PFAS Source Differentiation Concepts

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Federal Remediation Technologies Roundtable

Fall 2024 General Meeting

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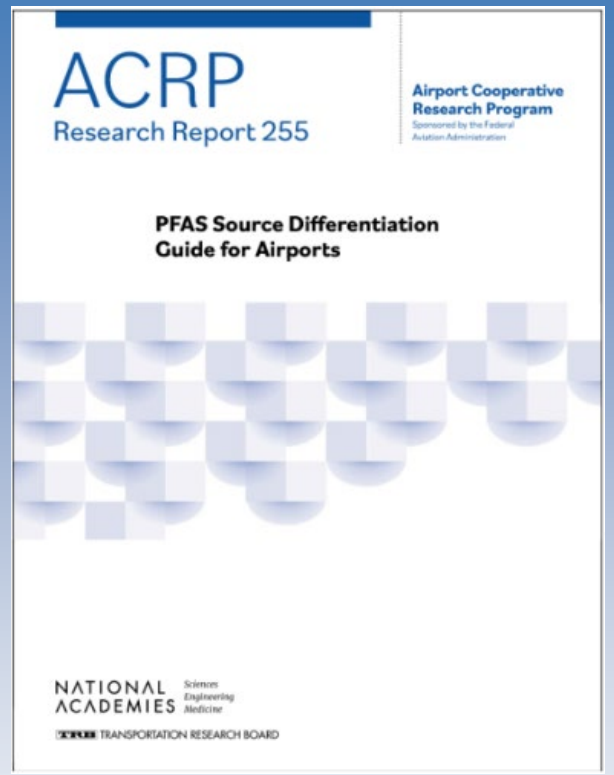

Airport Cooperative Research Program

Report 255

PFAS Source Differentiation Guide for Airports

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Airport Cooperative Research Program

- Managed by the Transportation Research Board of the National Academies
  - Sponsored by the FAA
- Industry-driven, applied research program that develops practical solutions to problems faced by airports
- Focuses on issues other Federal airport research programs do not address
- Funds more than 20 projects a year
- Industry participation encouraged to submit potential research topics, perform research work, and take part as panel members for peer-review of research projects
- https://www.trb.org/ACRP/ACRP.aspx

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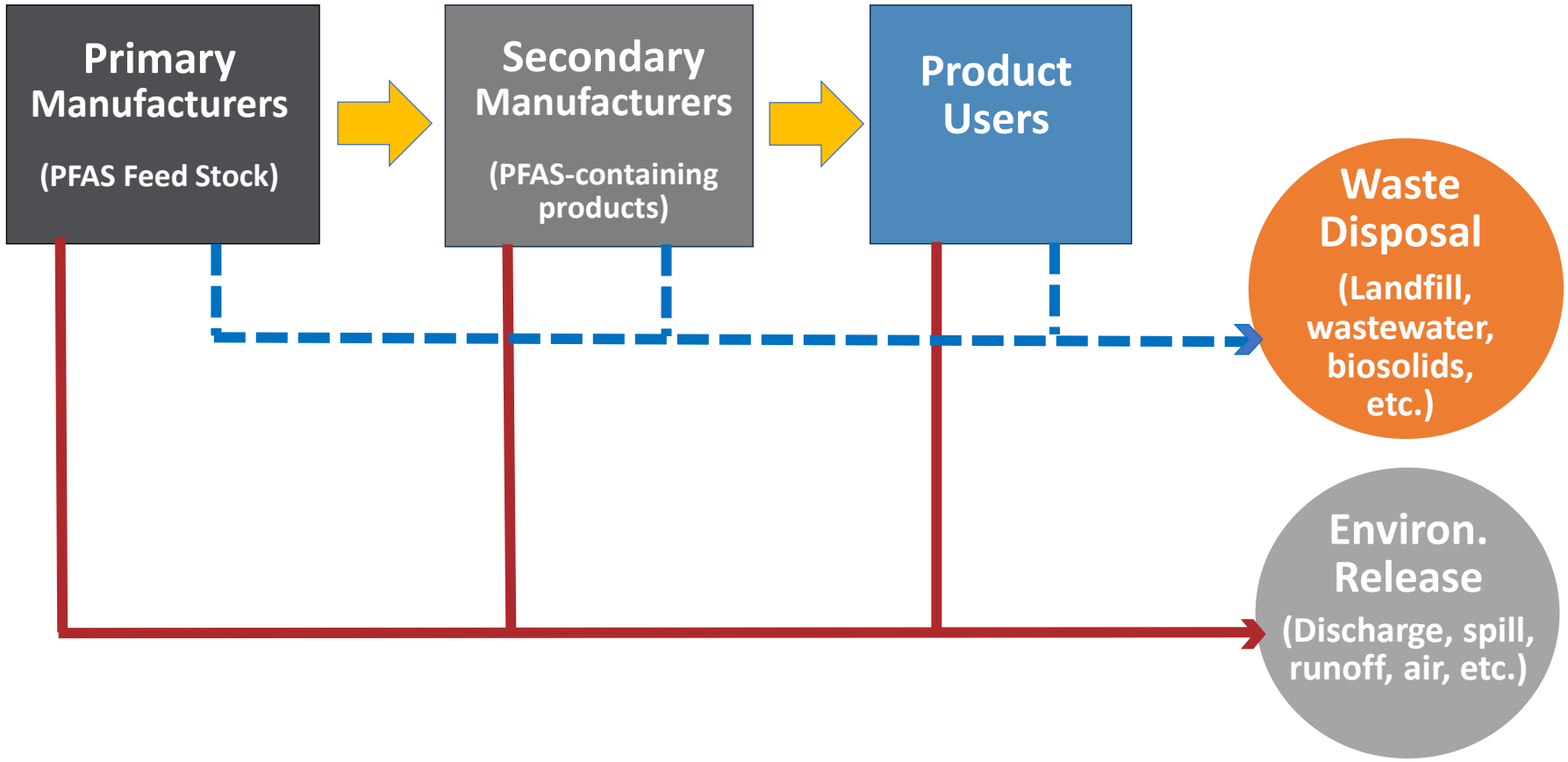
Project Research Goal

