Technical and Legal Considerations with PFAS

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Agenda

01 Welcome and Opening Remarks

02 Background on PFAS

03 Recent Regulatory and Technical Developments

04 Case Studies (2)

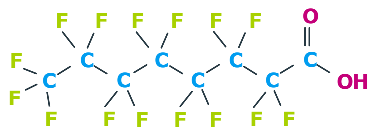
05 Closing Thoughts: Tips and Takeaways

06 Q&A

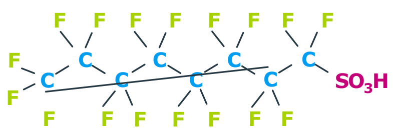
Background on PFAS

Background on PFAS

1. PFAS is a generic term for a large subclass of human-made fluorinated chemicals
2. Used in a wide range of industrial applications, commercial products and firefighting foams
3. Unique because of their ability to repel oil, grease and water
4. Exceptionally stable, non-reactive chemicals, resistant to degradation naturally and heat resistant
5. Properties/behavior varies dramatically

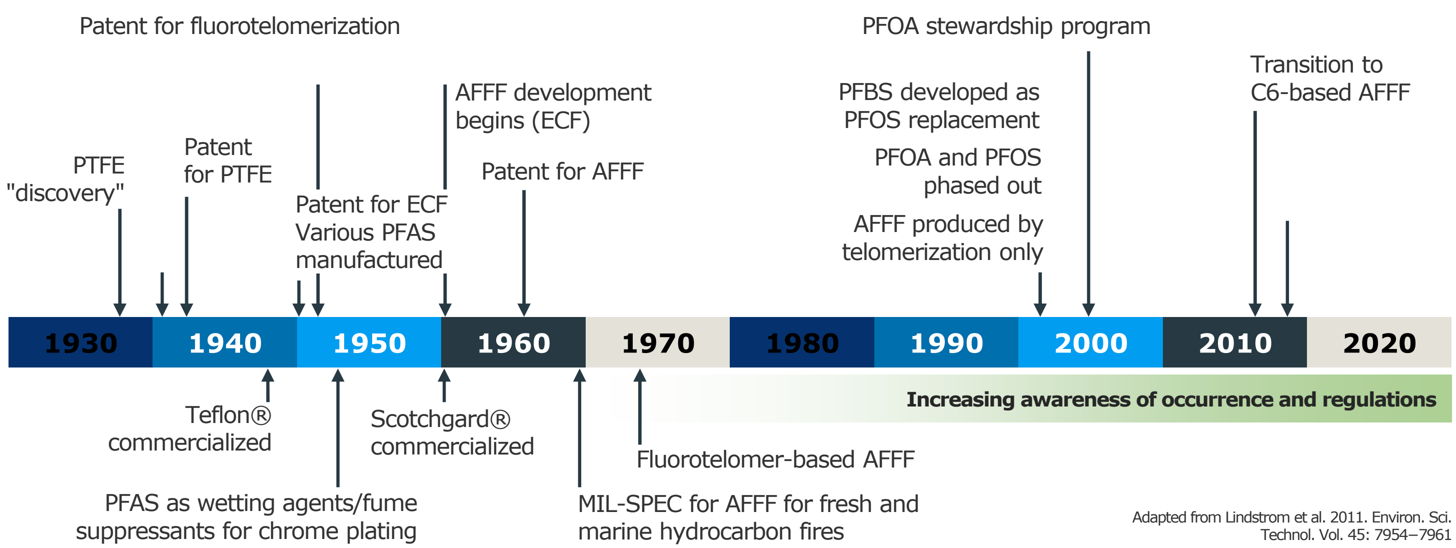


PFOA – perfluorooctanoic acid



PFOS – perfluorooctanesulfonic acid

PFAS: A Brief Chronology



Adapted from Lindstrom et al. 2011. Environ. Sci. Technol. Vol. 45: 7954–7961

Why the interest in PFAS?

- Ubiquitous in the environment
- Relatively mobile in the environment, moderately soluble
- Potential human toxicity
- Bio-accumulative
- Lengthy/varied history of use
- USEPA has identified more than 10,000 individual PFAS compounds

What are the sources of PFAS?

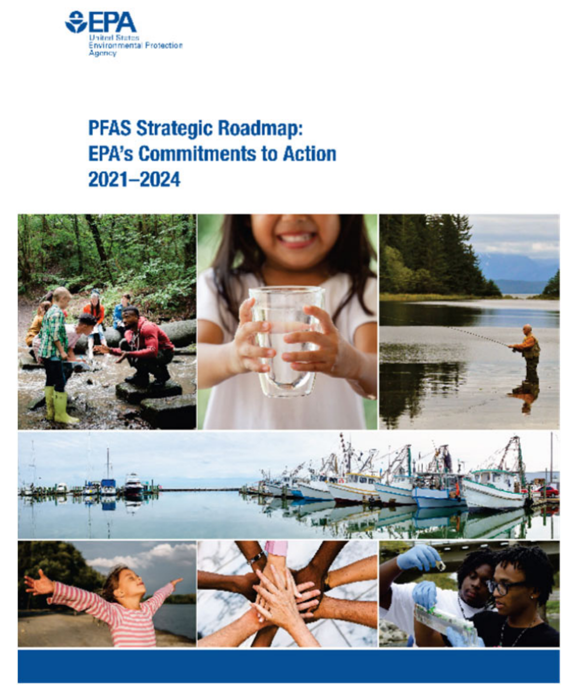



Household/ cooking	Apparel/ textiles	Personal care/ healthcare	Industrial/ specialized
Cookware	Stain-resistant clothing	Eyewear coating	Firefighting foams
Packaging	Outdoor gear	Cosmetics	Chrome plating
Carpet/fiber protector		Biomaterials	Aviation hydraulic fluids
Floor finishing		Medical devices	Semiconductor
			Coatings/adhesives

Recent Regulatory and Technical Developments

USEPA PFAS Roadmap – Goals and Objectives

- Published in October 2021
- Outlines USEPA’s approach and tentative schedule to addressing PFAS issues
- The ubiquity of these contaminants requires a holistic, integrated approach to their subsequent regulation
- USEPA is simultaneously tackling the PFAS issue on several different fronts, including:
    - *“**Research.** Invest in research, development, and innovation to increase understanding of PFAS exposures and toxicities, human health and ecological effects, and effective interventions that incorporate the best available science.*
    - ***Restrict.** Pursue a comprehensive approach to proactively prevent PFAS from entering air, land, and water at levels that can adversely impact human health and the environment.*
    - ***Remediate.** Broaden and accelerate the cleanup of PFAS contamination to protect human health and ecological systems.”*



USEPA PFAS Roadmap – Lifecycle Considerations

- PFAS are released into the environment as a result of manufacturing, processing, distribution in commerce, use and disposal
- Each action in this cycle represents a potential human or ecological exposure
- Their persistence in the environment means that even when PFAS are removed, they may create a waste that needs to be managed
- Technologies that destroy PFAS are seemingly preferred, but concerns over treatment efficiency and potentially hazardous by-products have stalled several efforts to treat certain wastes.

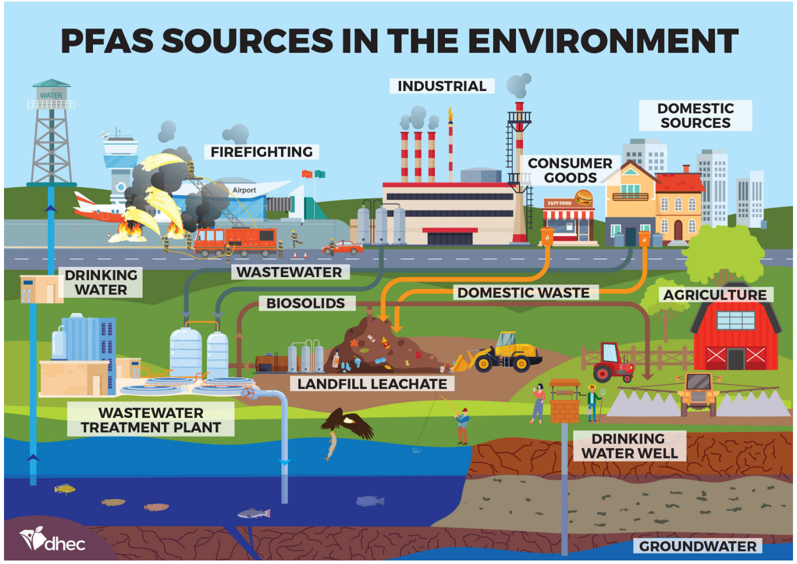


Image courtesy of South Carolina Department of Health and Environmental Control

USEPA PFAS Roadmap – Get Upstream

- A centerpiece of USEPA's strategy to confront the PFAS problem is **to prevent PFAS from entering the environment in the first place**.
- USEPA states that "a modest number of industrial facilities directly discharge PFAS into water or soil or air in large quantities", providing a clear opportunity to restrict releases into the environment.
- Other regulatory and permitting actions will likely be used to further limit releases.

