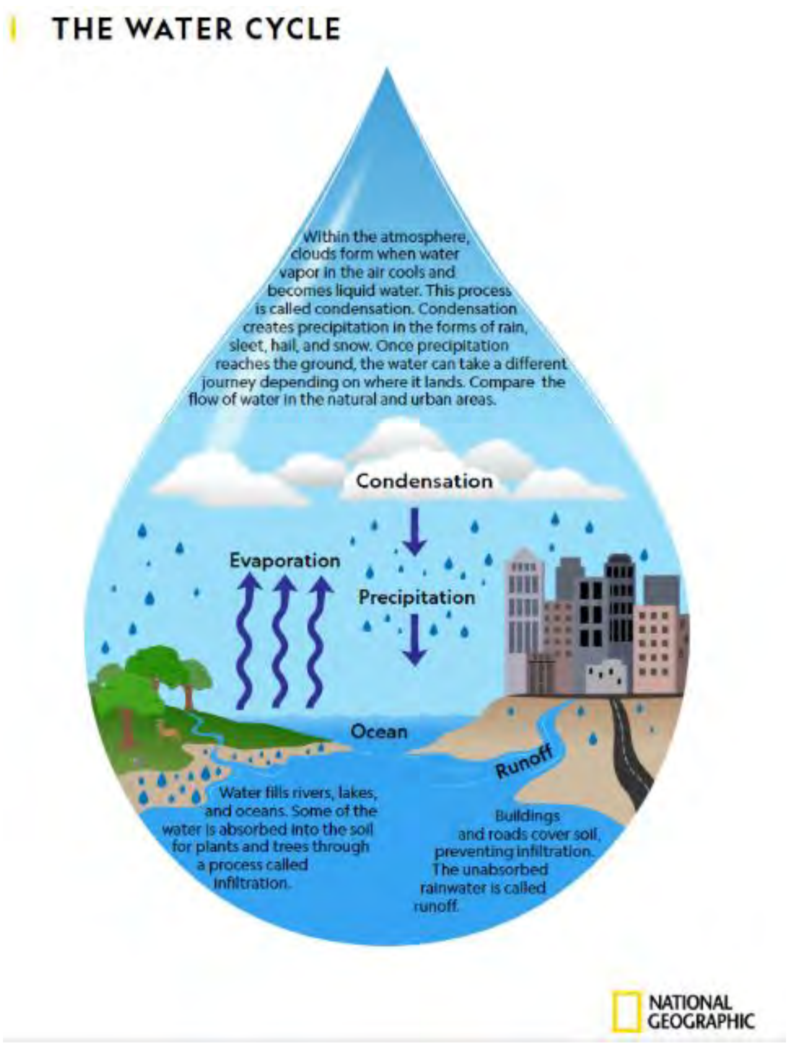
One Water Perspective: PFAS Management Strategies

- Management at Water Supply
  - o Municipal treatment
  - o Management of Source Waters when Possible
  - o Point of use treatment

- Treatment/Control at Source Areas
  - o Primary use sites (DoD, Manufacturing, Aviation)
  - o Spill Sites
  - o Landfill leachate
  - o Industrial pretreatment facilities

- Wastewater Treatment Plants (WWTP)
  - o Influent reduction via pretreatment
  - o Effluent treatment (including biosolids)



PFAS Potable Water Management Considerations

PFAS Management: Drinking Water

– Immediate Driver: Quick Response Needed

– Water Source / Conveyance Perspective

– PFAS treatment technologies

- GAC and IXR are default
- IXR may be used as polishing step for GAC
- Reverse Osmosis

– All result in PFAS-contaminated waste

– Water chemistry and pretreatment considerations prevail

Pictured: AECOM Project Site in West Virginia with Installation of GAC Vessels for Well Water Supply from July 25, 2019.

PFAS Management: Drinking Water

Municipal Potable Systems

- Granular Activated Carbon Plants (9 WTPs)
- Integration into process / wastewater mgmt
  - Fe/Mn Removal Plants
  - Softening Plants (with Cationic IX Resins)
  - Direct Disinfection
  - Varying Pumping/Pressure Conditions
  - Backwash Capabilities
  - Flood Plain Considerations

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PFAS Management: Drinking Water

- Lead/lag vessels treating treat PFAS from < 1 µg/L to 22 µg/L
- GAC changeout criteria: 15 ng/L (lag beds)
- Annual O&M of $1.4MM for 8 PSDs (total ~ 0.4 mgd)

Treatment Location	Influent PFOA Concentration (µg/L)		Operating Time Between Changeout (Months)			Total Volume Treated (million gallons)
	min	max	min	max	average	
PWS-1	0.138	0.49	4	11	**8**	2,948
PSW-2	0.19	1.2	2	6	**4**	420
PWS-3	1.8	14	2	4	**3**	2,150
PWS-4	0.24	1.3	2	10	**5**	2,121
PWS-5	0.0119	0.107	4	22	**7**	3,454
PWS-6	<0.001	0.021	6	17	**12**	627
PWS-7	<0.0032	0.041	6	18	**11**	395
PWS-8	0.0035	<0.021	10	13	**12**	660
Total Volume Treated*						**12,775**

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PFAS Industrial Management Considerations

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PFAS: Industrial Treatment

***Chemical Manufacturer,* Virginia**

INDUSTRIAL FACILITY

- 450 gpm Design
- Complex and active industrial site
- 4 extraction alignments (varying water quality)
- Pretreatment – significant Fe, Mn, Al, competing VOCs
- Residuals management

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PFAS Wastewater Management Considerations

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PFAS Management: WWTPs

- WWTP
  - Not source but natural collection point
- Occurrence affected by:
  - Geography-urban/rural
  - Type / number of industrial dischargers within sewershed or trucked to receiving stations
  - Past / current PFAS from groundwater or atmosphere entering during wet weather events via inflow and infiltration
- Fate affected by:
  - Seasonal variability
  - Treatment processes
  - Sludge Retention Time (SRT) and Hydraulic Retention Time (HRT)
  - Advanced treatment processes

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PFAS Management Challenge: Biosolids and Residuals

