

Full-scale Treatment of PFAS-impacted Wastewater Using OCRA Validated Using TOP Assay

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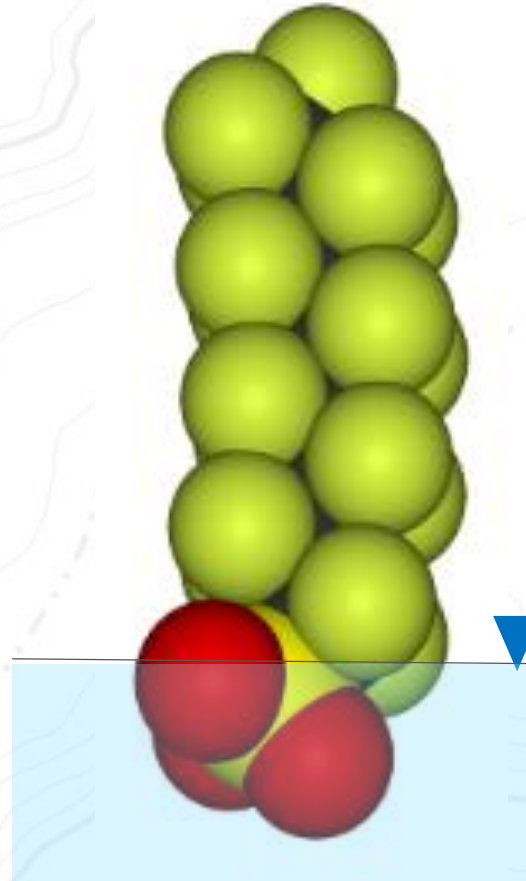


Contents

- Incident Background
- Decontamination
- PFASs Chemistry
- Evolving Regulations
- TOP Assay
- Ingenious Treatment Solution
 - Ozofractionation
 - Polishing
 - Sonolysis
- Conclusions

PFASs

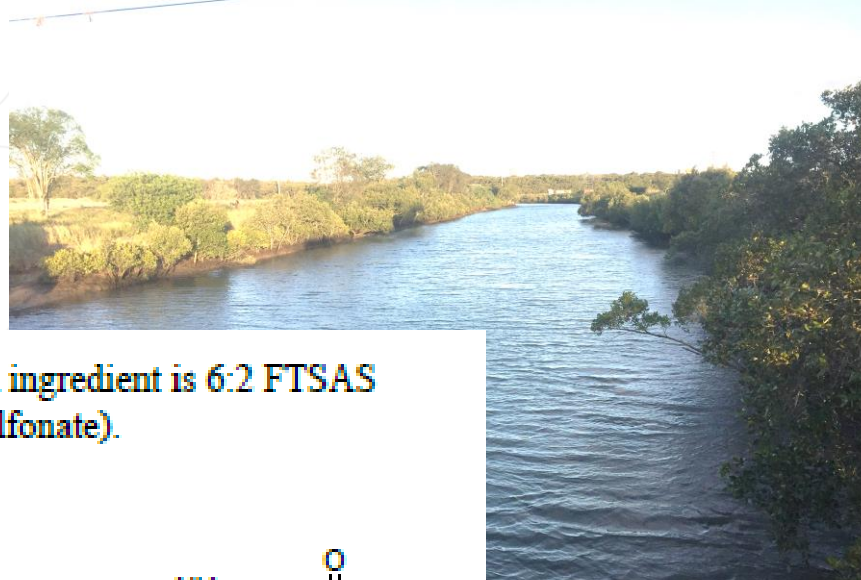
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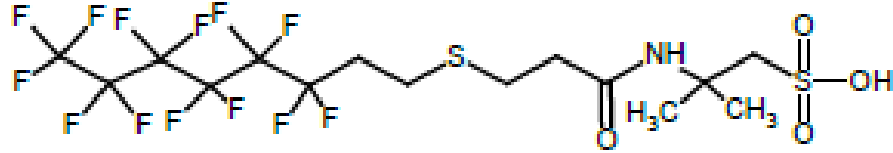
C6 Firefighting Foam Loss

Chemical Analysis of Selected Fire-fighting Foams on the Swedish Market 2014

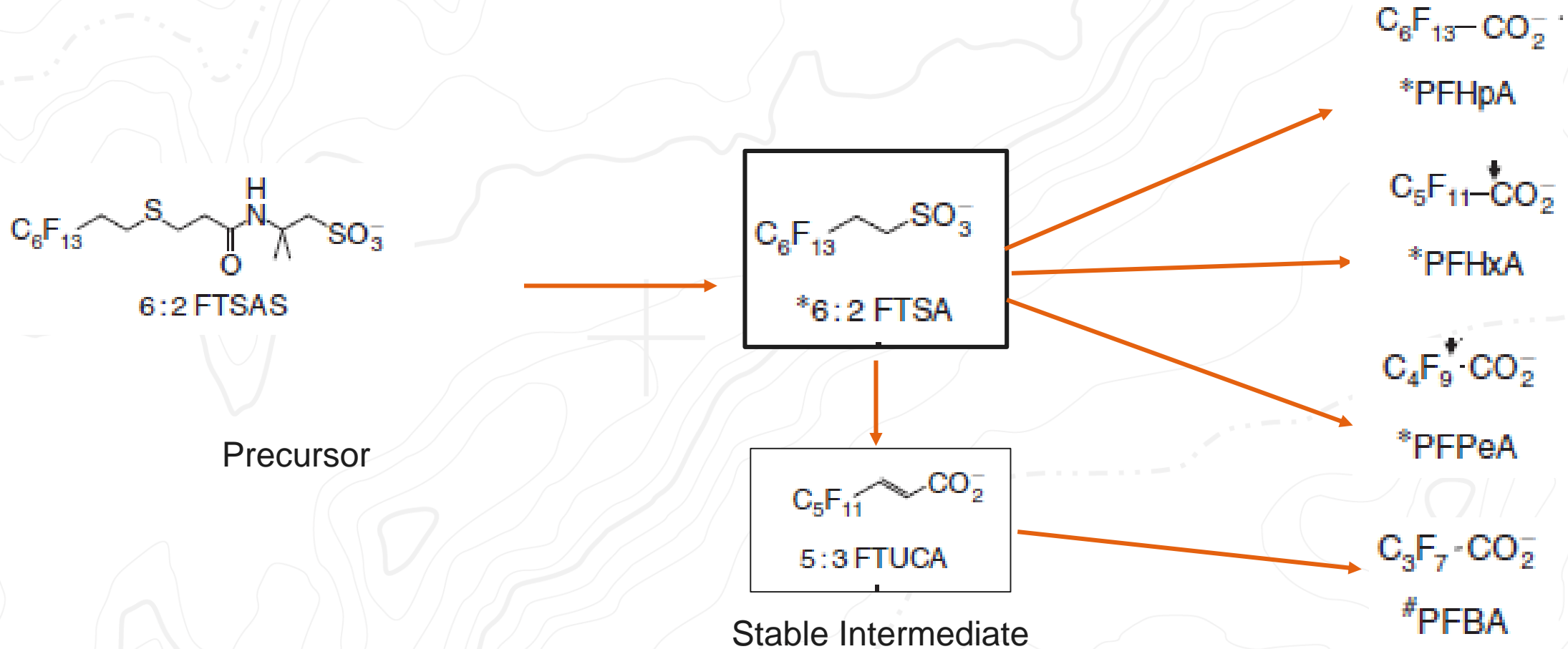
PM 6/15



Tentatively identified PFAS as a main ingredient is 6:2 FTSAS (fluorotelomermercaptoalkylamido sulfonate).



Fluorotelomer Foam



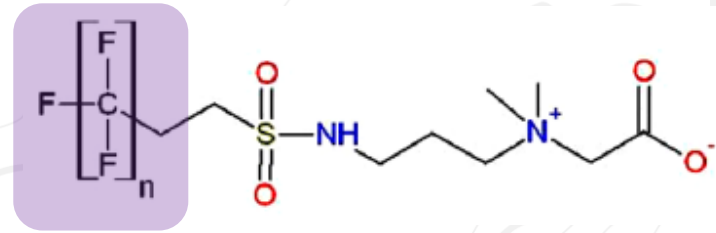
Source: Weiner et.al. 2013

Breakdown products of the C6 FT Foam: short-chain PFCAs

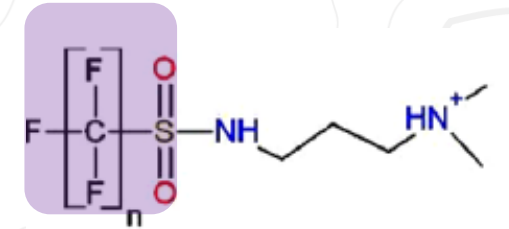
Perfluoroalkyl group –the forever functional group



