Making the Switch: Transitioning from PFAS Firefighting Foam to Fluorine-Free Alternatives

MONTROSE ENVIRONMENTAL

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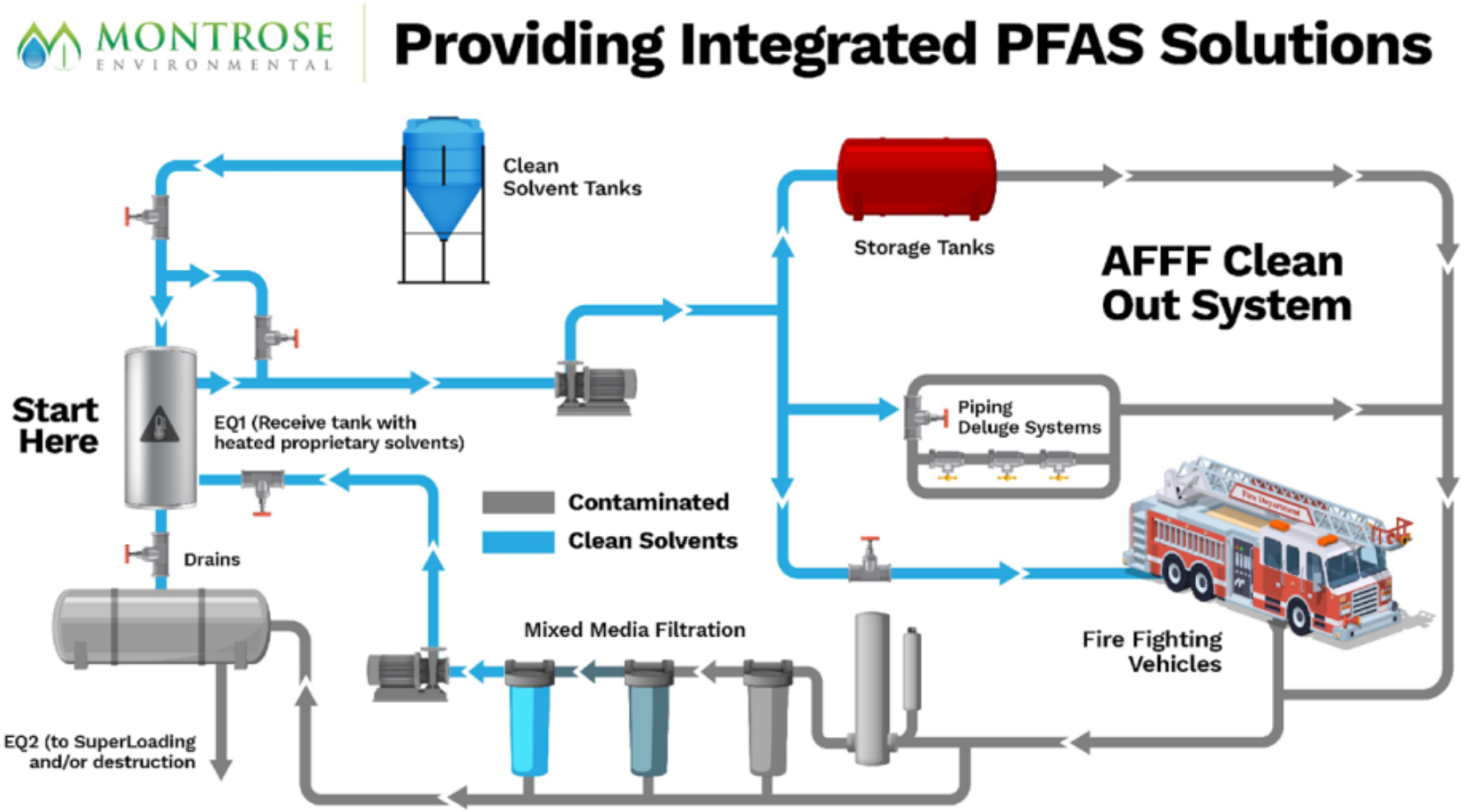
Agenda

- Problem Statement
- Bench-scale efforts
- Vehicle side-by-side study
- Rebound data
- Swipe data

Integrated Solutions for AFFF Transition



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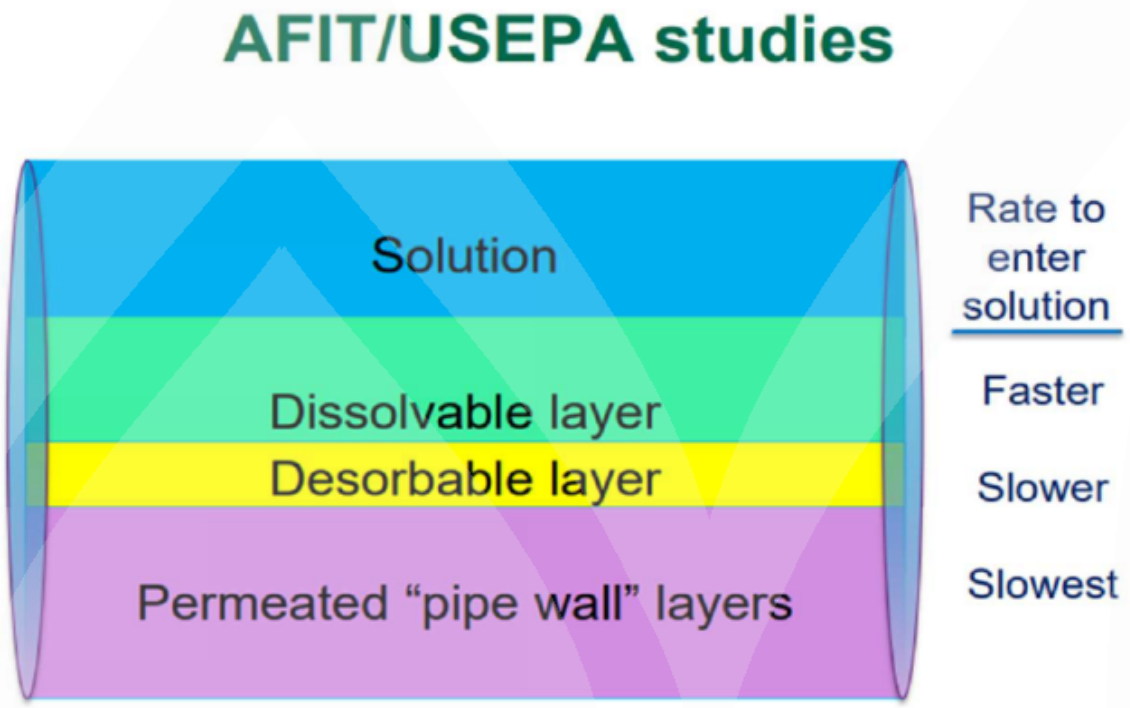
AFFF Transition – *The problem statement*

