Ohio's AFFF Takeback Program and Destruction of AFFF using SCWO

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Ohio Environmental Protection Agency

What is AFFF?

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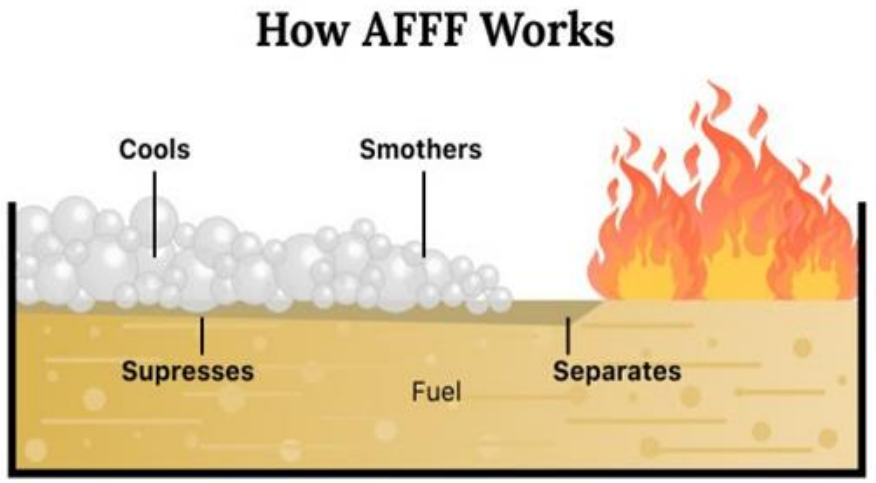
Overview/History of AFFF Usage to Fight Fires

- For decades, firefighters have used AFFF to suppress fires. AFFF firefighting foam was used in both actual fires and training exercises.

- The firefighting foam comes in a concentrate mixed with water. Firefighters use AFFF to extinguish fires that are difficult to fight with water alone, especially those that involve flammable liquids, like petroleum.

- In 2022, Ohio Governor Mike DeWine banned AFFF from training purposes.



Why Does AFFF Need to be Eliminated?

HUMAN HEALTH RISK

- Current scientific research suggests that exposure to certain PFAS may lead to adverse health outcomes.

- Research has shown that people can be exposed to PFAS by:
  - Working in occupations such as firefighting or chemicals manufacturing
  - Drinking water contaminated with PFAS.
  - Eating certain foods that may contain PFAS, including fish.
  - Swallowing contaminated soil or dust.
  - Breathing air containing PFAS.
  - Using products made with PFAS or packaged in materials containing PFAS.

- Firefighters have a higher risk of exposure to PFAS from:
  - Using AFFF for fire suppression operations and training;
  - Contact with contaminated PPE;
  - Handling equipment contaminated with AFFF;
  - Managing PFAS foam wastes; and
  - Occupation of contaminated fire stations.

ENVIRONMENTAL RISK

- AFFF, due to the presence of PFAS, poses a unique challenge to protecting the environment when it is released.
- Releases of AFFF to the environment that can lead to soil, groundwater, surface water, and potentially drinking water contamination.
- AFFF is typically discharged on land but can run off into surface water or stormwater or infiltrate to groundwater.
- The discharge of firefighting foams to the environment is of concern because of the potential negative impact they can have on ecosystems and biota.