- Develop a practical guidance document for PFAS Source Differentiation investigations
- Not just another “high-level technical report” or “white paper”
- Provide relevant information for a wide range of audiences

PFAS Environmental Releases



Multiple potential sources result in complex conceptual site models and liabilities

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Airport PFAS Landscape

- On-Airport PFAS Sources
- AFFF use in emergency response (mobile and fixed systems)
- Firefighter training
- Part 139 certification
  - ARFF truck foam proportioning system calibration
  - AFFF training areas
  - Timed response
- Maintenance of ARFF vehicles
- Accidental discharge (e.g., hangar)
- Spills and leaks from handling and storage of AFFF
- And maybe others…

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AFFF

Not all Class B Firefighting Foams Contain PFAS

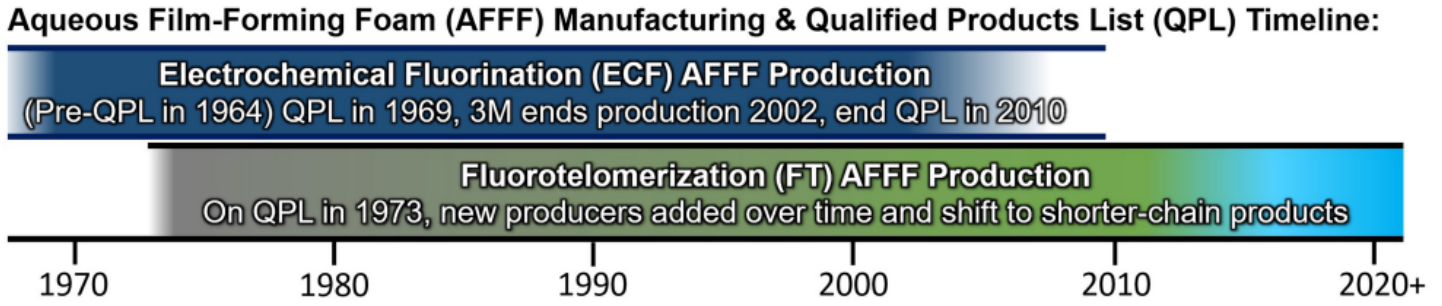

Figure 1. Summary of AFFF manufacturing process and years on the U.S. Department of Defense (DoD) AFFF QPL. ECF AFFF was produced the earliest and production has since been phased out in the U.S. Production of FT AFFF began later and has shifted to shorter-chain PFAS formulations in recent years (noted by color change from green to light blue).

2 *J. Gamlin et al.*/ Groundwater Monitoring & Remediation NGWA.org

Foams with PFAS

- Aqueous film-forming foam (AFFF)
- Alcohol-resistant aqueous film-forming foam (AR-AFFF)
- Film-forming fluoroprotein foam (FFFP)
- Alcohol-resistant film-forming fluoroprotein foam (AR-FFFP)
- Fluoroprotein foam (FP)
- Alcohol-resistant fluoroprotein foam (FPAR)

Foams without PFAS

- Protein foam
- Alcohol-resistant protein foam
- High expansion foams
- Synthetic fluorine-free foam (FFF or F3)
- *new* Fluorine Free (F3) Mil-Spec/FAA Approved foams

1967 USS *Forrestal* fire

But It's Not Just AFFF….

Examples of Products that MAY contain PFAS	
Aerosol propellants	Metallic and ceramic surfaces
Antifoaming agent	Pipes, pumps, fittings and liners
Ammunition	Plastic and rubber
Coatings, paints and varnishes	Refrigerant systems
Dispersions	Resins
Fire-fighting foam	Sealants and adhesives
Flame retardants	Soldering
Lubricants and greases	Wire and cable insulation, gaskets and hoses

Modified from *Gluge et al. 2020*

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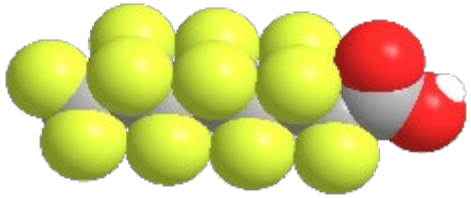
Environmental Focus – "PFAS of Relevance"

>12,000 PFAS Grouped by Chemistry; All Very Different Chemistries and Uses



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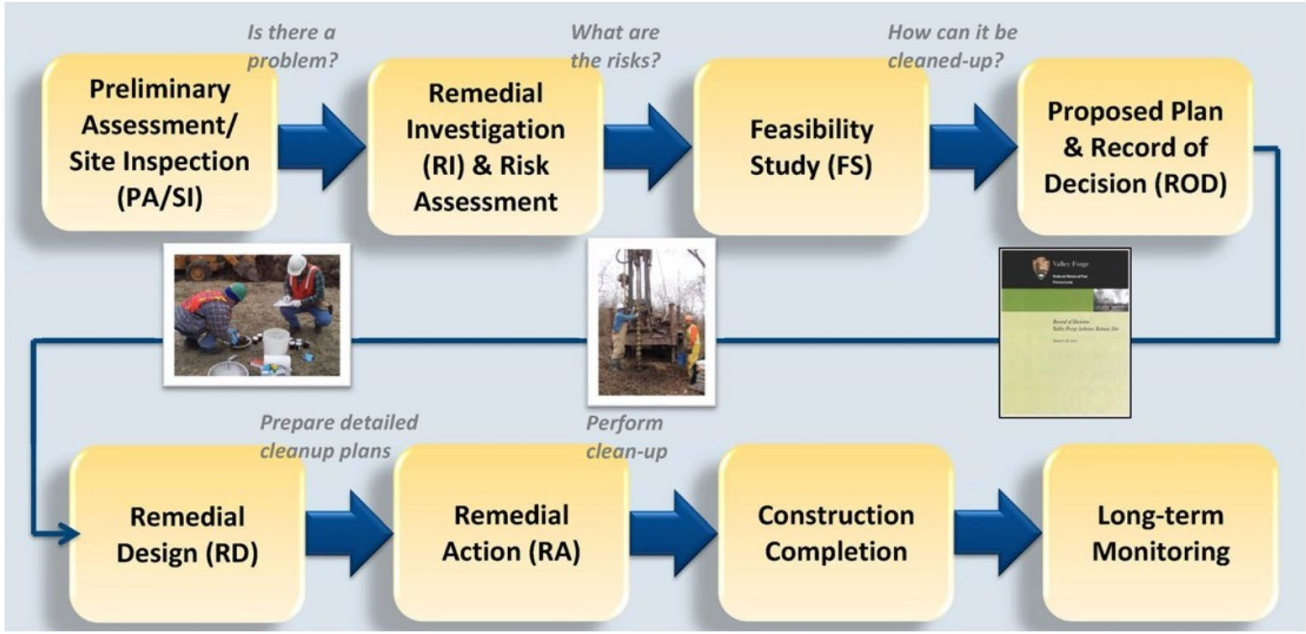
When Should One Ask About Potential PFAS Source Areas?