- Lack of treatment objectives
- Waste handling and minimization
- Rebound issues



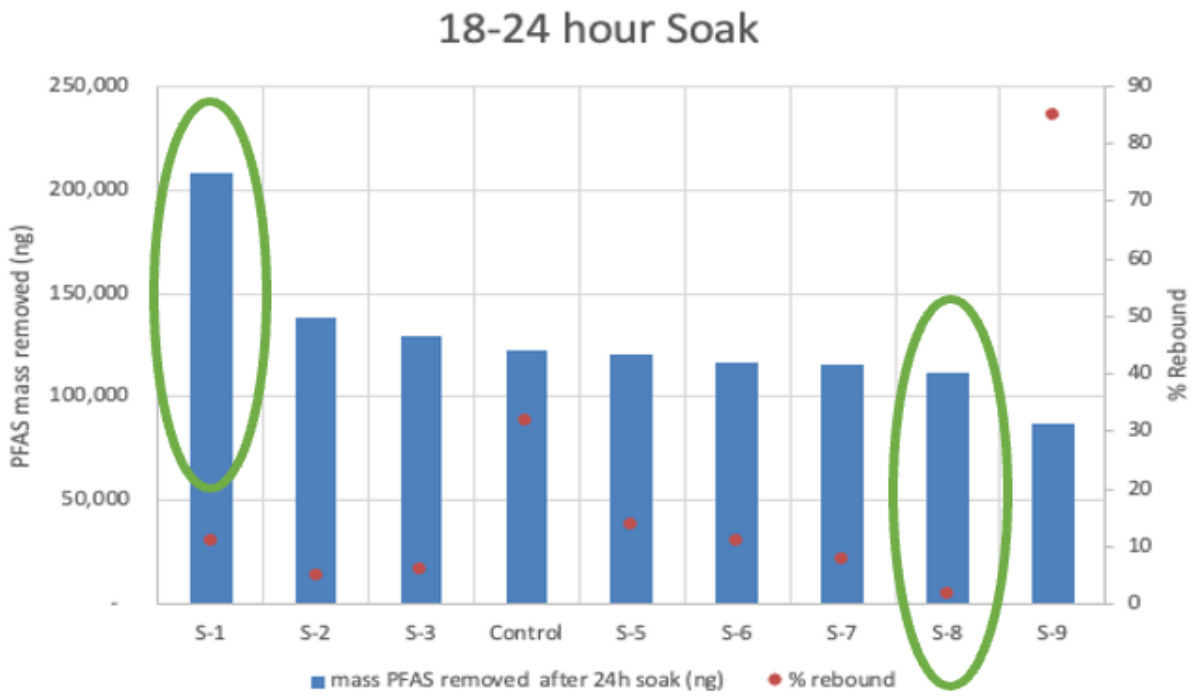
Graphic above from Magnuson, M., "Clean or Replace" Presentation, US EPA, 2022

Experimental Setup – *bench top*

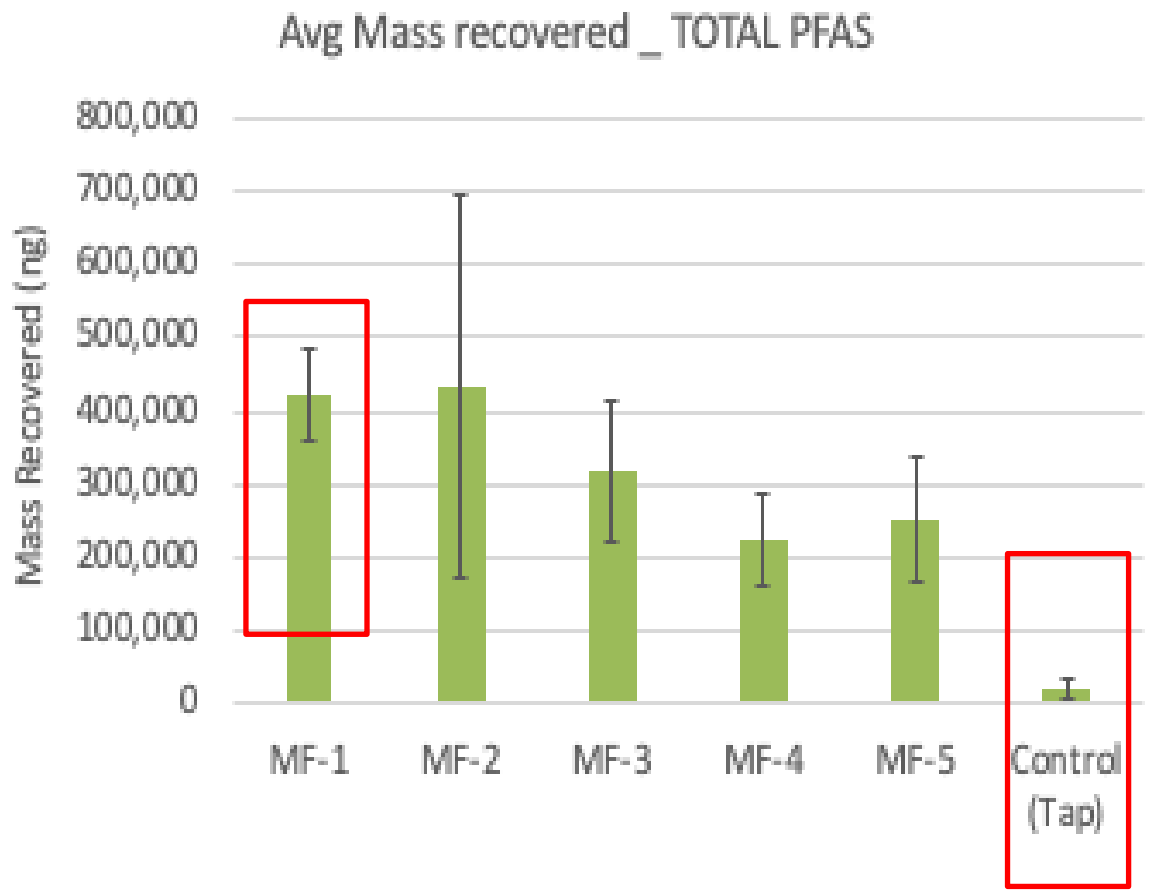
- **Qantas pipe samples from EPA**
  - 30 yr service period / 304 SS / 3” & 4” sections
- **Static**
  - 500mL hold-up volume
  - 9 solutions / 18hr hold time
  - Triple rinse
  - Rebound test with PFAS-free tap water
- **Motive**
  - 1L hold-up volume @ 500 ml/min
  - Control Round: tap water – rinse – tap water (each at 0.5, 1, 2, 4hr recirc/sample times)
  - 3 Rounds investigating 2 solution combinations, different rinse protocols (2hr recirc), dosing strengths
  - Rebound tests conducted for ea round / 18hr hold time