- Transfer PFAS from liquid phase to solid phase
  - WTP residuals
    - o Spent GAC and IXR
  - WWTP Biosolids
    - o Land Application
    - o Landfilled
- Transfer PFAS from liquid phase to gas phase
  - Incineration of spent GAC and IXR

PFAS still resides in the environment

State of Michigan WWTP PFAS Study

Aerial photo of the Grand Rapids wastewater treatment plant along the Grand River. (*City of Grand Rapids*)

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Study of Michigan WWTPs

WASTEWATER FACILITIES

- AECOM Study on Occurrence and Fate of PFAS in WWTP Facilities
  - Over 90 WWTPs
  - Largest (930 MGD)
  - Various treatment processes
  - Observe PFAS detection in all WWTPs and PFAS transformation through process of select facilities

Ambient Water Quality Standard (WQS) (ng/L)		
	PFOA	PFOS
Non-Drinking Water Source	12,000	12
Drinking Water Source	420	11

As of 8-29-2019 – 93 WWTPs

Bin 1: 42
No sources PFOS/PFOA found

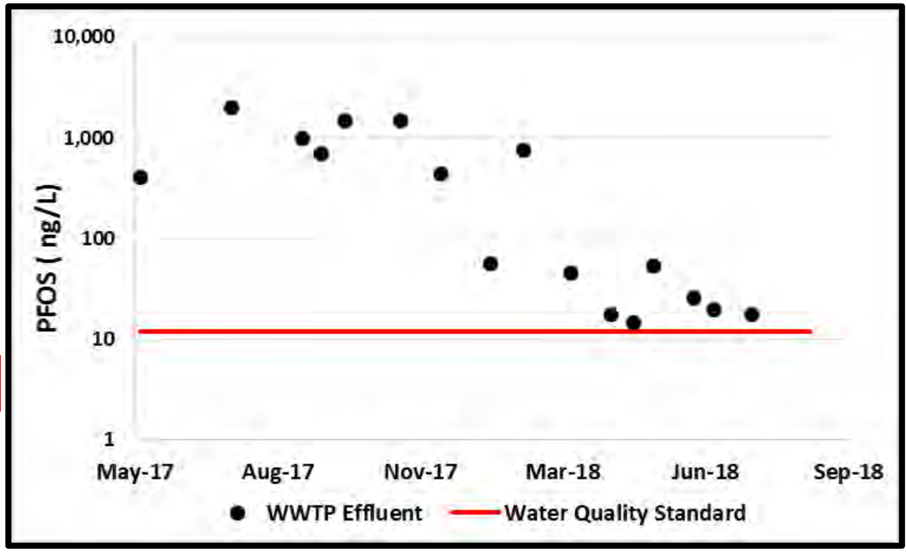
Bin 2: 25
Sources found but POTW Effluent ≤WQS[1]

Bin 3: 26
Sources found and POTW Effluent >WQS[1]

Industrial PFAS Source Contribution Analysis

SIU Sampling Source Identification (March 2019)

Industry	# of SIUs	# Significant Source	PFAS Range for Significant Sources (ngms/l)		# Not Significant Source
			PFOA	PFOS	
Airfields	2	2	21-140	220-240	--
Aluminum	1	--	ND	ND	1
Centralized Waste Treatment	7	6	10-1790	30-350	1
Chemical	3	2	28-120	310-840	1
Electroplating & Metal Finishing	83	18	ND-30	20-9,750	65
Groundwater	2	2	43614	14-96	--
Hospital	1	--	ND	ND	1
Iron & Steel	3	--	ND	ND	3
Landfills	13	13	ND-840	15-700	--
Laundry	3	2	ND-20	40-50	1
Leather Processing	2	1	43	14	1
Paint Formulating	1	1	20	60	--
Petroleum Refining	1	1	3.5-620	18-800	--
Plastics	2	--	ND	ND	2
Tank Cleaning	1	1	280	140	--
Other	13	3	ND-5	ND	10
Total w/Data	**138**	**52**			**86**



Example of Effectiveness of Source Reduction Strategies with Industrial Discharges to the System Resulting in PFOS Decreases over Time

(AECOM Michigan Study, 2018-2019)

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Michigan PFAS Initiative

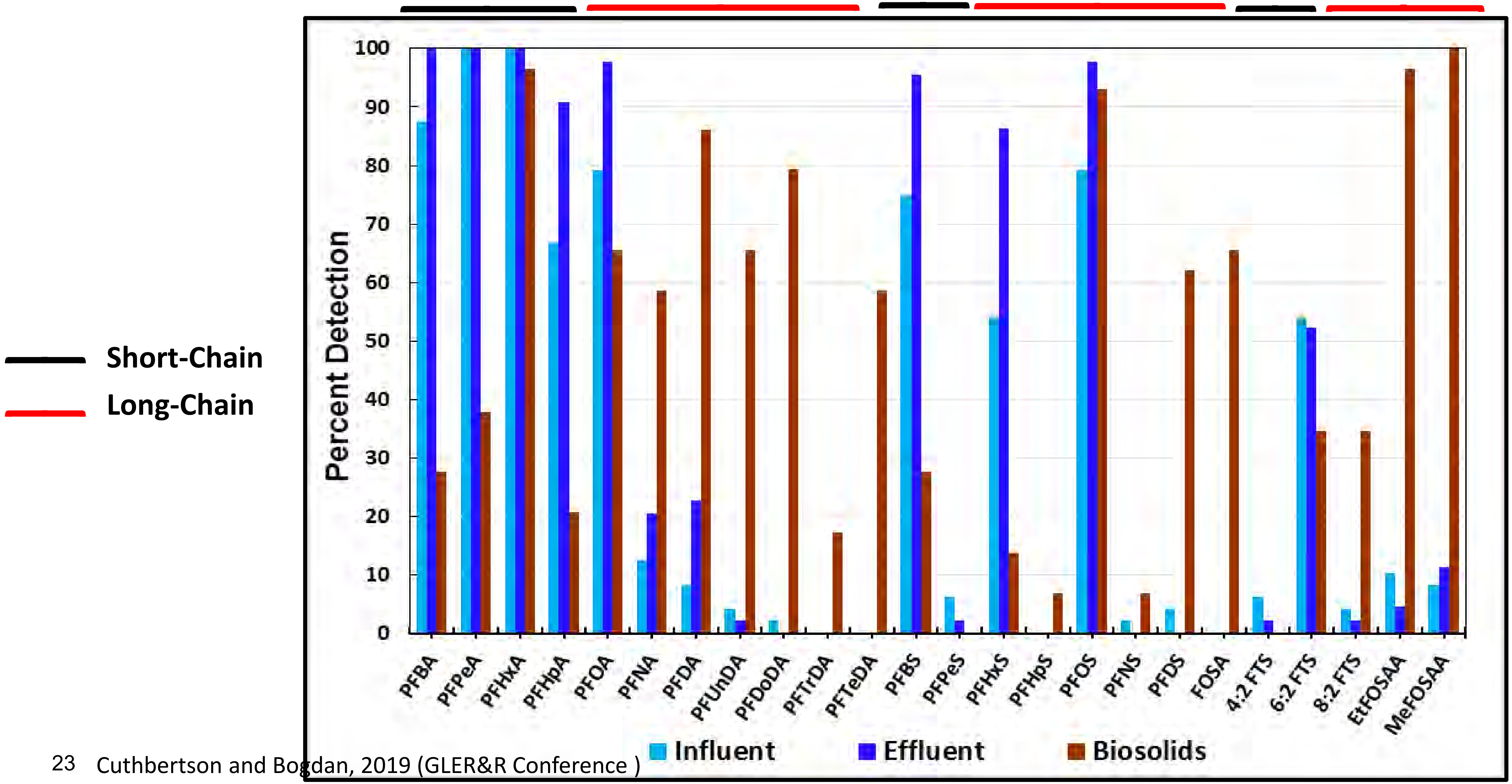
MI Department of Environment, Great Lakes, and Energy (EGLE) has identified 66 PFAS sites:

