Field Deployment of FRED-PFAS: a portable unit for Measuring total PFAS in the field

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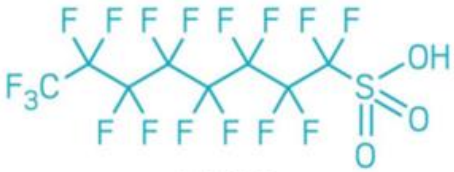
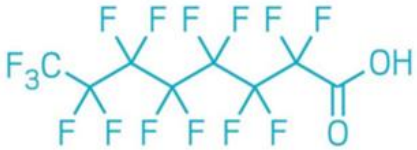
What are PFAS (Perfluoroalkyl and Poly- fluoroalkyl Substances)?

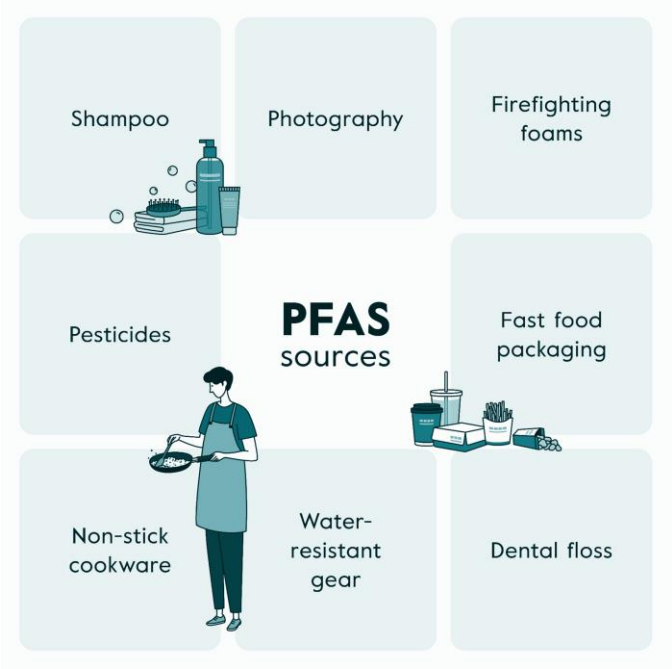
- **Forever chemicals**
- Large, complex, and ever-expanding group of manufactured chemicals that are widely used to make various types of **everyday products**
- Most abundant is **PFOA** (Perfluorooctanoic Acid) & **PFOS** (Perfluorooctanesulfonic acid)