Bench top results – *static tests*

- Identified superior cleaning solutions compared to control (tap water); some solutions equal/inferior to tap
- Wide range of rebound observed
- Top performing solutions advanced to motive/forward-flow testing



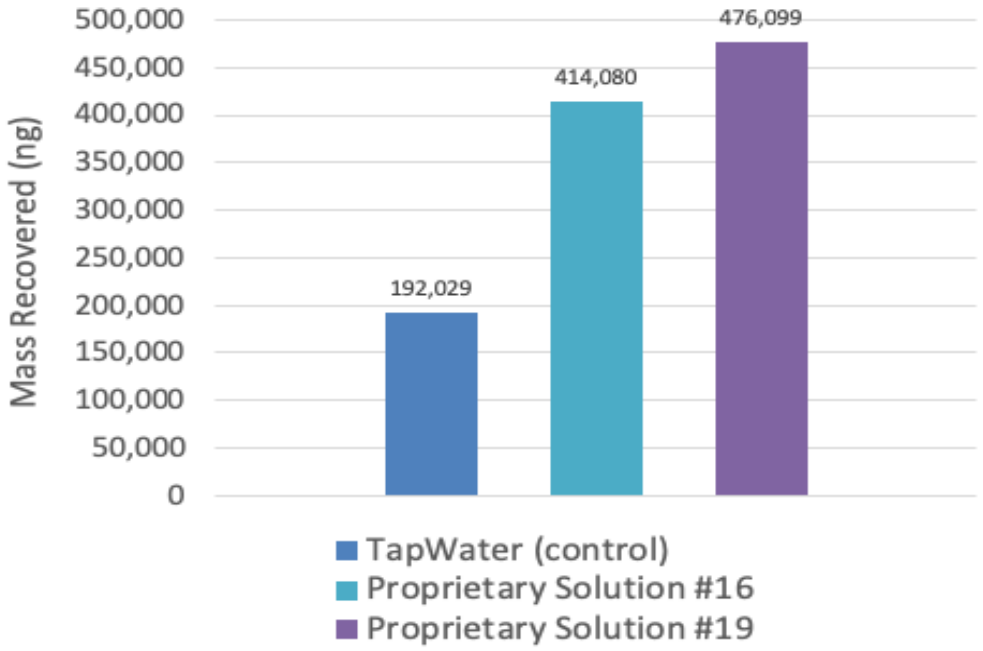
Bench top results – *motive flow*



- With forward flow, cleaning solutions outperformed control.
- Flow increases mass removal.
  - Soak tests (18 hrs): 130,000 ng (avg)
  - Flow through tests (4 hrs): 330,000 ng (avg)
- Temp increases mass removal (but not as impactful as motive force)
- 1st extraction does the heavy lifting; diminishing returns with increasing recirculation time (Lang, et al, 2022)

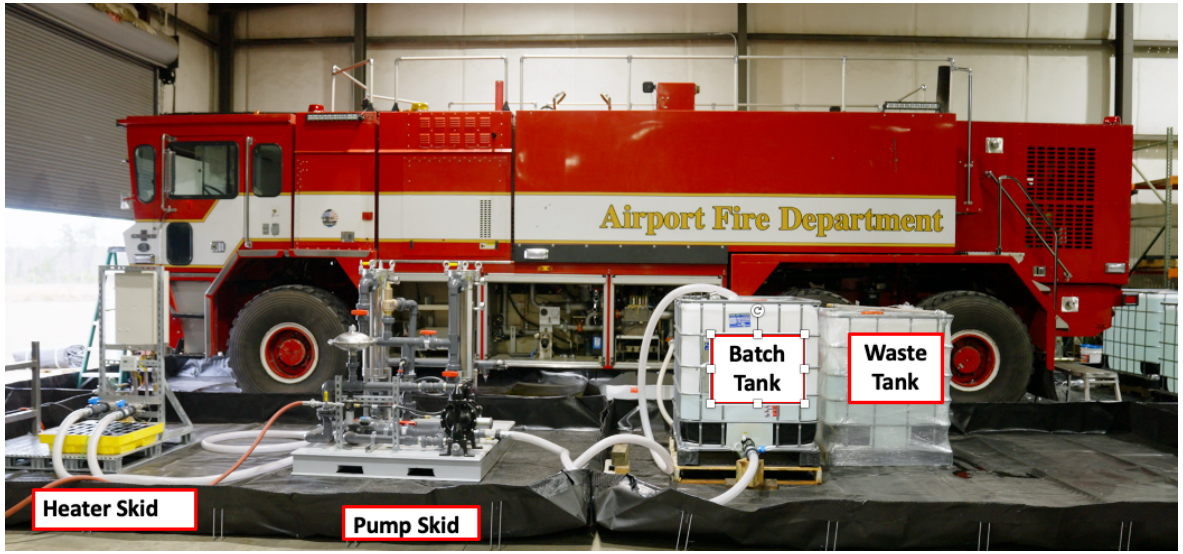
Bench top results – *advancing top performers*

- In all we ran 21 different tests/solutions/ conditions on PFAS-contaminated pipe
- Identified 2-part cleaning solutions with more mass removed than conventional triple rinse
- Options:
  - Cleaning to greatest extent – but takes more time and generates more waste
  - Cleaning to the quickest extent; better than triple rinse but could be cleaned even more w/ more time / passes
  - Waste minimization – incorporating GAC/IEX on backside for reduced waste volume



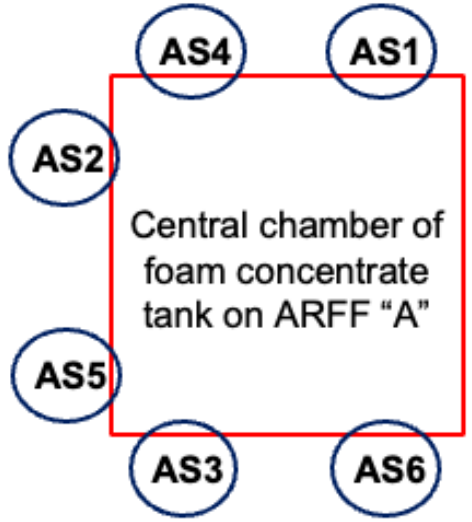
Oshkosh TI 3000 Side by Side– *Triple Rinse vs CIP Solution*

- Company Two Fire
  - OSHKOSH, KME, Rosenbauer, E-One
  - Develop working relationship w/ ARFF certification and know-how
  - Familiarization
  - Pragmatic and practical
- Rebound samples, Swipe samples collected
- Water returned to NC laboratory for treatment
- Process improvement focusing on waste minimization