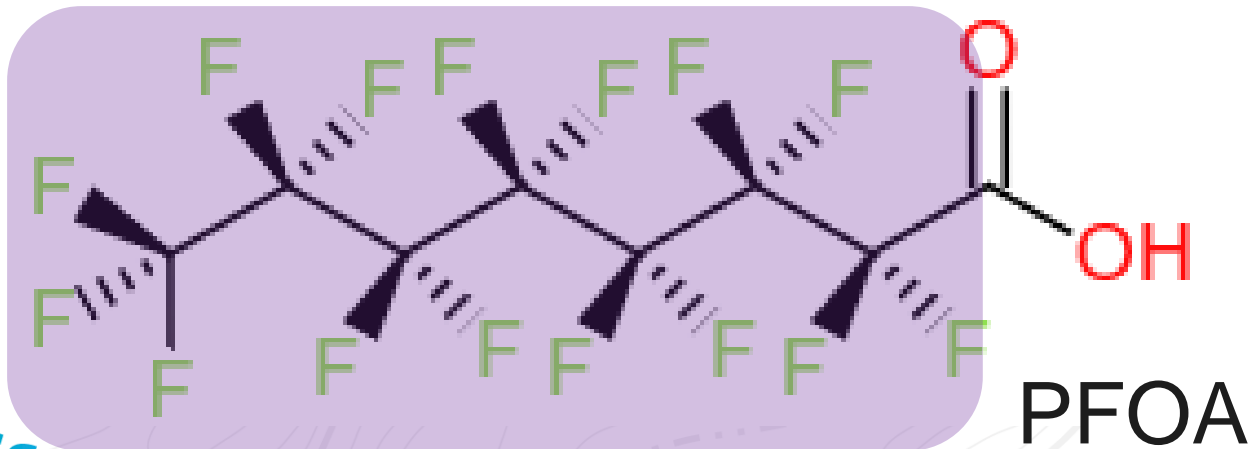
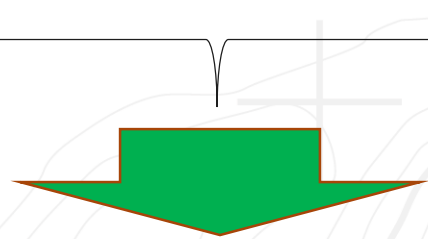
Fluorotelomer alcohol, 8:2 FTOH



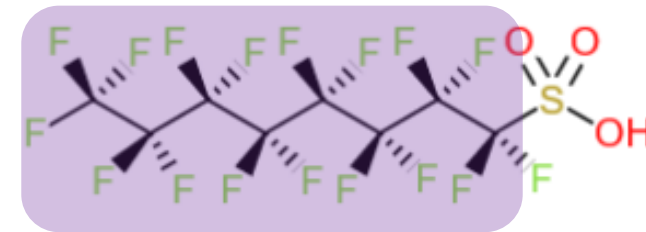
Fluorotelomer Sulfonamido Betaines



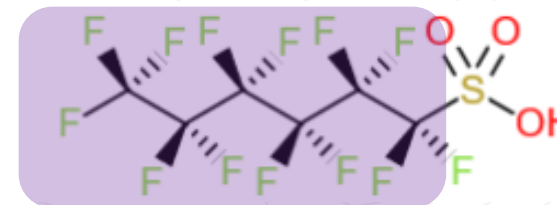
Perfluoroalkyl Sulfonamido Amines



PFOA



PFOS



PFHxS

Poly- and Perfluoroalkyl Substances (PFASs)

More Commonly Regulated

Polyfluorinated
compounds (~5,000
compounds)

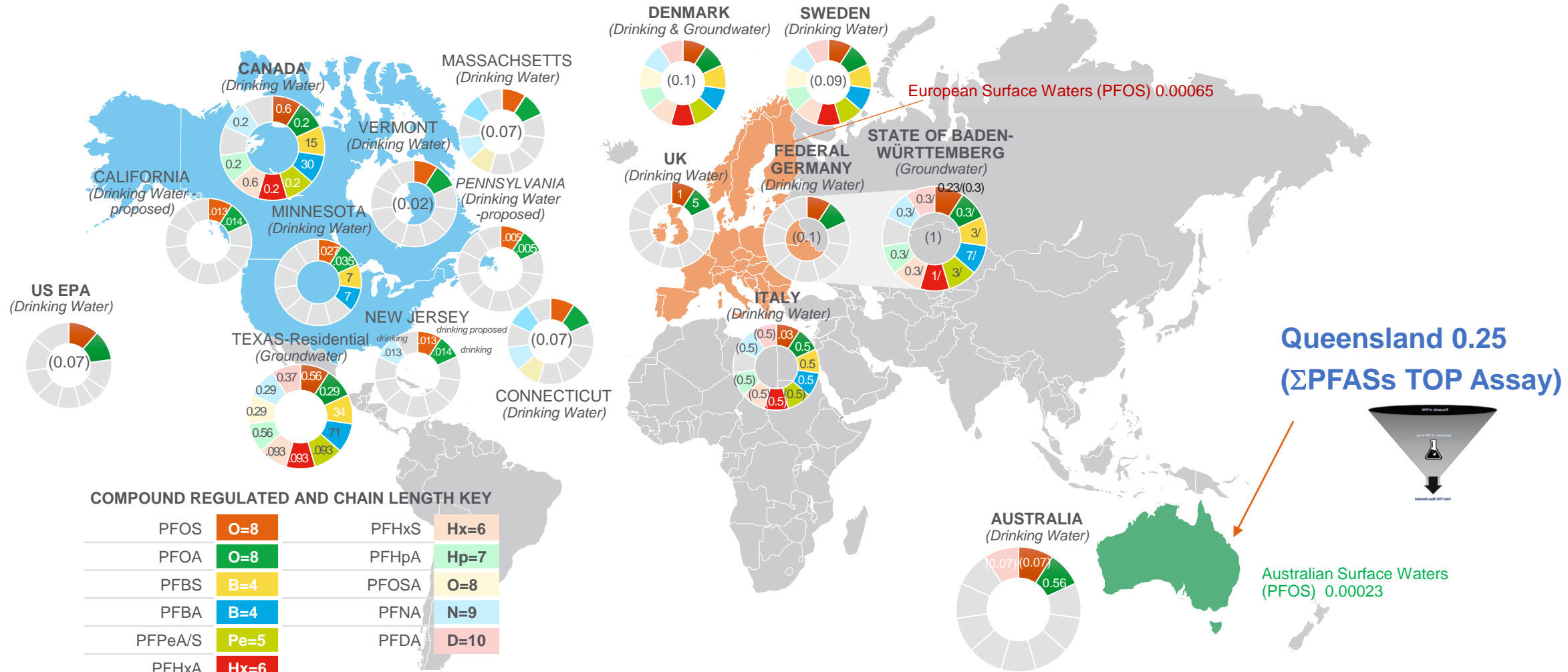
Perfluorinated Compounds (PFCs) aka
Perfluoroalkyl Acids (PFAAs)
~25 common individual compounds
but ~100's compounds
PFOS ,PFOA, PFHxS, PFBA, GenX

Microbial / Higher Organism Biotransformation

Aerobic Biotransformation Funnel: Conversion of Polyfluorinated Precursors to PFAAs

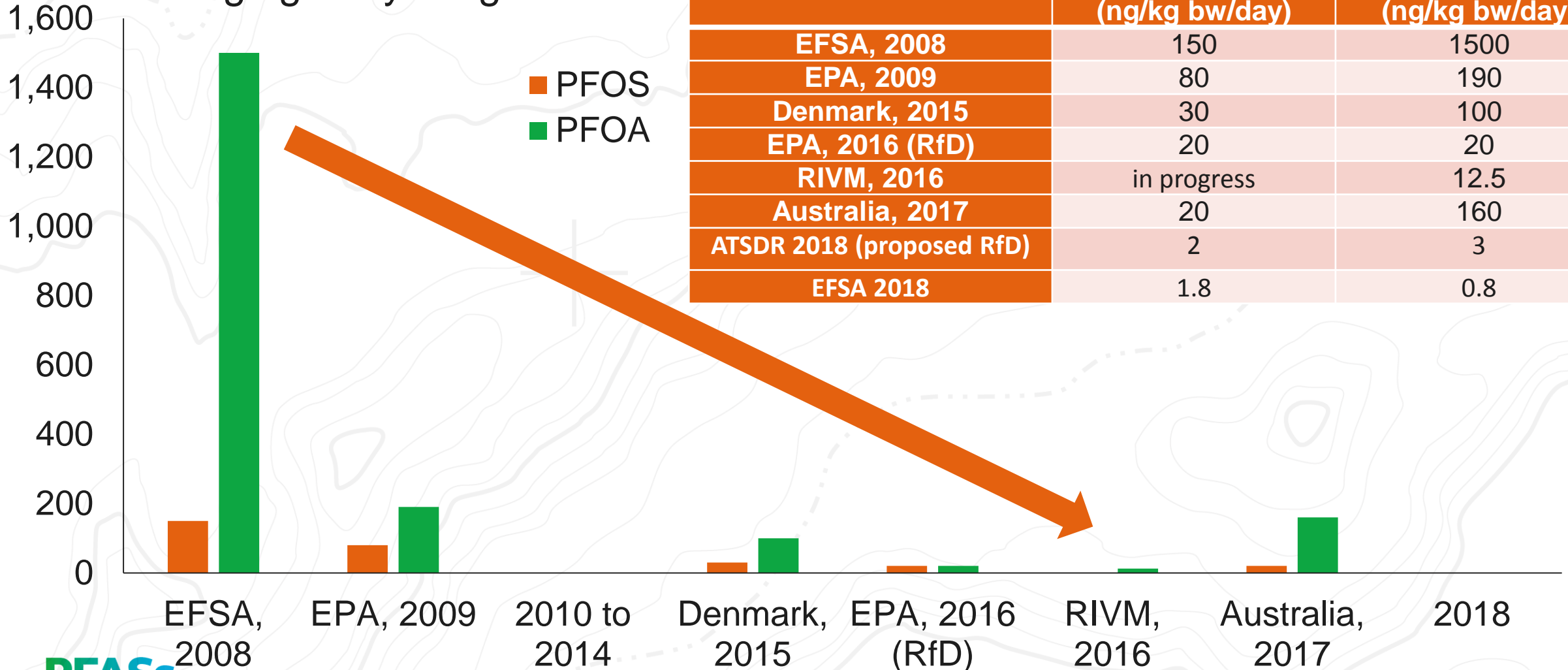


Evolving Regulatory PFAS Values



Tolerable Daily Intake (TDI)