PFOS

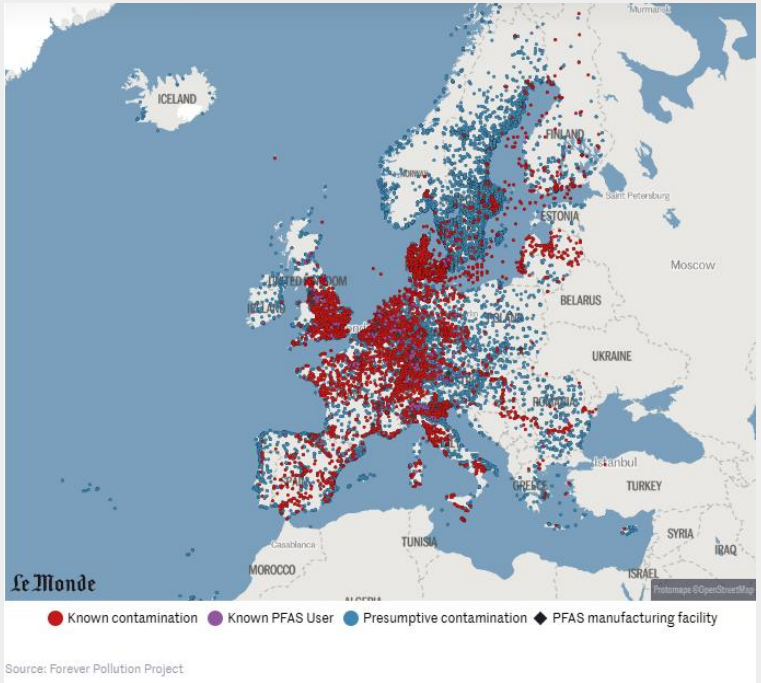


PFOA

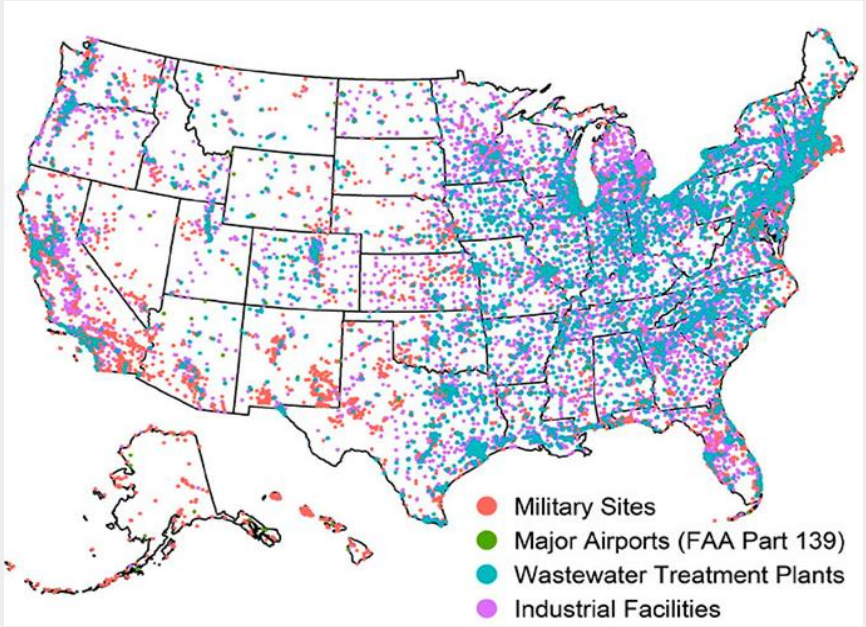


The Expanding PFAS Challenge

Europe: >23,000 sites where PFAS contamination has been detected. Additional >21,000 presumptive PFAS contamination sites

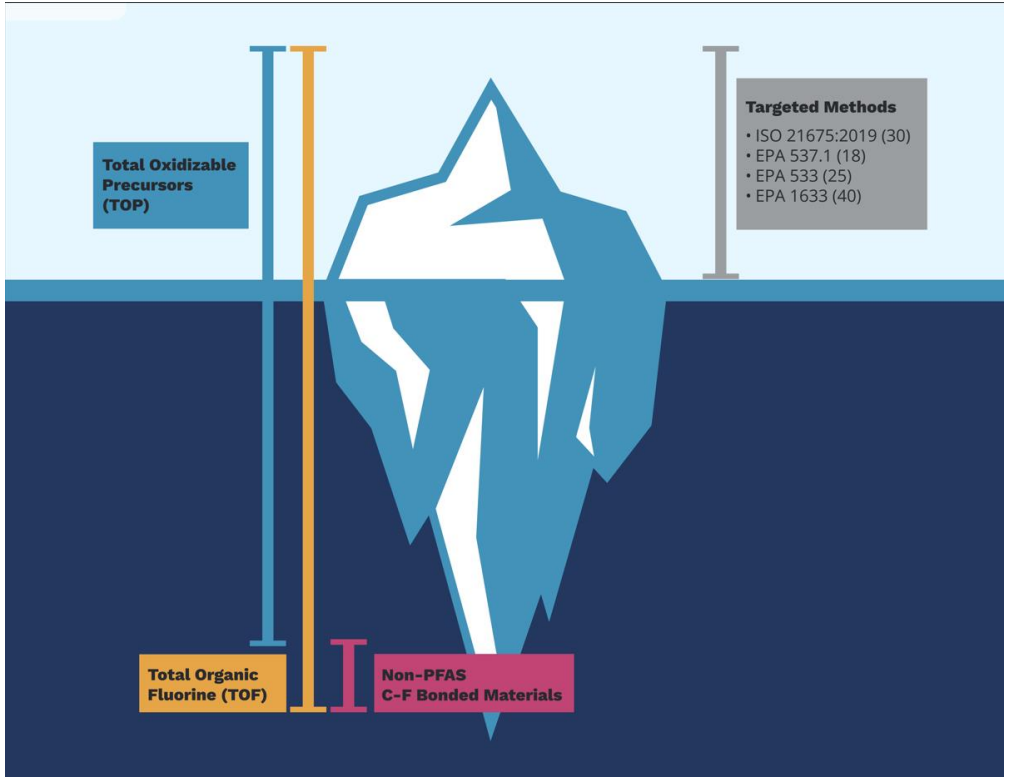


USA: >57,000 presumptive PFAS contamination sites. PFAS-contaminated drinking water estimated to affect ~200M people



1 Le Monde, 'Forever pollution': Explore the map of Europe's PFAS contamination (2023). Link
2 Environmental Science & Technology Letters, Presumptive Contamination: A New Approach to PFAS Contamination Based on Likely Sources (2022). Link

The PFAS Analytical Toolbox



Targeted Analysis

- Methods: **ISO 21675:2019, EPA 1633, EPA 537.1, EPA 533, Total Oxidizable Precursors (TOP)**
- Select PFAS species are measured individually
- Measured with liquid chromatography- tandem mass spectrometry (LC-MS/MS) in the laboratory

Total Measurements

- Methods: **Total Organic Fluorine (TOF), EPA 1621 (Absorbable Organic Fluorine)**
- Non-Targeted Fluorine Methods provide “Total PFAS” output
- Measured with Combustion Ion Chromatography (CIC)