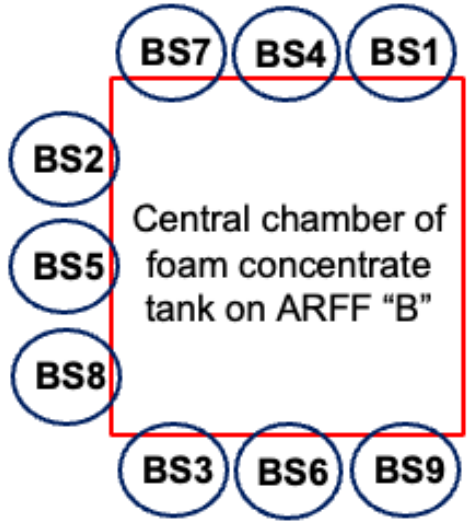


ARFF Cleanout – *Tank Wall Swipe Test*

Two sets of three samples for ARFF “A”

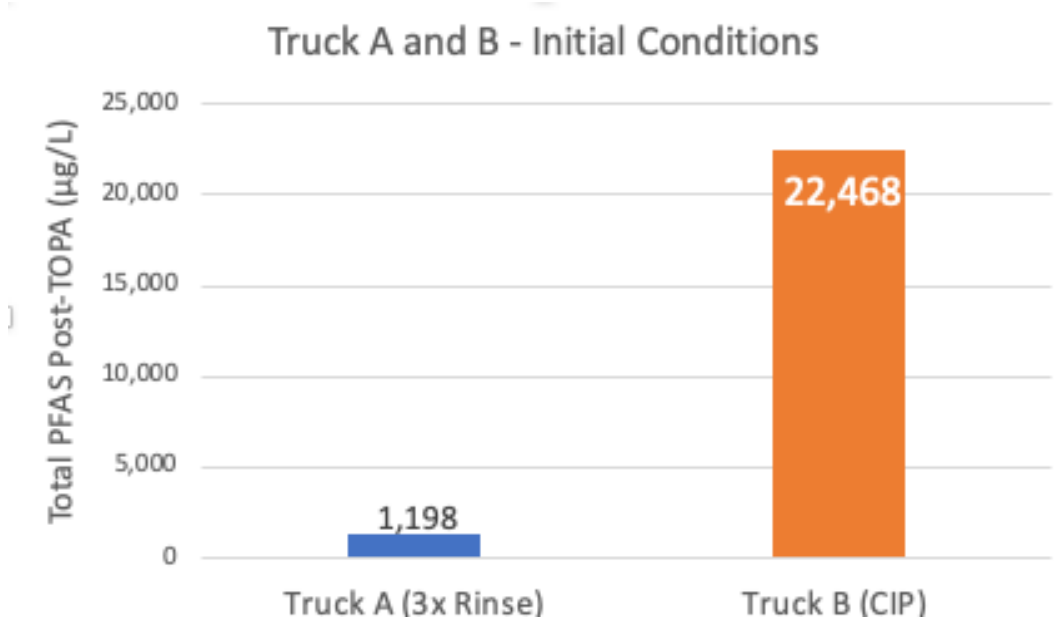


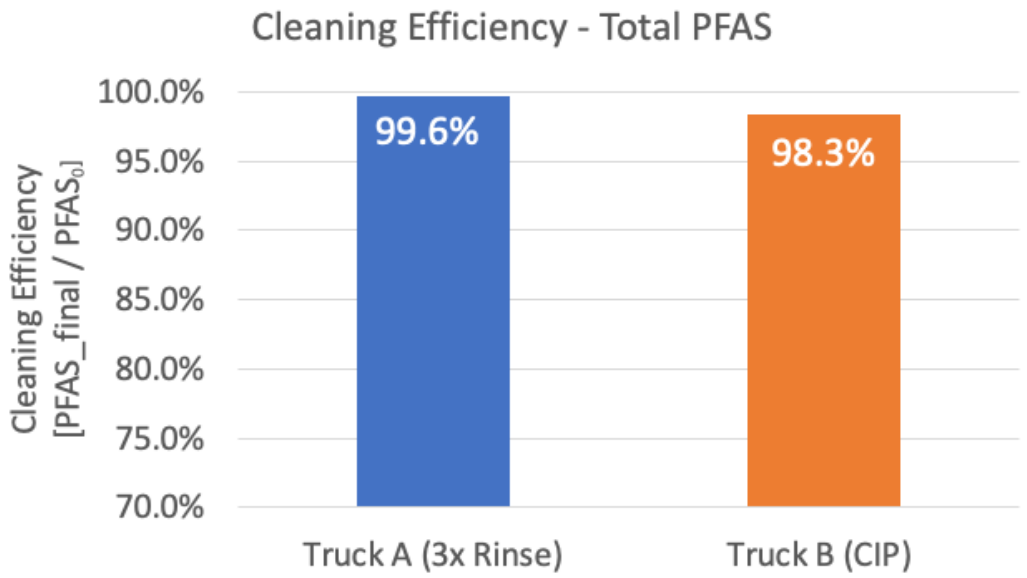
Three sets of three samples for ARFF “B”



ARFF Cleanout – *Side by Side Comparison*

Truck A = Triple Rinse; mostly fluorotelomer PFAS
Truck B = Montrose Clean In Place (CIP); mostly sulfonates, some fluorotelomers

