



Clean Harbors

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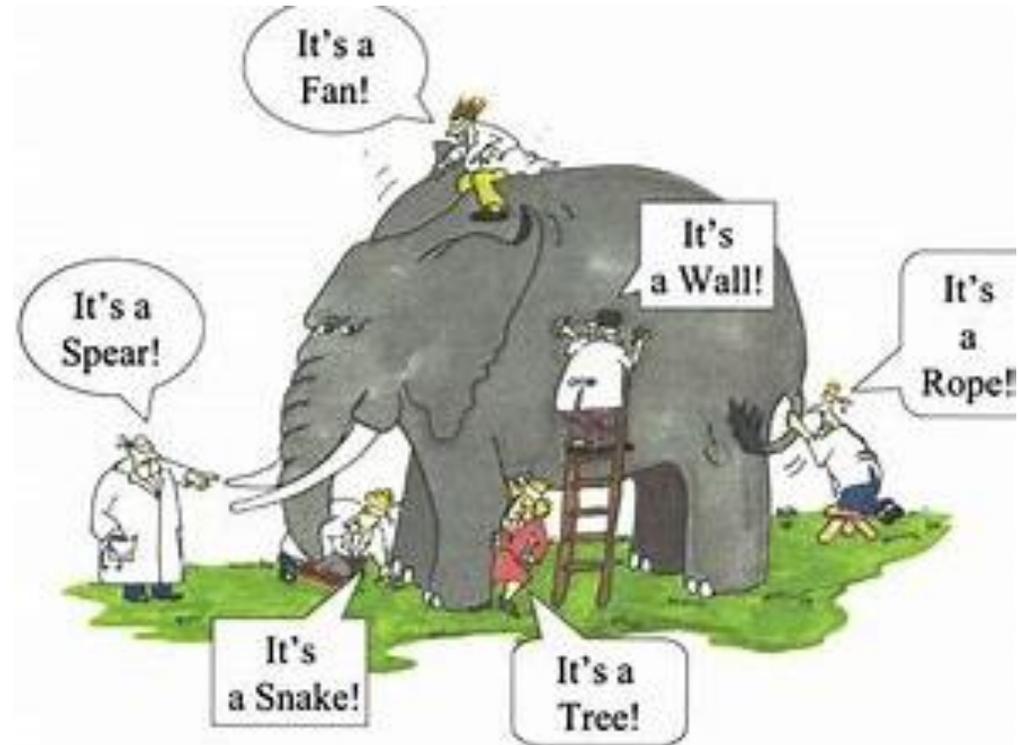
Introduction and Topics Covered

- State of PFAS How Did We Get Here And Where We Might Be Going
 - Evaluating Treatment Choices
 - Project Objective Agreement
 - SCID Removal Process (separation, concentration, isolation, disposal)
 - Project Examples of PFAS Disposal & Treatment Projects in Wastewater
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PFAS How Did We Get Here?

- UCMR 3
- Public Awareness
- States Developing Their Own Policies
- “Forever Chemicals”

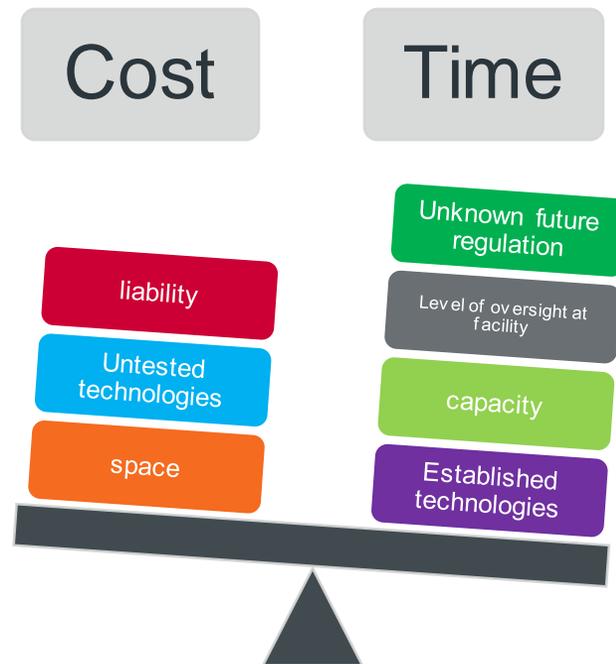


Considerations for Establishing PFAS Policies



Developing Internal and External PFAS Policies Without Federal Guidelines

- The EPA's Interim Guidance for PFAS Disposal was published in December 2020
- It provided an outline for practitioners to use when deciding whether to stockpile material or consider disposal or destruction options
- The document created an environment where engineering firms, industries, municipalities and waste disposal suppliers had to evaluate their options and make internal and external policy decisions.



State of PFAS Analytical Testing Methods

In 2015 200 ppt was an accepted reporting limit for UCMR3. In 2021 Labs are able to report sub ppt.