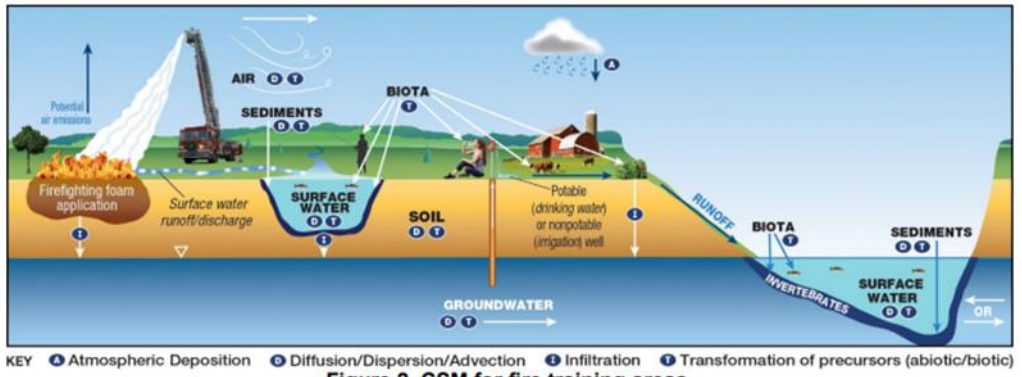


Figure 2. CSM for fire training areas.

Source: Adapted from figure by L. Trozzolo, TRC. Used with permission.

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Washington Works Facility

- Ohio was the first state to legally challenge DuPont.
- In November 2023, a $110 million settlement was reached with DuPont over the chemical contamination.
- Most of the Dupont settlement will go toward helping communities impacted by PFAS contamination from the Washington Works plant.
- Ohio EPA is meeting with communities identified in the settlement on potential remediation projects.

Mitigation
Ohio AFFF Takeback Program

Goal: *Obtain a grant to establish and execute an aqueous film-forming foam (AFFF) take back program to collect and destroy AFFF legacy stockpiles at fire departments throughout the State of Ohio to eliminate existing risks to human health and the environment.*

AFFF Takeback Program

Program Coordination and Collaboration

- The program was designed and is led by Battelle, an Ohio-based, non-profit research institute.
- Battelle coordinates and collaborates with the Division of State Fire Marshal, the Ohio Environmental Protection Agency and local fire departments to execute the program.

AFFF Take Back Program Process

<u>Volume Estimate</u>: 35,000 gallons of AFFF will be collected for destruction. The funding request will include a 25% contingency for additional volumes.

1. Develop and support a registration process for Ohio Fire Departments to participate in the PFAS-containing fire-fighting foam collection and destruction program;

2. Operate two collection sites at each of five Ohio regions whereby PFAS-containing fire-fighting foam will be delivered.

3. Transport collected PFAS-containing fire-fighting foams to a treatment facility located in the State of Ohio.

4. Dispose/destroy the collected PFAS-containing AFFF using the PFAS Annihilator™ technology.

5. Share the final testing outcomes of the disposal/destruction process
   - PFAS-containing fire-fighting foam collection and destruction program registration process
   - Final testing outcomes of the disposal/destruction process
   - Database of all PFAS-containing fire-fighting foams and supplies collected under the program

Program Benefits and Expected Outcomes

- Protects firefighters from exposure to PFAS chemicals
- Protects human health and the environment from potential releases of PFAS
- Defrays economic burden to local fire departments
- Mitigates future risk/liability by using destruction technology versus disposal or treatment options
- Provides certification of PFAS destruction

Commercial Operations

EPA's Recommendations for Treatment and Disposal

Stabilization and Landfill Disposal

Non-destructive

AFFF mixed with stabilizer

Immobilized and encapsulated

Deep Well Injection

Non-destructive

Injected into tectonically stable strata

Incineration

Destructive

AFFF destroyed or mineralized via heat

Efficacy under study

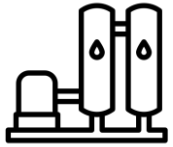
Potential Future Treatment or Disposal Technologies

New destructive technologies/ technologies under development

* EPA's current recommendation

Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances (USEPA, 2020)

Treatment Scenarios for AFFF Waste Streams

Scenario	PFAS Concentration	Pre-Treatment	Transport	Destruction
 Concentrate	Very High	None		
 Rinsate	High	Separation + Concentration 		Discharge Clean Effluent to POTW
 Firewater/ Groundwater	Moderate to Dilute	• Foam Fractionation (FF) • Reverse Osmosis (RO) • Granular Activated Carbon (GAC) • Ion Exchange Resin (IX)		

