A Collaborative Strategic Plan

Determining a PFOS Local Limit

Michigan Waste & Recycling Association
Prepared by LimnoTech, April 2022

Objective

This plan was prepared to assist the Michigan Waste & Recycling Association (and others) in addressing per- and polyfluoroalkyl substances (PFAS) in landfill leachate that is discharged to municipal wastewater treatment plants (WWTPs), and specifically to address whether there is an appreciable environmental benefit for certain landfills to pretreat/treat for perfluorooctane sulfonate (PFOS). The approach described herein considers the treatability of industrial wastes and user need when developing local limits for industrial users (IUs), rather than applying a uniform limit to all IUs.

Background

The Michigan Department of Environment, Great Lakes, and Energy (EGLE) has adopted ambient water quality criteria for PFOS and perfluorooctanoic acid (PFOA) and has required monitoring of municipal WWTP effluent for these substances. PFOS has been detected above its Michigan wastewater effluent standard (12 ppt) and is the primary focus of EGLE's strategy for addressing PFAS in municipal wastewater. Municipal WWTP permits have not yet specified effluent limitations for PFOS or PFOA, but EGLE has required WWTPs with industrial pretreatment programs (IPPs) to complete evaluations to determine whether they may be passing through PFOS and/or PFOA to surface waters above criteria, and to reduce and eliminate sources, where needed. Future NPDES permits may include effluent limitations for PFOS, and certain WWTPs with IPPs will likely need to develop local limits for industrial users. Local limits are developed to minimize pass-through of pollutants from IUs to surface waters, and to optimally manage potential interference with the treatment process.

Many landfills discharge leachate to WWTPs and are subject to IPP requirements. Landfills do not control the materials that enter the landfill that contribute contaminants to leachate, and leachate is very difficult to treat due to its complex matrix. MWRA contracted LimnoTech to assist landfills in developing a local limit strategy to evaluate how to determine the most environmentally protective local limits (when necessary) considering the characteristics of the WWTP and other IU's that contribute to the treatment plant's influent. The ultimate goal of this plan is to provide an alternative approach that can be used to establish an appropriate and environmentally protective local limit for landfill leachate discharged to a WWTP. In addition, this approach can be useful to demonstrate whether leachate pretreatment/treatment for PFOS in landfill leachate has an appreciable environmental benefit at a WWTP's designated local limit (i.e., for PFOS).

Approach

The plan necessarily relies heavily on *individual landfills* working closely with the WWTP that accepts their leachate. LimnoTech worked with EGLE and MWEA to develop an example method (Basis of Industrial User Need) for WWTPs to calculate PFOS local limits that consider treatability of industrial waste and different needs of industrial users when developing limits. To be effective, landfills must work with the WWTP in advance of local limit development.

MWRA will distribute Landfill best management practice (BMP) Guidance and Example Local Limits Calculations to landfills. In addition, to maximize effectiveness of this approach *MWRA* should: a) track EGLE permitting activities and compliance schedules in WWTP permits; b) track WWTP local limit development state-wide; c) make presentations to organizations such as the Michigan Manufacturers Association (MMA), Michigan Water Environment Association (MWEA) and others that would benefit from an understanding of the potential to take a flexible approach to local limits development; and d) explore the legality of 'purchasing or trading' PFOS discharge capacity from users that have excess capacity. Tracking of EGLE permitting activities and WWTP NPDES permits can be done via EGLE's MiWaters database[1], a searchable repository of permits and supporting documents for EGLE's Water Resources Division.

Action Items:

1. MWRA- Finalize BMP Guidance and Distribute to Landfills.
2. MWRA- Distribute the attached 'Basis of Industrial User Need' Local Limits Calculation Example and Instructions
3. Individual landfills- Establish a relationship with WWTP manager/Municipal Government and proactively begin PFAS discussions.
    a. Discuss costliness/difficulties for PFAS/PFOS leachate treatment
    b. Discuss the 'Basis of Industrial User Need' approach
        i. Determine whether the existing Sewer Use Ordinance (SUO) allows this approach. If not, the landfill will need to work with local officials to have the SUO modified; otherwise, the local limit calculation prescribed in the SUO must be used. Such calculations may treat all industries the same and limit flexibility.
        ii. Determine whether the IPP manager is amenable to the approach. The IPP manager may be reluctant to adopt an alternative approach that could seem more complicated. If the manager is not amenable, the landfill will need to decide whether (and when) to elevate the issue.
    c. Stay abreast of EGLE requirements to establish local limits
        i. If local limits are required for the WWTP, ask the WWTP to develop local limits for all alternatives allowed in their SUO AND the 'Basis of Industrial User Need' method
        ii. Offer assistance with local limit development
            1. Encourage a reasonably small safety factor (EPA guidance recommends at least 10%; EGLE often suggests more)

[1] Home - MiWaters (state.mi.us)