Reporting Limits
Going Down

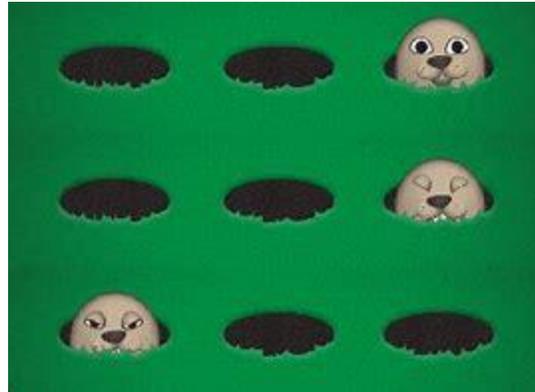
Analytical testing lists have gone from two compounds to over 45 compounds and the lists continue to grow. The TRI list consists of over 172 PFAS compounds



Compound
Lists Going Up

Evaluating PFAS Treatment Choices

- Viability
- Acceptance by regulators, general public
 - Cost
- Speed of deployment
 - Results record
 - Waste generated
 - Scalable



Starting at the End- Agreement on Project Objectives

- Acceptance of final product
- Define ultimate objectives and goal posts to reach those objectives
- Compound list
- Testing methods
- Is the objective non-detect and what definition do they have for non-detect (reporting limits)
- Acceptance of treatment technology
- Ultimate disposal of spent media or reject water
- This criteria will influence the approach to treatment plan

Trend Towards Higher Concentration Treatment and Lower Discharge Criteria

- Biosolids dewatering
- Landfill leachate treatment
- Emergency Response for AFFF releases
- Construction dewatering
- Industrial discharges

SCID* Approach to PFAS Water Treatment

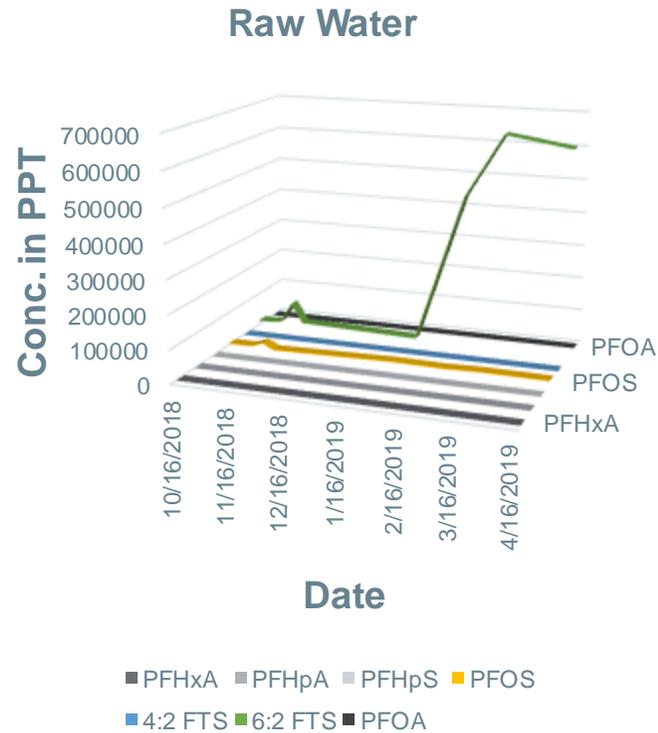
- Separate- Separate contaminants from the water by mechanical filtration, adsorption and ion exchange
- Concentrate- The contaminants are concentrated from large volumes of water onto relatively small quantities of media
- Isolate- The contaminants are isolated onto the media
- Dispose/Destroy- Choice for adsorptive and ion exchange media to be destroyed in MACT compliant hazardous incinerators or sent to closed loop hazardous landfills