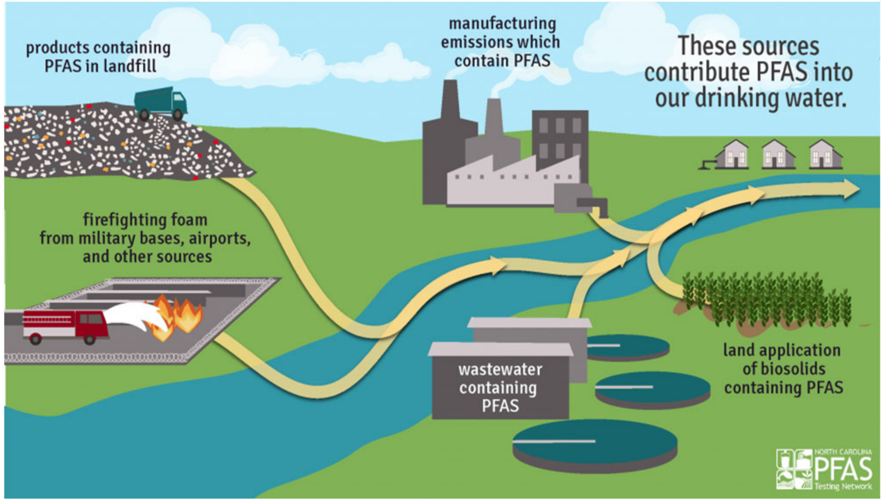
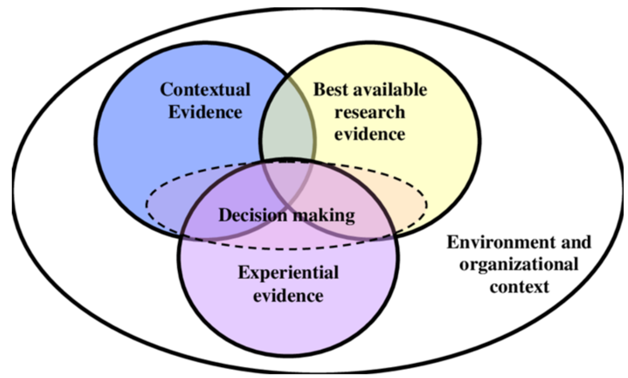


Image courtesy of North Carolina Department of Environmental Quality

USEPA PFAS Roadmap – Other Focal Points

- Hold polluters accountable
- Increase our understanding of PFAS behavior, treatment and toxicology
- Prioritize disadvantaged communities



UCMR 5

- Published on December 27, 2021
- Requires sample collection from the nation's drinking water systems between January 2023 and December 2025, including 29 PFAS compounds
- Will include surface water and groundwater systems

Image courtesy of United States Geological Survey (USGS)

PFAS Toxicity Assessments

- In October 2021, USEPA issued its final toxicity assessment for GenX chemicals[(1)]
  - The chronic reference dose (RfD) for GenX chemicals is now 3×10^{-6} mg/kg-day
  - By way of comparison, the chronic RfDs for PFOA and PFOS are 2×10^{-5} mg/kg-day
- USEPA has already signaled its intent to review the toxicity assessments for PFOA and PFOS

(1) https://www.epa.gov/chemical-research/human-health-toxicity-assessments-genx-chemicals

New PFAS Health Advisory Limits

- On June 15, 2022, USEPA issued updated or new drinking water Health Advisories (HAs) for four PFAS compounds: PFOA, PFOS, PFBS and GenX.
- HAs are non-enforceable, informational guidelines issued for certain chemicals that are not subject to National Primary Drinking Water Regulations
- The updated HAs are substantially more stringent than those issued in 2016. The interim updated HA for PFOA has been lowered from 70 ppt to 0.004 ppt – a 17,500-fold reduction. The HA for PFOS was lowered from 70 ppt to to 0.02 ppt – a 3,500-fold reduction.
- HAs were also established for GenX (10 ppt) and PFBS (2,000 ppt)

New PFAS Health Advisories – What's the Concern

- HAs are sometimes cited as benchmarks, such as litigation involving potential human health risks and the evaluation of chemicals in consumer articles
- The interim updated HAs for PFOA and PFOS are below current analytical quantitation limits, also below background levels (i.e., the concentration that have been reported in literature for global rainwater, surface water and residential wastewater samples collected from locales without a clear regional PFAS source).
- Current USEPA-approved analytical methods are not able to reliably detect or measure PFOA or PFOS at or below these concentrations.

New/Pending Regulatory Activity

- On March 14, 2023, USEPA issued proposed MCLs for 6 PFAS compounds:

PFAS Compound	MCLG (ng/L)	MCL (ng/L)
PFOA	0	4
PFOS	0	4
PFNA	1.0 hazard index	1.0 hazard index
Gen-X	1.0 hazard index	1.0 hazard index
PFHxS	1.0 hazard index	1.0 hazard index
PFBS	1.0 hazard index	1.0 hazard index

New/Pending Regulatory Activity (cont'd)

- Adaptive changes to Toxic Release Inventory (TRI) reporting for PFAS – elimination of *de minimis* exemption
- Under USEPA's Final Effluent Guideline Plan 15, a detailed study of potential PFAS discharges from the textile mill category will be conducted; and monitor discharge data from the pulp, paper and paperboard and airport categories
- USEPA is working to complete a full risk assessment on PFOA and PFOS in biosolids for release in 2024

Changing Regulatory Landscape – Quick Summary

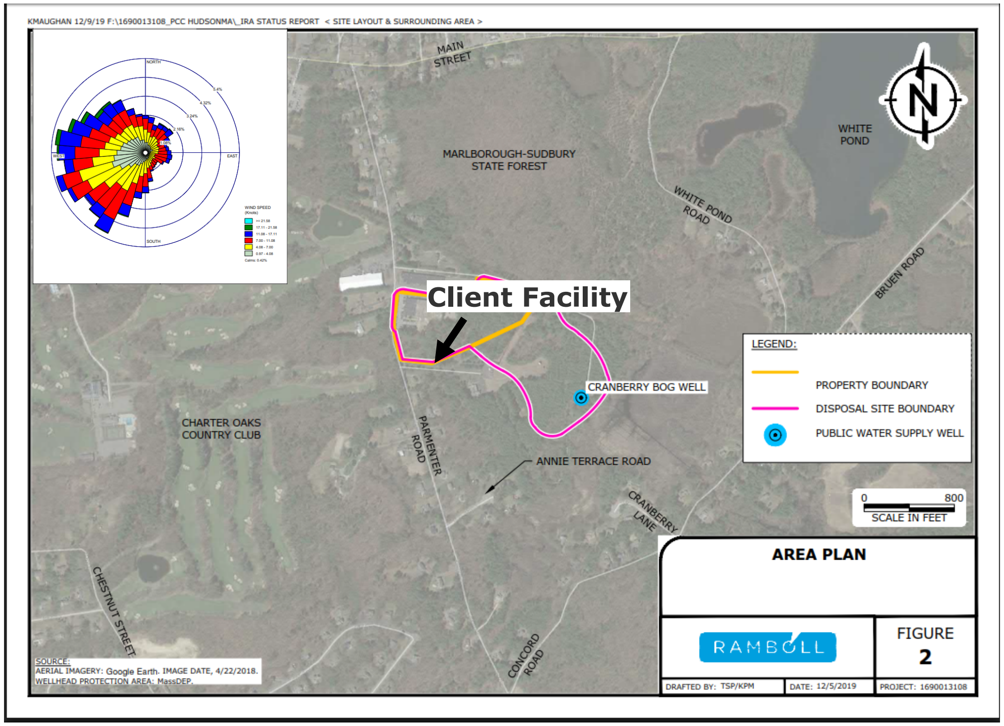
- **In October 2021, USEPA announced it would 1) propose adding PFOA, PFOA, PFBS and GenX as hazardous constituents under RCRA and 2) clarify the corrective action requirements under RCRA to make sure these four PFAS are covered.**
- **In September 2022, USEPA has proposed designating PFOA and PFOS as hazardous substances under CERCLA. A final rule is expected by mid-summer 2023.**
- **Consequently, individual states have been largely left to develop their own regulatory actions**
- Our ability to analyze and quantify PFAS has outpaced our understanding of the potential health effects associated with exposures to these emerging contaminants
- The result: a patchwork of approaches, thresholds and sensitivities

Case Studies

Case Study #1 –
Surface Coating Operation

Site Overview

- 13-acre property
  - 2.5 acres developed
- Northern New England
- Mostly residential
- Private country club
- State forest
- Multiple private and public water supplies in immediate area (surface water and groundwater)
- Prevailing winds out of the southwest