ng/kg/body weight/d



Digest AFFF precursors and measure the hidden mass: TOP Assay

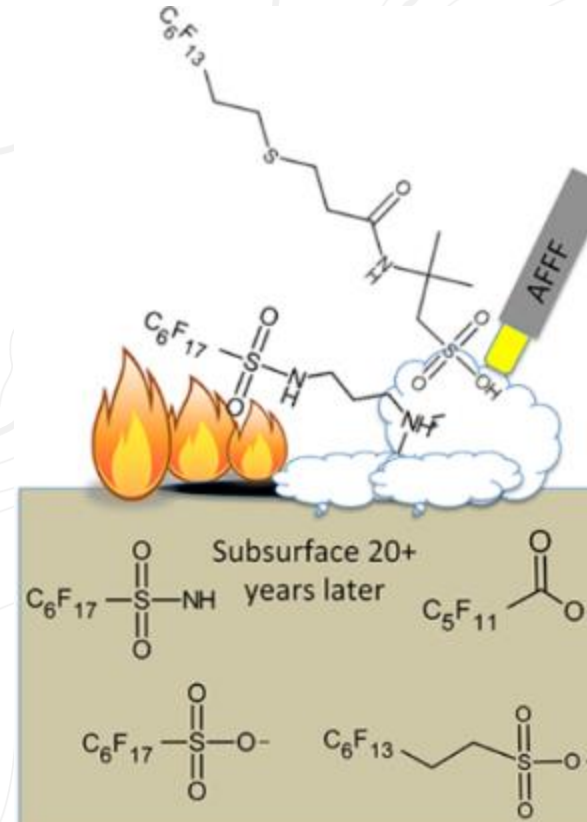
Microbes slowly make simpler PFAA's (e.g. PFOS / PFOA) from PFAS (PFAA precursors) over 20+ years

Need to determine precursor concentrations as they will form PFAAs

Too many PFAS compounds and precursors –so very expensive analysis

Oxidative digest convert PFAA precursors to PFAA's

Indirectly measure precursors as a result of the increased PFAAs formed

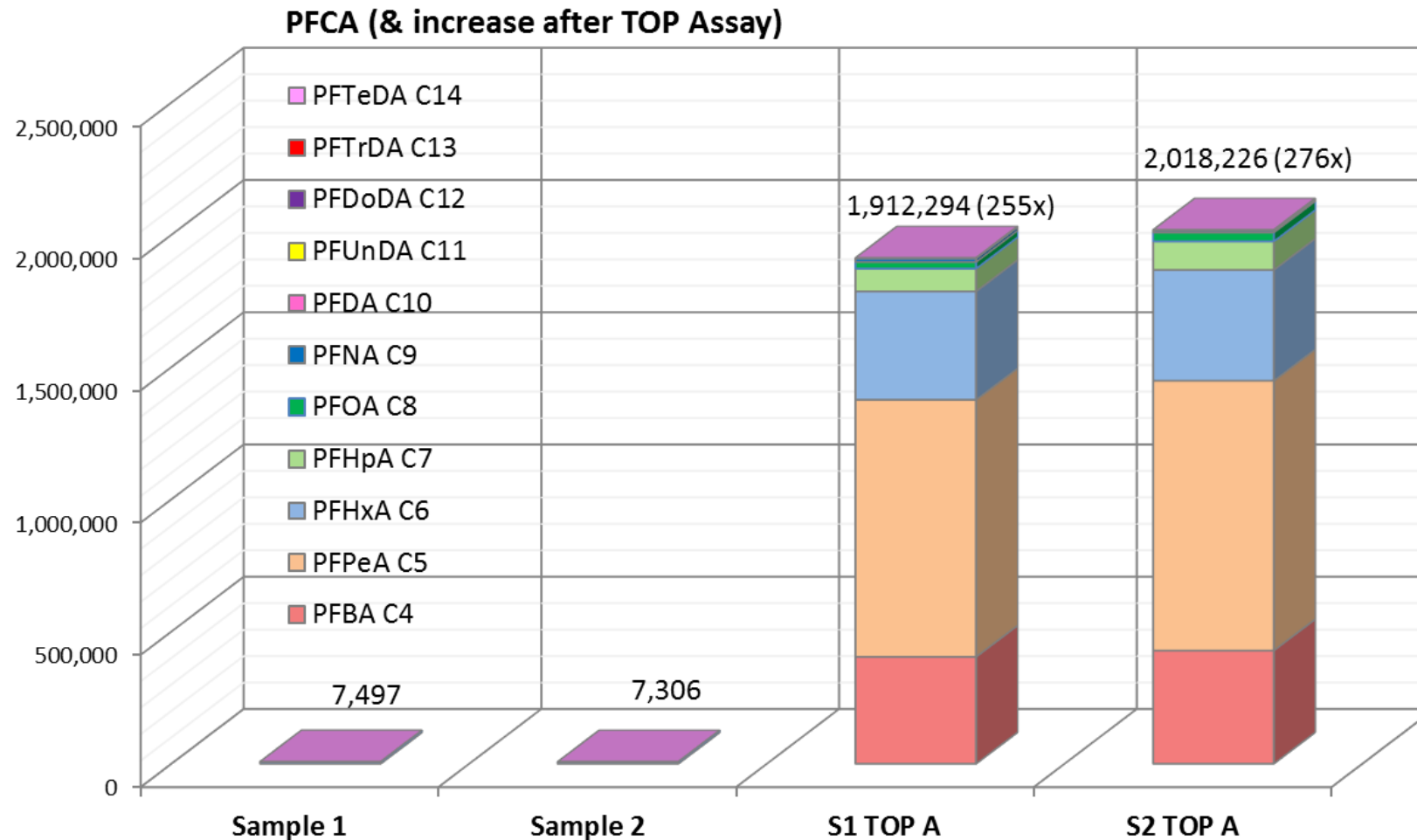


Persistence of Perfluoroalkyl Acid Precursors in AFFF-Impacted Groundwater and Soil

Erika F. Houtz,[†] Christopher P. Higgins,[‡] Jennifer A. Field,[§] and David L. Sedlak^{†,*}



TOP Assay Applied to Surface Water from Recent C6 Fluorotelomer Foam Loss



Sewer Decontamination



3.5 km of domestic/industrial sewer

**KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING**

FOR INDUSTRIAL USE ONLY
Arcadis Solvent V171

COMBUSTIBLE LIQUID

DANGER

1000 LT

Hazard statement(s)
H227 Combustible Liquid
H319 Causes serious eye irritation
H336 May cause drowsiness or dizziness
AUHD19 May form explosive peroxides

Precautionary statement(s) Prevention
P210 Keep away from heat/sparks/open flames/hot surfaces - No smoking
P271 Use only outdoors or in a well-ventilated area
P281 Avoid breathing mist/vapour/spray
P280 Wear protective gloves/protective clothing/eye protection/face protection

Precautionary statement(s) Response
P370+P378 In case of fire: Use alcohol resistant foam or normal protein foam for extinction
P312 Call a POISON CENTER or doctor/physician if you feel unwell
P303+P361+P353 IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower
P304+P340 IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing

Precautionary statement(s) Storage
P403+P235 Store in a well-ventilated place. Keep cool.
P405 Store locked up.

Precautionary statement(s) Disposal
P501 Dispose of contents/container in accordance with local regulations.

FIRST AID:
For advice, contact a Poisons Information Centre (Ph. 13 11 26) or a doctor if available. do NOT induce vomiting.
If in eyes, hold eyelids apart and flush the eye continuously with running water. Continue flushing until advised to stop by a Poisons Information Centre (Ph 13 11 26) or a doctor, or for at least 15 minutes.
If skin contact occurs, immediately remove contaminated clothing. Flush skin under running water and wash with soap and water.
IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. If breathing is laboured seek medical assistance.