            2. If necessary, subsidize the development of limits using the 'Basis of Industrial User Need' method

4. Suggested additional activities that individual landfill owners may undertake:
    a. Track NPDES permits to determine which facilities are likely to receive PFAS limits; track compliance schedules and requirements for local limits development for PFOS
        i. Determine permit expiration dates for municipal NPDES permits with landfill contributors.
        ii. Understand deadlines when PFOS local limits could be required
            1. Meet with EGLE (Water Resources Division) to ask them to consider the realistic timelines for constructing PFOS pretreatment at landfills when setting up compliance schedules for WWTPs (as presented by Brown and Caldwell at an MWEA/EGLE/MWRA meeting in 2021 (Appendix A)). At a minimum, learn what compliance timelines EGLE will allow.
    b. Review SUOs for WWTPs where local limit development impacting landfills appears likely
        i. Determine what it would take to make the 'Basis IU of Need' approach legal
        ii. Advocate SUO modification on a case-by-case basis
    c. Make presentations to MWEA and other groups to increase the likelihood of WWTPs being open to utilizing the 'Basis of Industrial User Need' local limit calculation method.
    d. Make contact with WWTPs at the political and/or technical level to advocate for evaluation of multiple local limit development alternatives, including the 'Basis of IU Need' method.
    e. Explore the legality of a landfill paying another user to give up some of their allotted capacity. The WWTP would write the permit to reflect this informal 'trading' agreement. EPA guidance suggests trading as a possibility, but formal trading is subject to many rules, could take years to set up, and is expected to require legal consultation. Trading has been available for decades but has been rarely used.
5. In the case of a centralized waste treatment facility that accepts leachate from multiple landfills, the landfills could work directly with the control authority to provide an increased allocation for the waste treatment facility.

Appendix A

Brown and Caldwell Presentation to MPART Work Group, September 8, 2021

Brown AND Caldwell

September 8, 2021

General Review of Technologies and Considerations for Leachate PFAS Treatment

Kevin D. Torrens, BCEEM

Introduction

Kevin Torrens, BCEEM

- Vice President, Brown and Caldwell
- Industrial Wastewater
- 37 years with Brown and Caldwell
- National Practice Leader Landfill Liquids
- 15 years leachate focus
- Dozens of leachate projects
- Alternative's evaluations, permitting, design, startup, optimization
- Pretreatment, discharge to surface water
- SBR, MBR, RO, Phys-chem
- PFAS Treatment bench and pilot studies, preliminary design
- Research (EREF, internal)

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Agenda

1. Technology Overview/Status
2. Implementation Considerations
3. Costs
4. Summary

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Leachate PFAS Treatment Challenges

- Most technology research on GW or drinking water
- Leachate is a very complex matrix compared to GW or drinking water or POTW effluent
  - Many competing contaminates
  - Many fouling contaminates
- Residuals disposal
- Operational complexity (matrix driven)