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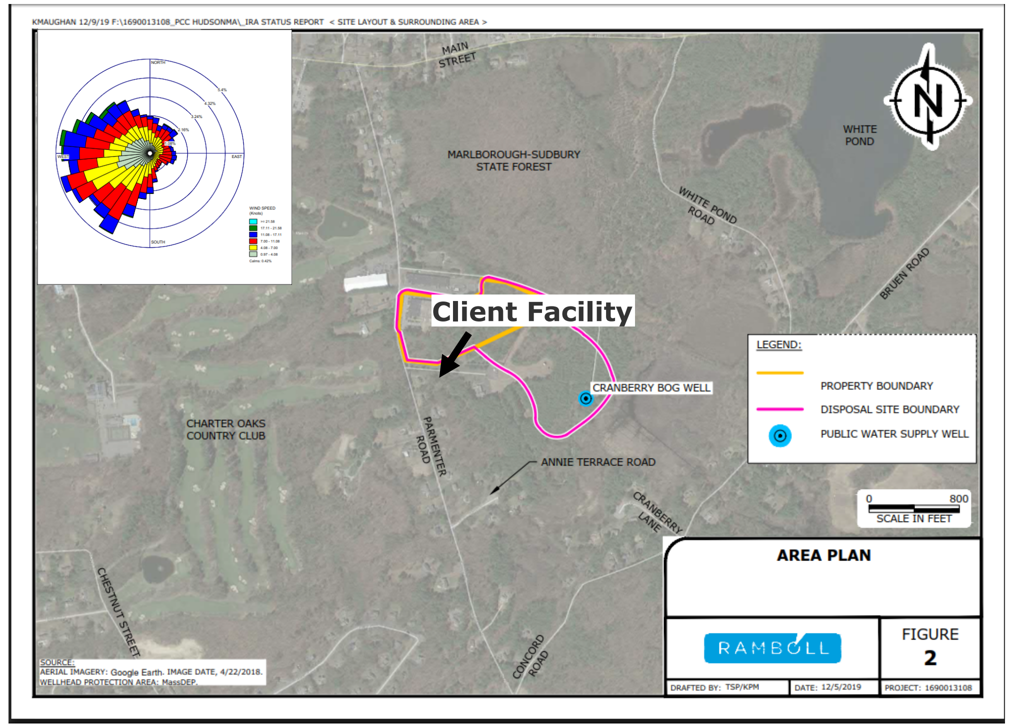
Site Overview

- PFAS found in public water supply well (UCMR3)
- PFAS in private drinking water wells
- Concentrations above regulatory thresholds
- State regulations triggered investigation
- Very complex and extensive site investigation
- This presentation: air emissions and potential PFAS migration via the air pathway



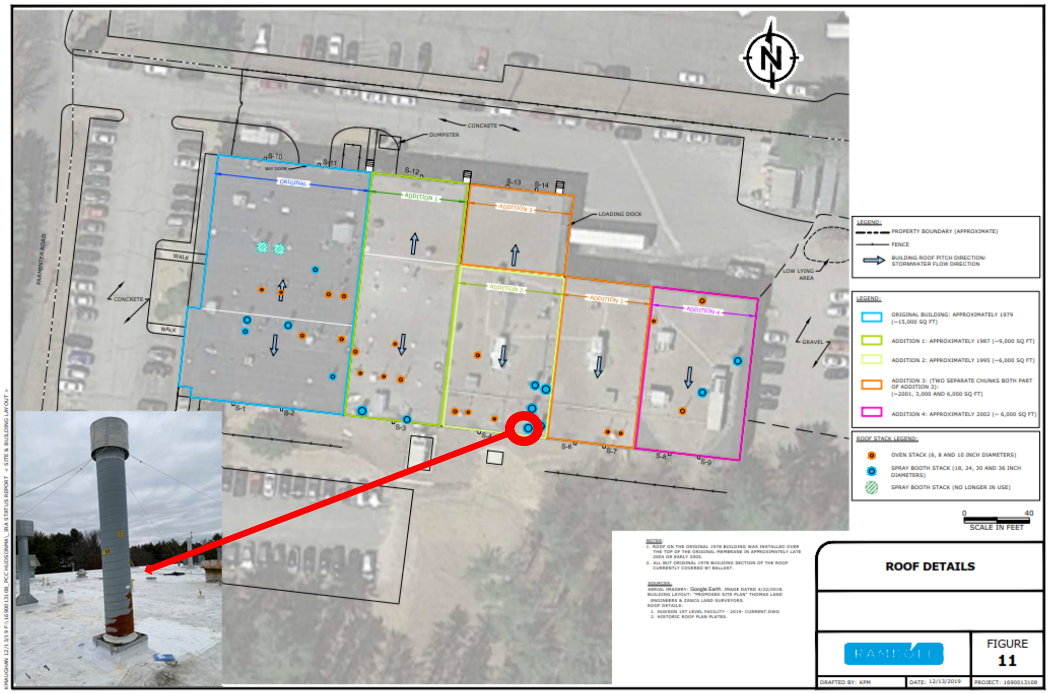
Operations Summary

- Facility = ~45,000 sf
- 40+ years of same ops
- Manual and robotic spray application of coatings containing dispersions
- Solvent- and aqueous-based coatings
- Application in spray booths with HEPA filtration systems
- Vertical stack discharge
- Curing in IR and convection-type ovens with direct vent via stacks

*100’s to 1000’s of similar businesses in the US . . .

Roof Details

- 15 vertical spray booth stacks (initially)
  - Damper/flapper vents (rain protection)
- 22 vertical bake oven stacks (initially)
  - Most with damper/flapper vents
- ~10'-12' above roofline; ~ 30' above grade
- Eight "drainage areas" on the roof (indicated by arrows)
- Stormwater flows off roof via 14 scuppers



Initial Investigation Summary

TASK	INVESTIGATION OBJECTIVE		
	Source Evaluation	**Transport Pathway Evaluation**	**Receptor Evaluation**
Materials Testing (Dispersions, Additives, Filters, Residue)	X		
Roof Ballast and Roof Sediment Testing	X		
Air Emissions Testing	X		
Air Dispersion Modeling		X	X
Roof Scupper Stormwater Sampling	X	X	
Surficial Soil Sampling	X	X	X
Overburden and Bedrock Groundwater Sampling	X	X	X
Public and Private Water Supply Well Sampling			X

Preview of Selected Investigation Components

Objective: Is the Facility contributing to PFAS found in the supply wells and other environmental medial?

Site visit	Materials testing	Air emissions testing	Air dispersion modeling
• Emissions testing design • Initial evaluation of potential sources-pathways-receptors ✓ Confirmed potential for complex and multiple PFAS migration pathways to exist, including from residual PFAS in stacks, on structures, and on equipment	• Are PFAS present in materials used at the Facility? ✓ PFAS present in dispersions ✓ PFAS found on the roof and in Facility equipment ✓ PFOA found to be the more significant COC	• Are PFAS found in the materials used emitted from the Facility under current operations (vs. predecessor)? ✓ PFAS present in emissions ✓ PFOA found to be the more significant COC	• Could dispersion account for impacts observed near and distant from the Facility? ✓ Modeling results informed a "step-out" sampling plan of soil, surface water, sediment radially around the Facility

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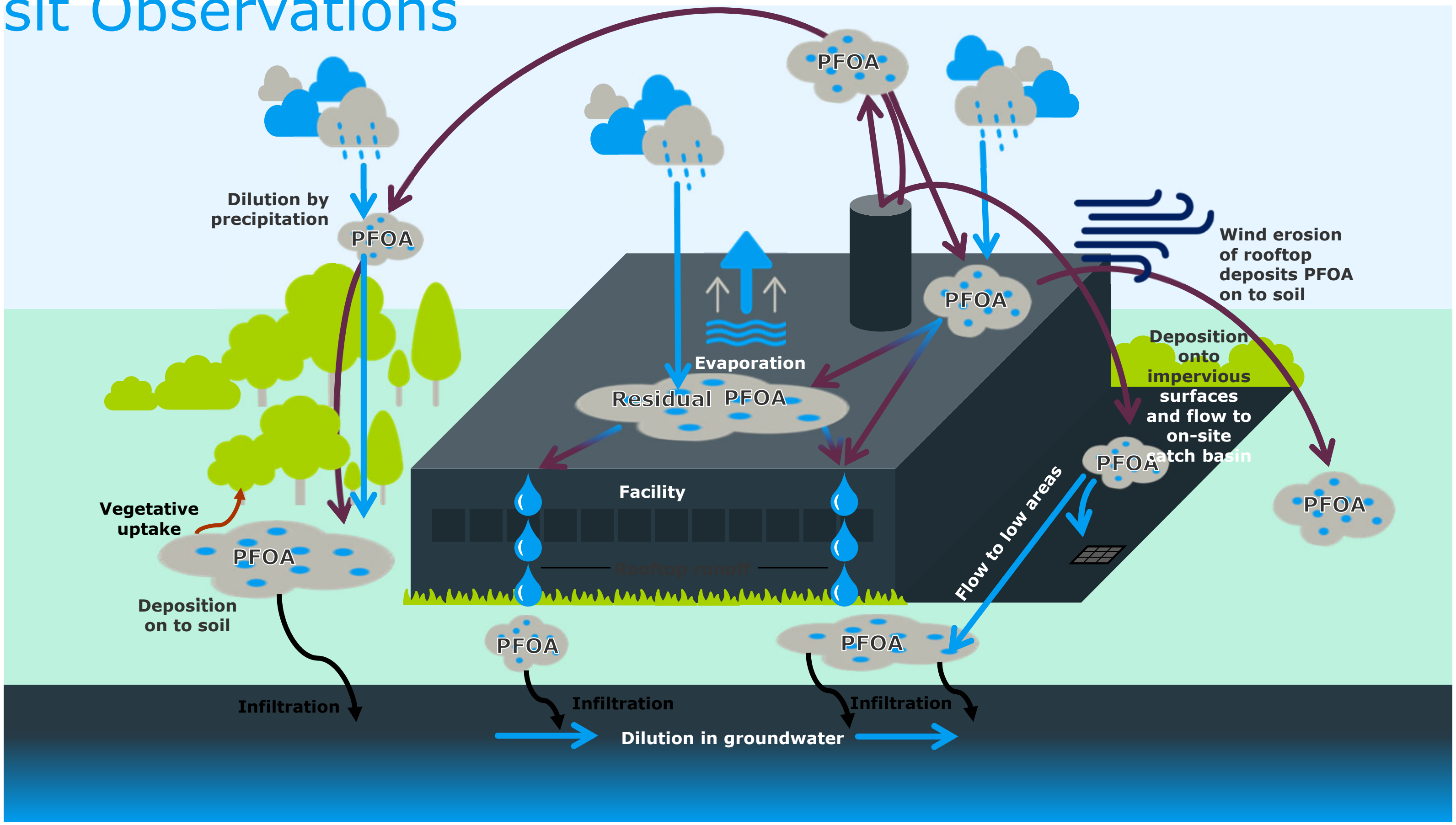
Site Visit Observations