- Department of Defense
- Airports
- Refineries
- Fuel Suppliers
- Shoe Manufacturing
- Landfills
- Plastic Manufacturers
- Chrome Platers
- Paper & Cardboard Manufacturers

Industrial Pretreatment Program

- Potential source screening
- Monitor probable sources
- If sources found:
  - Reduce/eliminate PFOS & PFOA sources
  - Monitor WWTP effluent against standards
  - Biosolids monitoring and potential restrictions
- Continue source reduction & monitoring

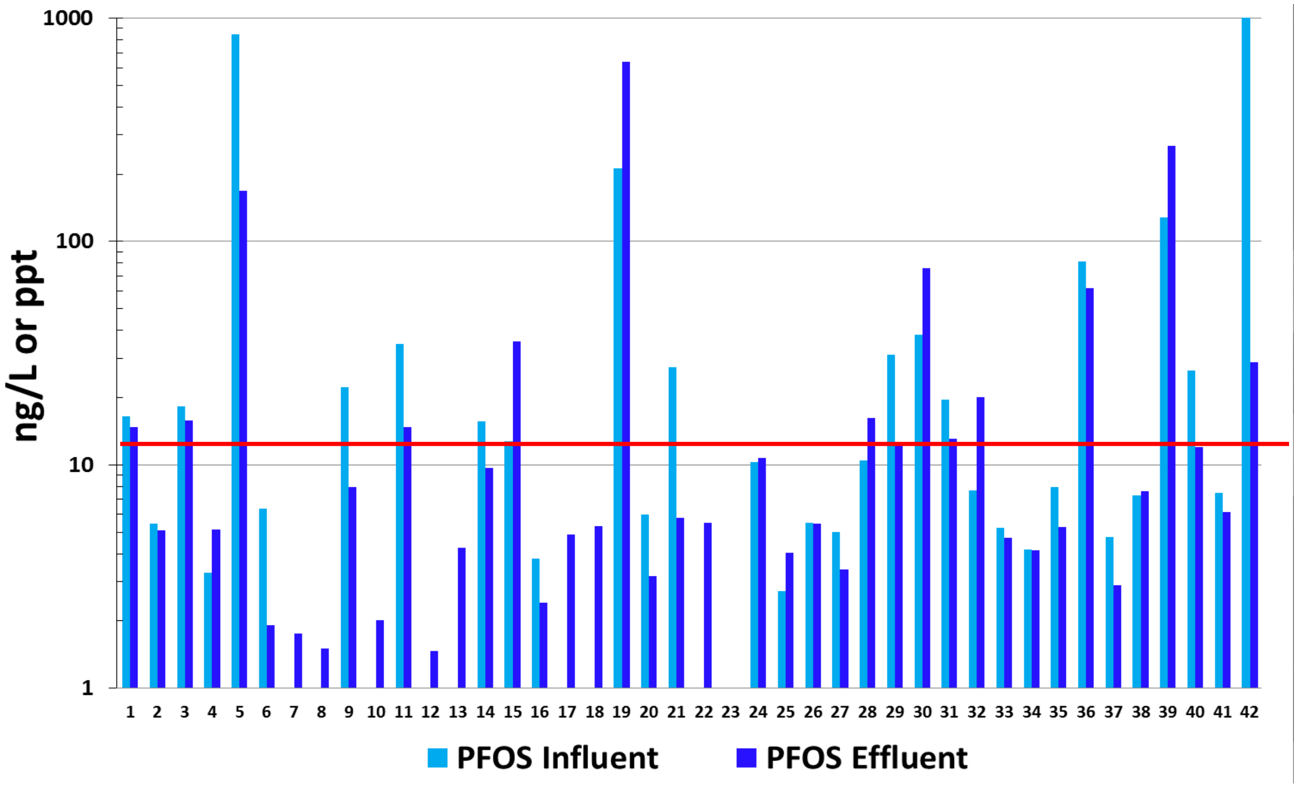
PFAS Detection Frequency – WWTP Study



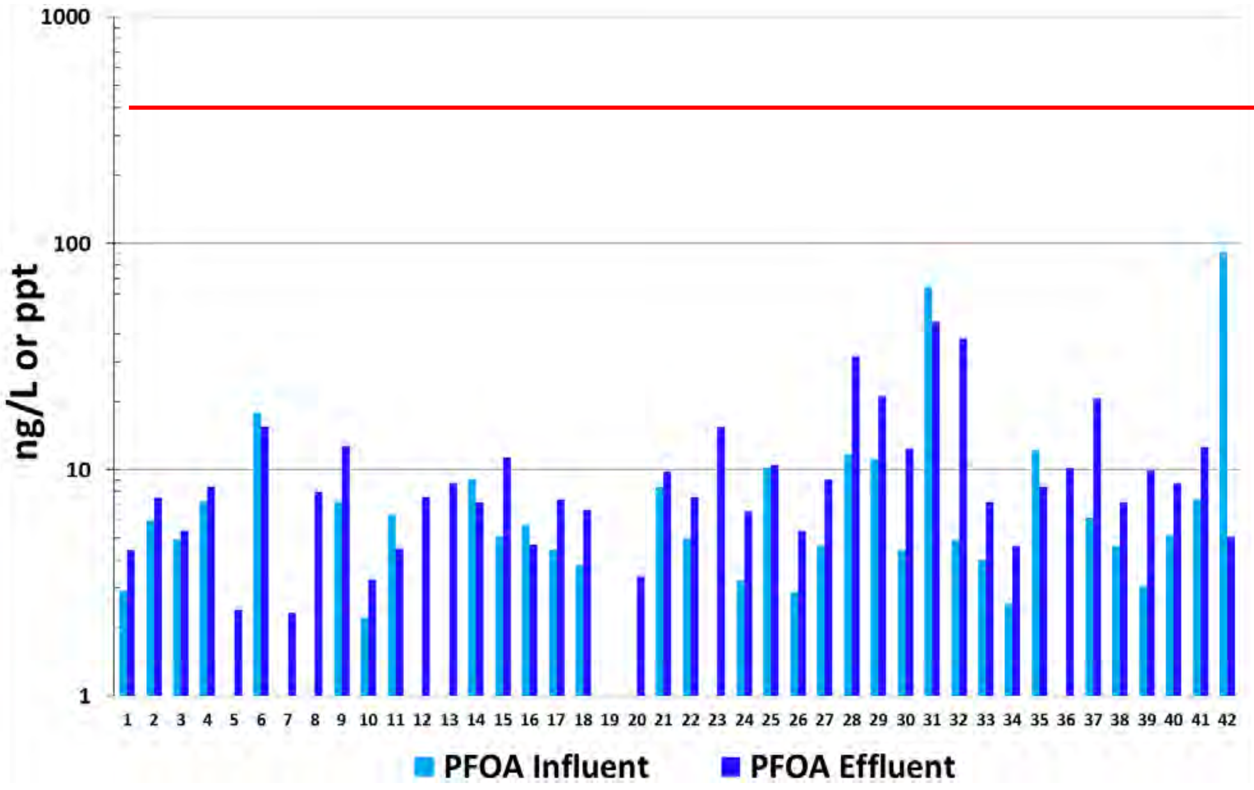
Cuthbertson and Bogdan, 2019 (GLER&R Conference)

Influent vs. Effluent PFOA / PFOS Concentrations

Michigan PFOS WQS (Drink) = 11 ng/L



Michigan PFOA WQS (Drink) = 420 ng/L



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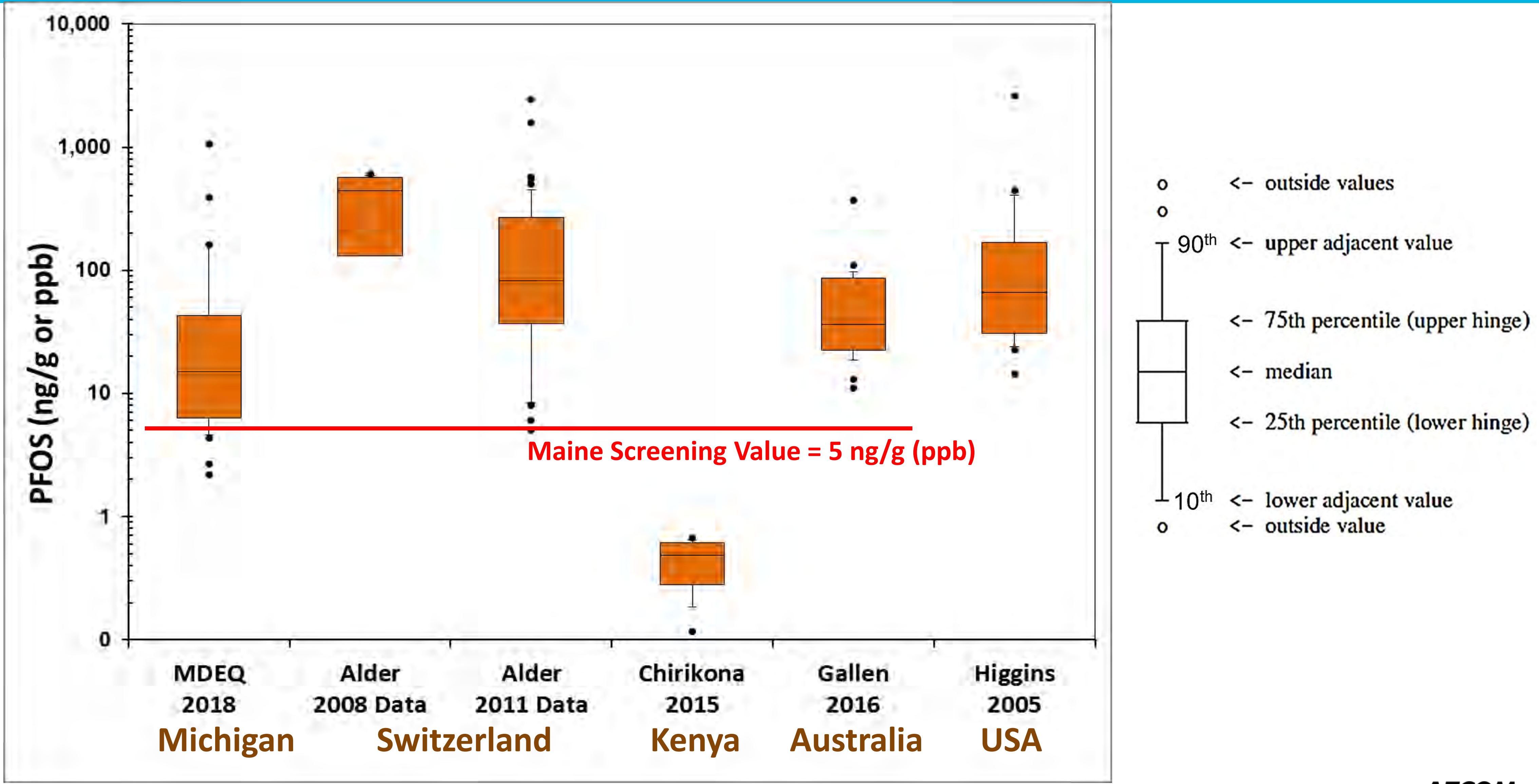
Michigan vs. Published Biosolids Studies