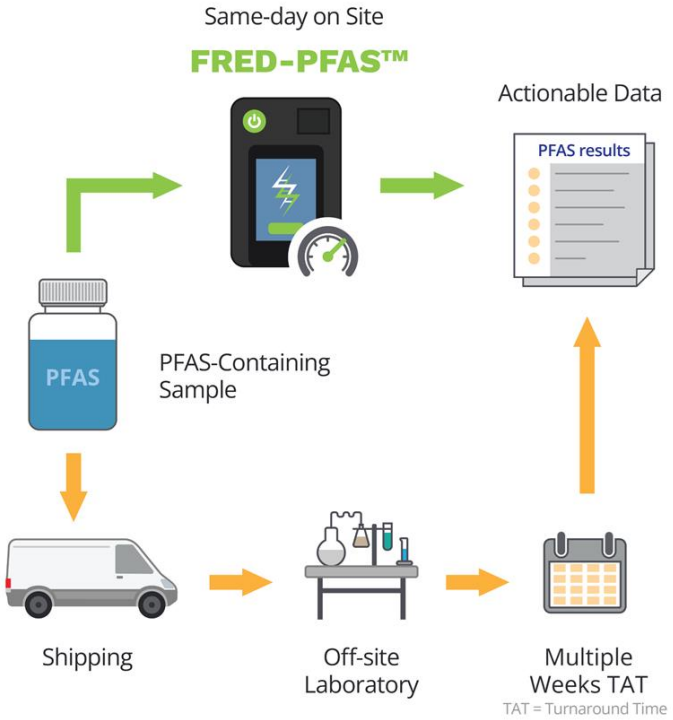
Laboratory Results Take Weeks

LC/MS based methods dominate the market

Method	Results	Laboratory Turn Around Time
ISO 21675: 2019	Targeted 30 PFAS	2-6 weeks
EPA 1633	Targeted 40 PFAS	2-6 weeks
Total Oxidizable Precursors (TOP) Assay	Total (1633 + Precursors) **Interesting for AFFF**	4-12 weeks
Total Organic Fluorine (TOF)	Total Fluorine	2-4 weeks

All require highly trained professionals and lots of time.

What if there was a Field Screen for PFAS?



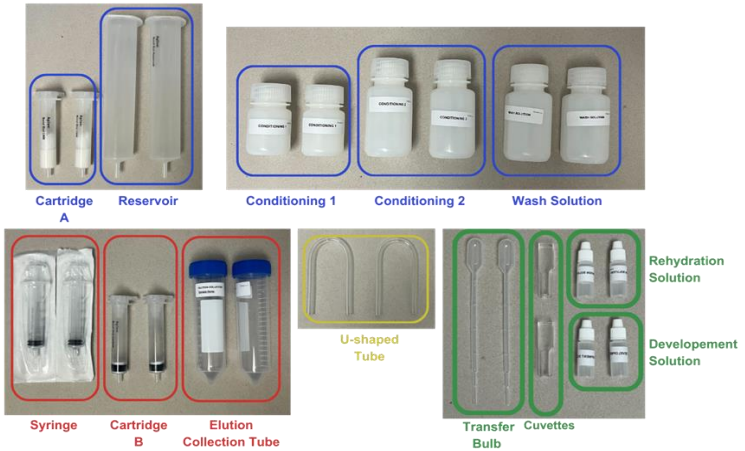
Same-day onsite PFAS Screening can:

- Create **dynamic workflows** for proactive decision-making in the field
- Complement targeted laboratory analysis
- **Expedite** project timelines
- **Save** on project costs
- Relax REACH regulations for AFFF foam transition projects by using **best available technologies**