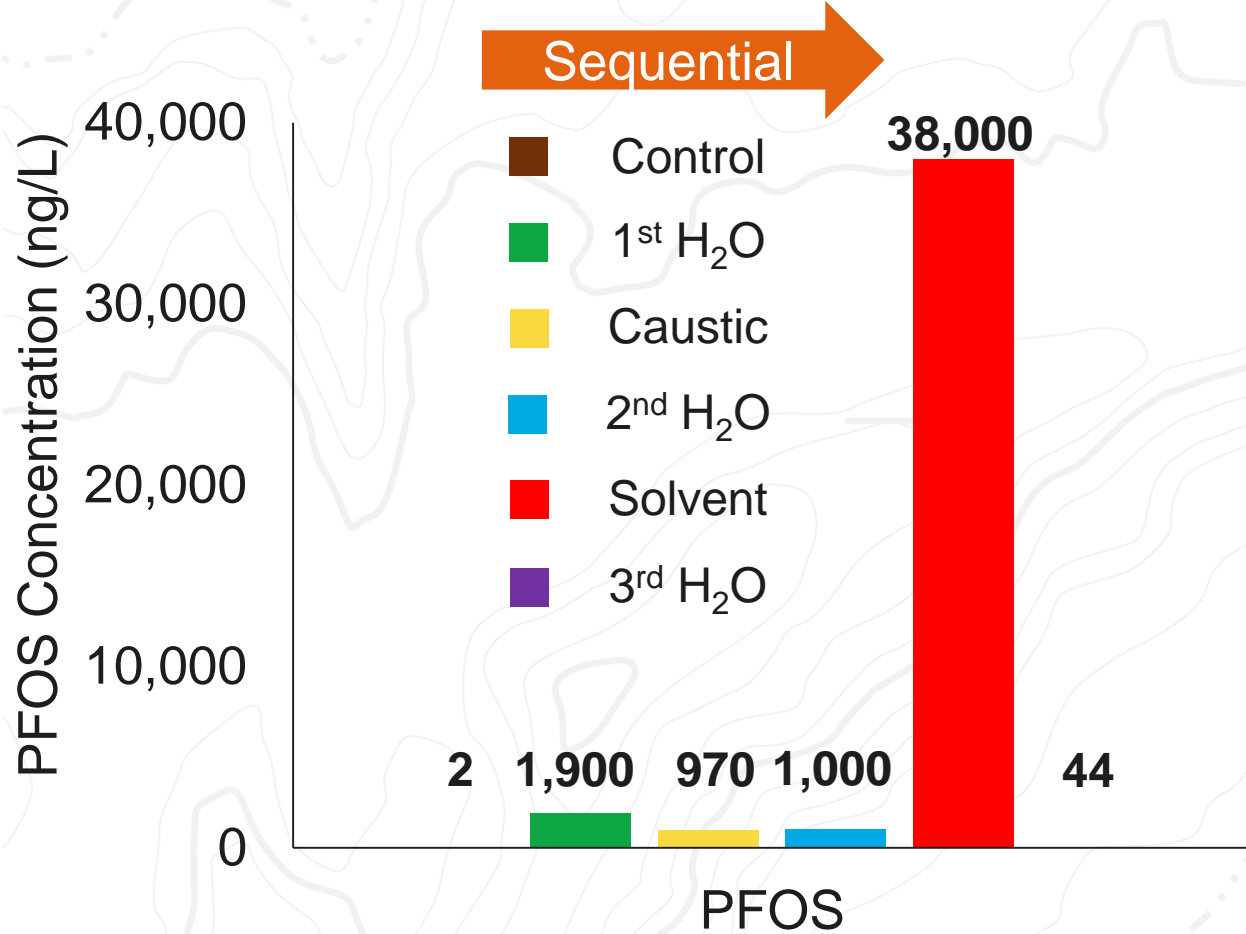
TOLL MANUFACTURED ON BEHALF OF
AGRIndustries Pty Ltd
ABN 52 609642471
160 Musgrave Road
Coopers Plains, QLD 4108
Web www.agret.com.au

650 Tanks

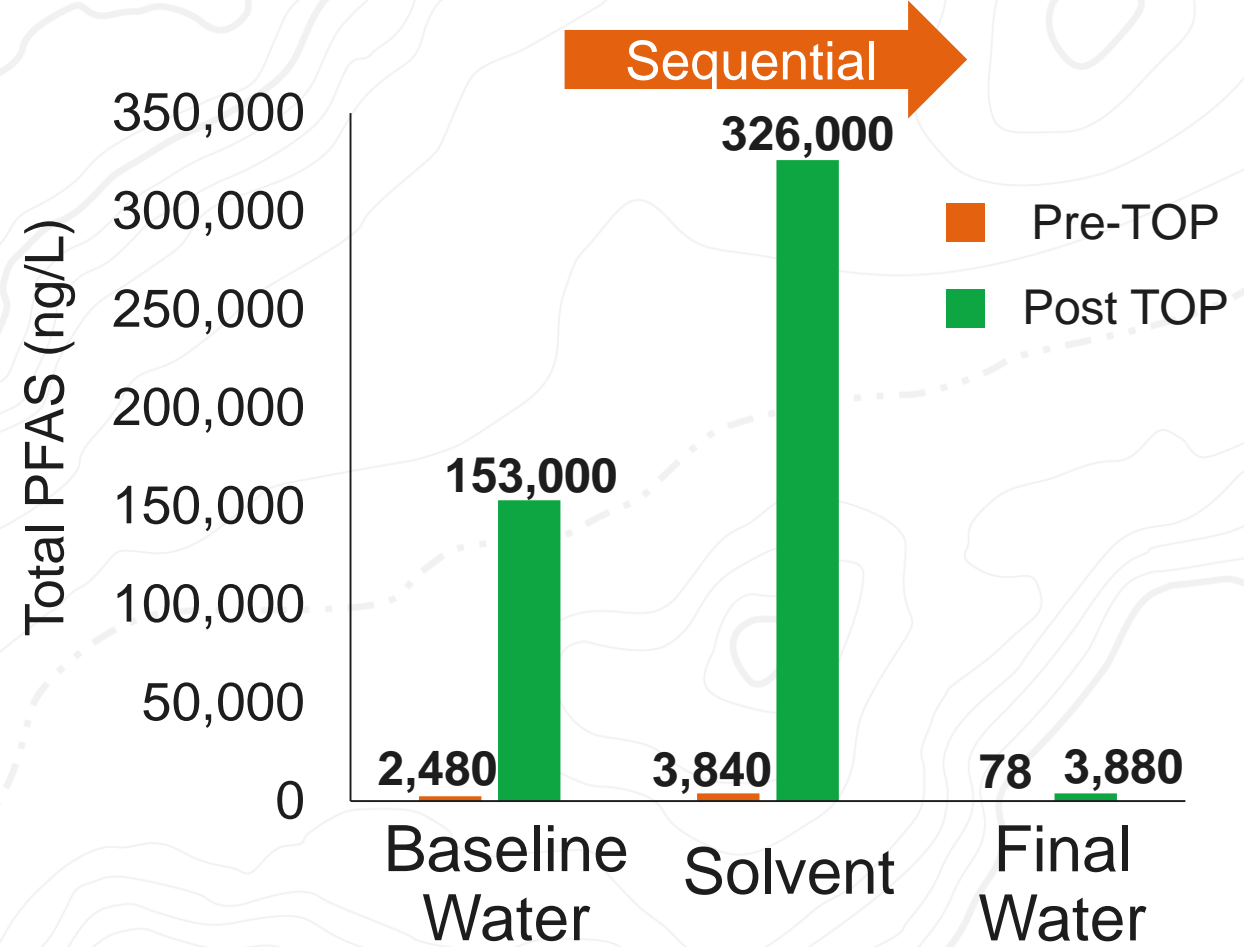


Foam Cleanout/Decontamination

Sewer Decontamination Trial



Foam Tank Cleanout – TOP Assay



The Challenge

- **+ 15 ML** - Sewage, Tradewaste, Brackish Creek Water, Chemical Flush Fluids, and Stormwater
- **Emergency Response** – full-scale onsite in three weeks
- FF Foam Concentrate – Precursors, 5,000 $\mu\text{g/L}$ PFAS
- Multiple Contaminants (1,500 mg/L COD)
- Small Footprint
- Treatment Objective: 0.25 $\mu\text{g/L}$ sum of PFASs measured by TOP assay



Emergency Response

2 weeks
permitted



3 weeks
system
onsite



4 weeks
installed



Lab Scale

Ozofractionation

Large volume high COD, high PFAS impacted wastewater

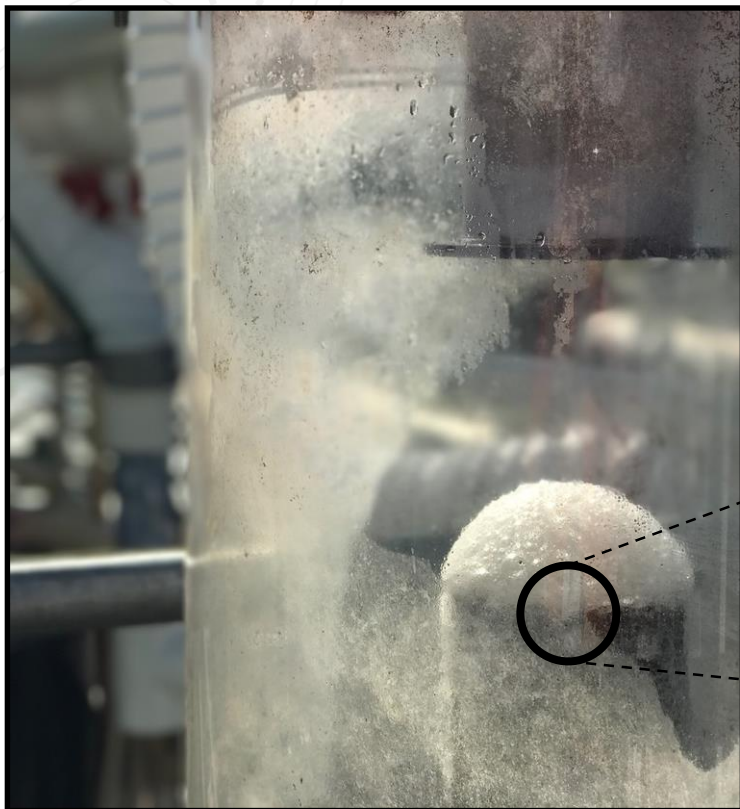
- ~3.6 million gallons of water
- Total [PFAS] ~ 3,950 $\mu\text{g/L}$; targeted discharge [PFAS] = $<1 \mu\text{g/L}$
- Laboratory analysis includes total oxidizable precursor (TOP) assay per country-specific regulations

Treatment train operation selected

- Ozofractionation with engineered polish
- Polish necessary for low discharge limit
- Foam concentrate currently to be destroyed offsite