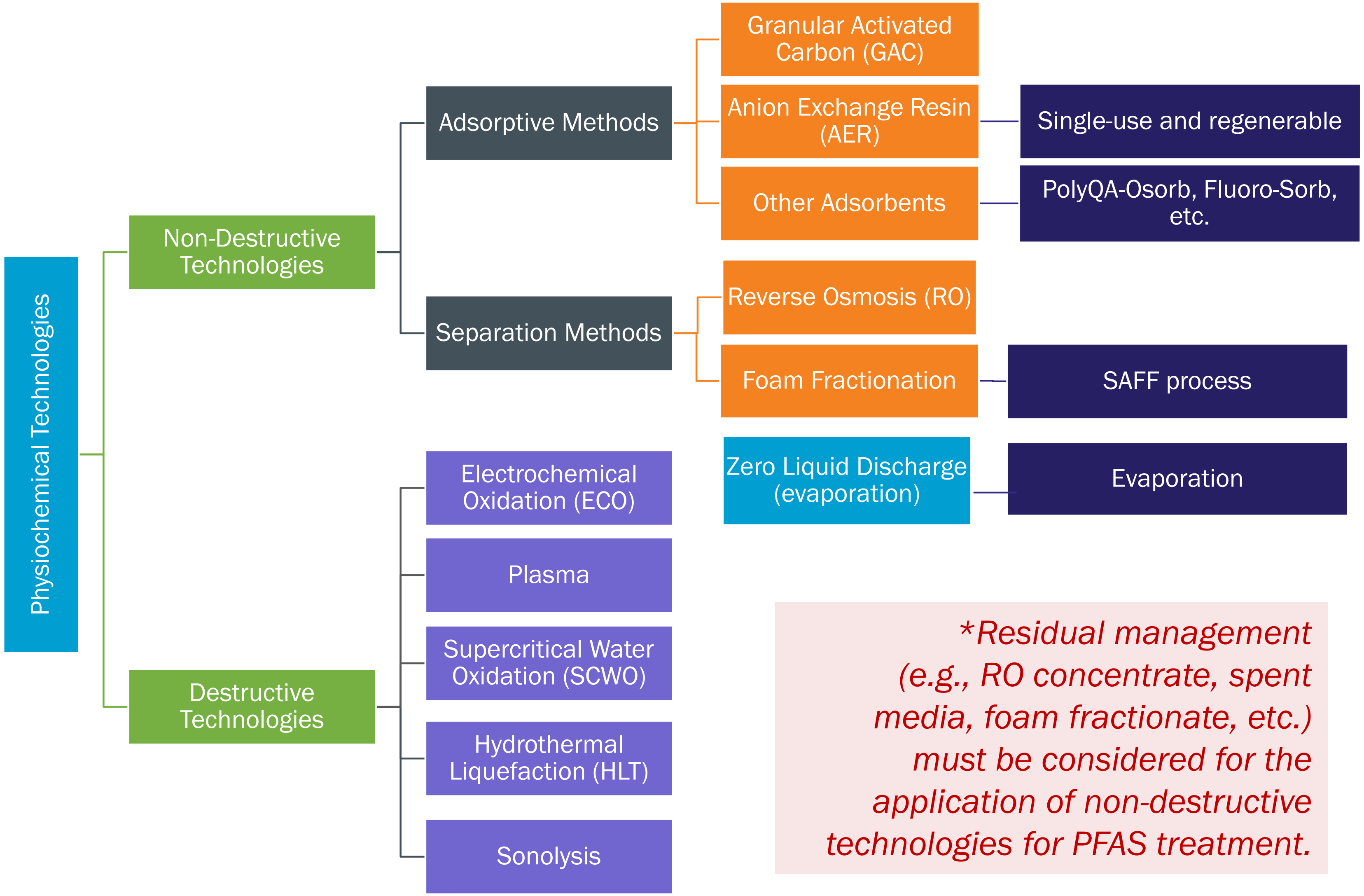
MSW Leachate vs. Domestic Wastewater

Parameter	Unit	Domestic Sewage[1]		Landfill Leachate			
		Weak/Medium	Strong	Young (<3/4 yrs)	Old (>8 – 10 yrs)	Typical[2]	GWL & Condensate[3]
BOD_5	mg/L	110 – 190	350	2,000 – 30,000	100 – 1,000	500 – 3,300	10,000 – 50,000
COD	mg/L	250 – 430	800	3,000 – 60,000	100 - 500	1,800 – 4,350	40,000 – 110,000
TOC	mg/L	80 – 140	260	1,500 – 20,000	80 – 160	-	
NH_3	mg/L	12 – 25	45	10 - 800	20 – 40	150 – 2,250	1,500 – 3,000
NO_2/NO_3	mg/L	0	0	0	0	0	0
Total P	mg/L	4 – 7	12	5 - 100	5 - 10	3 - 10	5 – 15
TSS	mg/L	120 – 210	400	200 – 2,000	100 - 400	50 - 150	500 – 1,500

Notes

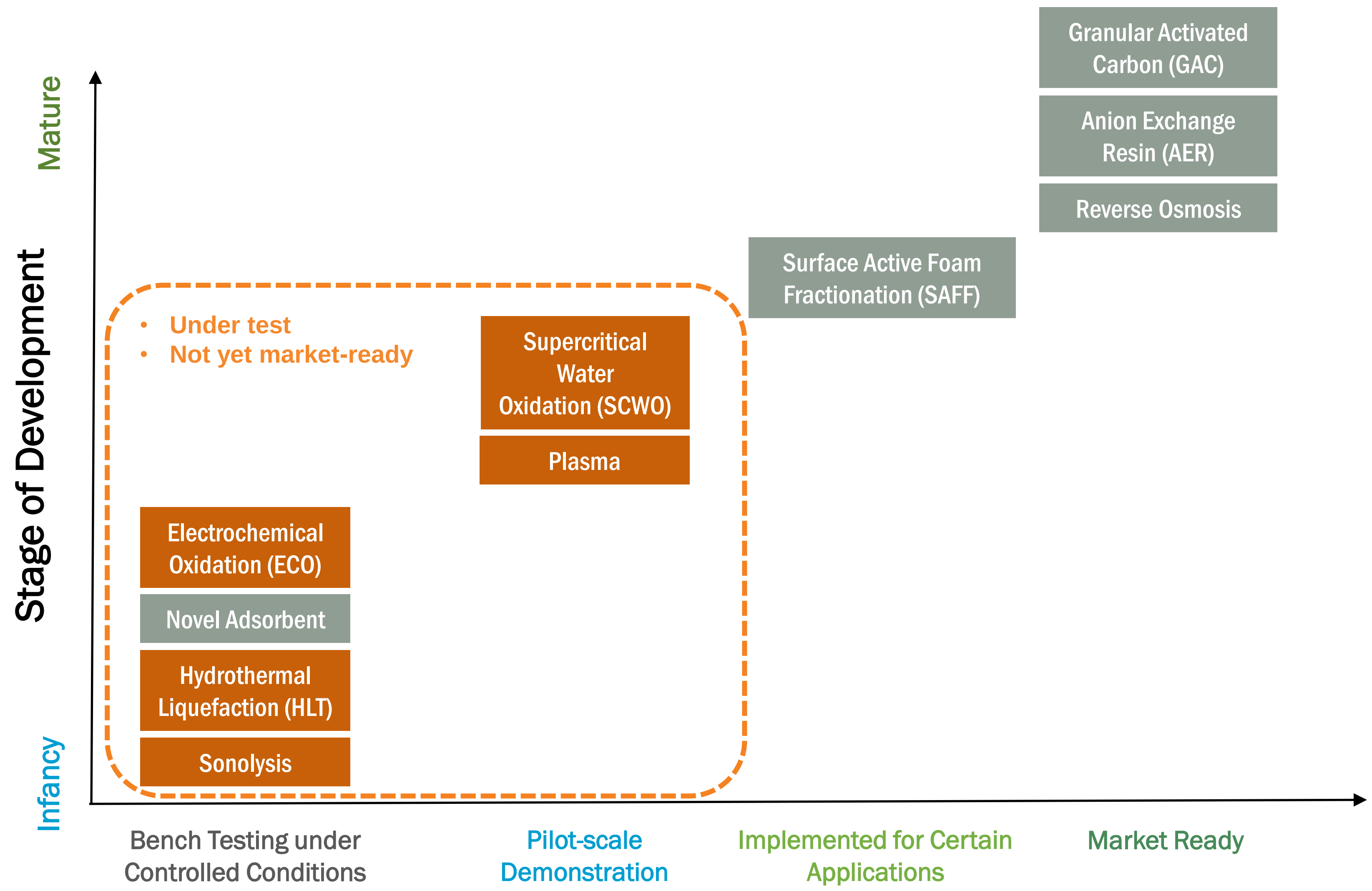
1. Adapted from Table 3-15 from Metcalf & Eddy, 4th Edition.
2. Leachate collected from onsite storage tanks.
3. Metals and VOC/SVOC concentrations can be 3x – 10x higher than observed in leachate.