EARLY and OFTEN

- Preliminary Assessments
- Site Inspection work planning
- Remedial Investigations site characterizations
- Feasibility Studies
- Baseline risk assessments
- Setting of remedial objectives and goals
- ANY and ALL data evaluations



CERCLA Process
NPS

https://home.nps.gov/goga/getinvolved/cercla-steps.htm

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So…. Whose PFAS Is It? (also: How Many Source Areas Are There?)

- Recommend a data-driven, practical approach
- ACRP Report Research:
  - Used input from real-world experts and airports currently "in the mix"
  - Designed to be applicable at any point - from initial questions to assessing multiple years of PFAS data
  - Includes analysis of 800,000+ PFAS data to develop PFAS source area patterns

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"Lines of Evidence" Approach

DESKTOP REVIEW

- On-Airport Sources
- Off-Airport Sources
- Site Characteristics

CONVENTIONAL SAMPLING

- Available Methods
- Best Practices
- Source Screening

ADVANCED FORENSICS

- State-of-the-Science
- When to Consider
- What to Expect

- **There is no "silver bullet" when it comes to PFAS forensics**
- **Many advanced technologies are becoming available, but still need to be validated**
- **There are numerous evaluations that can be done with conventional data and a good conceptual site model**

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Desktop Review – *Potential* PFAS Sources

Resources for Information About Potential On- and Off-airport PFAS Sources

- Manufacturing / Landuse history
- Environmental Site Assessments (Phase 1 and Phase 2)
- Toxic Release Inventory (TRI)
- EPCRA sections 311-312 reporting
- NPDES permits
- Federal and state environmental databases
- Others - 11 additional listed in Table 3.5, ACRP Research Report 255

Image Source: https://officiency.com/organizecomputerfiles/

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Desktop Review – *Potential* PFAS Sources

Results Might Include

- Identification of potential on-site release areas
- Identification of potential off-site release areas
- Prioritization for data collection
  - Confirmation PFAS sampling
  - Conceptual Site Model data including hydrogeology

Image Source: https://officiency.com/organizecomputerfiles/

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Conventional Sampling –
Complicated Data Interpretation, but Can Be Useful

- Use the full set of PFAS data
  - Don’t focus on only “risk-driving” PFAS or PFAS with regulatory values
- Make sure the conceptual site model is well-defined
  - Hydrogeology/Geology/Soils
  - Depth to groundwater
  - Flow direction
  - Bedrock type and competency
  - Soil properties
  - Climatological setting
  - Manufactured conduits (utility corridors/trenches)
- Understand stormwater infrastructure
- Consider precursor transformation
- Consider PFAS-specific fate and transport

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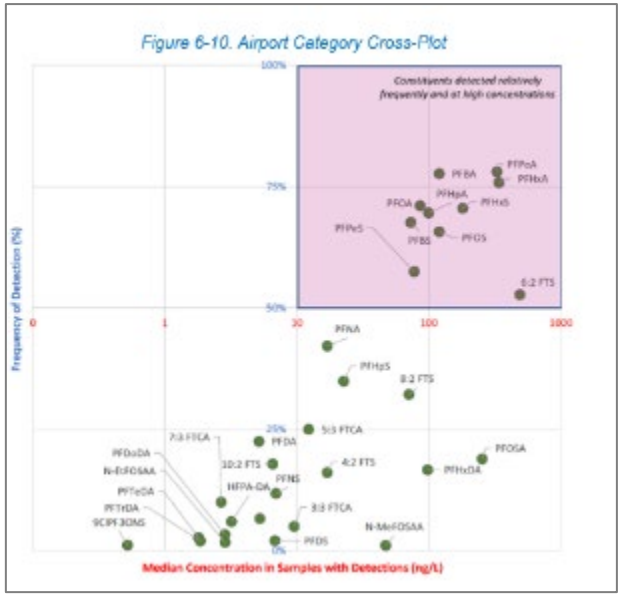
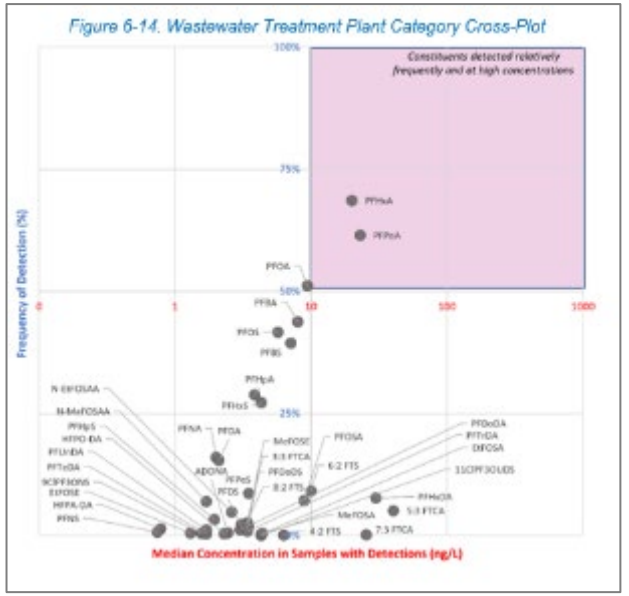
PFAS Compositional Distribution Visualizations