Introducing FRED-PFAS

FRED-Capture and FRED-Fluor Devices

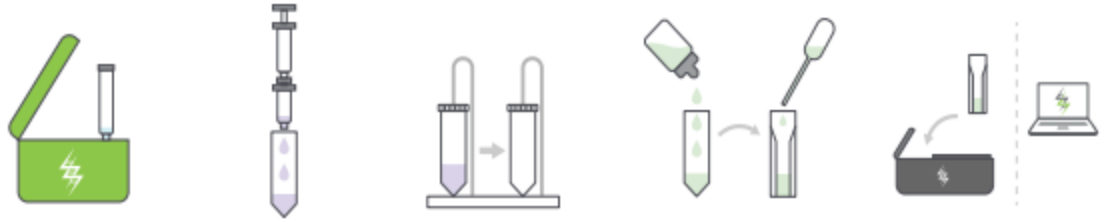
Consumable Reagent Packs



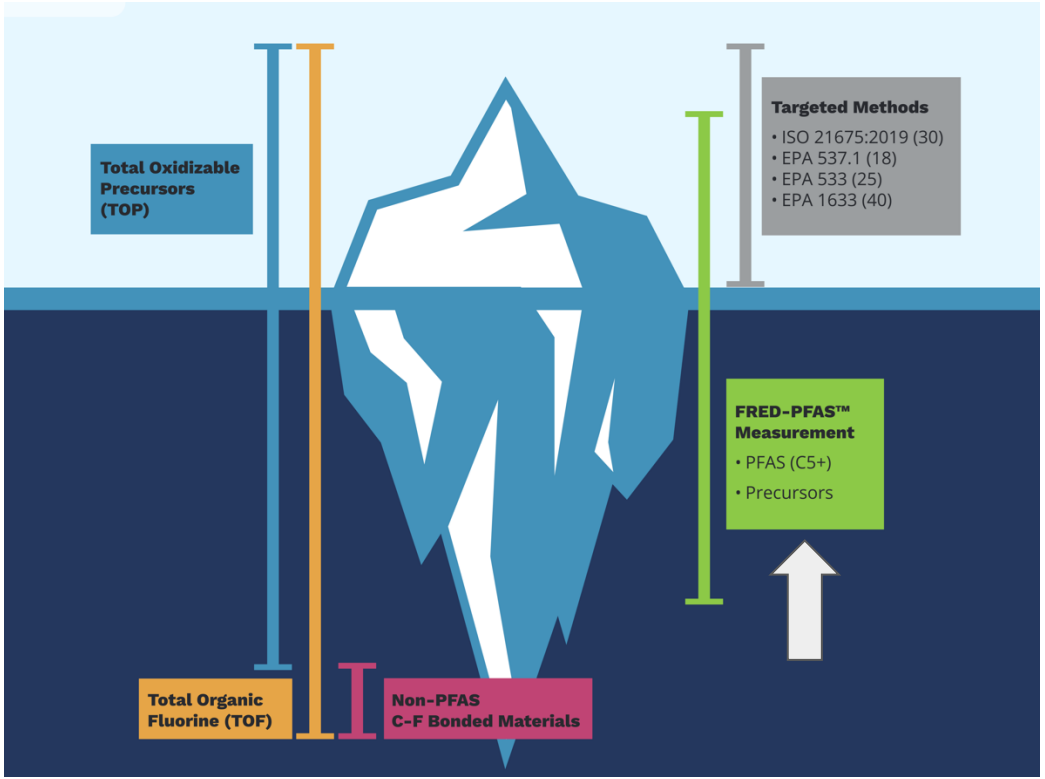
- Rugged and Field-Capable
- Lightweight (5.4 Kg)
- Simple 5-step manual process
- Fast Screening (12 tests/day/unit)
- 1,000 ng/L (1 ppb) Limit of Detection

FRED-PFAS: The First Field Screening Method

- Measure down to **1,000 ppt** in real-world matrices with results in 3 hours
- Accurate and reproducible measurements designed for use by operators and consultants
- Comparable to Third Party Lab Data
- Simple **5-Step process** from Sample Collection to Results



The New PFAS Analytical Toolbox



FRED-PFAS output is akin to a Total PFAS Measurement

- Non-Targeted **Screening Tool**
- **Highly selective** to fluorocarbon backbones of PFAS molecules
- Detects C5+ PFAS and Precursors
- Works well in **AFFF-impacted matrices and "clean" industrial matrices**

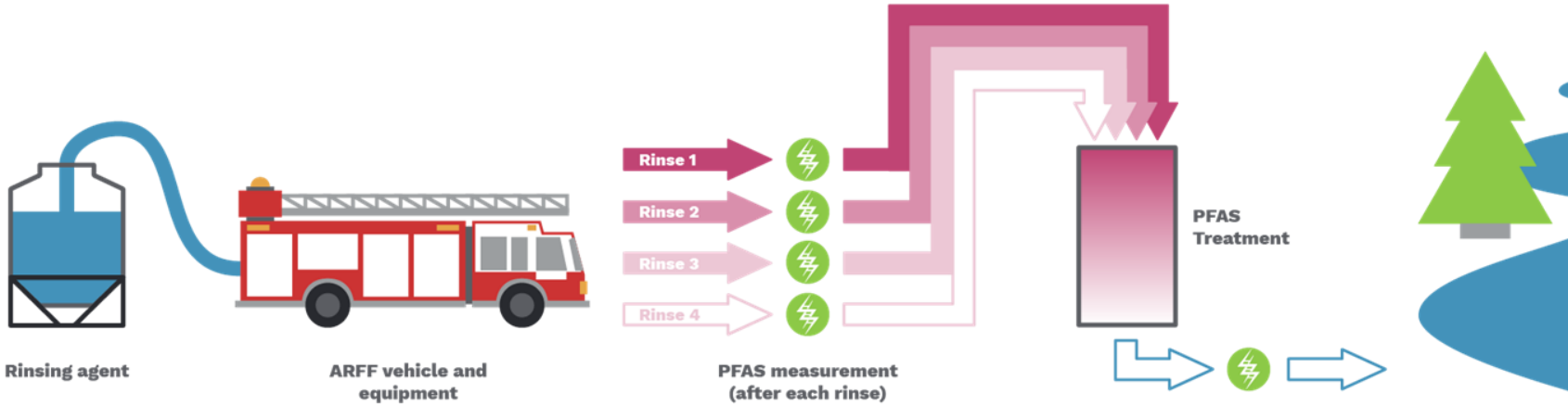
Applications

AFFF changeout
Accelerate project timelines, early indicators on efficacy of cleaning regimes.