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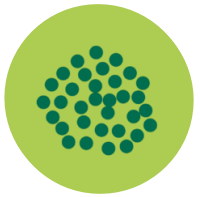
PFAS Treatment – Commercial & Developing Technologies

Commercially Available

Developing

SEPARATION/CONCENTRATION

Granular Activated Carbon



Ion Exchange Resin

Reverse Osmosis

Foam Fractionation

Novel Sorbents

Electrocoagulation

DESTRUCTION

Thermal / Incineration

Electrochemical Oxidation

Advanced Oxidation (SCWO)

Plasma

Hydrothermal Alkaline Treatment

New/Emerging Technologies – PFAS Destruction

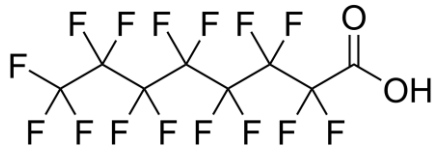
	SCWO (Supercritical Water Oxidation)	HALT (Hydrothermal Alkaline Treatment)	ECO (Electrochemical Oxidation)	Plasma
Readiness	• Commercial, Permitted • > 20 years Operational Success	• Pilot + Designing scaled-up system for testing	• Pilot	• Design + Initial field pilot
Strengths	• Most comprehensive depth and breadth of PFAS destruction • Can handle wide variety of contaminated aqueous matrices • Short residence time	• Very effective on long chain PFAS • Lower corrosion vs SCWO given lower temperatures • Short residence time	• Highly mobile unit • Low energy consumption for PFAS destruction	• Highly mobile, low-cost unit • Low energy consumption for PFAS destruction • Can handle PFAS-containing air streams
Considerations	• Susceptible to salt plugging • Susceptible to corrosion given high temperatures • Readiness being established for solid matrices	• Susceptible to salt plugging • Optimization for short chain PFAS	• Difficulty handling foam fractionated / concentrated waste streams • Effectiveness on short chain PFAS not yet proven • Long residence time	• Limited breadth and depth of PFAS destruction • Impacted by water quality • Long residence time • Potential for air emissions

Sources: TME: The Military Engineer, Society of American Military Engineers (July • August • Vol 115 • No 46), https://online.fliphtml5.com/fedq/opti/#p=55; Revive internal analysis

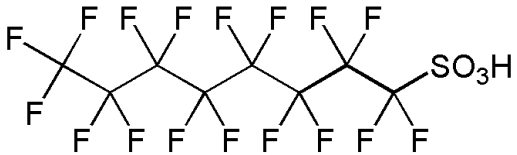
What is Supercritical Water Oxidation?

- **Supercritical water exhibits unique properties**
  - Gas and liquid phases become indistinguishable
  - Density is about 10% of water above the supercritical point
  - Water no longer behaves as a polar solvent
  - Oxygen is fully soluble
- **High temperature in an oxidizing environment overcomes activation energy to break C-F bond**

PFOA

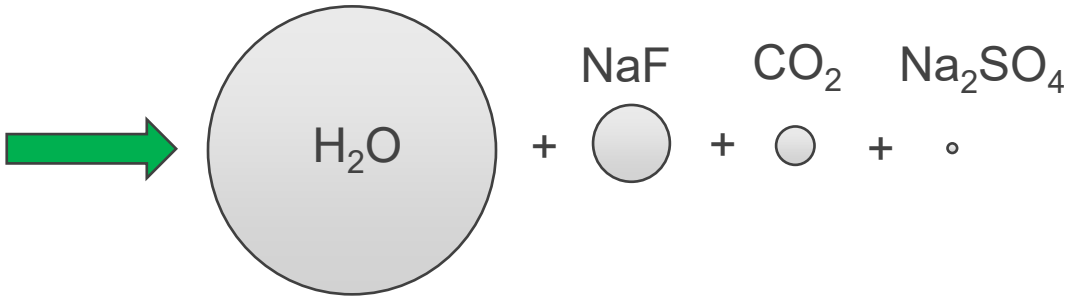


PFOS



+ H_2O_2 (oxygen source)