Patterns gleaned from >800,000 PFAS data points:

Pattern Identification Options:

- Family Tree Pie Charts
  - sulfonates v. carboxylates
  - chain-length
- ECF-based products versus FT-based products
- PFAS Ratios
  - PFOS/PFHxS; PFOA/PFHxA; PFOS/PFOA; PFHxS/PFOA
- Linear versus branched isomers
- Principal Component Analysis
- Sum of Target PFAS along flow path (should decrease)
- many more…





Plots for:
Airport, Chrome Plating, Industrial, Cleanup, Landfill, WWTP, DW

Limitations:
No geospatial information is available for most of the data points
Most likely "near source" samples dominate database

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PFAS Compositional Distribution Visualizations

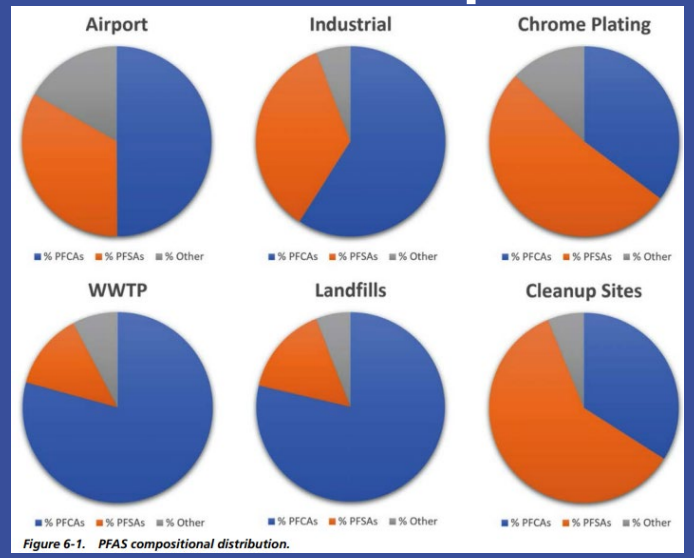

Figure 6-1. PFAS compositional distribution.

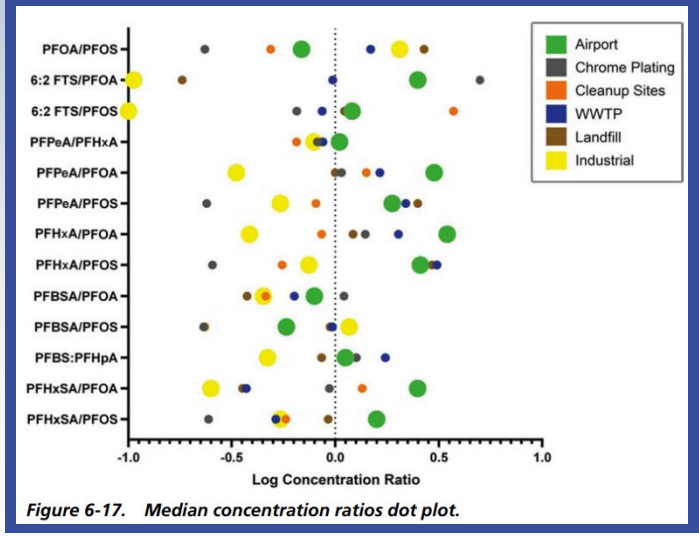

Figure 6-17. Median concentration ratios dot plot.

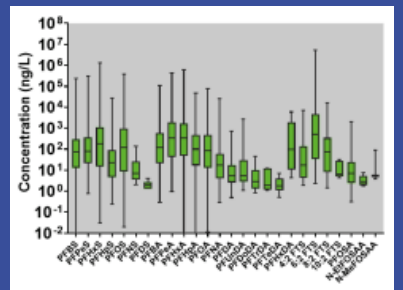

Figure 6-2. Airport category PFAS concentrations.

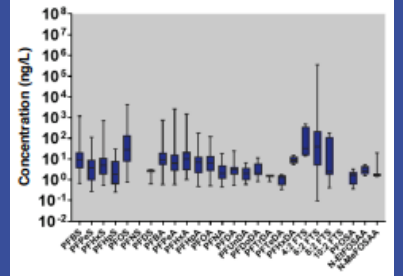

Figure 6-3. Chrome plating category PFAS concentrations.

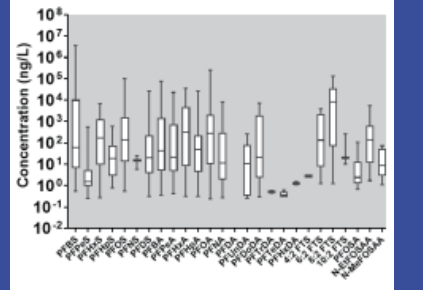

Figure 6-4. Industrial category PFAS concentrations.

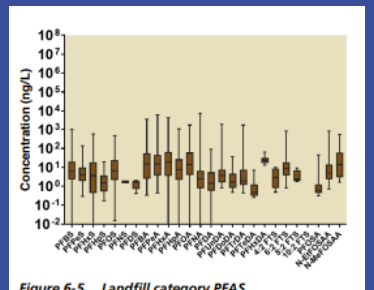

Figure 6-5. Landfill category PFAS concentrations.