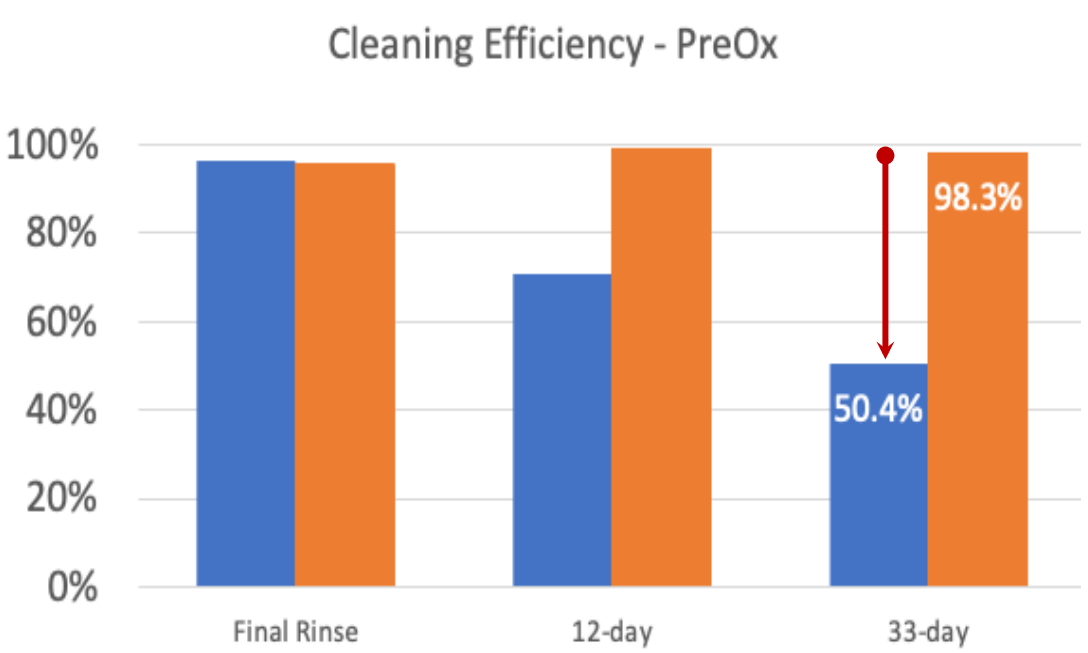


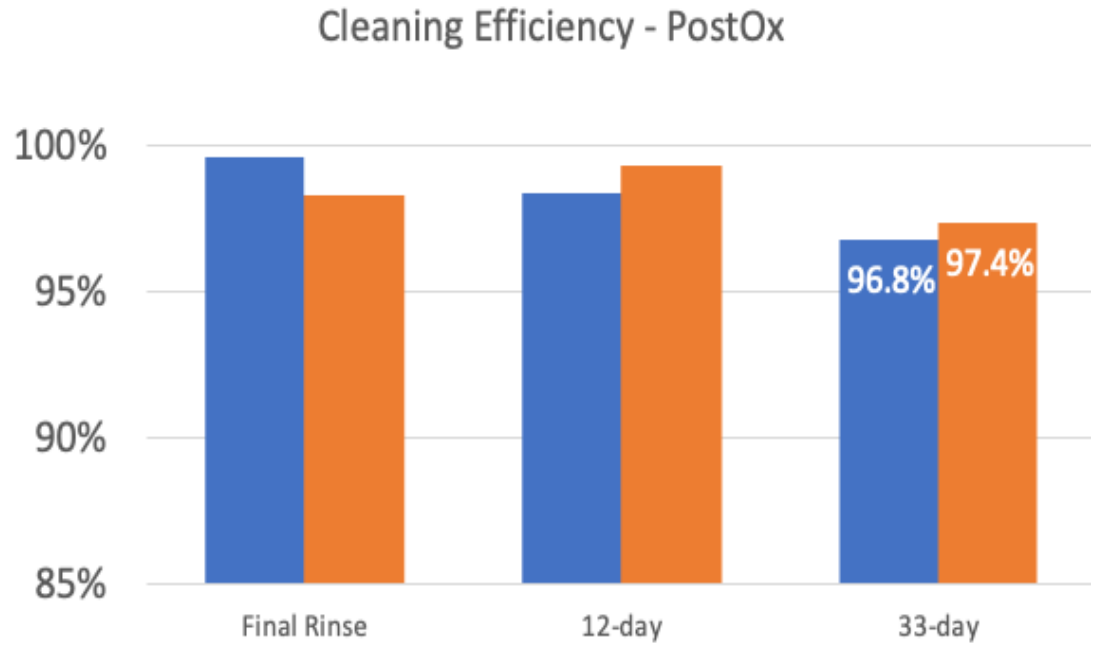


Dissimilar trucks (PFAS loading and AFFF type) but similar cleaning efficiencies

ARFF Cleanout – *Rebound Analysis*

Truck A = Triple Rinse
Truck B = Montrose Clean In Place (CIP)



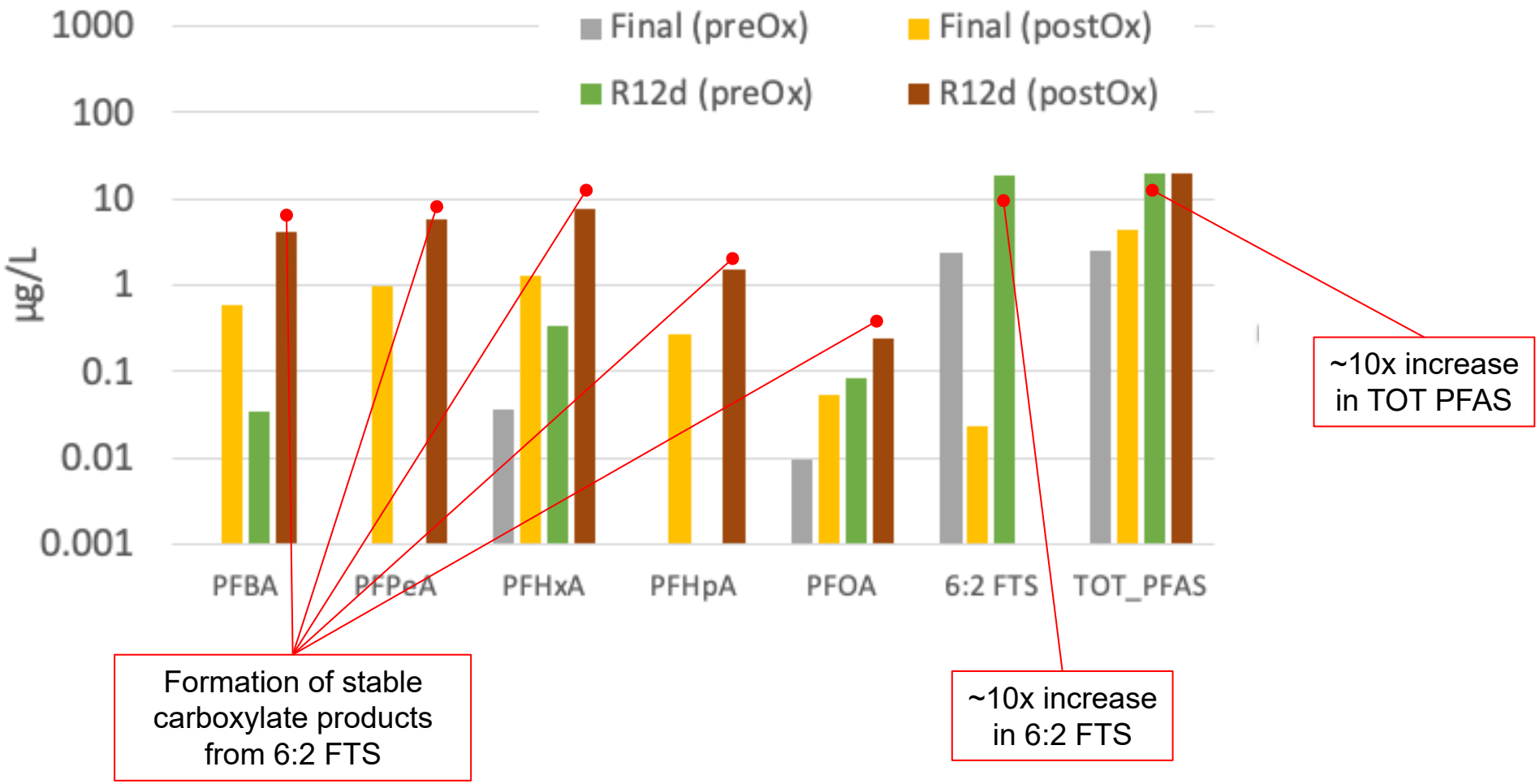


Truck A Truck B

TOPA sample results:
- Significantly more rebound with 3x rinse compared with CIP (pre-TOPA)
- Similar rebound between methods (post-TOPA)