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Site Visit Observations and Residual Testing

Examples of Coating Agglomeration and Chunking

Coating Agglomeration on Inside of Stack Cap
≤17,200,000 ng/Kg PFOA

Roof Ballast and Roof Stack

Residue Under Roof Ballast

PFAS Residue in Roof Ballast from Chunking of Coating Agglomeration Occurring in Stacks
≤13,000,000 ng/Kg PFOA

Air Emissions Testing
Objectives

01 Determine if PFAS are being emitted from spray booth exhausts and bake oven exhausts at the Facility.

02 Compare emissions from aqueous and solvent coatings.

03 Evaluate potential variability in emissions during use of polyester or carbon-pleated filters.

04 Evaluate particulate matter and condensable particulate matter emissions from spray booth and bake oven exhausts.

Air Emissions Testing
Results

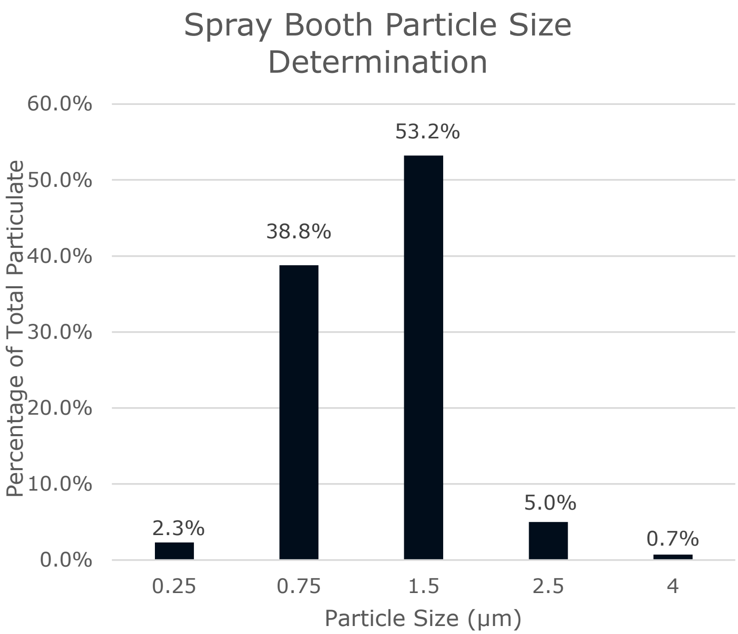
01 PFAS are being emitted from spray booth exhausts and bake oven exhausts at the Facility.

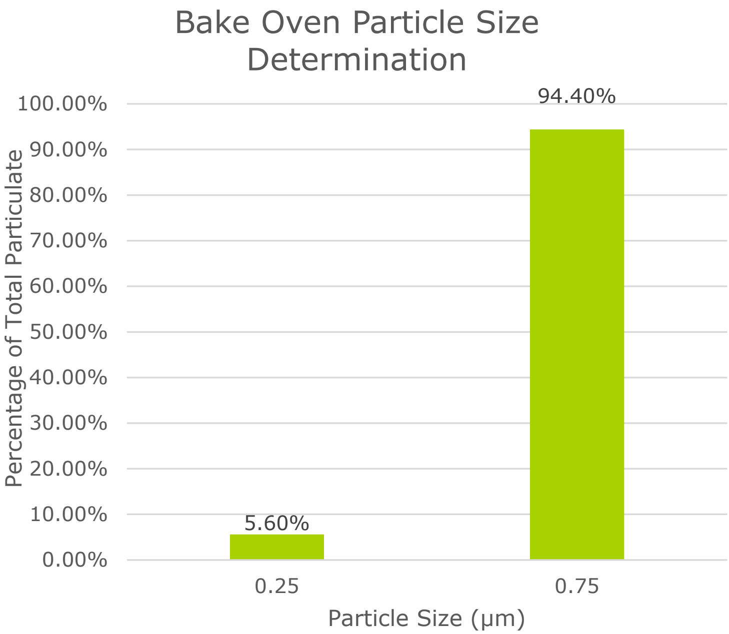
- PFOA - Estimated at 2.9 g/year (less than ~½ of a teaspoon).
- 90% of emissions - Spray booths; 10% bake ovens

02 Calculated discharge rates did not vary significantly for aqueous- vs. solvent-based coating applications.

03 PFAS emissions were higher with the use of carbon-pleated filters vs. polyester (not statistically significant). Condensable particulate matter was higher using the carbon-pleated filters.

Particle Size Distribution Results

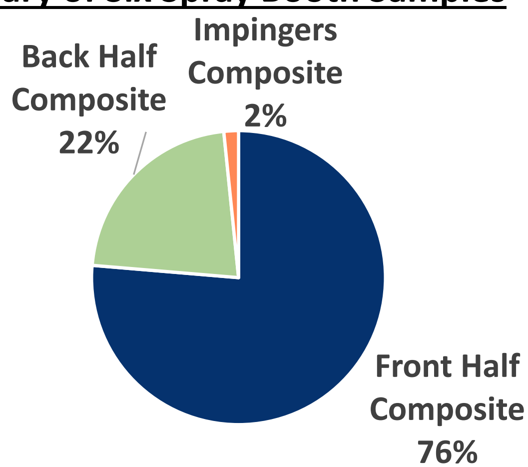




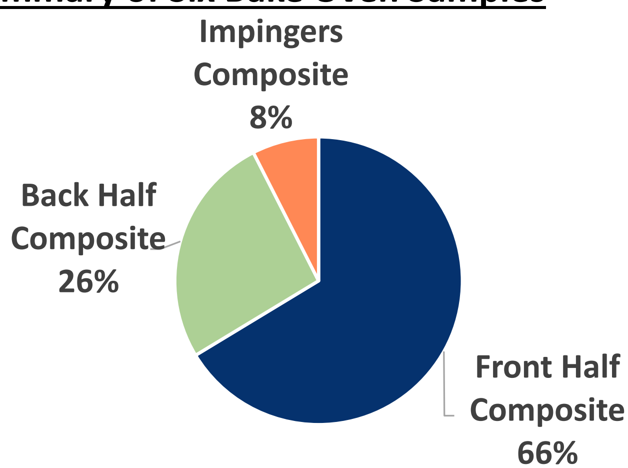
- ✓ > 98% of particles < 3 microns
- ✓ Majority between 0.5 – 2 microns.
- ✓ Enhanced filtration may have little benefit

PFOA Mass by Sample Fraction

Summary of Six Spray Booth Samples



Summary of Six Bake Oven Samples



- ✓ Sulfonated compounds were not filterable.
- ✓ ~66-76% present in filterable form
- ✓ Alternative PM controls could further reduce emissions, if needed.