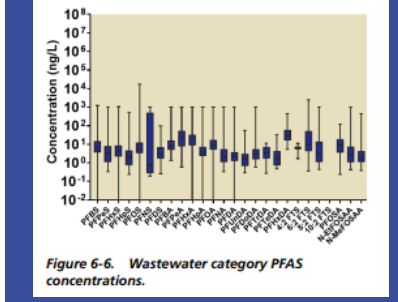

Figure 6-6. Wastewater category PFAS concentrations.

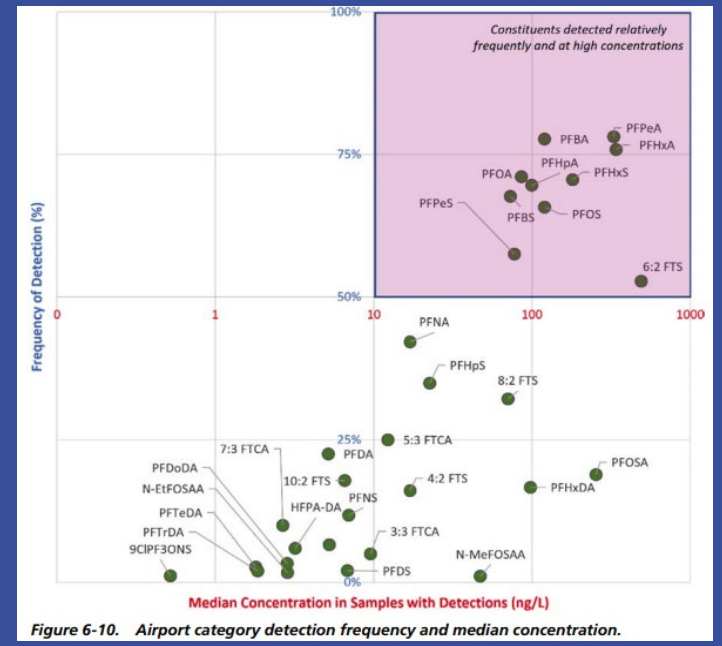

Figure 6-10. Airport category detection frequency and median concentration.

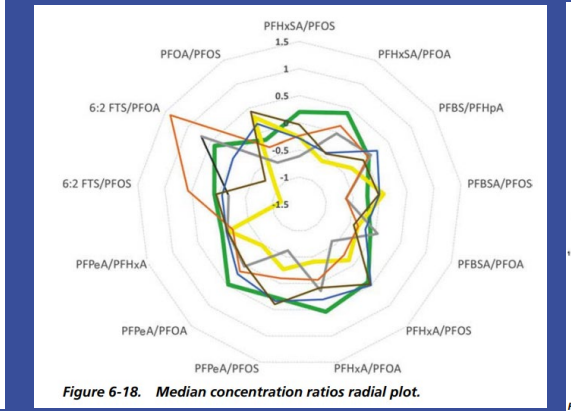

Figure 6-18. Median concentration ratios radial plot.

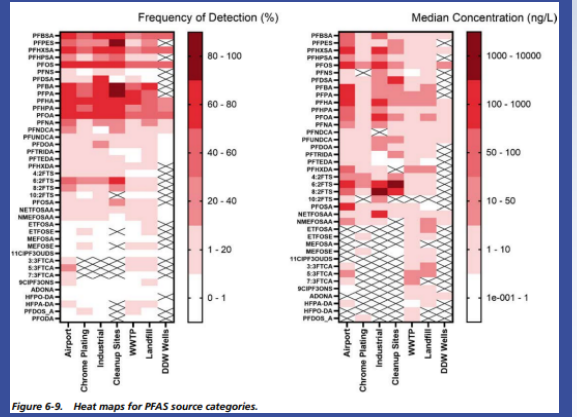

Figure 6-9. Heat maps for PFAS source categories.

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Conventional Sampling –
Complicated Data Interpretation, but Can Be Useful