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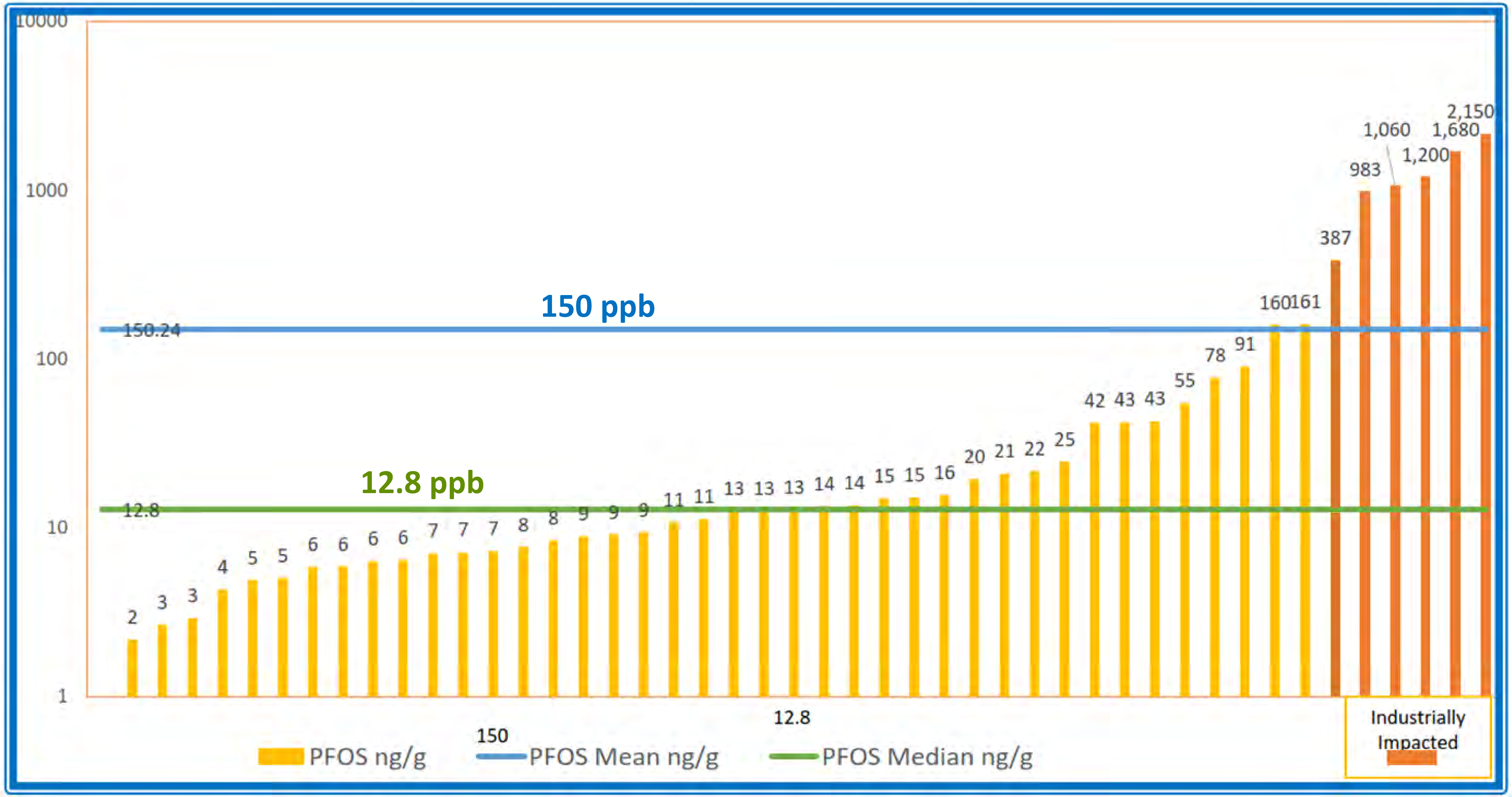
Biosolids/Sludge PFOS Concentrations