Non-destructive and Destructive Treatment Technologies for Landfill Leachate



**Residual management (e.g., RO concentrate, spent media, foam fractionate, etc.) must be considered for the application of non-destructive technologies for PFAS treatment.*

Destructive Technologies Are Not Mature Yet



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Summary of Potential Technologies for PFAS in Leachate (Most Require Pretreatment)

Technology	Mechanism	State of Development	Effectiveness	Typical Pretreatment
GAC	Adsorption	Demonstrated and available at full-scale	Interference from competing organics. Variable depending on chain length	Biological or phys/chem+filtration for organics and solids
Ion exchange	Adsorption and replacement	Demonstrated and available at full-scale	Interference from competing organics and inorganics. Broad removal of anionic PFAS	Biological or phys/chem+filtration for organics and nitrate, sulfate etc.
Reverse osmosis	Separation via semi-permeation	Demonstrated and available at full-scale	Variable depending on feed matrix	Filtration for solids (ROCHEM), Biological or phys/chem+filtration for organics and solids (conventional)
Precipitation and sedimentation	Formation of solids	Demonstrated and available at full-scale	Partial removal, additional treatment needed	Serves as a pretreatment process
Foam fractionation	Formation of fine air bubbles, partition PFAS to foam	Demonstrated at full-scale with MSW leachate	Removes long-chain effectively to low concentrations	Filtration for solids removal
Other adsorbents (e.g. Fluorosorb)	Adsorption	Limited data with leachate	Interference from competing organics and inorganics	Biological or phys/chem+filtration for organics and solids and iron
Evaporation (ZLD)	Concentration through evaporation of liquid	Demonstrated and available at full-scale, air emissions not defined	Broad removal of PFAS	pH adjustment, antifoam, antiscalant

Leachate Pretreatment Before PFAS Treatment

- Most PFAS removal technologies require significant pretreatment due to competing and fouling contaminants in leachate and their elevated concentrations relative to POTW effluent, GW or drinking water
  - Biological fouling
  - Organic fouling
  - Inorganic fouling/scale
  - Competing contaminants
- Pretreatment needed to near POTW effluent quality or better
  - Biological processes
  - Oxidation
  - Coagulation/flocculation/precipitation
  - Solids separation/filtration
  - Pretreatment residuals management (contain PFAS)

Residuals Management

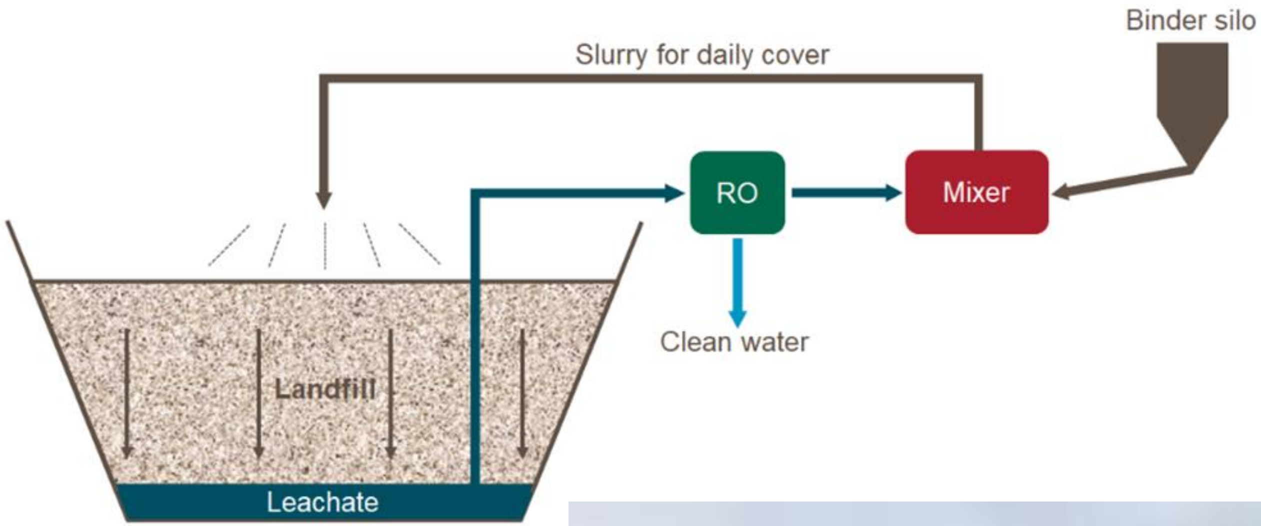
Currently Available

- Incineration
  - Few if any facilities accepting residuals
  - EPA evaluating technology, air emissions
- Class 1 Deep well injection
  - Few facilities (2 closest in Ohio)
- Super Critical Water Oxidation
  - Limited availability
  - High cost, complex
  - Small capacity
- Solidification/Encapsulation
  - Simple
  - On-site management

In Development

- Plasma
- Electrochemical oxidation (e.g., BDD)
- Sonolysis
- Hydrothermal liquefaction
- Pyrolysis
- Oxidation/Reduction