OCRA - Concept

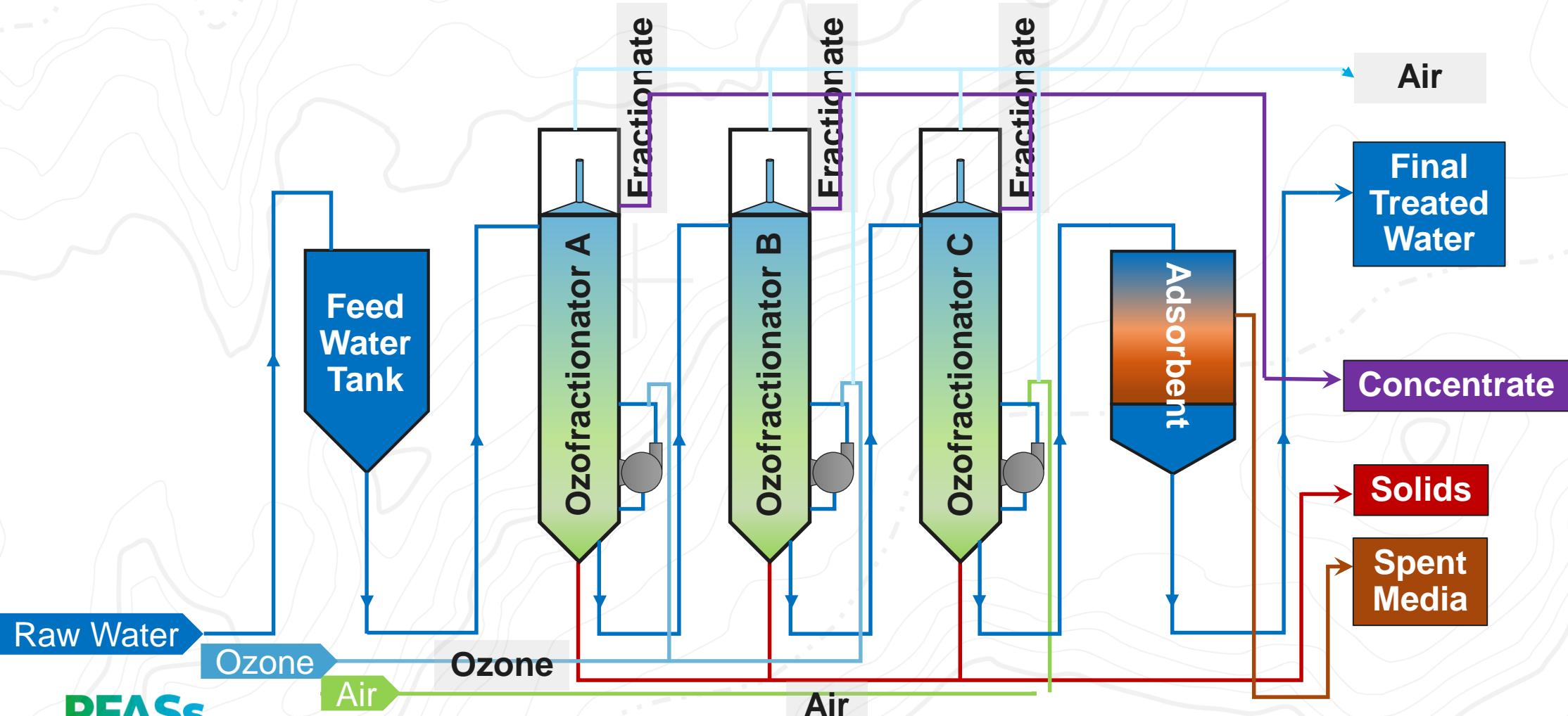


Photos courtesy Evocra - July 2017

PFASs

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Ozofractionation - Concept



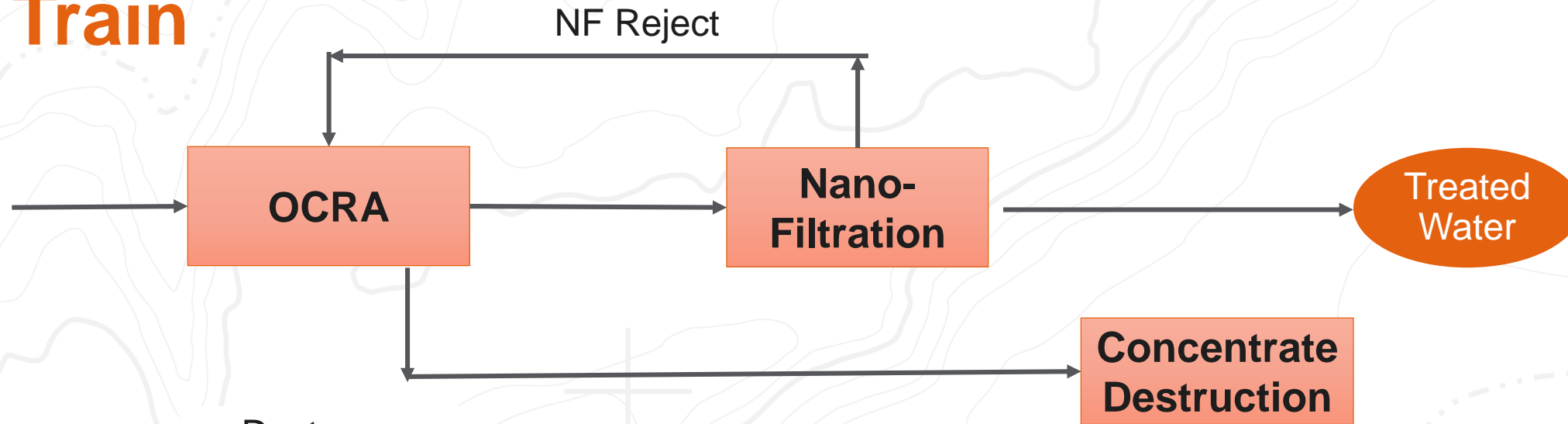
Wastewater Treatment System 5,000 L/hr (20 gpm)



PFASs

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Treatment Train

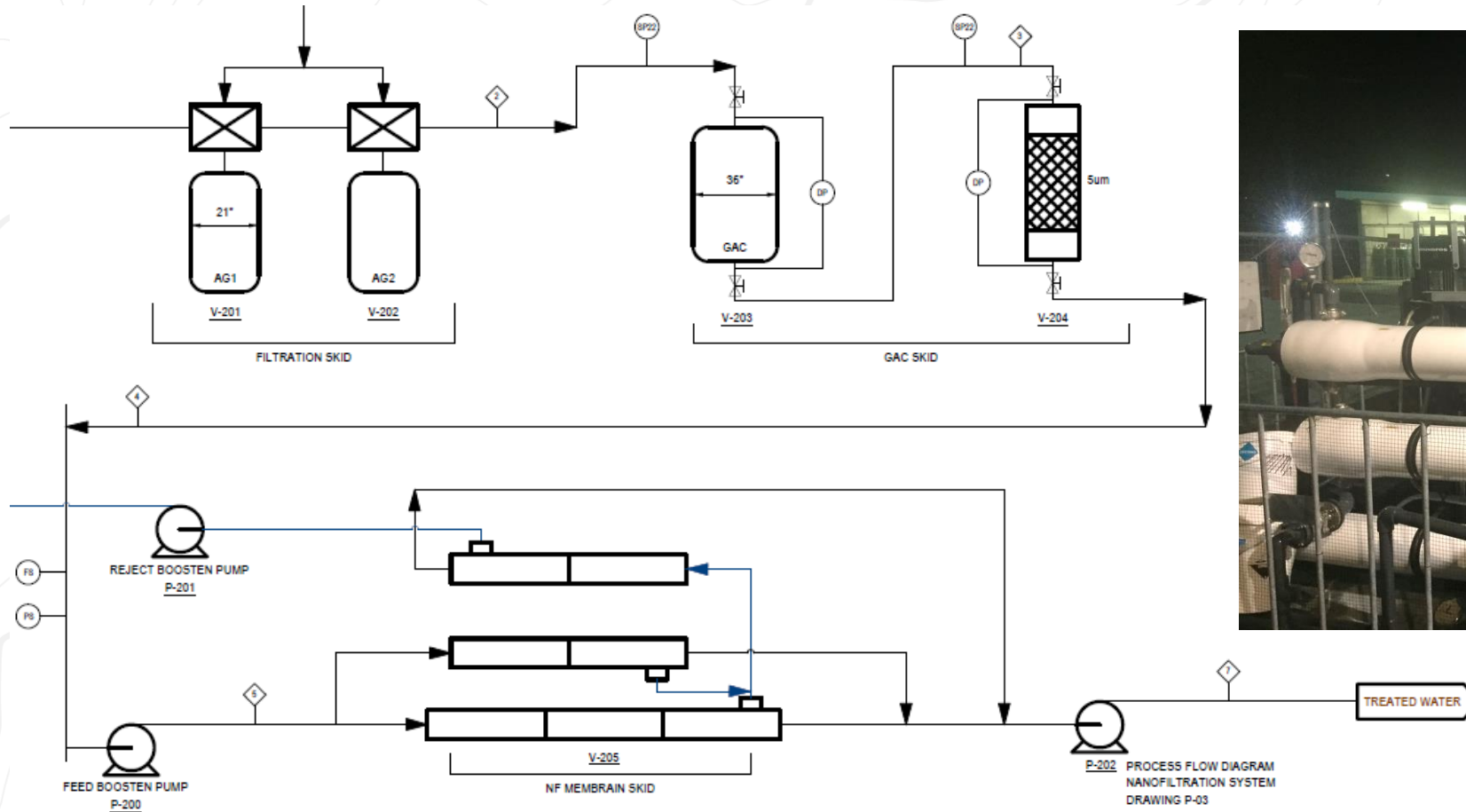


- Destroy organics
- Remove PFAS incl. short chains
- Remove and manage solids
- Manage odour