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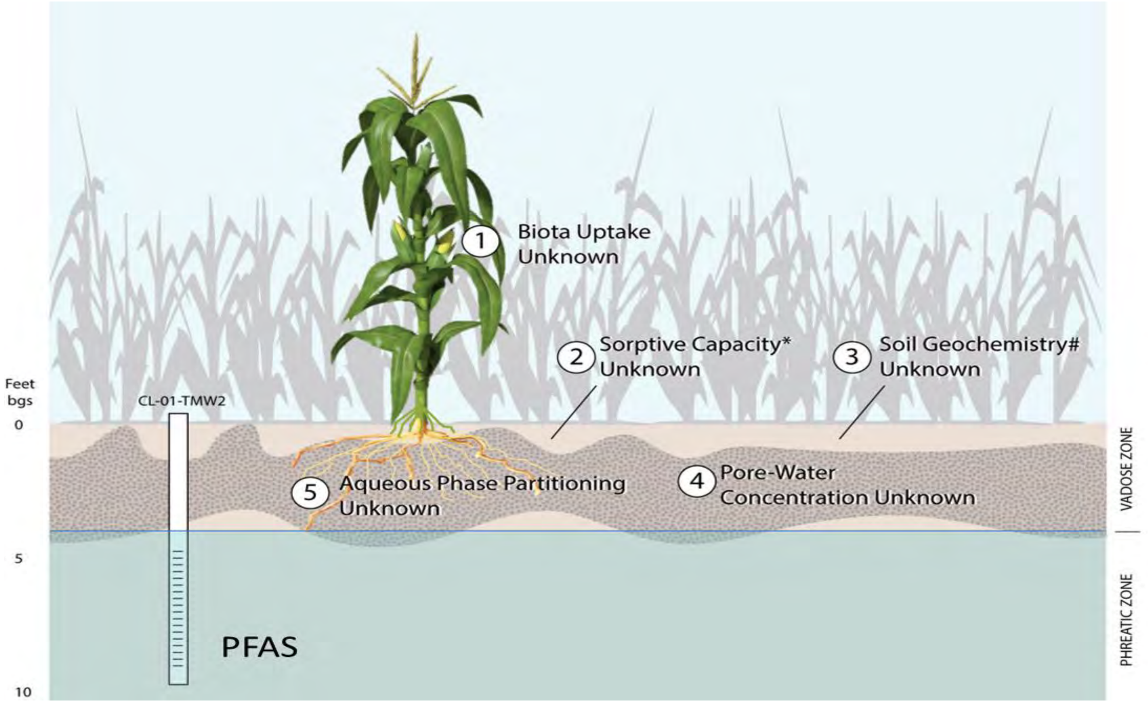
Michigan WWTP PFAS Evaluation Conclusions

- PFAS were detected in all WWTPs
- MI biosolids have lower PFOS concentrations than other previously published studies
- Some PFAS removed at WWTPs concentrates in biosolids and can limit beneficial reuse
- Industrial effluents: can be a significant source of PFAS to the WWTPs
- Short-chain PFAS: tendency to remain in liquid
- Long-chain PFAS: higher affinity to the biosolids
- Evaluation of potential impacts of land application of biosolids is ongoing
  - using screening tools to prioritize

Michigan Biosolids / Agricultural Fields Evaluation

Agricultural Fields

- Associated with 7 WWTPs
- Soil, surface water, and groundwater sampling
- Biosolids PFOS Concentrations
- Dates of Land Application
- Application Rate (dry tons per acre (dT/Acre))



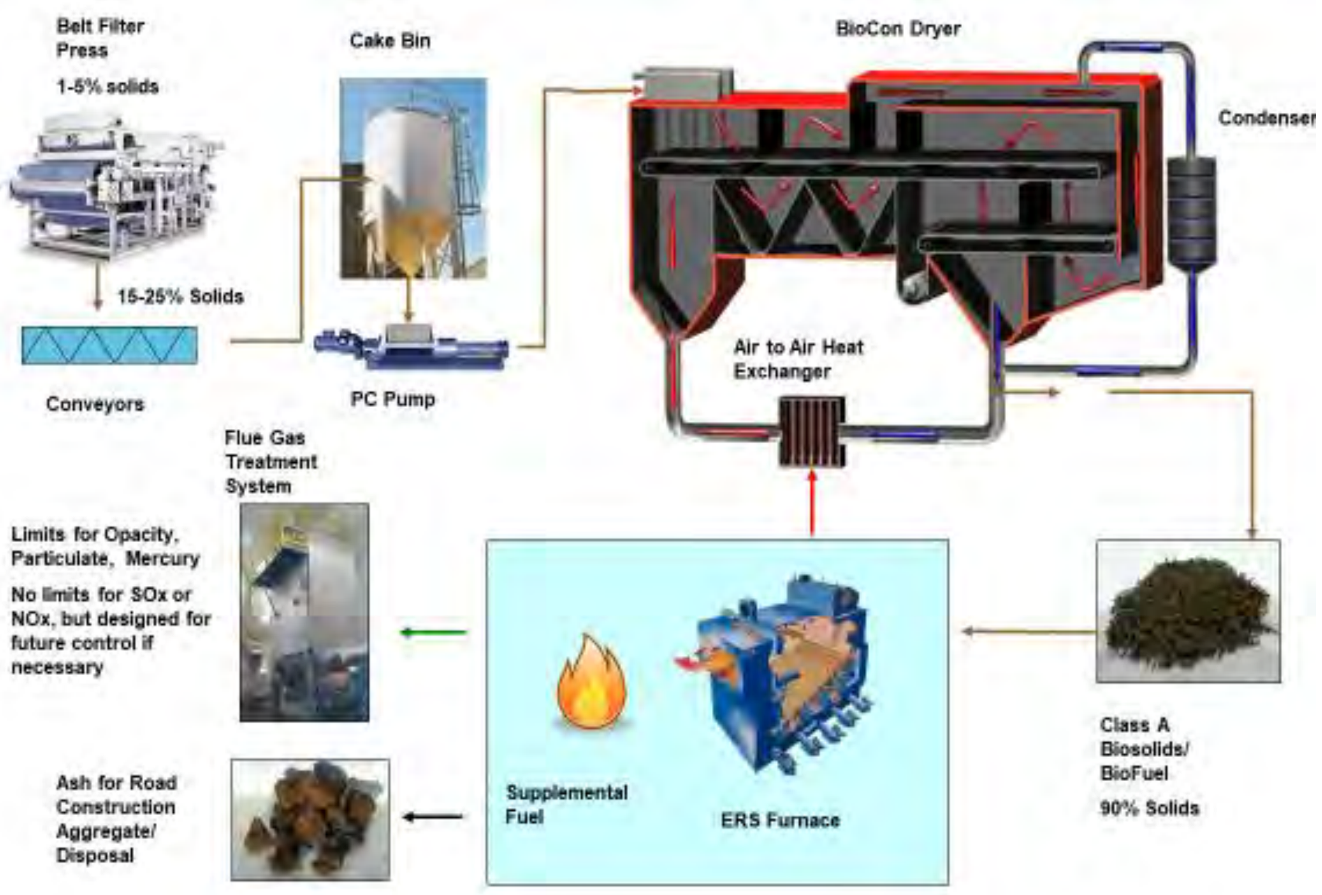
WWTP Concentrations		Total dT Applied	Average dT /Acre	Weighted Use Ratio (Total dT/Site Acres)	Soil	Groundwater	Surface Water
Effluent	Biosolids						
2-5	3-90	176 - 400	2-10	6 - 23	ND – 9	N/A	ND – 5
169 - 2,000	1,060 - 2,100	39 – 1,422	1 - 4	4 - 28	1 – 145	ND - 18	ND – 2,080