Residuals Solidification/Encapsulation



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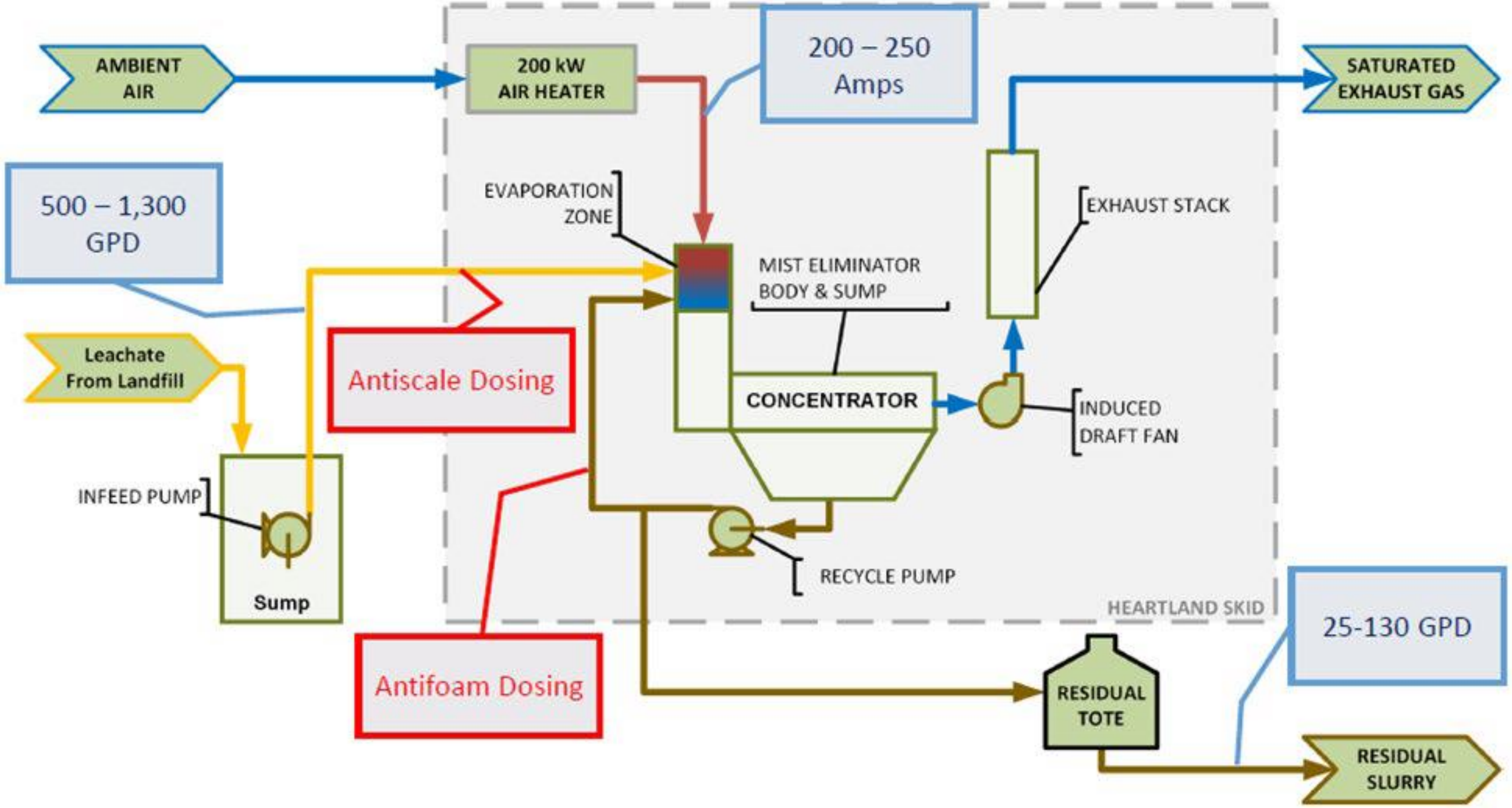
ZLD (Evaporator)



Implementation Considerations and Costs

Process Assessment for Implementation (24-33 months)

- **Characterization and design basis development (flows, concentrations, loads):** 3 months
- **Technology alternatives review:** 2 months
  - Proven matrix compatibility
  - Commercially available
  - Costs
  - Identify residuals disposal options
- **Bench-scale testing (Feasibility):** 1 month
- **Pilot-scale testing:** 3+ months
- **Design:** 6-9 months
- **Construction:** 9-15 months

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Example Leachate PFAS Treatment Costs

Technology	% PFAS Removal	Residuals Management	Capacity (gpd)	CapEx ($)	Annual OpEx ($/yr)	OpEx Only ($/gal)
Standalone 3 Stage RO+Evap	>99	Evap+Off-site (deepwell)	50,000	13,700,000	4,015,000	0.22
	>99	Evap+Solidification	50,000	14,200,000	2,190,000	0.12
	>99	On-site Solidification	85,000	12,000,000	4,033,250	0.13
	>99	Deep well	100,000	14,800,000	5,100,000	0.28
Standalone 3 Stage RO	>99	Foam Fractionation+Solidification	50,000	10,200,000	2,030,000	0.111
MBR+GAC+IX	50	Regen/Disposal	50,000	7,800,000	1,200,000	0.07
MBR+Conventional RO	>99	Off-site Solidification	100,000	19,700,000	9,700,000	0.53
Evaporation (ZLD) No LFG	100	On-site Solidification	50,000	10,300,000	7,070,000	0.39
Evaporation (ZLD) W/ LFG	100	On-site Solidification	50,000	6,600,000	3,900,000	0.21
Foam Fractionation	98	Evap+Off-site (deepwell)	50,000	4,100,000	537,000	0.043