Treatment Operations
High concentration remediation and industrial feed monitoring optimization

Site investigations
Optimize mobilizations and plume delineation

Case Study 1
Using FRED-PFAS™ To Optimize AFFF Changouts



Aircraft, rescue, and firefighting (ARFF) vehicles and equipment are cleaned using specialized rinsing agents, which must be treated prior to discharge.

FRED-PFAS™ measures PFAS levels at equipment outlet after every rinse. Same-day results allow crews to better optimize the number of rinses needed, saving both time and money.

FRED-PFAS™ also measures PFAS levels after treatment to ensure the water is safe to discharge into the environment.

= FRED-PFAS™ measurements taken

FREDsense What's in your water?

AFFF Transition North America

Start Date: May 2025

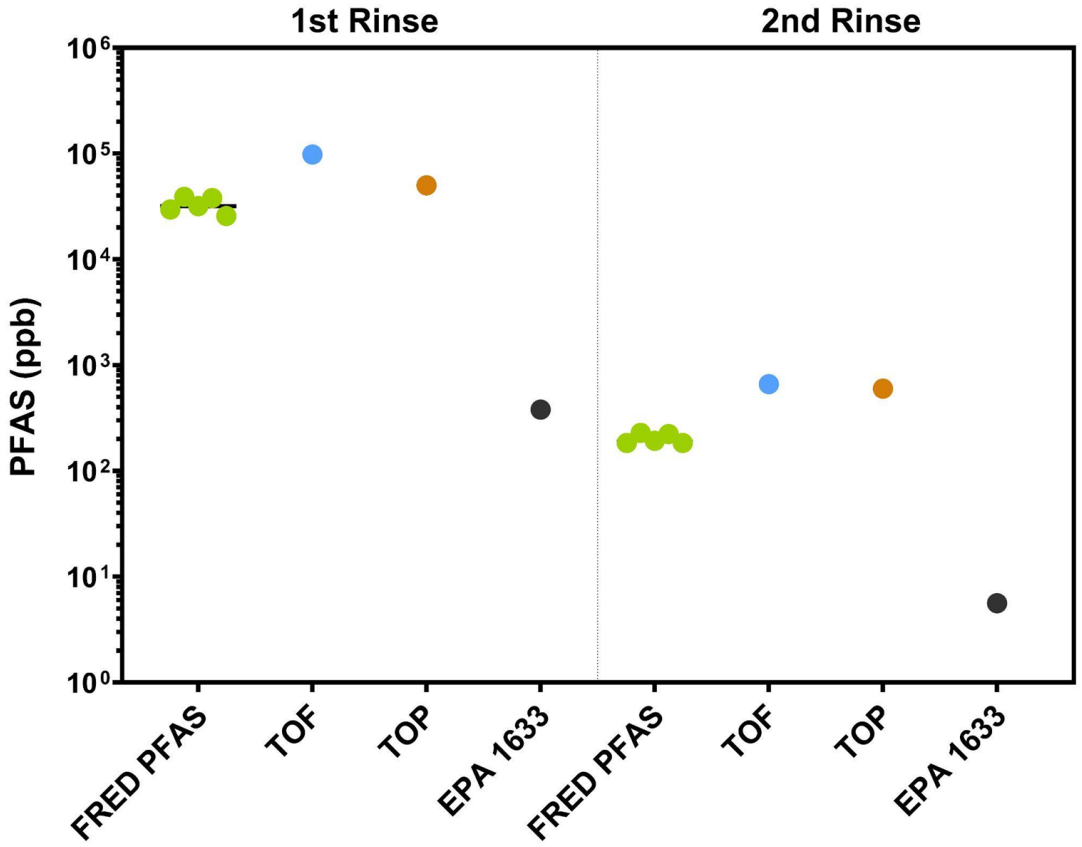
Objective: Evaluate the utility of rapid clean out data for an ARFF Truck cleanout in Southern California

Partner: ECT2

Project Set-up

- Samples were collected onsite for both CIP and Rinsate streams
- A total of ten (10) samples were tested across five (5) different FRED-PFAS units
- Samples also sent to third party laboratories for analysis by US EPA Method 1633, the Total Oxidizable Precursor (TOP) Assay, and Total Organic Fluorine (TOF).