PFOS: Aqueous = ng/L or ppt, Solid = µg/Kg or ppb

Cuthbertson and Bogdan, 2019 (GLER&R Conference)

Biosolids Treatment Strategy Example for PFAS

- Combustion is emerging as a leading candidate for complete destruction of PFAS from sludge
- Combines convective air belt dryer with a biomass furnace using biosolids
- ERS combusts sludge between 1,400 and 1,800 deg F (760 to 870 deg C)
- Evaluation of fate of PFAS through process being studied by University of Dayton Research Institute, OH
- Dried biosolids combustion systems are still not widely used. (~2 in USA)



BioCon® Energy Recovery System (ERS) System. (*Veolia*) - Process Flow Diagram

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Emerging PFAS Treatment Technology – Electrochemical Oxidation

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DE-FLUORO™ Electrochemical Oxidation

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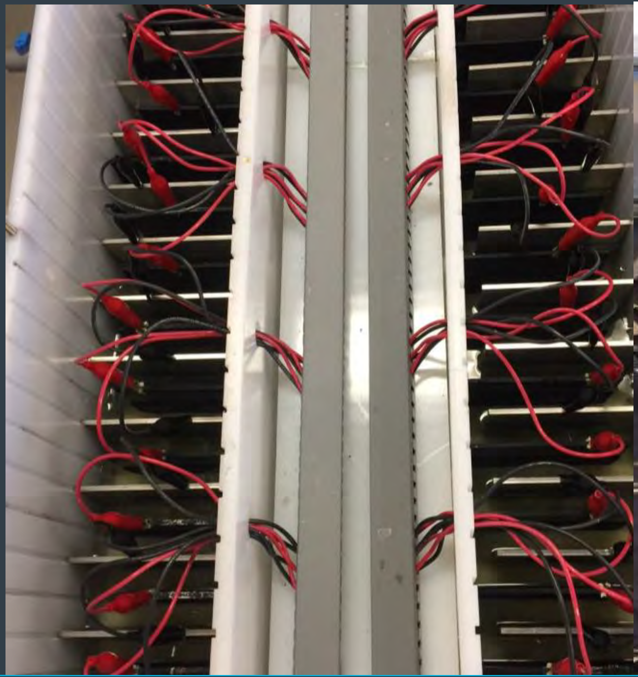
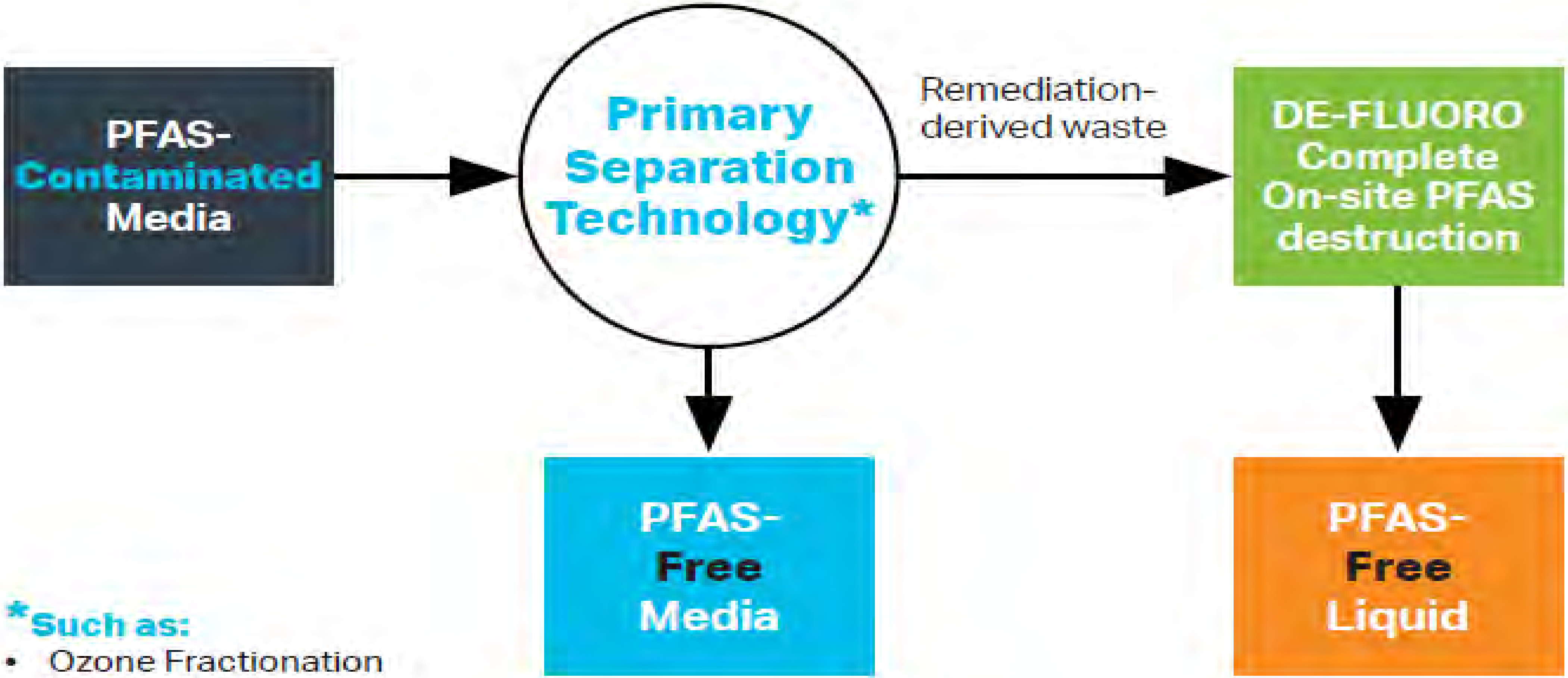