+ NaOH (Neutralization)



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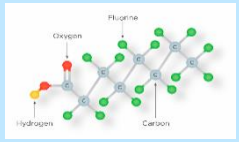
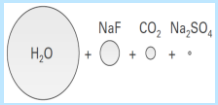
PFAS Annihilator™ Differentiators



>99.99% Destruction

- Short- and Long-chain compounds
- Dilute or Concentrated streams



Minimal Waste

- PFAS is mineralized not moved
- By-products: Water, Inert salts, CO_2

Highly Efficient

- Short residence time (<10 seconds)
- Heat Exchangers for influent/effluent

Permit Ready

- Below air permitting thresholds
- Process underway across multiple states

Complementary

- Works well with pre-concentration
- Not inhibited by organic co-contaminants

Commercial Ready

- March 2023 deployment in Michigan
- 6 more units in 2023; 18-24 in 2024

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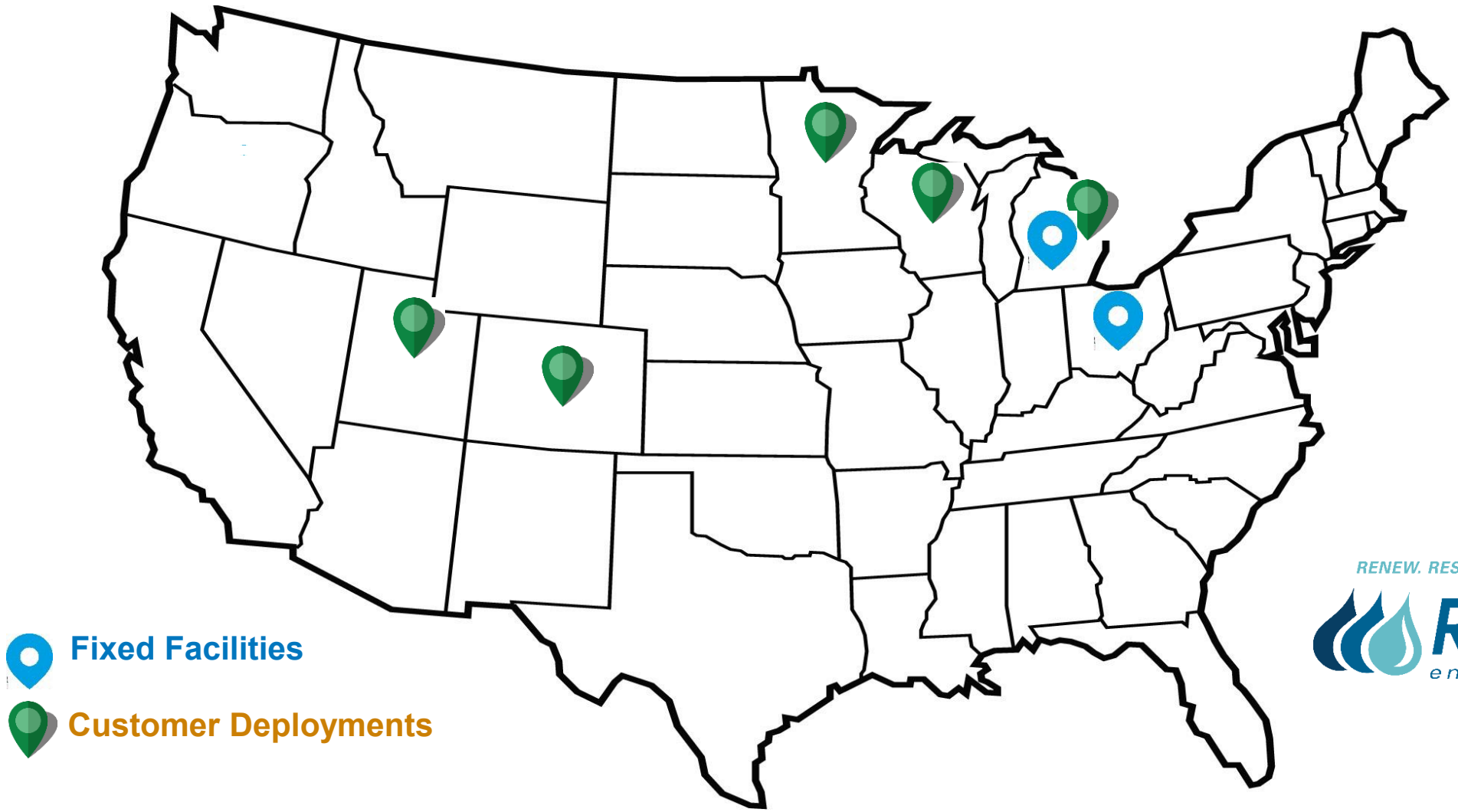
2025 PFAS Annihilator® Deployments