Air Dispersion Modeling
Objectives

01 Estimate extent of PFAS deposition from emissions and air deposition rate (inform field sampling scope to define boundaries of disposal site)

02 Compare PFAS deposition on the Facility roof with elsewhere

03 Evaluate potential to reduce PFAS deposition through changes to stack discharge if needed

Air Dispersion Modeling
Methods

01 Used USEPA's AERMOD and Building Profile Input Program-Prime.

02 Rural dispersion curves and five-year meteorological dataset from sources near the Facility used.

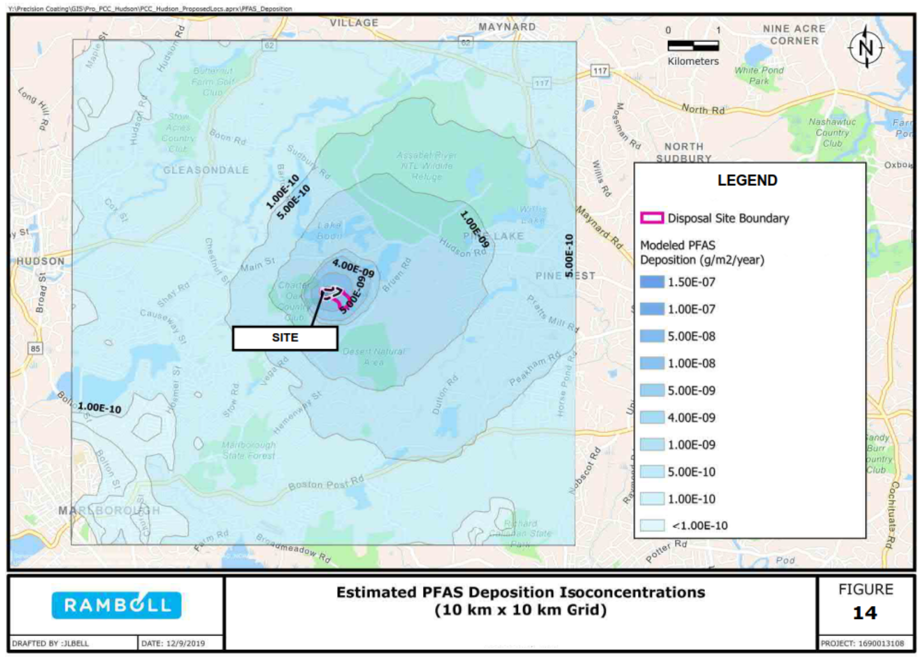
03 Nested Cartesian receptor grid used with a spacing of 10m, 25m, 100m, and 250m extending to 50m, 250m, 1,000m, and 5,000m from the Facility.

04 Used Method 1 of AERMOD (PSD reasonably well known); wet and dry deposition considered.

05 Used model for a comparative/qualitative evaluation rather than absolute or quantitative due to assumptions and variables involved (e.g., spatial allocation of emissions across various types of process sources).

Air Dispersion Modeling
Results

- Deposition rates greatest near the Facility and drop off with distance
- Deposition predicted to extend beyond the 10km grid simulated
- 0.015% of modeled emissions land on the roof
- 99.985% of modeled emissions land beyond the roof
- Travel distances affected by PM size (i.e., PFOA: filterable vs PFOS: sub-micron)



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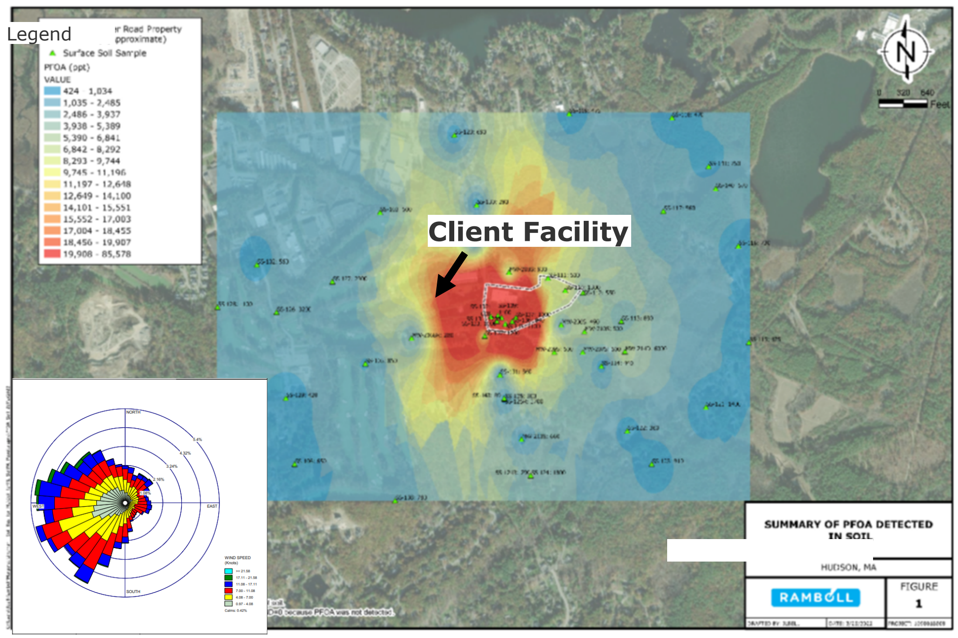
Surface Soil Sampling Results

- Similar pattern as predicted by modeling
- Soil pattern not fully aligned with wind rose data (not unexpected)
- **Areas of soil concentrations exceeding regulatory thresholds were constrained to a much smaller area than the simulated depositional area**



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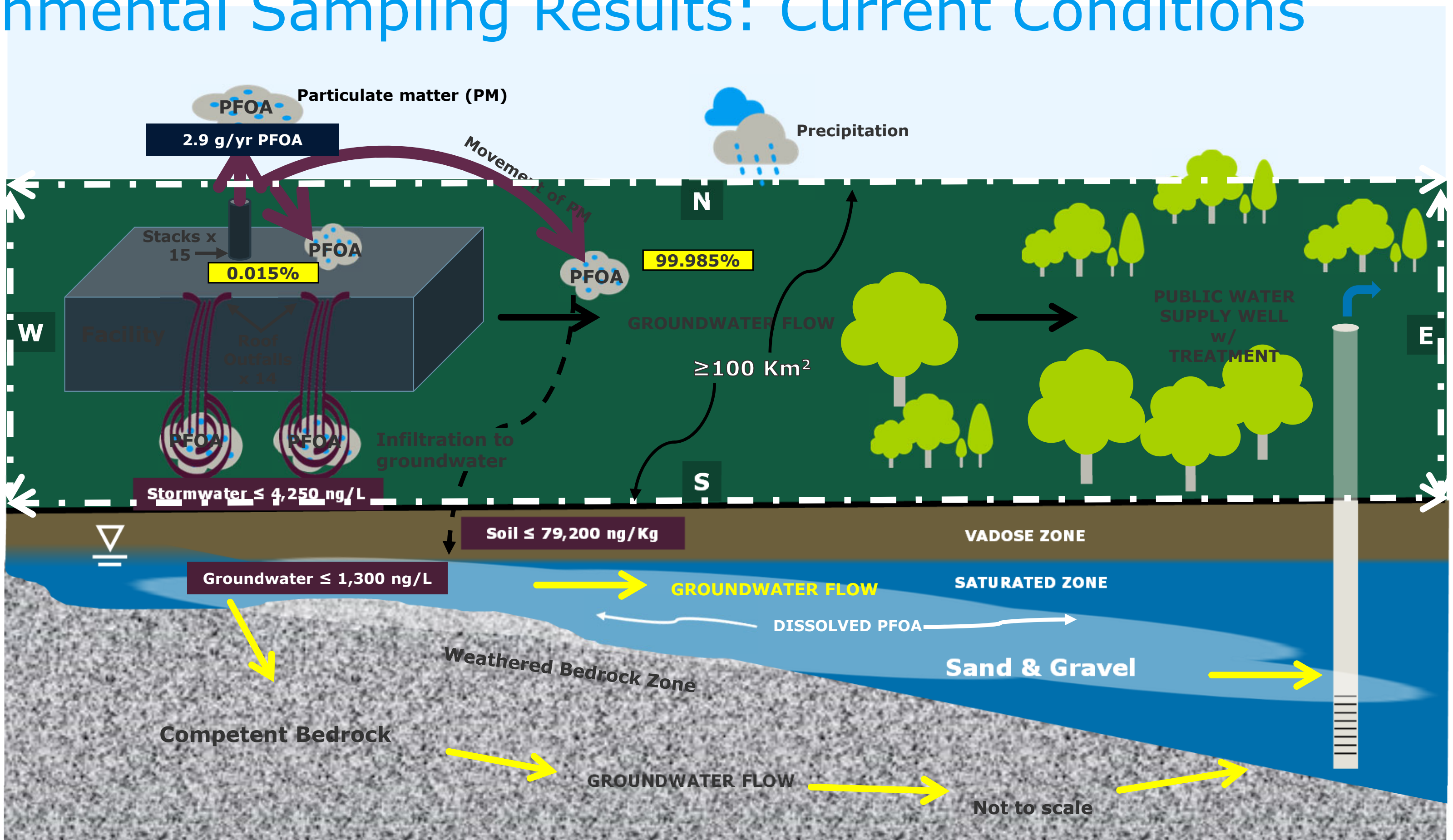
But That’s Not the End of the Story…