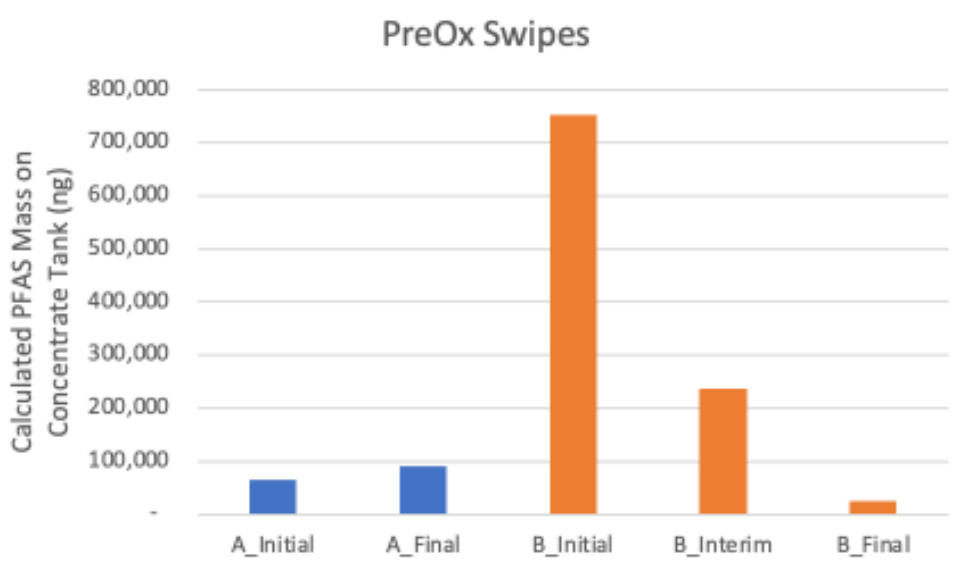
Truck A ARFF Cleanout – *Rebound Analysis*

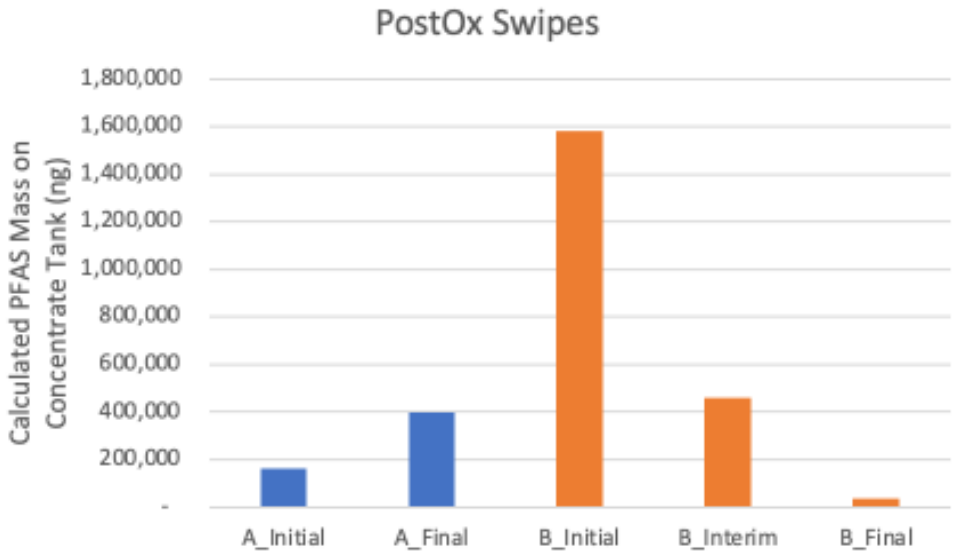
Truck A = Triple Rinse; mostly fluorotelomer PFAS



ARFF Cleanout – *Swipe samples*

Truck A = Triple Rinse
Truck B = Montrose Clean In Place (CIP)



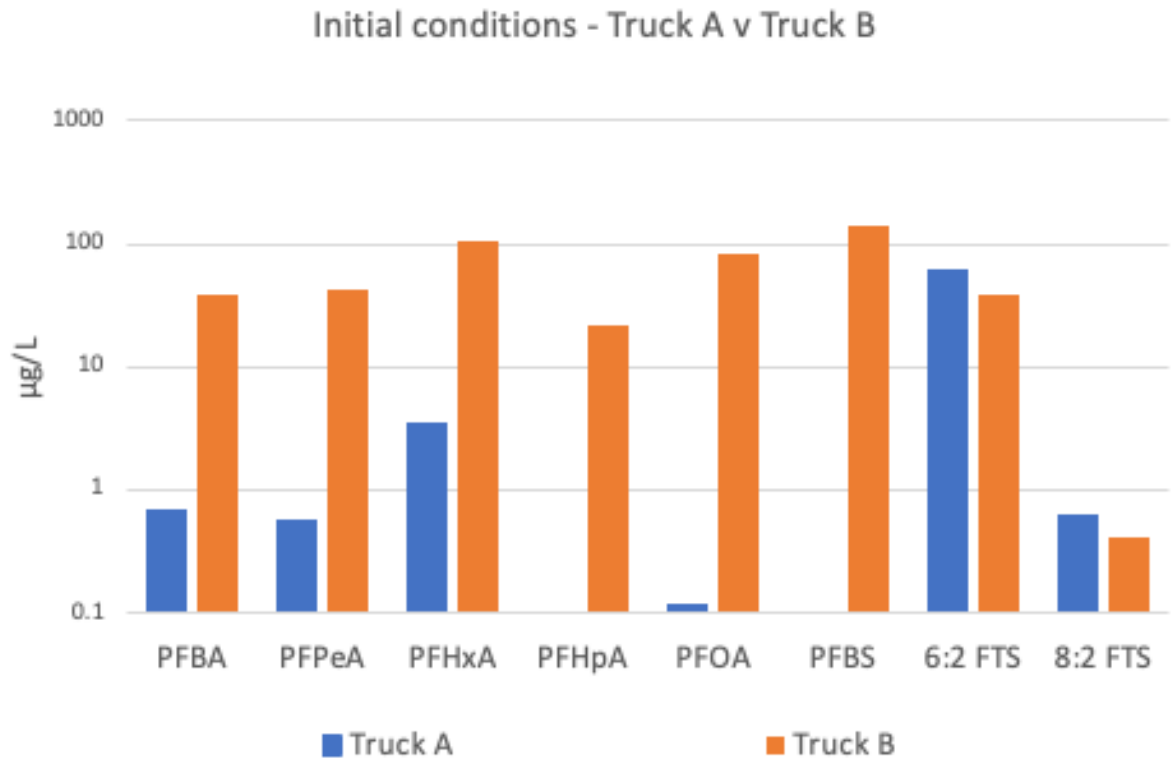


Sample ID	Max contamination to SFFF with 100% desorption (µg/L)
A_Initial	0.10
A_Final	0.25
B_Initial	1.00
B_Interim	0.29
B_Final	0.02