Results



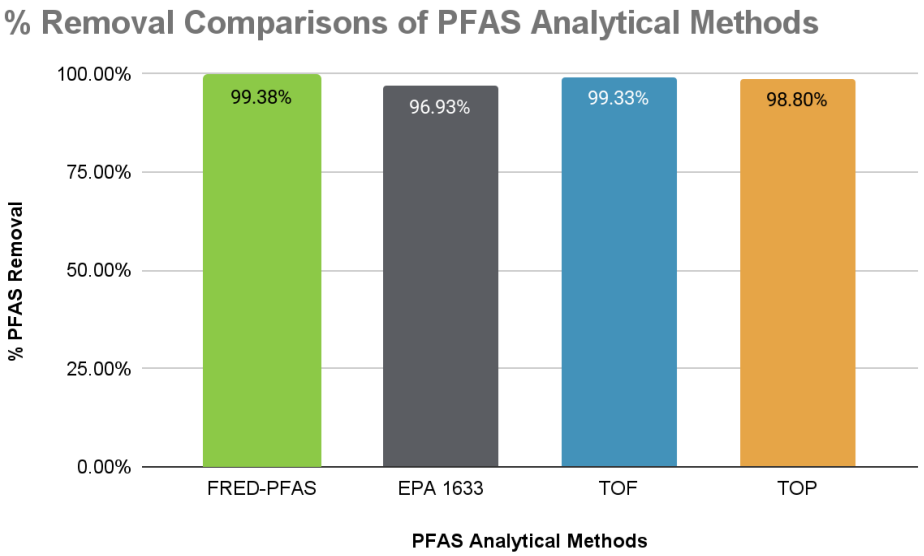
- FRED-PFAS results were consistently between EPA 1633 and TOF values.
- High TOP values compared to 1633 for both samples indicate high amounts of precursors present within the samples
- %RSD was 17% for first rinse and and 11% for second rinse (on 5 replicates)

FRED-PFAS Summary of Results

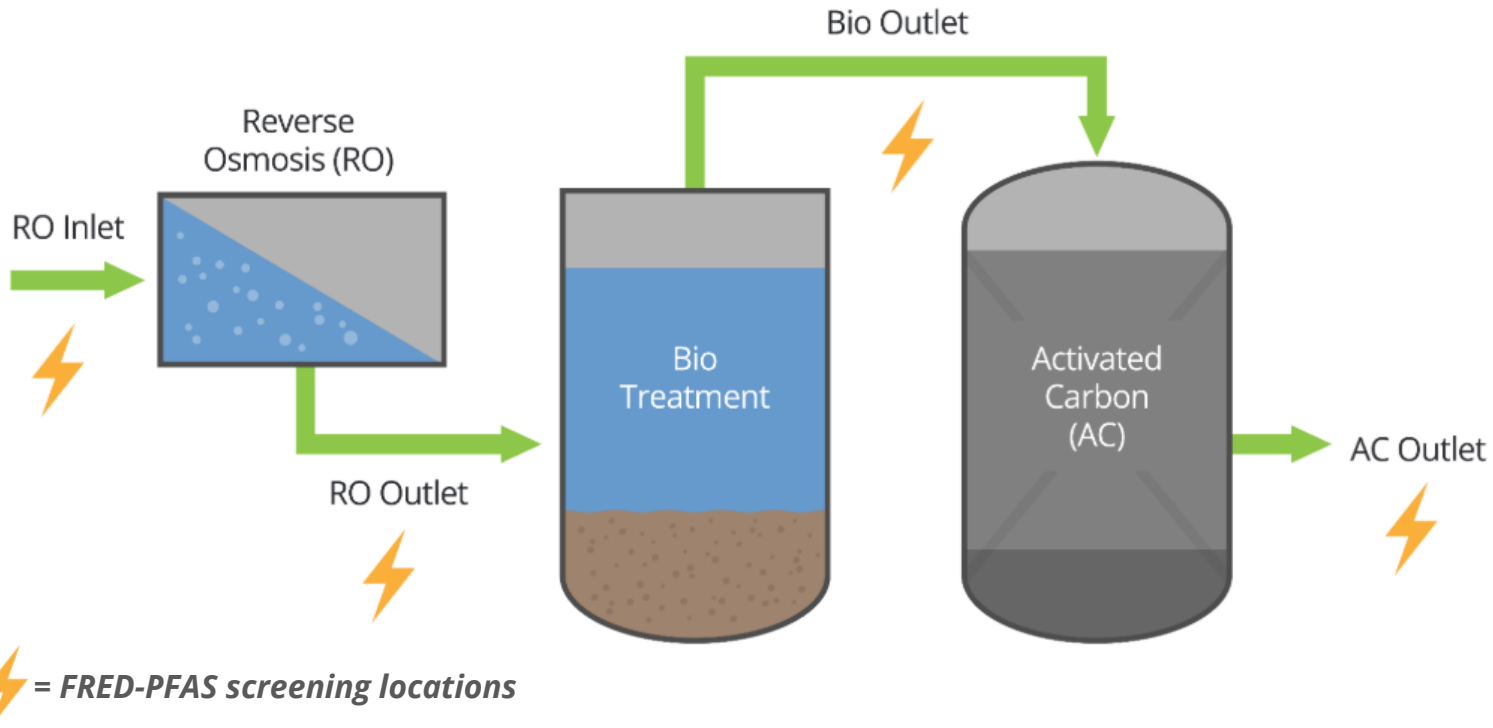
High Repeatability: High precision between 5 devices and 10 samples (11-17%)