Pilot Reactor Demonstration Project, Coupling Technology for PFAS Destruction

Developed by: Rachael Casson (AECOM), Shangtao Liang, Ph.D (AECOM), Rebecca Mora (AECOM) and Qingguo (Jack) Huang, Ph.D (University of Georgia)

Path to Total PFAS Destruction

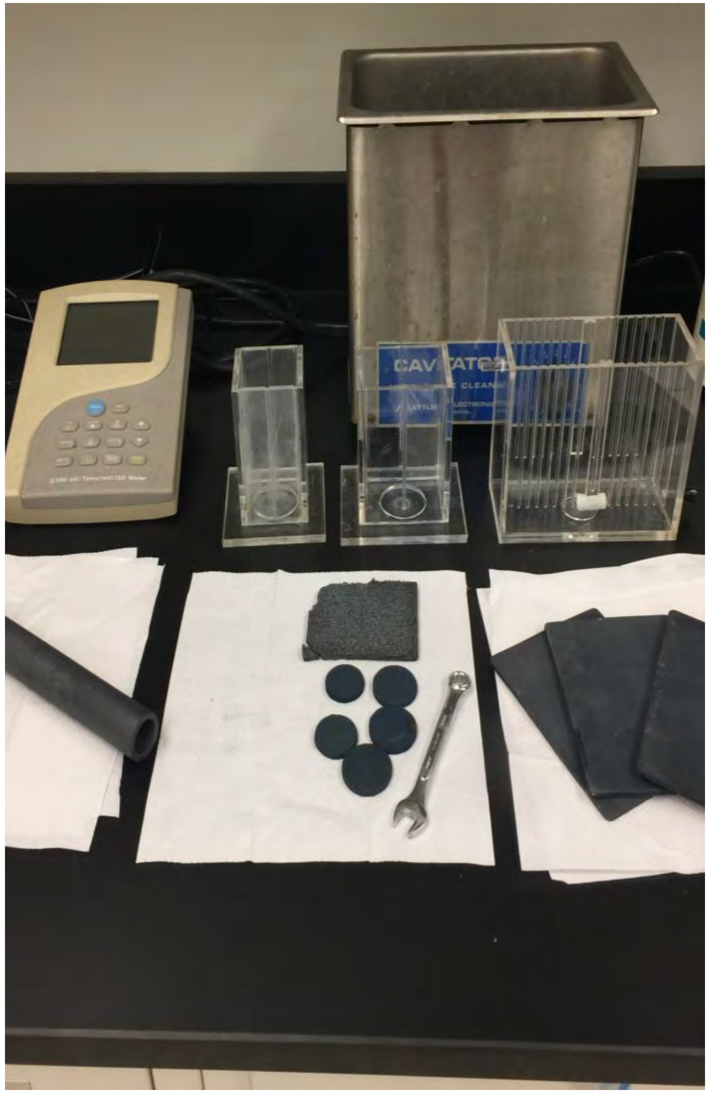


*Such as:

- Ozone Fractionation
- Soil Washing
- Regenerable IX
- Foam Fractionation
- Reverse Osmosis

Emerging Technologies – Electrochemical Oxidation

- **DE-FLUORO™ Technology for PFAS Destruction – Demonstration Project Objectives:**
  - **DE-FLUORO™**: **D**egradation via **E**lectrochemical oxidation / reduction of per- and poly**fluoro**alkyl substances
  - DE-FLUORO™ utilizes a proprietary, high durability and low-cost electrode that can be in different sizes, forms and shapes for different applications
- Demonstration Team's objectives were to evaluate:
  - The effectiveness of DE-FLUORO™ Model 1 and Model 2 – do they work for real world samples?
  - Is DE-FLUORO a stand alone or coupling technology?
  - Scalability and viability – Preliminary assessment?



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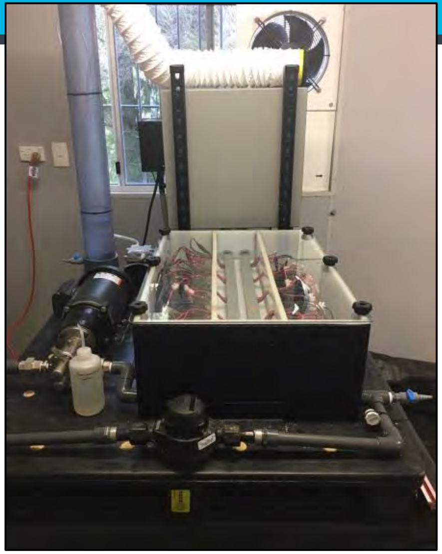
Summary of DE-FLUORO™ Testing Results

Trial #	Sample Description	Initial total PFAS concentration (ug/L)	Mass Reduction
1	Source area groundwater	455	99.7%
2	Industrial wastewater	411	99.5%
3	Remediation derived wastewater	13,600	99.2%
4	Remediation derived wastewater	1,590	90.7%
5	Source area groundwater	27.3	83.8%
6	Spent C6 AFFF solution	4,620	83.3%
7	IX R	2,370	63.6%
8	AFFF Concentrate / Product	6,380,000	60 %

Field Pilots/Treatability Tests

– U.S. Air Force – AFCEC BAA Project (on-going)
  - Wright-Patterson AFB
  - Treat AFFF-impacted groundwater
  - Coupling approach of IX-R + DE-FLUORO™



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Field Pilots/Treatability Tests (con't)

- Australia (2020)
  - Treat stockpiled spent C6 AFFF
  - DE-FLUORO™ stand-alone Model 2.0 - Jaws

- Treatability Test (on-going)
  - Testing DE-FLUORO's ability to destroy PFAS on Membrane Bioreactor (MBR) effluent feeding a Reverse Osmosis (RO) influent and RO Reject waste streams

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Thank You!

Christopher Curran, PE

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