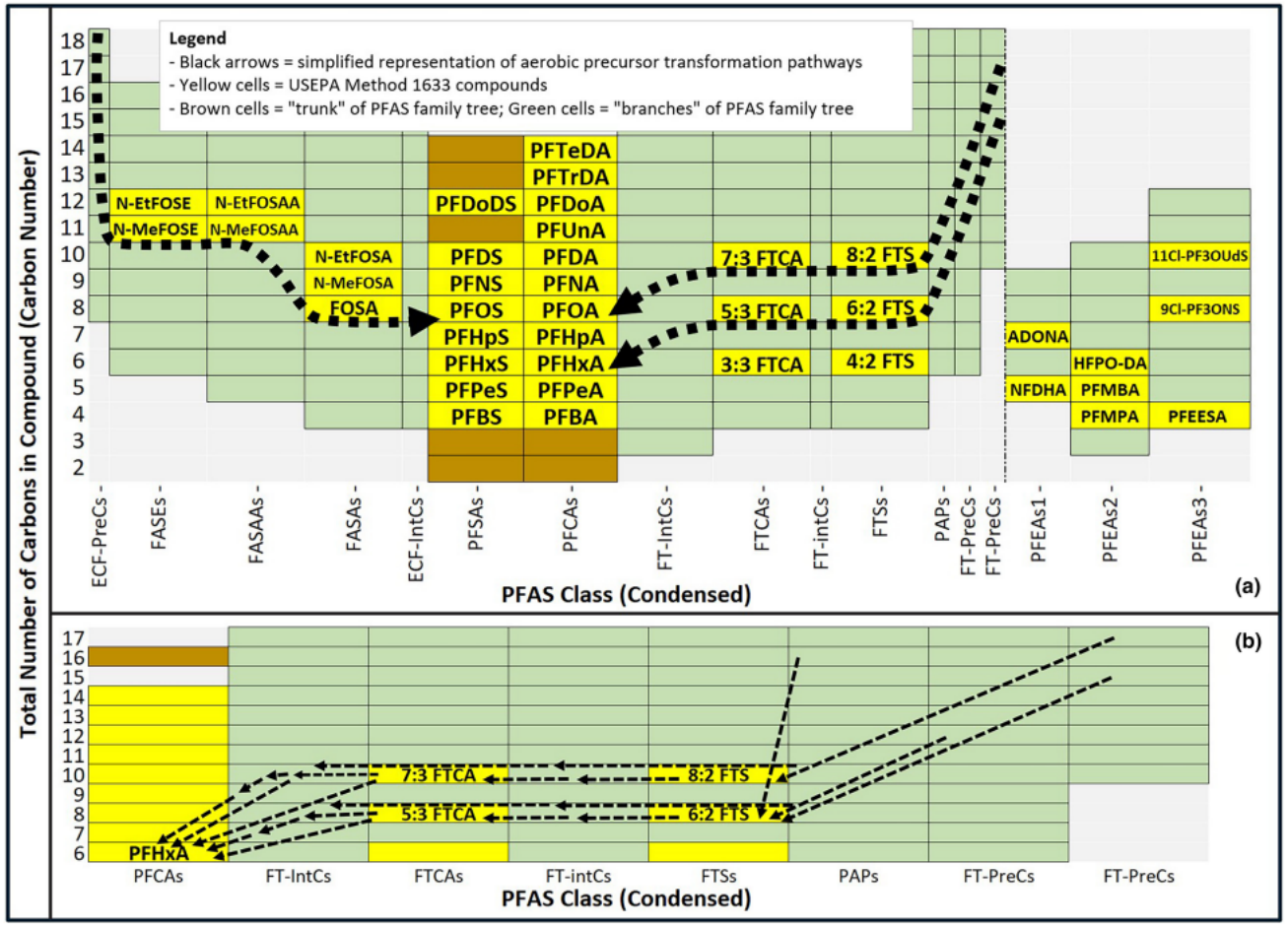

Figure 2. (a) USEPA Method 1633 PFAS Family Tree; and (b) zoom-in of a representation of aerobic precursor transformation steps specific to PFHxA (see Supporting Information for expanded family trees and precursor transformation steps showing a mixture of PFAAs can be formed). Arrows are an approximate representation of precursor transformation steps documented in literature. Empty boxes, and transformation arrows connected to them, may represent multiple non-target compounds.

Groundwater Monitoring&Remediation

Research Article

Data Evaluation Framework for Refining PFAS Conceptual Site Models

by Jeff Gamlin, Charles J. Newell, Chase Holton, Poonam R. Kulkarni, Jonathan Skaggs, David T. Adamson, Jens Blotevogel and Christopher P. Higgins

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Uncertainty Using Conventional Data

Table 6-3. High detection and frequency PFAS for source categories.

Source Type	Airport	Chrome Plating	Industrial Sites	Other Cleanup Sites	Wastewater Treatment Plants	Landfill
Compounds that exhibited high median concentrations and high frequencies of detection	PFPeA PFHxA PFBA PFHxS PFOS PFHpA PFOA PFBS PFPeS 6:2 FTS	PFOS PFHxA 6:2 FTS	PFOA PFHxA PFOS PFHxS PFHpA PFHxS PFBS PFBA PFPeA PFDS	PFBA PFPeA PFPeS PFHxS PFOS PFHxA PFOA 6:2 FTS	PFHxA PFPeA	PFBA PFHxA PFPeA PFOA

Understanding PFAS Source Differentiation Limitations

No such thing as a **definitive** PFAS signature using conventional commercial data.

Because there were only a few primary manufacturers of PFAS, products tend to have several PFAS in common (e.g., PFAAs) and may even share similar chemical signatures.

Degradation eventually converts polyfluorinated precursor compounds to a limited set of perfluorinated end products (PFAAs), common among all PFAS source types.

It is critical to carefully consider supporting CSM information

A multiple-lines-of-evidence approach is necessary

Source: https://imperialwriters7.medium.com/research-project-why-limitations-of-the-study-should-come-at-the-end-of-the-project-3282c8c1e36

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Conventional Sampling –
Complicated Data Interpretation, but Can Be Useful

Results might include

- Identification of data patterns confirming known/suspected source areas
- Identification of data patterns suggesting alternative source areas
- Identification of data patterns that require additional analysis to interpret

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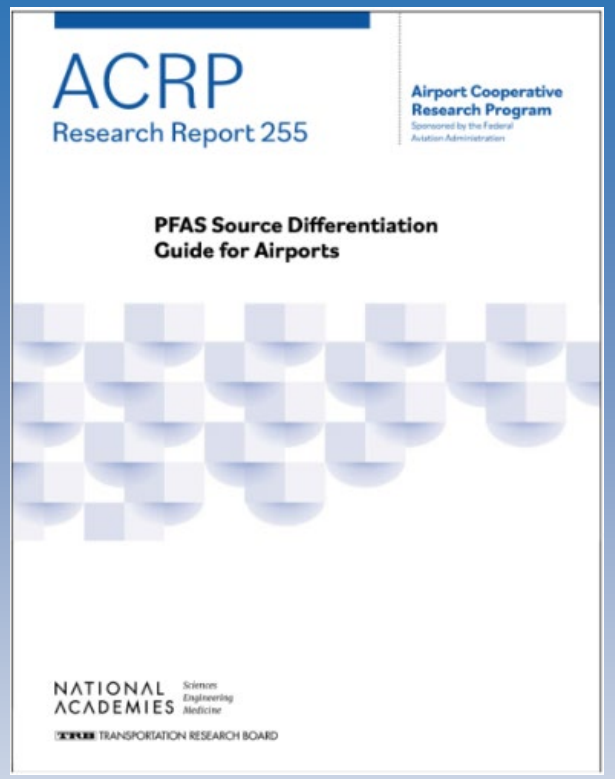

Desktop Review Progress Tracker

Potential PFAS Sources at Your Airport

Objective:

Provide topics of consideration to help identify potential off-airport PFAS sources.

Instructions:

Input responses to the questions or statements below on how much consideration has been given to the following topics related to off-airport PFAS sources. For more details on each item, please consult the referenced Guidebook section.