FRED-PFAS data trended **between 1633 and TOF**

% mass removal comparable between all methods



Case Study 2
Using FRED-PFAS™ in Industrial Wastewater



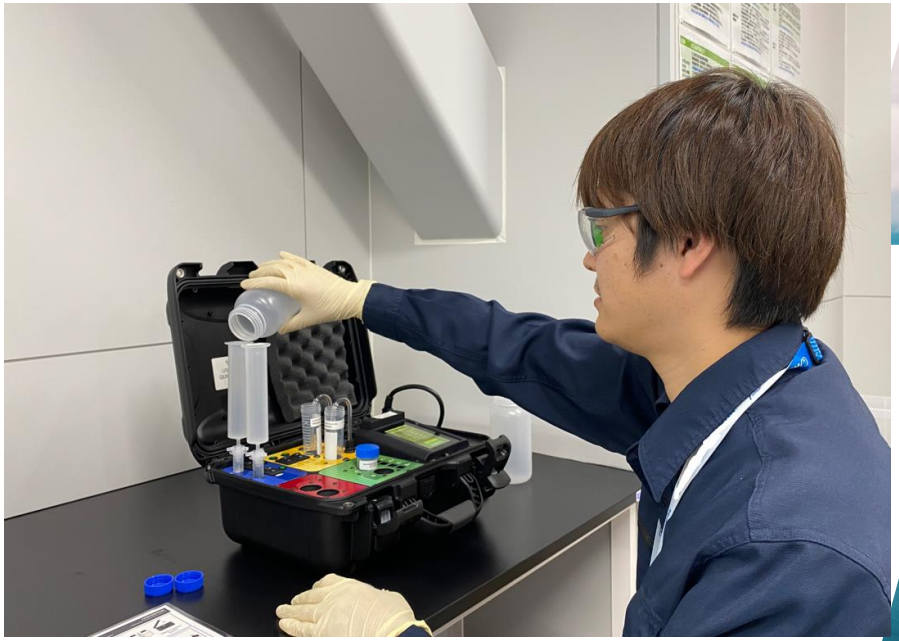
Industrial Wastewater PFAS Screening

Start Date: March 2025
Objective: Validate FRED-PFAS accuracy and precision on industrial wastewater process streams
Partner: Leading Wastewater Treatment Equipment and Services Provider in Asia

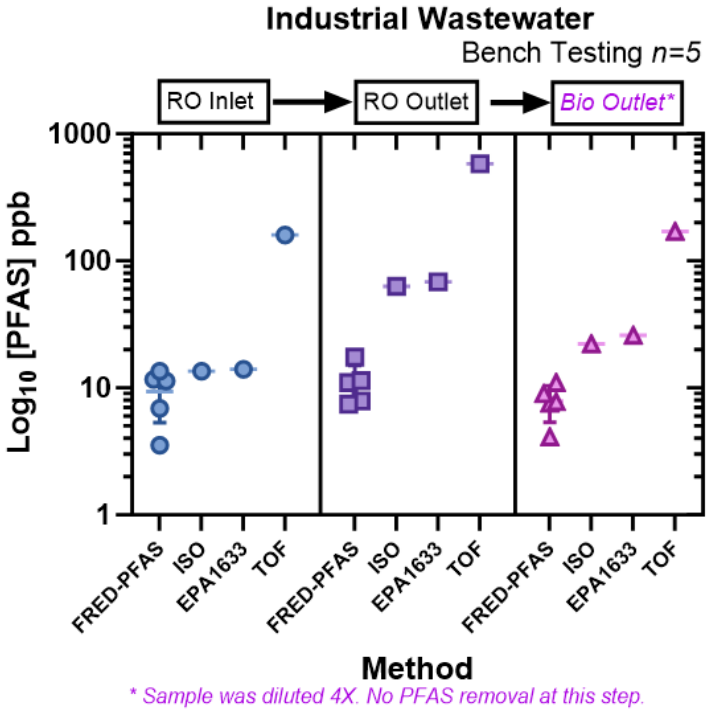
Success Metrics:

- **Accuracy:** ±50% relative error (%RE)
  % relative error = (absolute error / true value) x 100.

- **Precision:** ±35% relative standard deviation (%RSD) for multiple repetitions.