Standard	Criteria
GreenScreen Certified Firefighting Foam Std	1 ppm by TOF-CIC
MIL-PRF-32725	1 ppb by 1633

ARFF Cleanout – *Making comparisons …*

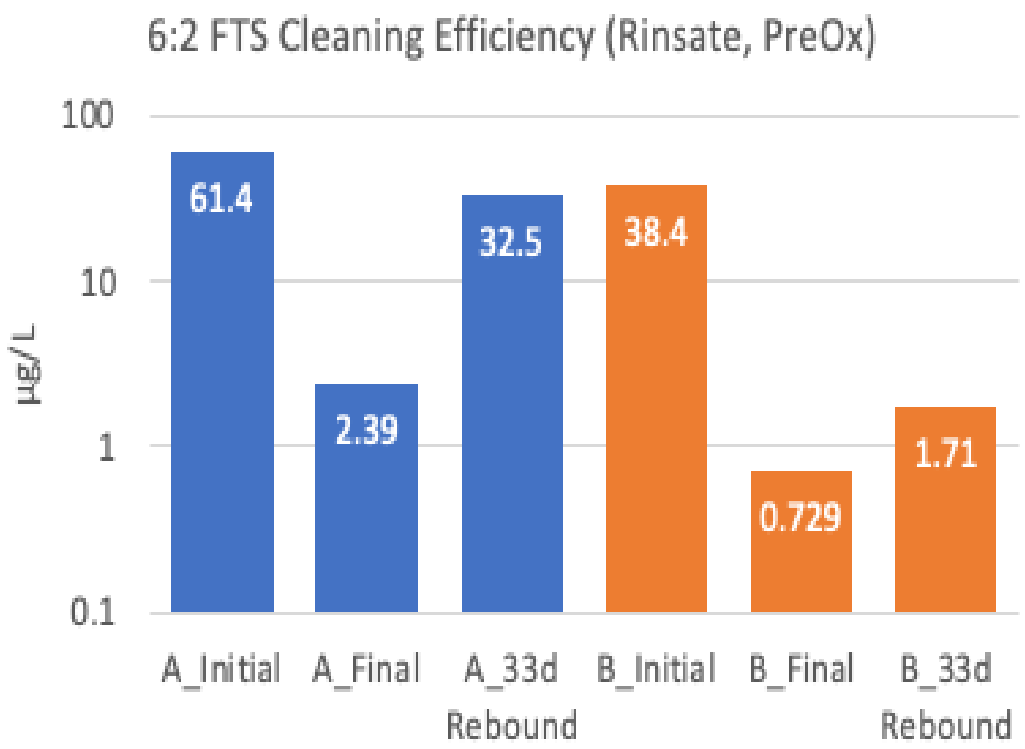
Truck A = Triple Rinse; mostly fluorotelomer PFAS
Truck B = Montrose Clean In Place (CIP); mostly sulfonates, some fluorotelomers