	Have you considered the following ARFF-related potential AFFF use?	Response	Weight	ACRP Guidebook Section	Comments/Notes
1	AFFF use during emergency response (aircraft accident, vehicle fires, etc.)		5	3.1.1	
2	ARFF truck Part 139 foam proportioning system testing		4	3.1.1	
3	ARFF firefighter AFFF training with mobile fire units		4	3.1.1	
4	ARFF firefighter training pits/sites		5	3.1.1	
5	AFFF use during Part 139 annual certification timed response drills		4	3.1.1	
6	Operational testing of ARFF truck foam system		3	3.1.1	
7	Maintenance of ARFF vehicles with AFFF discharge		3	3.1.1	
8	Unintentional release of AFFF including from handling, storage, or other activities		3	3.1.1	
	Have you considered the following non-ARFF potential AFFF use?				
9	Hangar fire suppression systems with AFFF		3	3.1.2	
10	Fuel farm fire suppression systems with AFFF		3	3.1.2	
11	Military ARFF activities		5	3.1.3	
	Have you considered other sources of relevant PFAS releases?				
12	Aircraft hydraulic fluid releases		1	3.1.2	
13	Application of biosolids from wastewater treatment facilities		3	3.1.2	

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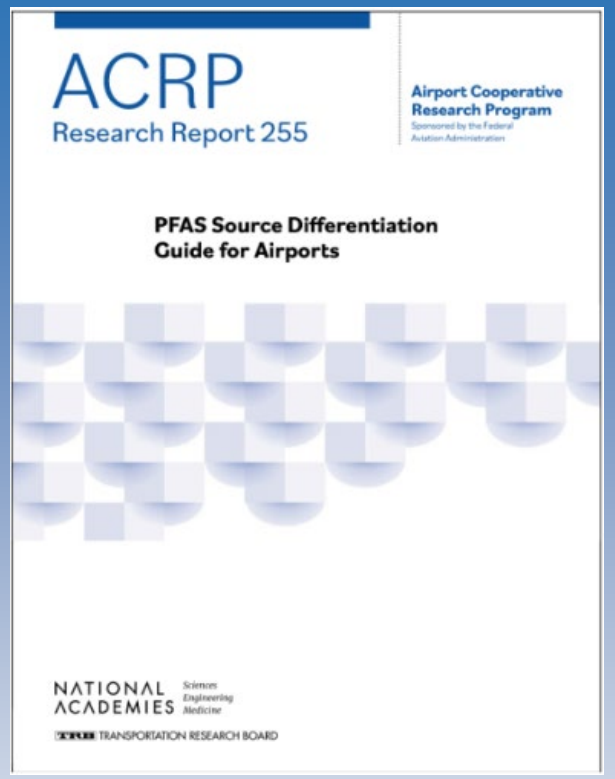


Desktop Review Progress Tracker

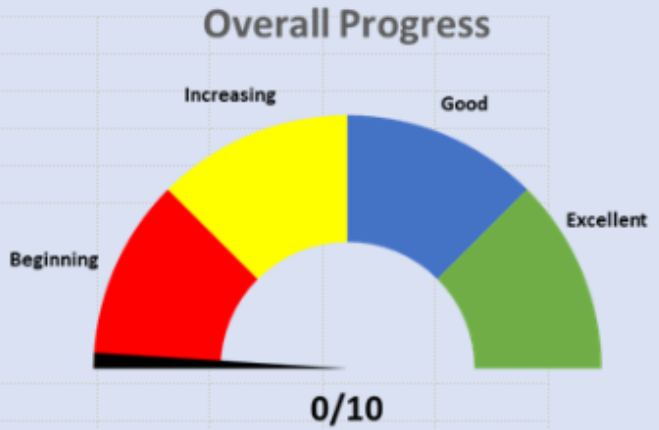
PFAS Source Differentiation Desktop Review Feedback

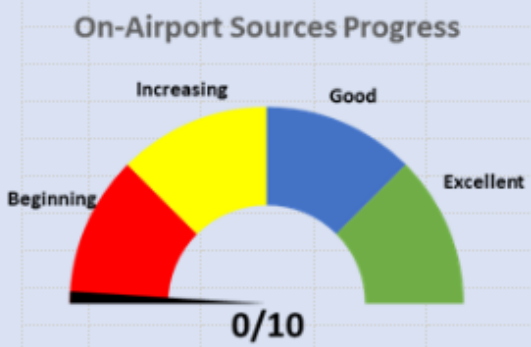
Objective:

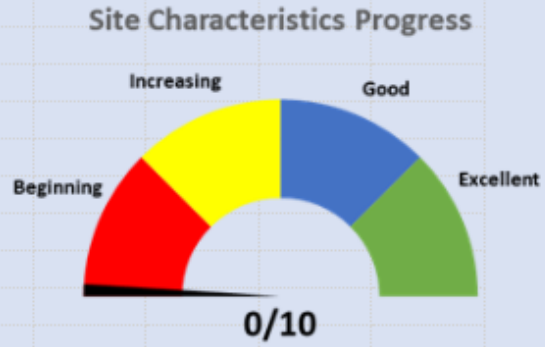
Provide progress feedback on PFAS source differentiation desktop review efforts.

Instructions:

Input responses to the questions or statements for each category (separate tabs) on the level of consideration given to the topics related to PFAS sources .