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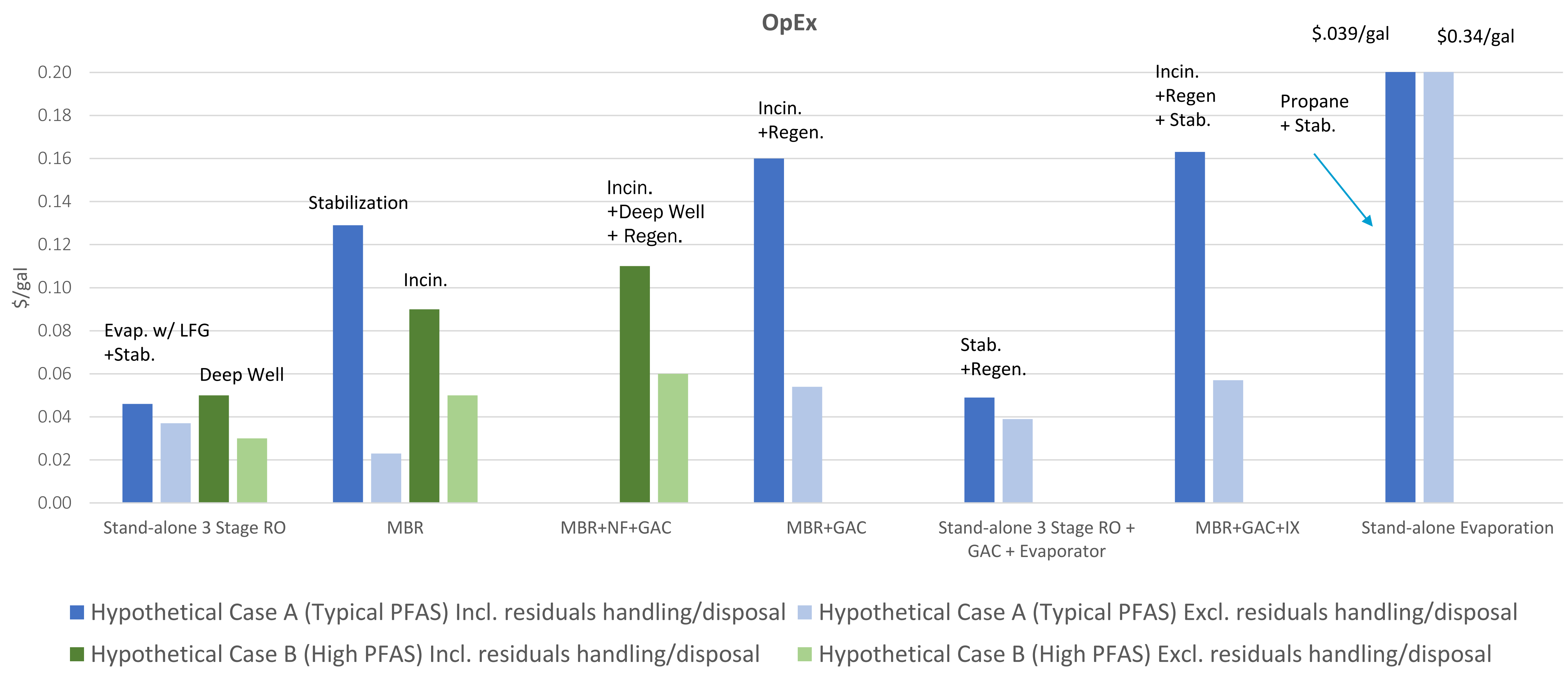
Relative Leachate PFAS Treatment OpEx Costs