Difference Between SCID and non-SCID Treatment

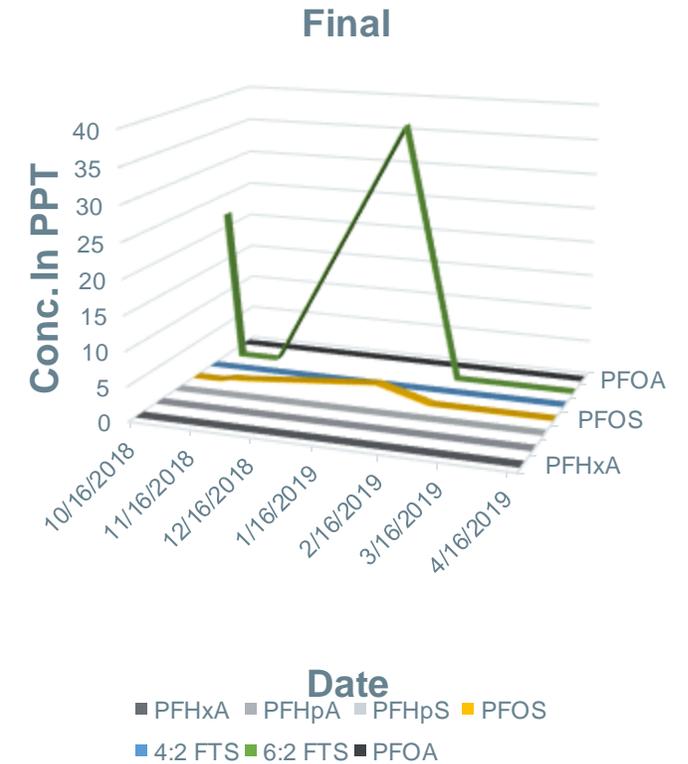
- SCID Options
 - GAC- Widely accepted treatment option for PFOA and PFOS shorter chained PFAS compounds dictate very short exchange cycles
 - Resin- Different resins are good options for longer chained compounds, PFOA, PFOS and for shorter chained PFAS that are poorly adsorbed by GAC. Shorter EBCT
 - Clays, Zeolites and other adsorptive medias- Very effective for non potable applications with high concentrations used as a pretreatment step and also as standalone media in certain applications
- Non-SCID Options
 - Oxidation and other destructive technologies- have shown effectiveness of breaking down longer chained compounds. Our hesitation is that with the complex influent water we see and rapid deployment we may not have time to do full studies to calculate required energy in a timely manner. A static system with full-scale piloting would be an ideal situation for this type of application
 - Reverse Osmosis- Very effective with PFAS compounds but the reject stream can be substantial and skilled RO operators are in very high demand



Industrial Wastewater High Concentration PFAS Treatment



Industrial wastewater system with PFAS Concentrations as high as 700,000 ppt total PFAS consistently brought down to ND. Clean Harbors has designed and installed a system to treat 120 gpm daily. This treatment system has allowed customer to meet discharge parameters since installation.



Case Study – Military Installation West Coast

High Concentration PFAS, VOC, TOC, SVOCs, O&G, TSS, TDS

- In collaboration with on-site engineering firm Clean Harbors designed, built, installed and trained staff to operate a mobile high concentration PFAS treatment system that addressed TOC, VOCs, SVOCs, O&G, TSS, TDS and other contaminants to meet strict discharge limits for a local POTW. The system has continued to successfully treat influent water with concentrations in excess of 8ppm to less than 2 ppt for PFOS, PFOA and short chained PFBS.
- **System Operation & Maintenance** - Clean Harbors initiated the startup of the system in order to properly balance the system and train the on-site staff of engineering firm. Clean Harbors continues to assist with ongoing treatment decisions, media change-outs and disposal services for the spent media
- The Clean Harbors' team consisted of the Project Manager, a Field Supervisor, and a two-man crew including a foreman and field technician. The PM and Supervisor worked with the onsite engineering consultant to carry out the installation and system operation.



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Case Study – Petroleum Processing Client, Upper Midwest

PFAS Capture – Post-fire Construction and Operation of Treatment System

- **System Design** – Clean Harbors recommended the proper combination of equipment, filters, activated carbon, and resin needed to process PFAS concentrations. System is capable of flow rates up to 400 gallons per minute (gpm).
- **System Construction** – The entire system was transported, then constructed on-site in less than 3 days. After one day of performance testing, the system successfully reduced PFAS concentrations to non-detectable levels. System operates at 250 gpm.
 - PFAS concentrations in the discharge water are well below permit limits. A second, similar system was installed on a similar schedule six weeks later.
- **System Operation & Maintenance** – Clean Harbors was contracted to operate the system to properly balance the treatment system alongside the on-site wastewater treatment plant operations. Clean Harbors then trained client personnel. Client staff assumed responsibility for system operation several weeks later.
 - Clean Harbors continues media change-out and disposal services, including incineration and hazardous landfilling.



Case Study – Industrial Plater, Michigan

PFAS Control – Emergency; Full Scale Treatment Design and Implementation

Clean Harbors was contracted by a Michigan plating and surface finishing firm after discovery of multiple PFAS compounds in its discharge to the local publically owned treatment works. The POTW set strict PFAS limits and demanded compliance within a limited time or cessation of all discharges. Clean Harbors provided services that met its client's discharge permit limits, allowing continued operations.

- **Operations analysis** – Fluctuations in product demand triggered irregular treatment, discharge, and renewal of individual baths, which yielded a waste stream of constantly changing chemical composition.
- **Media testing** – Clean Harbors tested a number of adsorbent media, individually and in series. Each was intended to adsorb PFAS compounds or inorganic and organic waste components that interfered with PFAS capture.
- **Full-scale system design** – Testing data and the extensive experience and expertise of Clean Harbors staff were used to develop a treatment system.
- **System installation and operation** – Clean Harbors constructed and started the treatment system, which met POTW permit limits before the deadline. Clean Harbors commenced support of client staff through media exchange and disposal services, as well as performance testing.



Take-Aways

- Regulations are in Development Stage
- Science Continues to Outpace Regulations
- Expect Attention to Stay on PFAS
- Varied Solutions are Available