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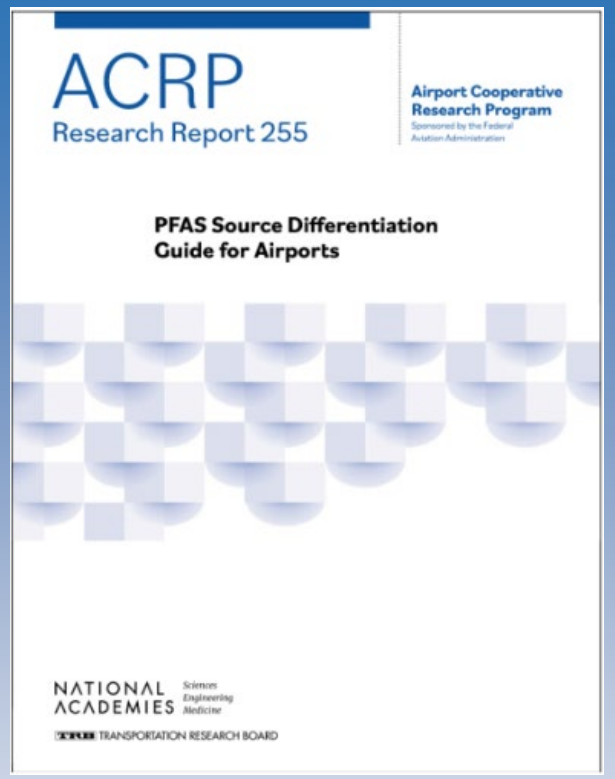
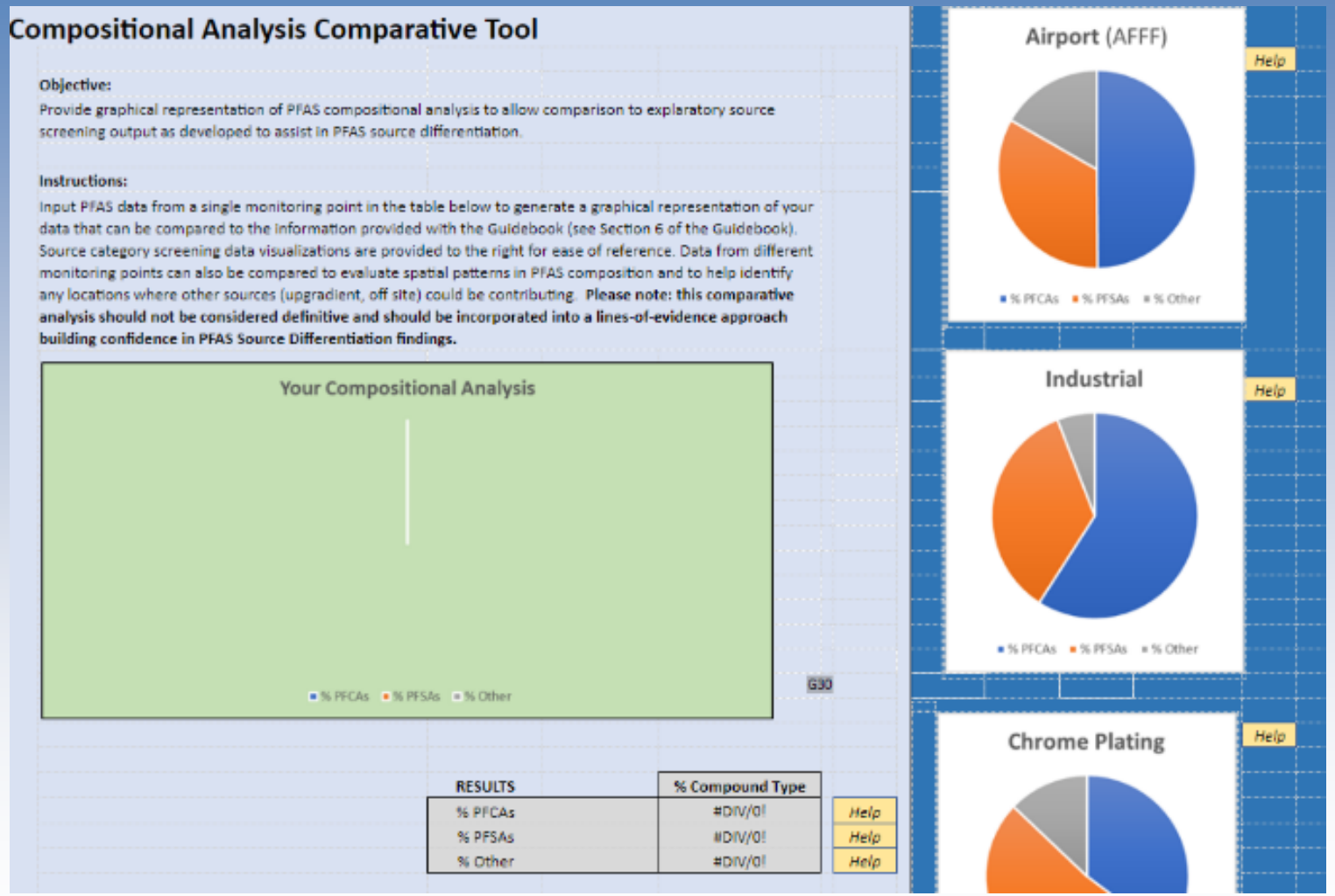


Compositional Analysis Visualization



Advanced Forensics

What

- Specialized commercial or academic analytical methods
- High-resolution mass spectrometry, non-target analysis, and computer learning algorithms
- May include alternative sample processing and analysis methods (e.g. TOP assay)
- Largely QUALITATIVE, but quantitative approaches coming
- Significant on-going research

When

- Confirming screening results from conventional data
- Informing inconclusive information
- If source allocation is of relevance

Who

- Analytical chemistry experts
- U.S. EPA Office of Research and Development
- Battelle PFAS Signature®
- Others…

Limitations:

- **Not necessarily definitive, largely unvalidated**
- **Difficult to communicate/validate**
- **Generated using non-standardized methods**
- **Costly and limited commercial availability**

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Main Conclusions

There is no “silver bullet” when it comes to PFAS source differentiation.

A “lines-of-evidence” approach is recommended using available information, which may include desktop reviews, info on historical operations, airport site characteristics, potential off-site sources, and laboratory analytical data.

Conventional data can be used, but only in conjunction with other lines of evidence and site-specific CSM. Advanced forensic techniques are evolving quickly!

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Questions?

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