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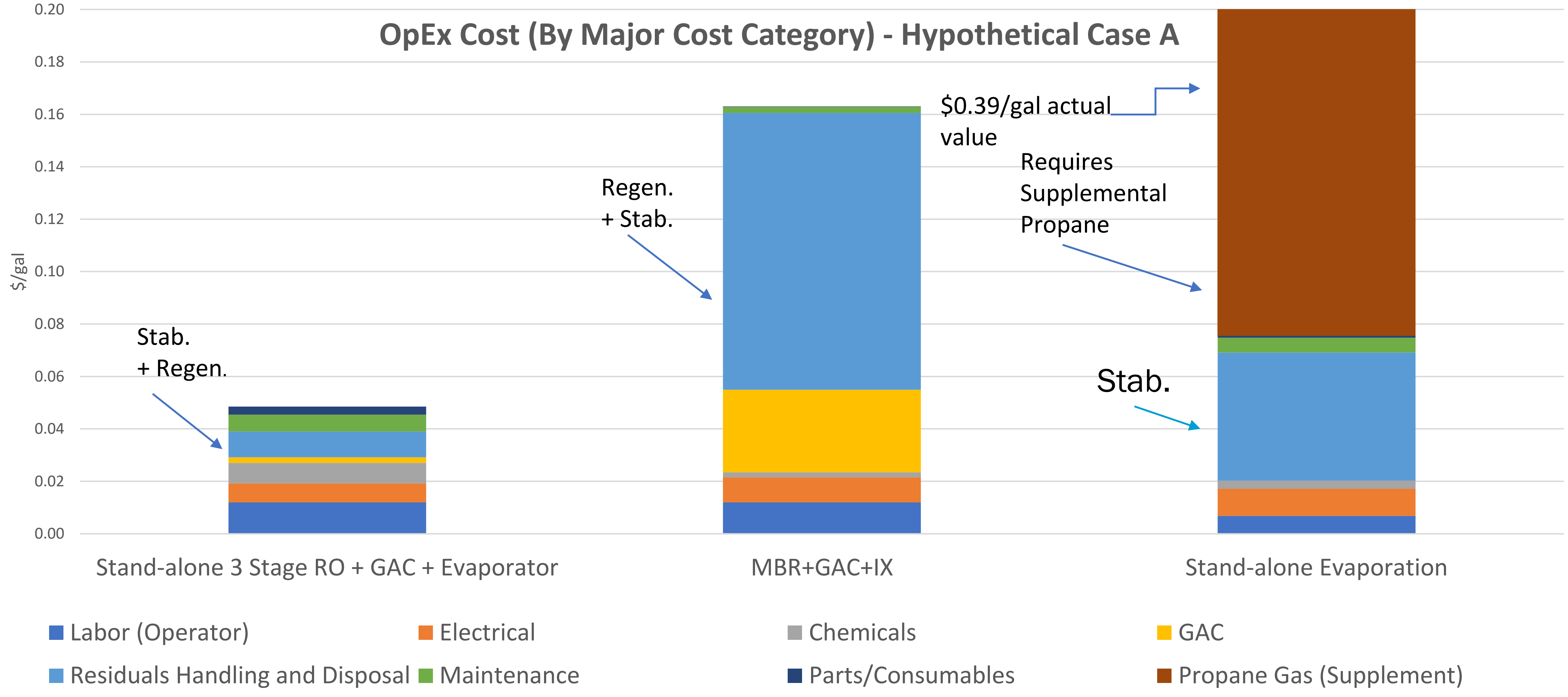
OpEx Cost Breakdown



Leachate and Metal Plating Comparison

Leachate

- Limited to no PFAS source control possible
- LFs are a safe repository for PFAS waste
- PFAS not used for financial benefit
- No simple technology for PFAS removal to MCL levels due to complex matrix
- Leachate disposal costs 2-5x higher with PFAS treatment
- Current leachate management cost is >30% of LF operating budget
- Increased costs for PFAS removal will increase tipping fees by 15-30% or more
- Tipping fees affect POTWs (sludge), commercial, and residential customers
- Residential customers are impacted twice (Trash and Wastewater bills)

Chrome Plating

- Similar number of chrome platers to landfills
- PFOS concentrations in chrome plating are about 10-100x higher than leachate
- PFAS used during production for financial benefit
- Source control is possible via substitution (low financial impact)
- PFAS treatment is relatively simple (GAC and/or AER)
- CapEx and OpEx are comparatively low
- Cost implications have limited impact on consumers and no impact on POTWs

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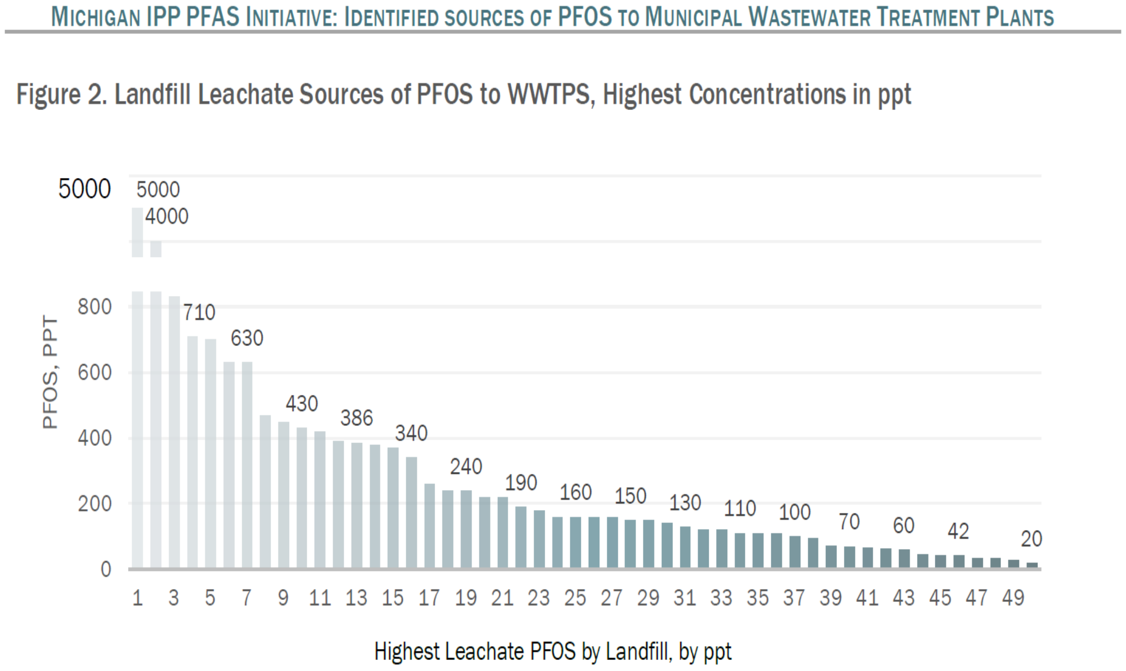
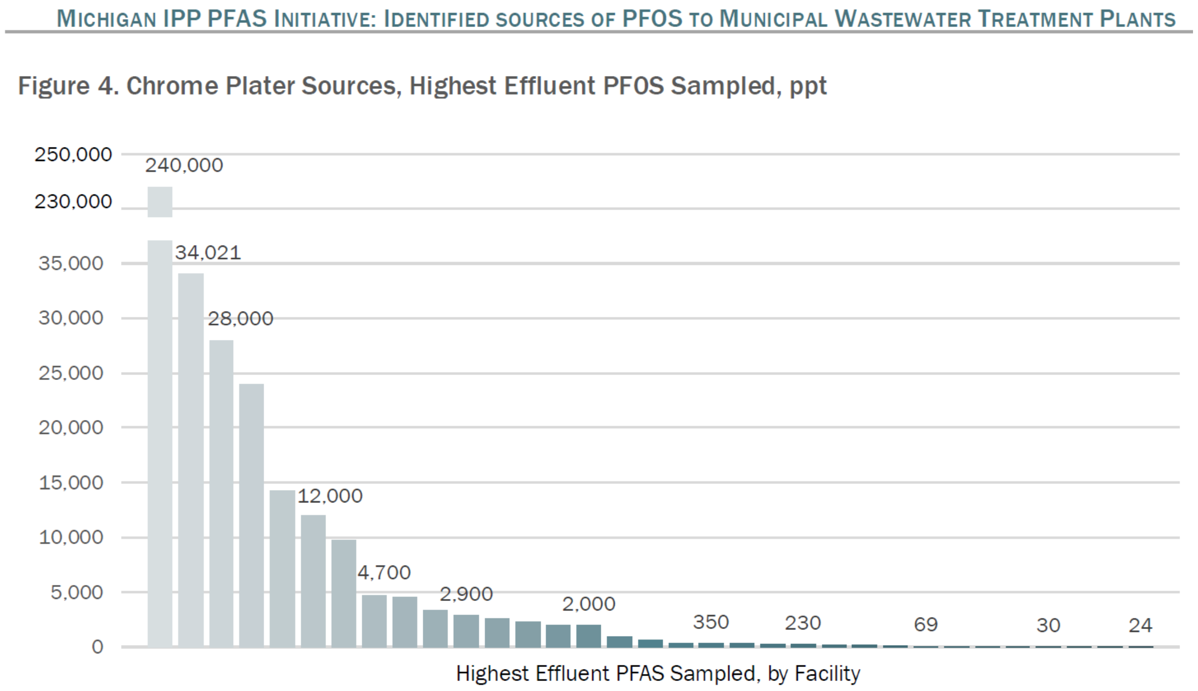
PFOS concentrations in chrome plating are about 10-100X higher than leachate