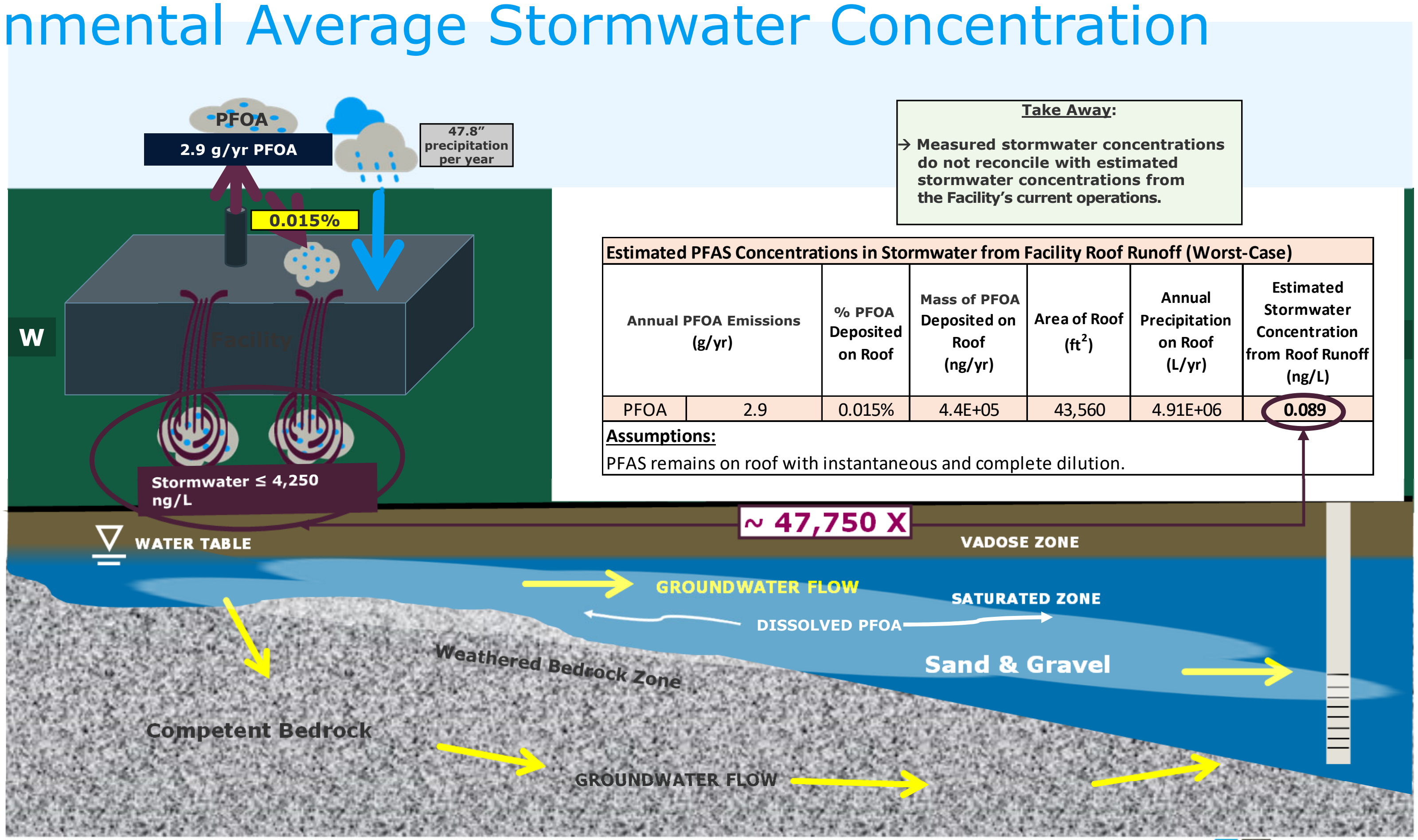
Reconciliation of Environmental Sampling Results to Estimate of Current Emissions

Can the estimated emissions of 2.9 g/yr of PFOA from the Facility account for the sampling results measured in the various environmental media around the site?

Environmental Sampling Results: Current Conditions



Environmental Average Stormwater Concentration



Take Away:

→ Measured stormwater concentrations do not reconcile with estimated stormwater concentrations from the Facility's current operations.

Estimated PFAS Concentrations in Stormwater from Facility Roof Runoff (Worst-Case)

Annual PFOA Emissions (g/yr)		% PFOA Deposited on Roof	Mass of PFOA Deposited on Roof (ng/yr)	Area of Roof (ft^2)	Annual Precipitation on Roof (L/yr)	Estimated Stormwater Concentration from Roof Runoff (ng/L)
PFOA	2.9	0.015%	4.4E+05	43,560	4.91E+06	0.089

Assumptions:

PFAS remains on roof with instantaneous and complete dilution.

Estimated Soil Concentrations

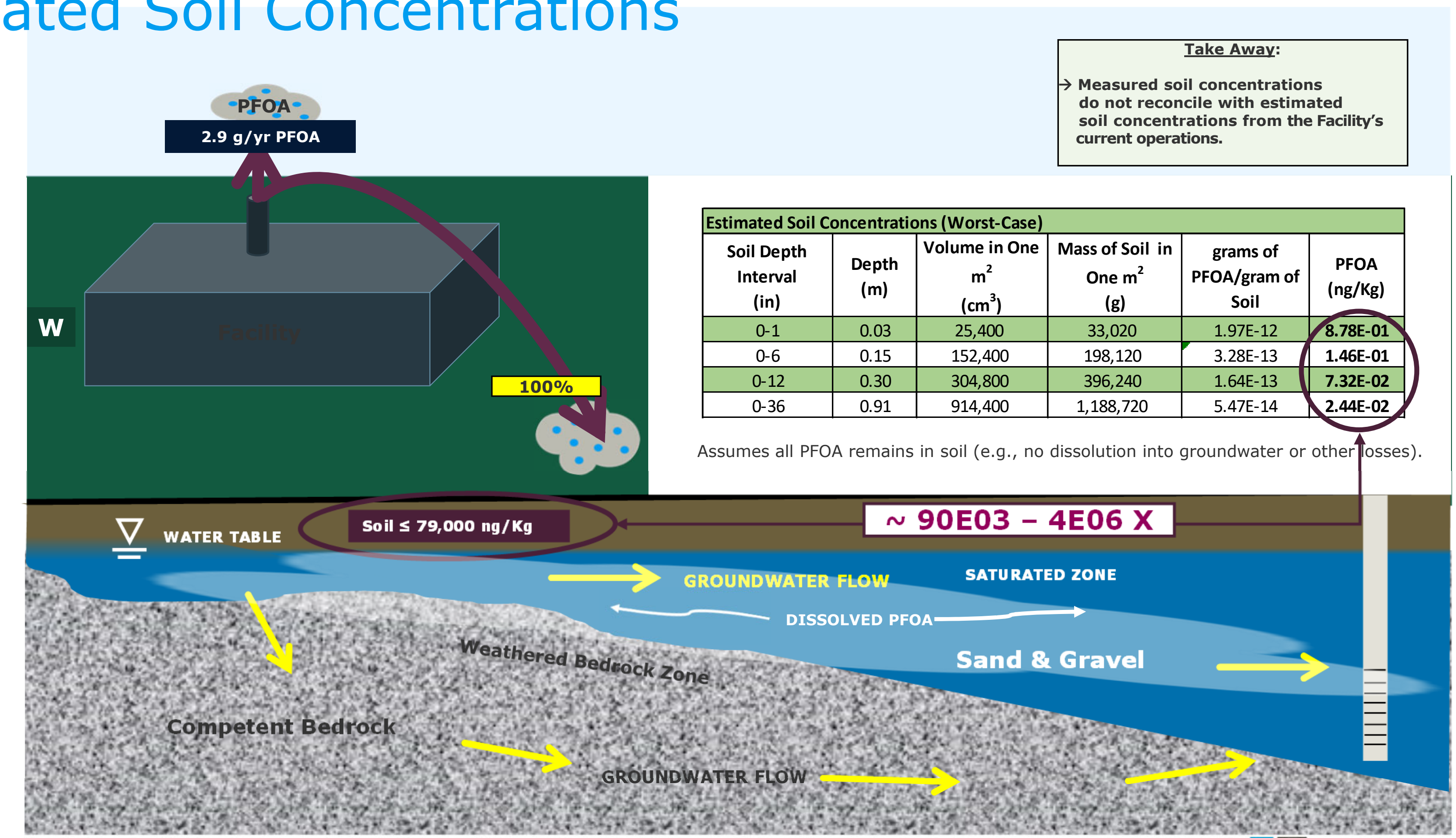
Take Away:

→ **Measured soil concentrations do not reconcile with estimated soil concentrations from the Facility's current operations.**