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AFFF Takeback Program Process

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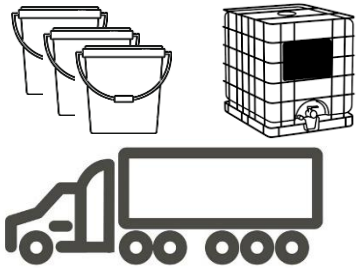
Registration

Collection



Destruction

Validation

Revive in partnership with Battelle provides a Turnkey, Full Lifecycle Solution that destroys PFAS + Eliminates Liability

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Collection: Full-Service, Onsite

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- Revive provides Drivers + Staff
- Staff check in FDs and update registration/manifest as needed
- Pails, Barrels consolidated into IBC Totes by Formula/Product
- Spill Containment + Cleanup
- Transport to Revive facility

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Destruction: PFAS gone w/no harmful byproducts

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- All PFAS and other Organics in the AFFF is mineralized
- No harmful byproducts – only water, nominal CO_2, inert salts
- Tracking of AFFF through the whole process
- Discharge after 3rd party analytical validation

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Validation: Analytical/Reporting

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- Validated destruction by Battelle's certified laboratory
- Discharge clean water to POTW once validated
- Reporting to State on AFFF Collected + Destroyed

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Permit Requirements

- Grab sample for PFAS by method 1633 for each batch discharged
- Monthly for metals and BTEX
- pH daily
- Reported monthly
- Any batch that exceeds PFAS limits is recycled back through the process; roughly 95% meets effluent criteria after first pass

Applicable Federal and Local Discharge Limitations					Industrial User Monitoring Requirements		
Parameter	Discharge Limitations				Frequency	# Days	Sample Type
PFOA	Special	Batch Max	4.0	ng/l	Per Batch	-	GRAB
PFOS	Special	Batch Max	4.0	ng/l	Per Batch	-	GRAB
PFHxS	Special	Batch Max	10.0	ng/l	Per Batch	-	GRAB
PFNA	Special	Batch Max	10.0	ng/l	Per Batch	-	GRAB
HFPO-DA (Commonly known as GenX Chemicals)	Special	Batch Max	10.0	ng/l	Per Batch	-	GRAB

Lessons Learned

- Impact of unique AFFF formulas and other co-contaminants on destruction throughput and equipment uptime
- Supply chain risks and the availability of replacement parts can impact developing technology
- Inventory first and recognize that inventory information provided by local FDs may not be accurate
- Be aware of and be prepared for unsealed and unknown containers
- Establish clear and frequent communication channels
- Establishing a support hotline from the outset is very helpful to navigate inventory issues and well-received by the FDs

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It can be done

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