Leachate



Chrome Plating



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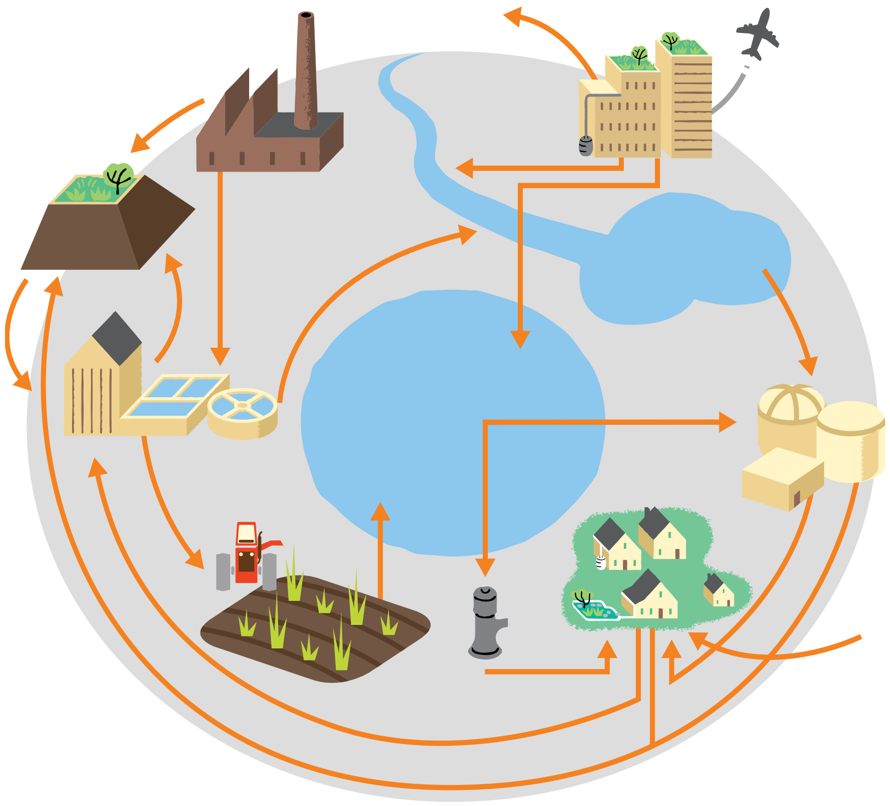
Landfill/POTW Interaction and Social Responsibility: Challenge and Opportunity

- ✓ Mutual dependency
- ✓ Leachate is a small contributor of PFAS in most cases
- ✓ Both are “end of the line” managers of consumer wastes
- ✓ Both are tasked as protectors of the human health and the environment
- ✓ Should be viewed as a couplet rather than individually regarding PFAS
- ✓ POTWs should consider employing mass-based limits that are allocated to reflect landfills role as society’s primary PFAS waste repository and to limit impacts to residents



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Thank you.
Questions?

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