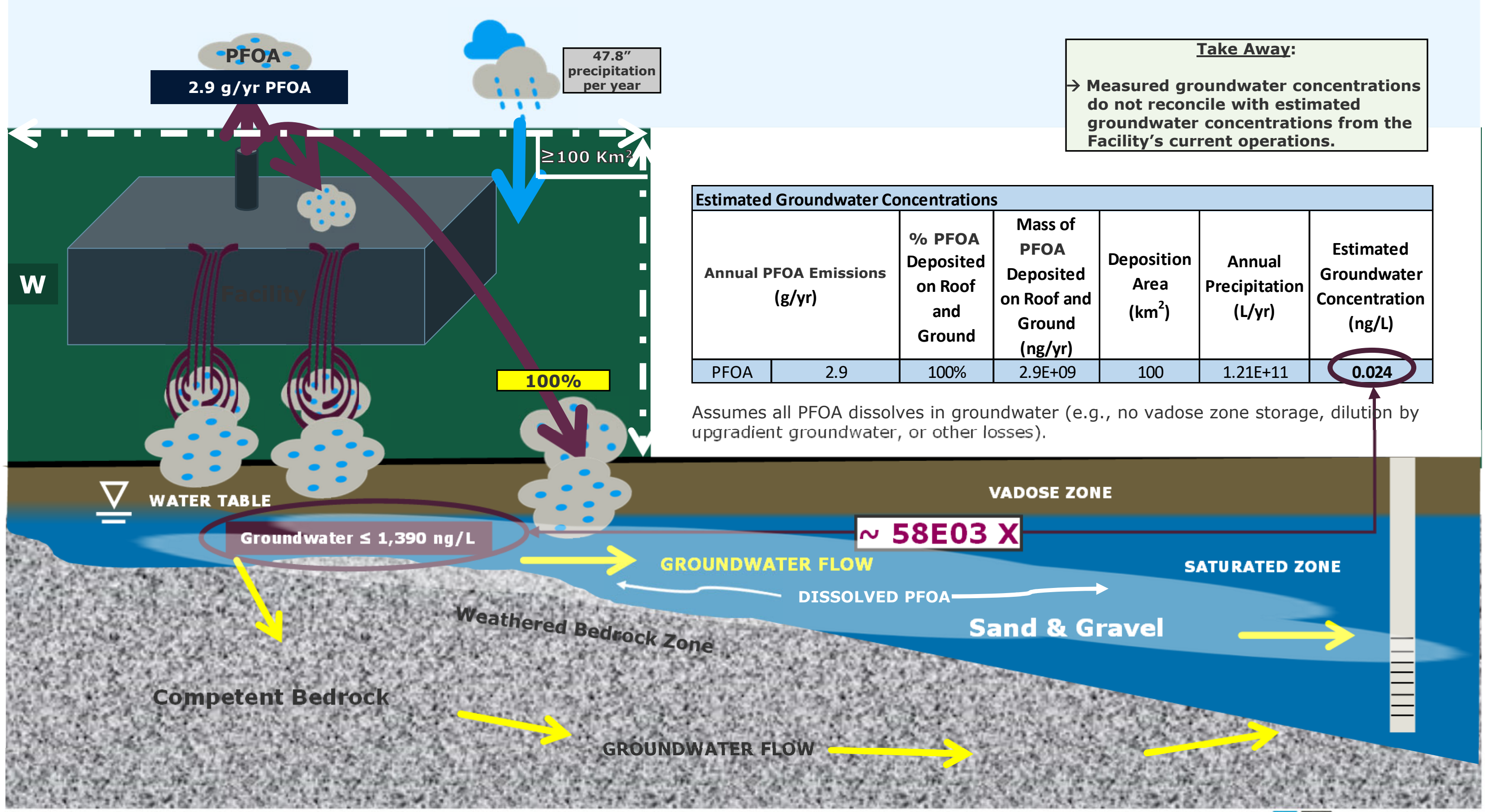
Estimated Soil Concentrations (Worst-Case)

Soil Depth Interval (in)	Depth (m)	Volume in One m^2 (cm^3)	Mass of Soil in One m^2 (g)	grams of PFOA/gram of Soil	PFOA (ng/Kg)
0-1	0.03	25,400	33,020	1.97E-12	**8.78E-01**
0-6	0.15	152,400	198,120	3.28E-13	**1.46E-01**
0-12	0.30	304,800	396,240	1.64E-13	**7.32E-02**
0-36	0.91	914,400	1,188,720	5.47E-14	**2.44E-02**

Assumes all PFOA remains in soil (e.g., no dissolution into groundwater or other losses).



Environmental Average Groundwater Concentration



Take Away:

→ **Measured groundwater concentrations do not reconcile with estimated groundwater concentrations from the Facility's current operations.**

Estimated Groundwater Concentrations

	Annual PFOA Emissions (g/yr)	% PFOA Deposited on Roof and Ground	Mass of PFOA Deposited on Roof and Ground (ng/yr)	Deposition Area (km^2)	Annual Precipitation (L/yr)	Estimated Groundwater Concentration (ng/L)
PFOA	2.9	100%	2.9E+09	100	1.21E+11	**0.024**

Assumes all PFOA dissolves in groundwater (e.g., no vadose zone storage, dilution by upgradient groundwater, or other losses).

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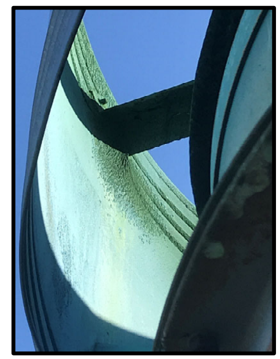
Reconciliation of Environmental Sampling Results to Estimate of Current Emissions

01 **The emissions of 2.9 g/yr of PFOA from the Facility's current operations do not reconcile with any of the sampling results measured in the various environmental media on the site.**

Media near facility explained by PFAS residue remaining in equipment from historical operations (e.g., spray booth components, air handling equipment).

Spray booth stack residue sampling



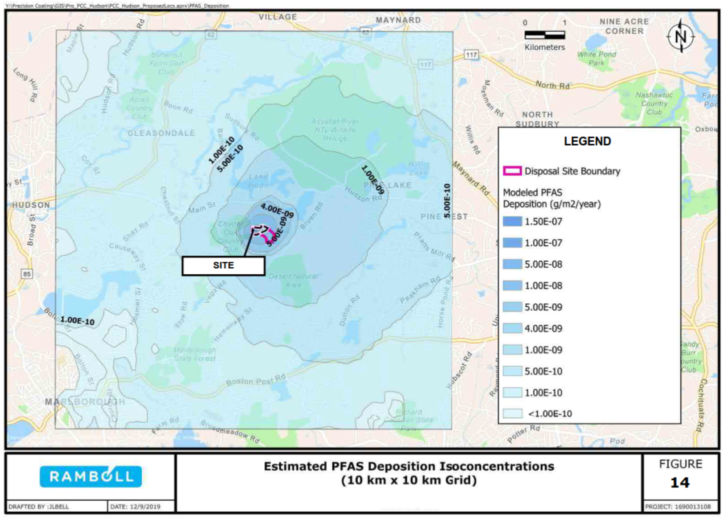
≤17,200,000 ng/Kg PFOA

Reconciliation of Environmental Sampling Results to Estimate of Current Emissions

01 **The emissions of 2.9 g/yr of PFOA from the Facility's current operations do not reconcile with any of the sampling results measured in the various environmental media on the site.**

Surficial soil distant from the facility (beyond the reach of stormwater) explained by:

- Deposition via the air pathway
- Material balance of current operations compared to predecessor's operation
- PFAS concentrations in predecessors dispersions >>> current operator



KEY TAKE-AWAY FROM CASE STUDY #1

01 Air pathway has potential to create many complex migration pathways for PFAS

02 Air pathway can distribute PFAS mass to environmental media over a relatively large area

03 Consider equipment and structures as an on-going source of PFAS (agglomeration, chunking, residual contamination) resulting from emissions

04 Historical operations can still create a significant source of PFAS

05 The air pathway is likely to become more prevalent and a factor in PFAS investigation and remediation with time; facilities like this one (many in the US alone) will likely follow a similar regulatory path.