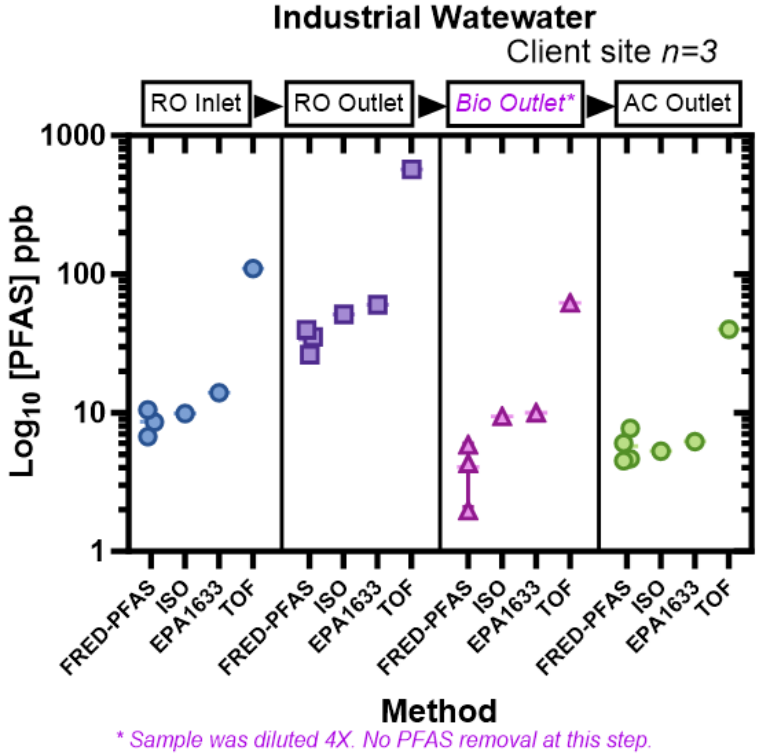
Results - Samples tested at client facility by FREDsense operators



The results showed **strong correlation between FRED-PFAS and laboratory methods** ISO and EPA1633, with the exception of RO Outlet.

This particular sample displayed a yellow color which may indicate the presence of some sensor inhibitors in the RO concentrate, such as organic matter or others.

Results - Onsite Samples by Client Operators



Testing showed that **precision metrics were met for all samples except sample 3 (Bio Outlet)**, which had higher standard deviation likely due to lower sample concentration.

Spike recovery showed good results at the client site.

FRED-PFAS Summary of Results

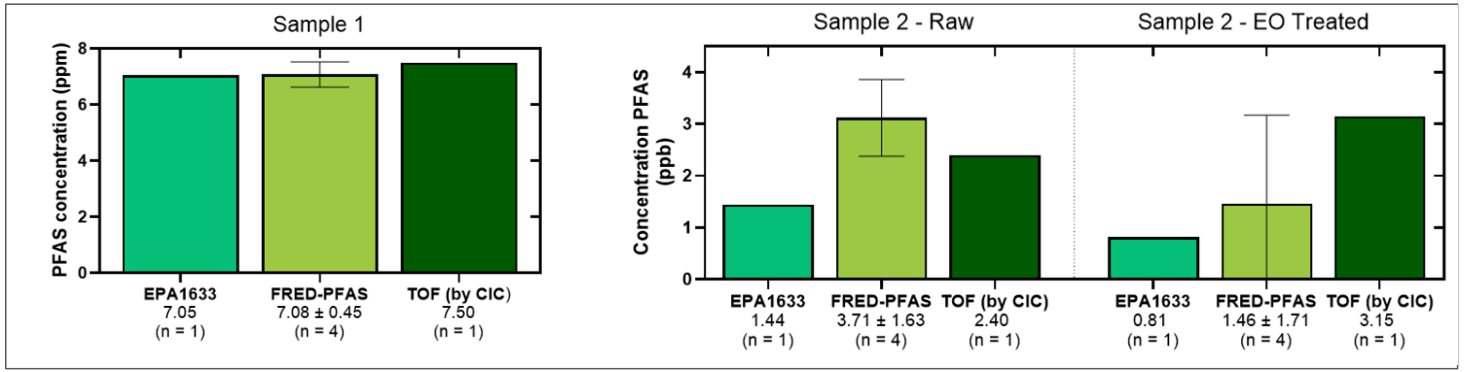
Success Metrics:

- **Accuracy:** ±50% relative error (%RE) on spiked samples.
  - **Met all but one sample point (RO inlet)**

- **Precision:** ±35% relative standard deviation (%RSD) for multiple repetitions.
  - **Met for of 7 of 11 samples** (with as low as 9.4% RSD in the best case and 48.5% RSD in the worst case)
  - FRED-PFAS variability was prominent in the Bio outlet and RO Inlet sample points, likely due to a matrix interference.

Case Study 3
Using FRED-PFAS™ in Groundwater

- Pilot project done with WSP in Montreal, Canada
- Groundwater samples before and after EO and GAC treatment were with tested using FRED-PFAS by 4 WSP operators (n=4)
- Data was compared to EPA1633 and TOF



Takeaways

- While laboratory methods play an important role in PFAS analysis, **field screening tools are emerging** to augment the PFAS analytics toolbox.
- **FRED-PFAS screening data trends with TOP, TOF and sum of 1633** methods across AFFF-impacted and industrial matrices to enable PFAS data in hours (instead of weeks).
- **Further development is required to overcome interferences** and their impacts on accuracy and precision.

Questions?

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