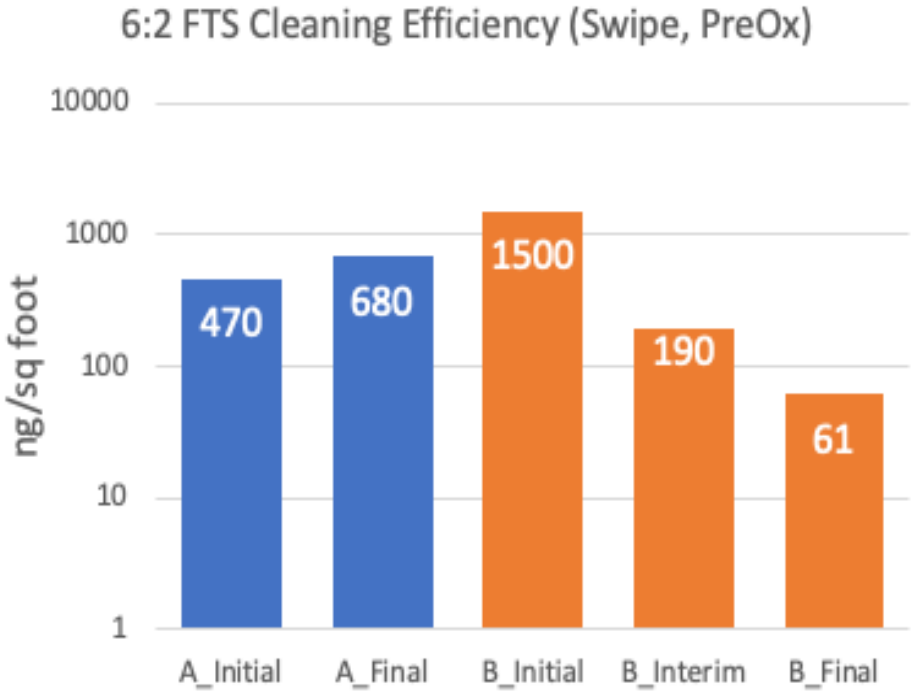


Similar FTS concentrations makes comparisons possible …

ARFF Cleanout – *6:2 FTS cleaning efficiencies*

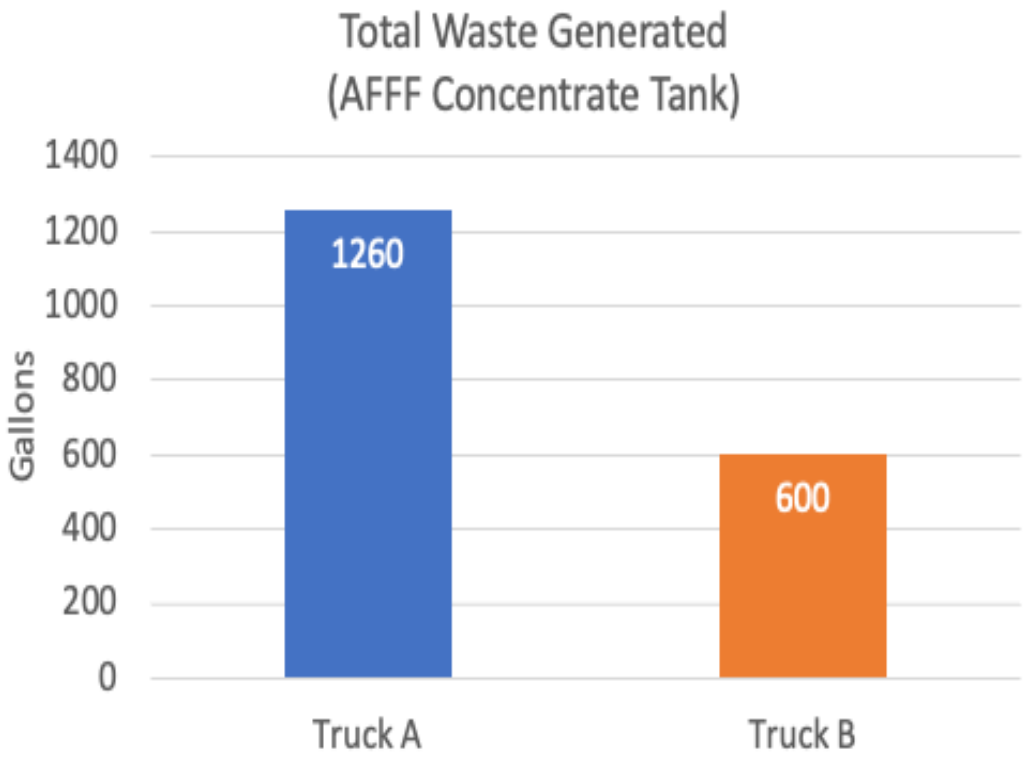
Truck A = Triple Rinse; mostly fluorotelomer PFAS
Truck B = Montrose Clean In Place (CIP); mostly sulfonates, some fluorotelomers

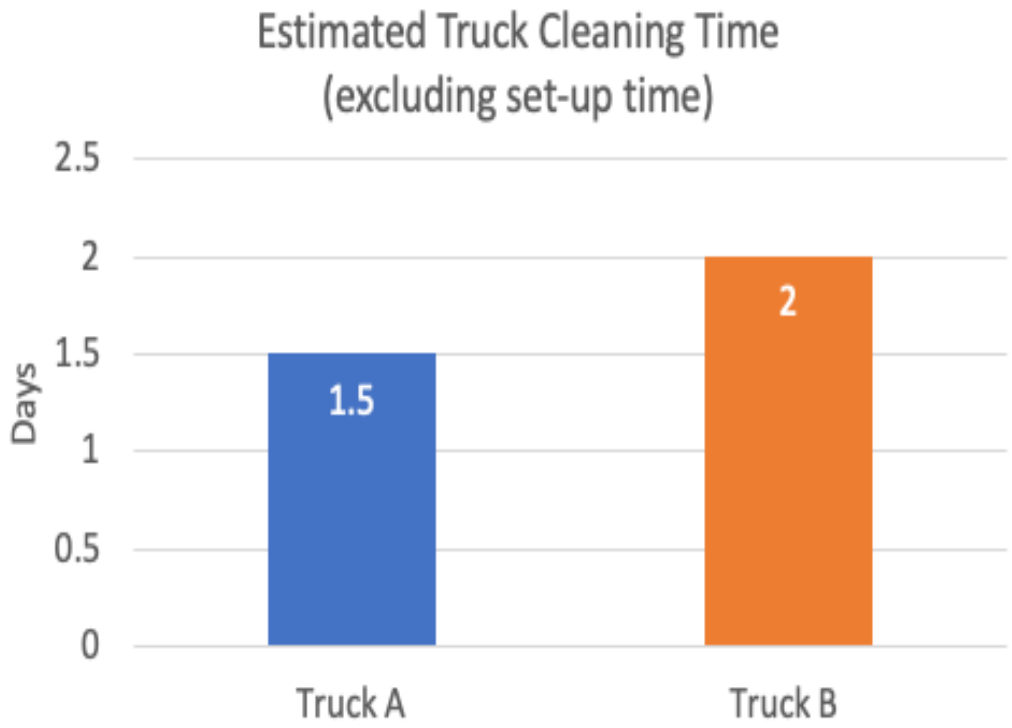




Considerably more rebound for 3x rinse; Swipe indicates effective cleaning w/ CIP

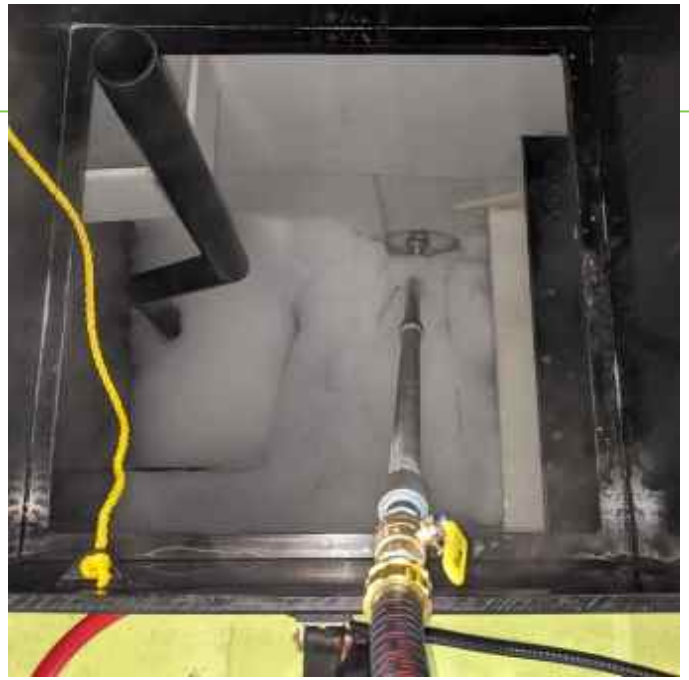
ARFF Cleanout – *Side-by-side comparison*





Waste minimization – CIP process generates less waste for disposal

Summary - *What can we say …*



What we have:

- Experience w/ C6 transition / clean-out ops for the USN; experience with ARFF cleaning ops
- Familiarity across different platforms
  - (Oshkosh, KME, E-One, Rosenbauer)
- More know-how than anyone in effluent / rinsate treatment
- Occupational health expertise with ChemSteer (CTEH)

- Preliminary numbers suggesting a solution that outperforms 3x H_2O rinse (rinsate, swipe samples)
  - Further study necessary
- Generation of lower volumes of waste for disposal

What we don't have:

- Rebound numbers beyond 33 days
- Initial concentrations of PFAS on materiel (t=0)