- Remove remaining PFAS <math><0.25\mu\text{g/L}</math>

- Onsite Destruction –Sonolysis Trials
- Offsite Thermal Destruction

Polish with Nanofiltration



Ozofractionation

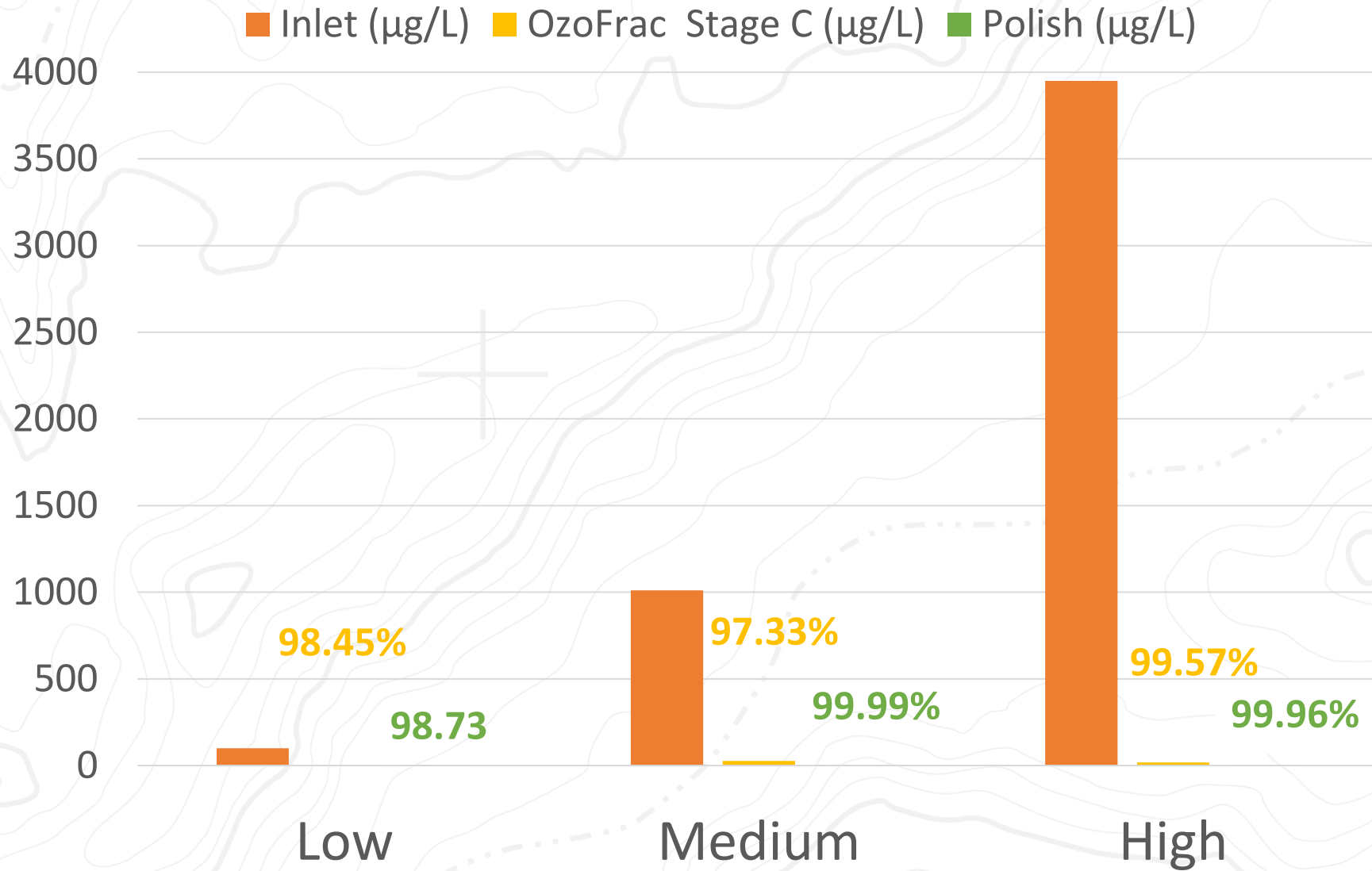
Ozofractionation highly effective at removing PFOS, PFOA, and C6 PFAA precursors.

Ozofractionation converted some C6 precursors to PFHxA, PFPeA – net production of these compounds

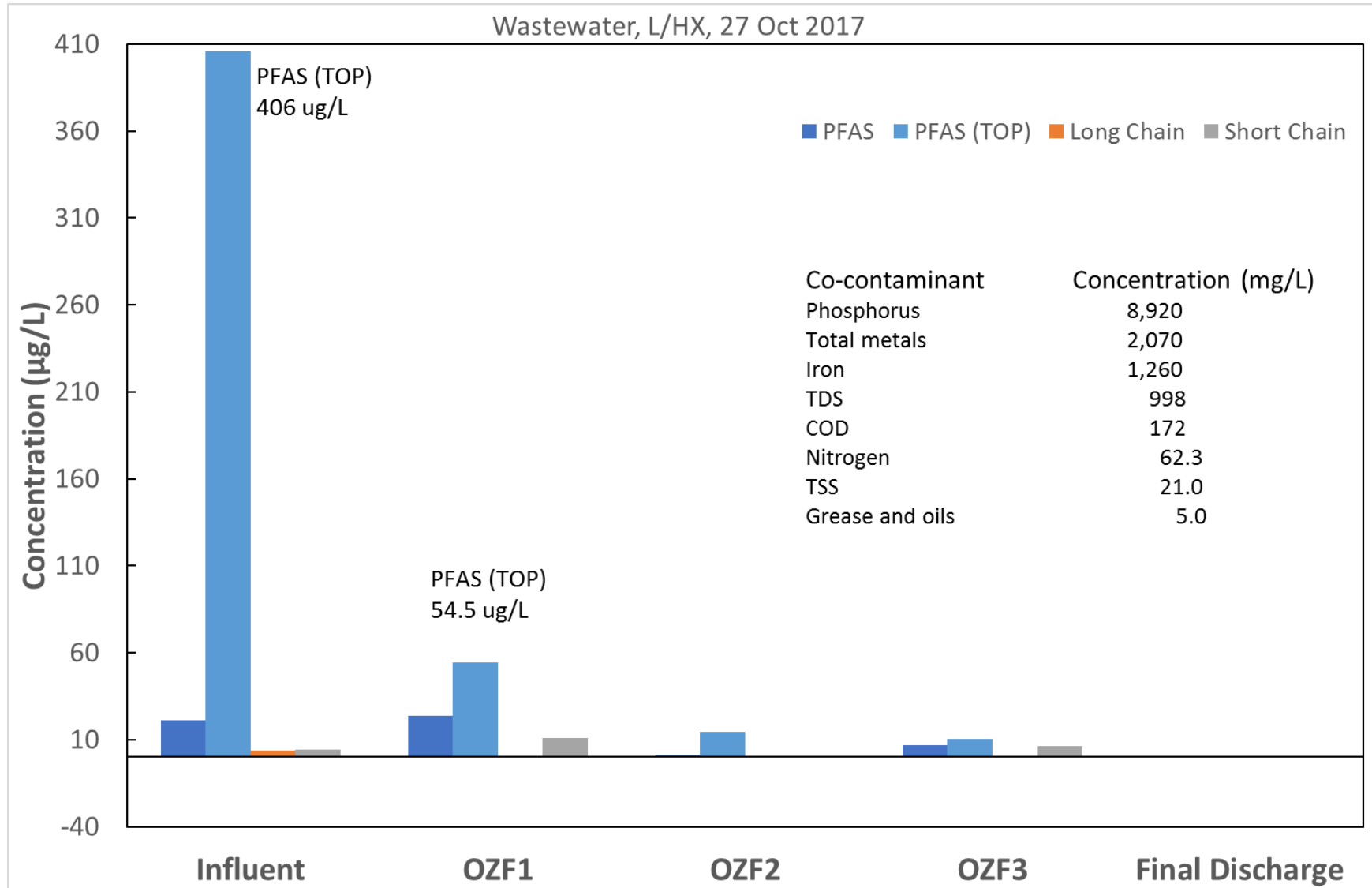
Polishing adsorption stage was effective at removing PFHxA and, to a lesser extent, PFPeA; PFBA was not detectable in these samples

Identification	Influent (µg/L)	Ozofraction % Removal	Adsorbent % Removal	Treated Water (µg/L)	Total % Removal
PFOS	2.61	98.2%	81.3%	0.009	99.7%
PFOA	1.37	97.4%	94.4%	0.002	99.9%
6:2 FtS	87.4	95.6%	89.2%	0.416	99.5%
PFPeA	2.08	-66.3%	83.4%	0.575	72.4%
PFHxA	6.91	-66.4%	99.7%	0.034	99.5%
Sum PFAS	103	78.8%	95.1%	1.07	99.0%
Total PFAS, TOPA	3,950	99.6%	89.6%	1.76	99.96%