06 The need to discern "sites" from other regional sources and from "background" conditions will likely grow in importance

Case Study #2 –
The Looming Biosolids Crisis

PFAS in Biosolids – Background Information

- In April 2022, Maine became the first state to entirely ban the beneficial reuse of biosolids as agricultural amendments
- In December 2022, USEPA issued guidance to all state NPDES permit authorities, recommending PFAS wastewater and biosolids monitoring requirements to be placed in permits for POTWs with known or suspected PFAS contributors.
- As of January 2023, 14 states had at least one standard/guidance value for PFOA in soil (either as a cleanup objective, or for the protection of drinking/ground/surface water, excluding soil screening levels)
- These values range from 4 ppt (WA) to 10 ppm (MI)

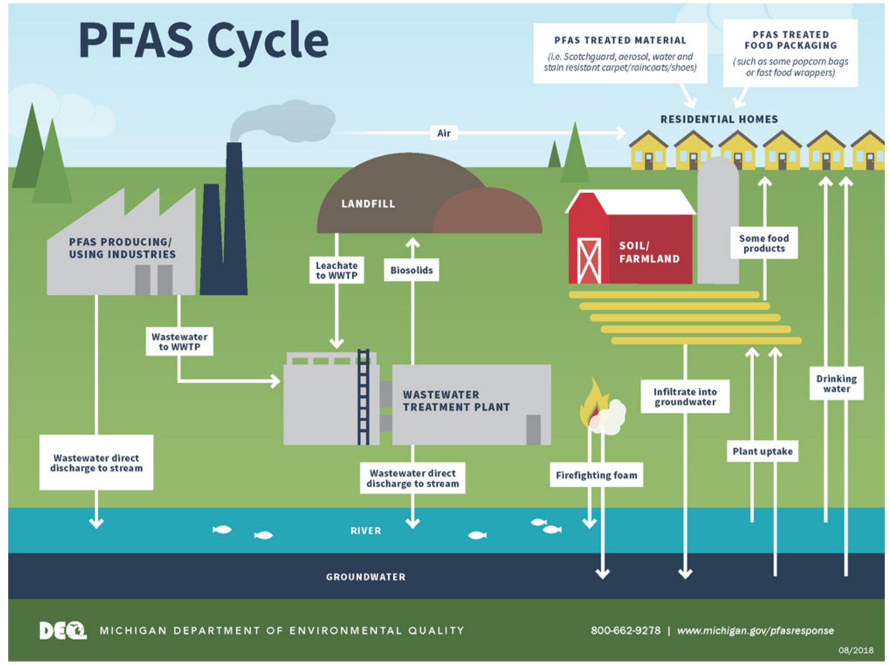


Image courtesy of Michigan Department of Environmental Quality

PFAS in Biosolids – Technical Concerns

- In 2022, WWTPs in the U.S. generated approximately 6.3 million tons per year of biosolids
- Biosolids are typically land-applied (43%), landfilled (42%), or incinerated (14%)
- Primary concerns:
  - Incineration of biosolids may not effectively destroy PFAS
  - Landfilling may generate PFAS-impacted leachate, which is often sent to the WWTP
  - Bans on land application may exacerbate issues with the two other disposal options

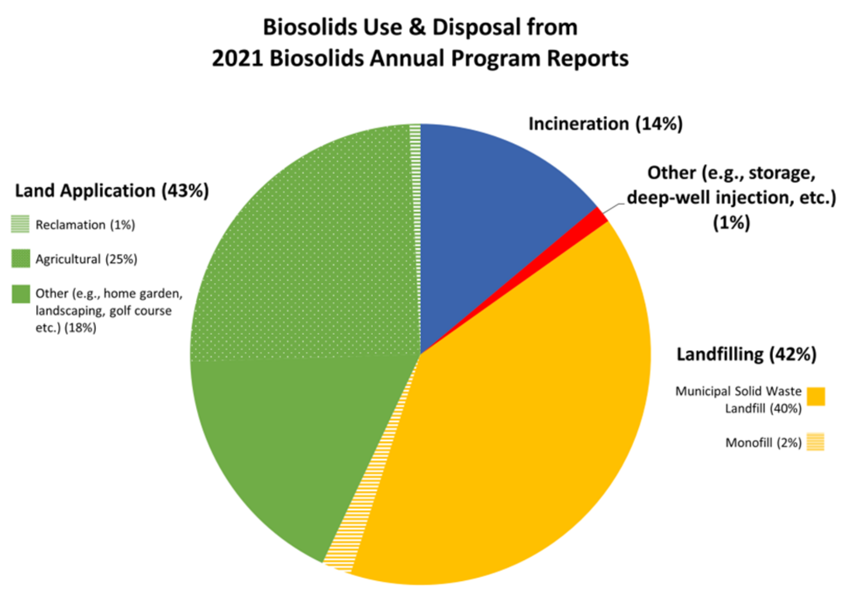


Image courtesy of the United States Environmental Protection Agency

PFAS in Biosolids – Technical Concerns (continued)

- Consensus: PFAS destruction via incineration requires 1850-2000 and 2 seconds of residence time (RT)
- Sewage sludge incinerators (SSI) typically operate in the 1400-1700 °F with 2-5 seconds of RT
- Vast majority of SSI are located along the East Coast – insufficient geographical coverage
- Concerns over products of incomplete combustion (PICs)

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PFAS in Biosolids – Summary

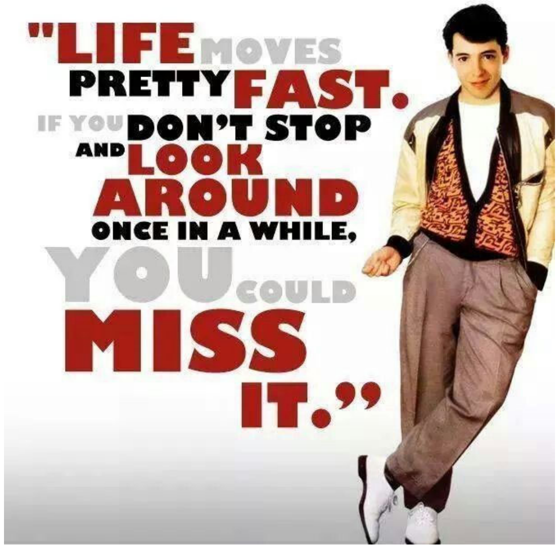
- Absent a ban on the future use of PFAS compounds, adaptive changes to the way we manage biosolids will need to occur
- More research is needed on the efficacy of SSI for PFAS destruction; on the face of it, current technology is not capable of achieving high-levels of destruction
- Broader-scale bans on land application of biosolids may result in several impacts, including:
  - Increased transportation costs
  - Increased use of landfills for biosolids disposal
  - Leachate treatment for PFAS may become standard practice
  - More use of hazardous waste landfills in the event PFAS concentrations are unacceptably high
  - More SSIs may need to be sited

Photo courtesy of Albuquerque WUA

Closing Thoughts

Closing Thoughts (Tips & Takeaways)

- PFAS is everywhere; yet we are still learning about their fate and transport in the environment and the risks they may pose
    - Begin understanding where PFAS may be used at your facilities
    - If you do not need AFFF-based extinguishers, replace them with non-AFFF systems
    - Switch to liquid soap for fire training and fire equipment testing
    - You may not be able to rely on supplier notifications, at least for a while
    - Be careful when responding to a request to certify you product or raw materials are "PFAS-free"
    - Remember that current detection limits for PFAS are considerably higher than current health advisory levels; thus, supplier certifications that raw materials are "PFAS free" may not be accurate
- Our technical understanding of PFAS is increasing at a rapid pace, which in turn, is expected to result in a blistering pace of regulation soon thereafter
    - Monitor regulatory developments; they will occur quickly



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Closing Thoughts (Tips & Takeaways)

- Action levels are in the ppt and/or ppq range; the ubiquitous nature of these contaminants will make background concentrations and forensic analysis key priorities for many investigations
    - Impacts above background should be the expectation
    - Discerning the source of PFAS may be equally important
- Front-end risk management
    - Investigate on-site sources and off-site context
    - Eliminate discharges through product substitution and operational changes
    - Characterize remaining discharges
    - Consider developing a confidential, internal "PFAS strategy plan"
    - De minimis
- Both science and policy are evolving regularly
    - Important to know where there's solid ground and where there isn't
    - But also know that PFAS = uncertainty = risk

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Questions?

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For more than 35 years, Steve Haughey has been representing clients across the country in regulatory compliance counseling, permitting, rulemaking challenges, enforcement litigation, citizen suits, criminal prosecutions, and cleanup of contaminated property. He has particular expertise in all aspects of wastewater and water-related permitting, counseling and enforcement defense, including wetland/stream Section 404 permitting, and in defending citizen suits and CERCLA contribution actions. Steve has presented several winning oral arguments to the Ohio Supreme Court, the Sixth Circuit Court of Appeals, and numerous District Courts across the Midwest. His science background enables him to work closely with consultants on a variety of technical issues involved in site cleanups and related litigation. Steve is Trial Counsel in the largest PFAS-contaminated water-supply lawsuit pending against a military base in the U.S., involving a 70 mgd treatment plant that supplies water to close to a half million people and businesses.

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Mr. Traister has more than three decades of environmental consulting experience and provides technical expertise and expert services in a variety of air quality matters. For the past five years, Mr. Traister has been involved in several projects, both domestically and abroad, involving the quantification and control of PFAS emissions and the study of their fate and transport. These projects have been performed for surface coating operations, chemical manufacturers, semiconductor facilities, textile finishing operations and remediation systems. As a professional chemical engineer, Mr. Traister assists clients in identifying replacement chemistries and/or modifying their industrial processes so as to minimize the discharge of air contaminants to the environment. Mr. Traister also frequently presents on PFAS matters at national and regional conferences, including the Carolina Air Pollution Control Association, the Midwestern States Environmental Consultants Association, and those sponsored by the Air & Waste Management Association.