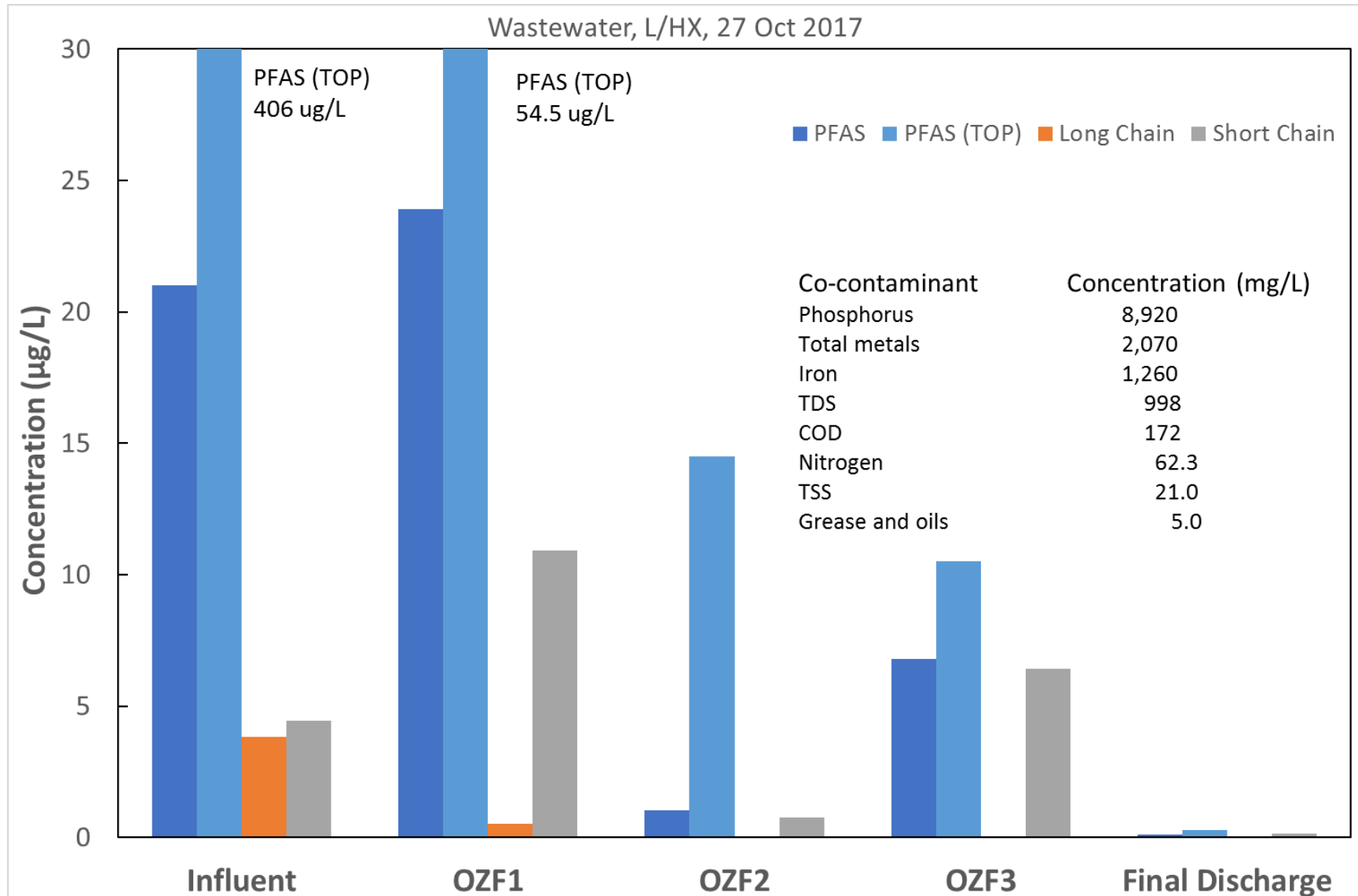
Trial Phase Percent Reduction



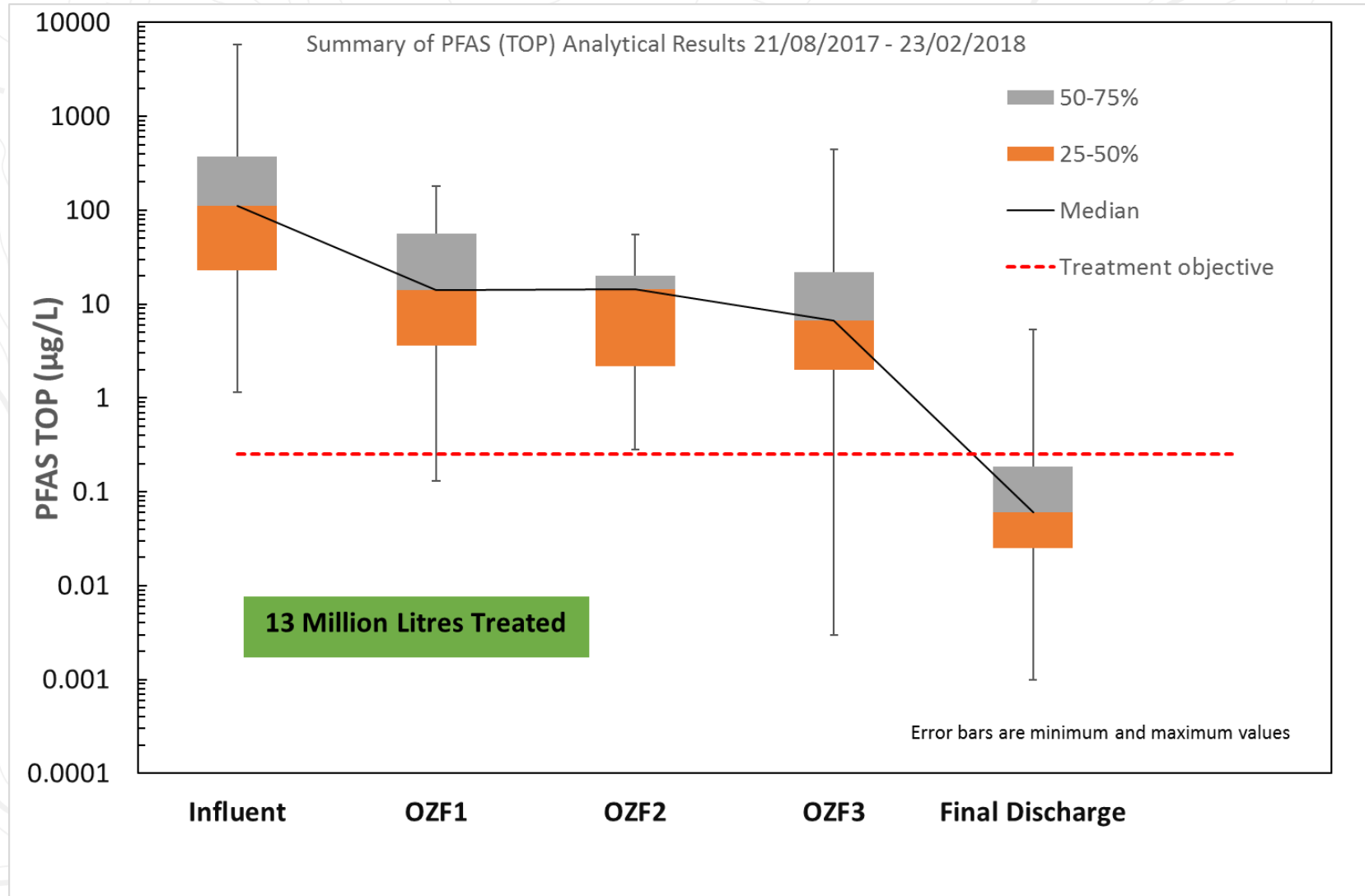
Wastewater Performance



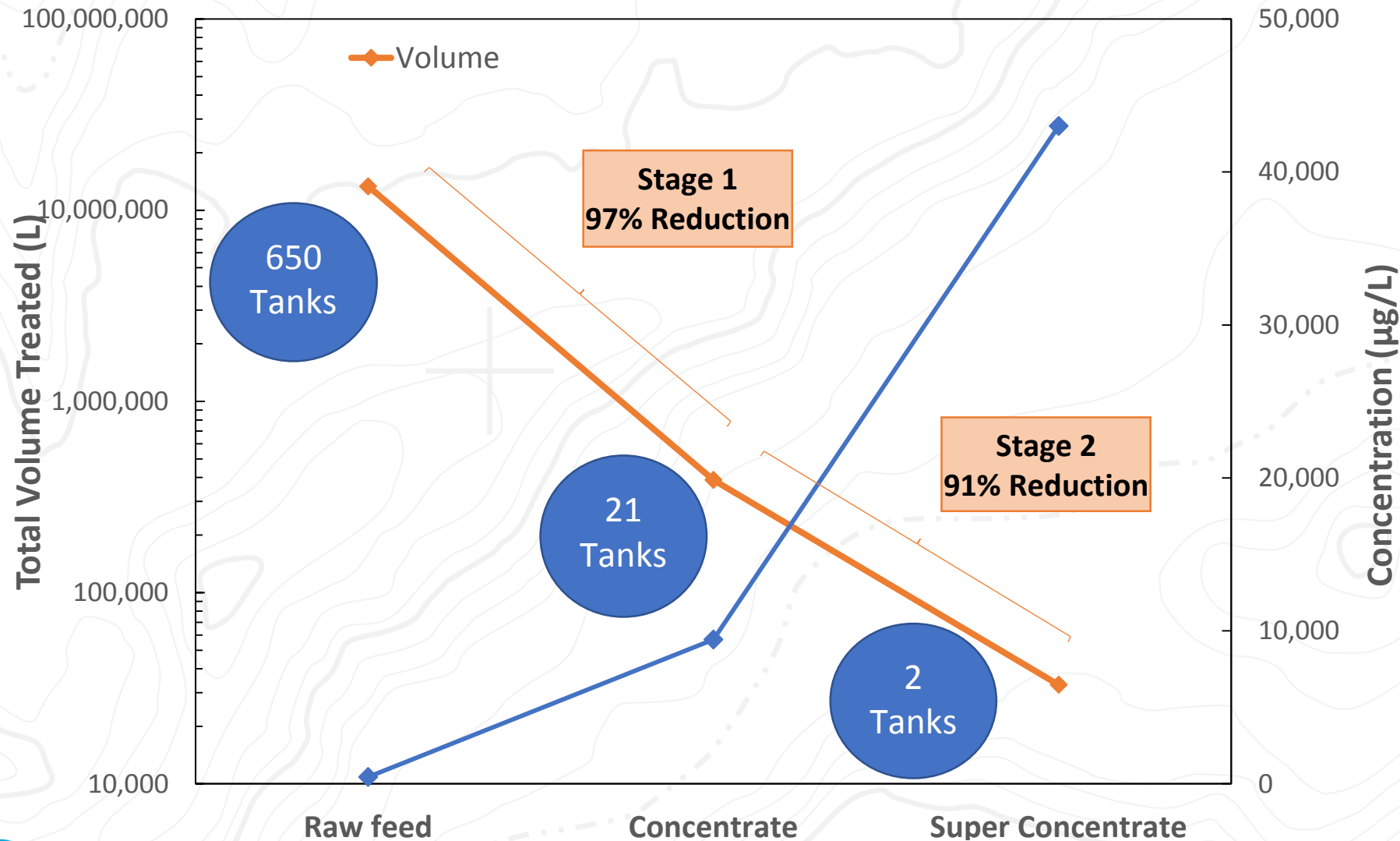
Wastewater Performance



Overall Plant Performance



Reconcentrate



Sonolysis

Applicability:

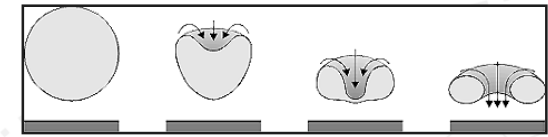
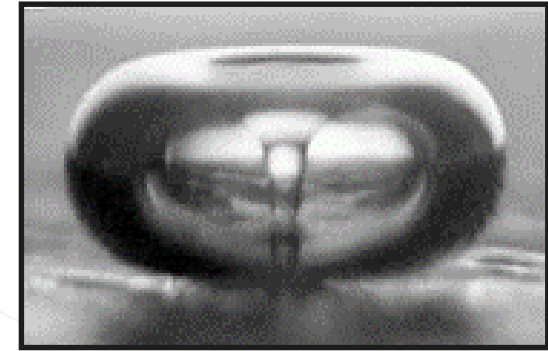
- Ultrasound applied to water results in successive rarefaction/compression of microbubbles ultimately yielding cavitation with extremely high temperatures on the surfaces of the bubbles resulting in pyrolysis of PFAS.

Benefits:

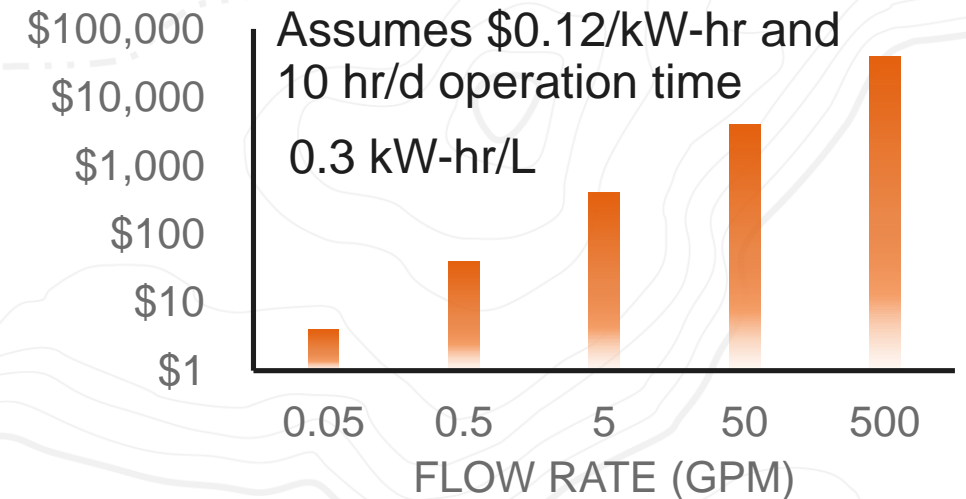
- Can reliably destroy concentrated PFAS waste streams with literature supported fluoride mass balance.
- Opportunities to use green energy sources as technology develops (i.e., solar power).

Limitations:

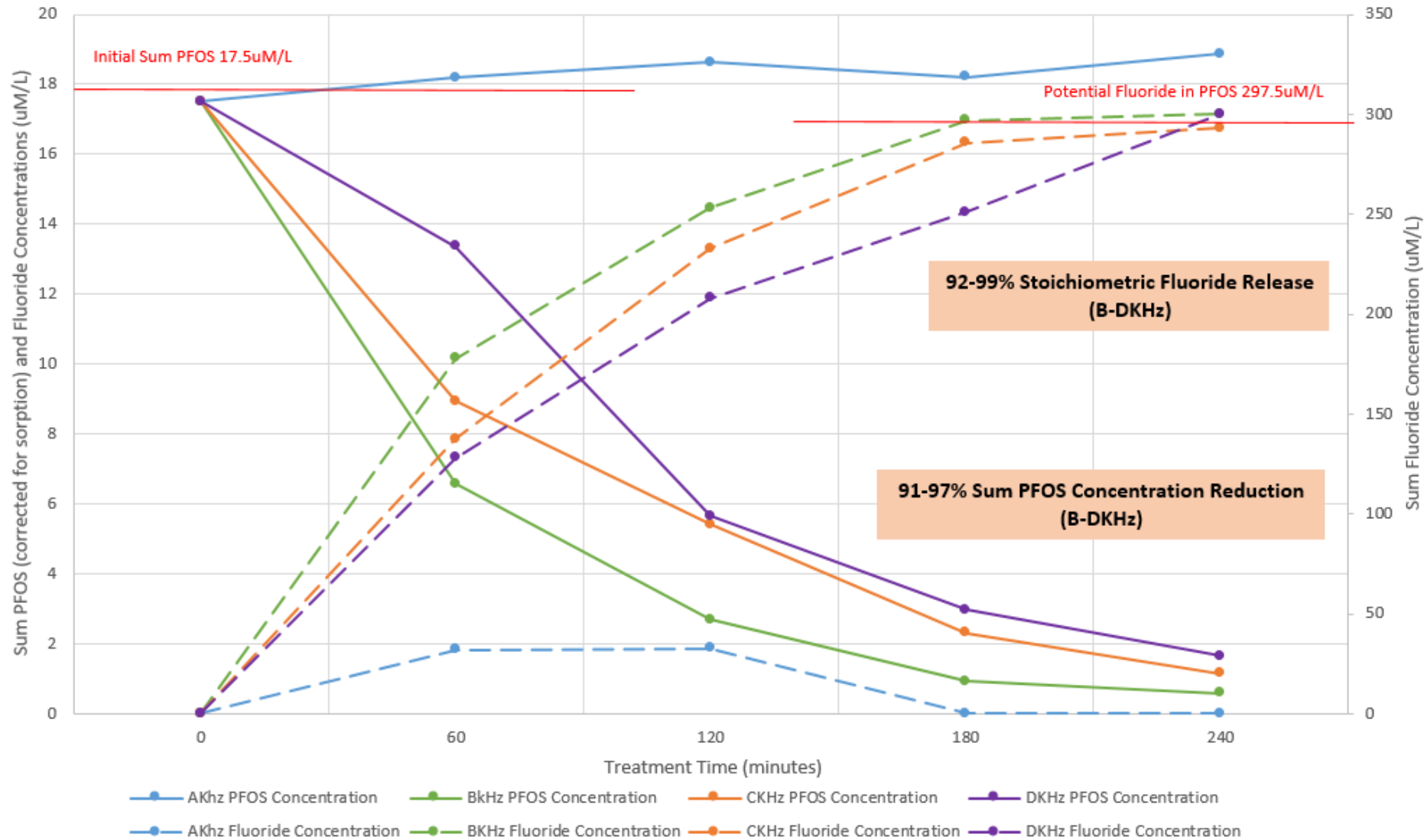
- PFOA rate > PFOS rate. PFOS will require longer residence times and/or more energy. Effective below 10,000 ppt?
- Requires specialized equipment and skilled implementation.
- High energy consumption and low flow rates.



ENERGY COST (USD)



Sonolysis – Proof of Concept Testing



Summary



- Designed, permitted, and installed PFASs wastewater treatment plant;
- Took a new technology from the lab to full-scale in 4 weeks;
- Treated 13.5 ML of domestic and industrial wastewaters from multiple sources, and creek water;
- Co-contaminants treated without pretreatment: high organic load, surfactants, metals, nutrients;
- Removed short-chained PFASs and precursors;
- Meet stringent regulatory treatment objectives for PFASs;
- Generated no spent media, little or no solid waste



Proving F3 Foams for Real-World Fires

A CORE CHANGE FOR THE INDUSTRY.

OCTOBER 16-18, 2018

- DFW Foam Summit Conference Event and Fire Extinguishment Demonstrations

OCTOBER 8-12, 2018

- Large Scale Fire Extinguishment Testing (Research Burns)



**DFW
FOAM
SUMMIT**

at the Fire Training Research Center



FIREFIGHTING FOAM SUMMIT & FIRE EXTINGUISHMENT TESTS

An independently-managed event reviewing the current situation related to selection, use, and management of firefighting foam.

A holistic approach to lifetime foam management, balancing fire performance and potential environmental liabilities. The Foam Summit aims to review the current status and options for future foam policies concerning poly- and perfluoroalkyl substances (PFAS).

PRESENTED BY:

