EBC Solid Waste Management Program

Impact of PFAS on Solid Waste Operations

EBC
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Daniel K. Moon

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Robert D. Cox, Jr.

Managing Partner

Bowditch & Dewey, LLP

Introduction and Program Overview

Gretchen Carey

Program Co-Chair and Moderator

LEED Green Associate
Recycling & Organics Coordinator
Republic Services

PFAS in Wastewater, Biosolids, & Residuals and Implications for Solid Waste Management

Ned Beecher

Senior Projects Manager

North East Biosolids & Residuals Association nebra Recycled organics: Tools for sustainability.

PFAS in Wastewater, Biosolids

and Implications for Solid Waste Management

Ned Beecher, MS • NEBRA • Tamworth, NH

November 12, 2019

EBC New England • Framingham, MA

NEBRA…
www.nebiosolids.org

- Founded in 1997
- Non-profit, tax-exempt membership organization
- New England and Eastern Canada
- Mission - *Promoting the environmentally sound recycling of biosolids and other residuals in the greater New England region.*
- Funding from public wastewater agencies, private biosolids management companies, environmental engineers, end users of biosolids, project grants.
- Provides networking information hub (website, newsletters), public education, fosters research

*Acknowledgements & Sources: these PFAS slides

Inclusion on this list does not imply endorsement. Views expressed are those of Ned Beecher/NEBRA only.

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- Sarita Croce, Merrimack, NH
- Shelagh Connelly, RMI
- Jeff McBurnie, Casella Organics
- *And many others (apologies for any omissions):*
  - Sally Brown, Univ. of WA
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  - Mike Person, MI DEQ
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  - Kerri Malinowski, ME DEP
  - Layne Baroldi, Synagro
  - Sally Rowland, NY DEC
  - Stefanie Lamb, formerly NH BIA
  - Lakhwinder Hundal, formerly Chicago WRRF
  - Rufus Chaney, USDA (retired)
  - Andrew Carpenter, Northern Tilth
  - Ed Topp, Agriculture & Agrifood Canada
  - Charles Neslund, Eurofins
  - Matt Berg & Sherri van der Wege, WEAT

AND organizations across North America who are funding NEBRA's PFAS work in 2019.

THANK YOU!

Recycling organic "wastes" benefits society & the environment.

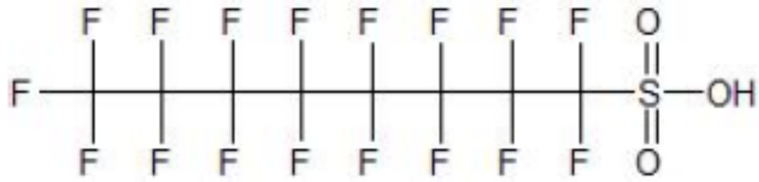
Wastewater, biosolids, & other organic residuals are treated, tested, regulated, and recycled routinely – and have been for decades. This does amazing things:

- enhances soil health
- recycles nutrients – macro & micro
- sequesters carbon (mitigating climate change)
- reduces fertilizer & pesticide use
- strengthens farm economies (thousands of farmers choose to use biosolids, because they work)
- restores vitality to degraded lands
- puts to productive use residuals that every community has to manage
- is part of the circular economy

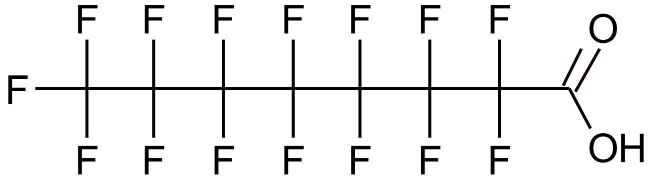
PFAS & any emerging contaminant must be addressed in ways to continue to maximize these known benefits.

perfluorinated:

PFOS



PFOA

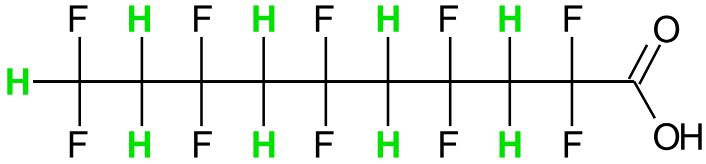


PFAS

an extreme, worst-case CEC

the only *common* trace contaminant of drinking water regulated in low ppts

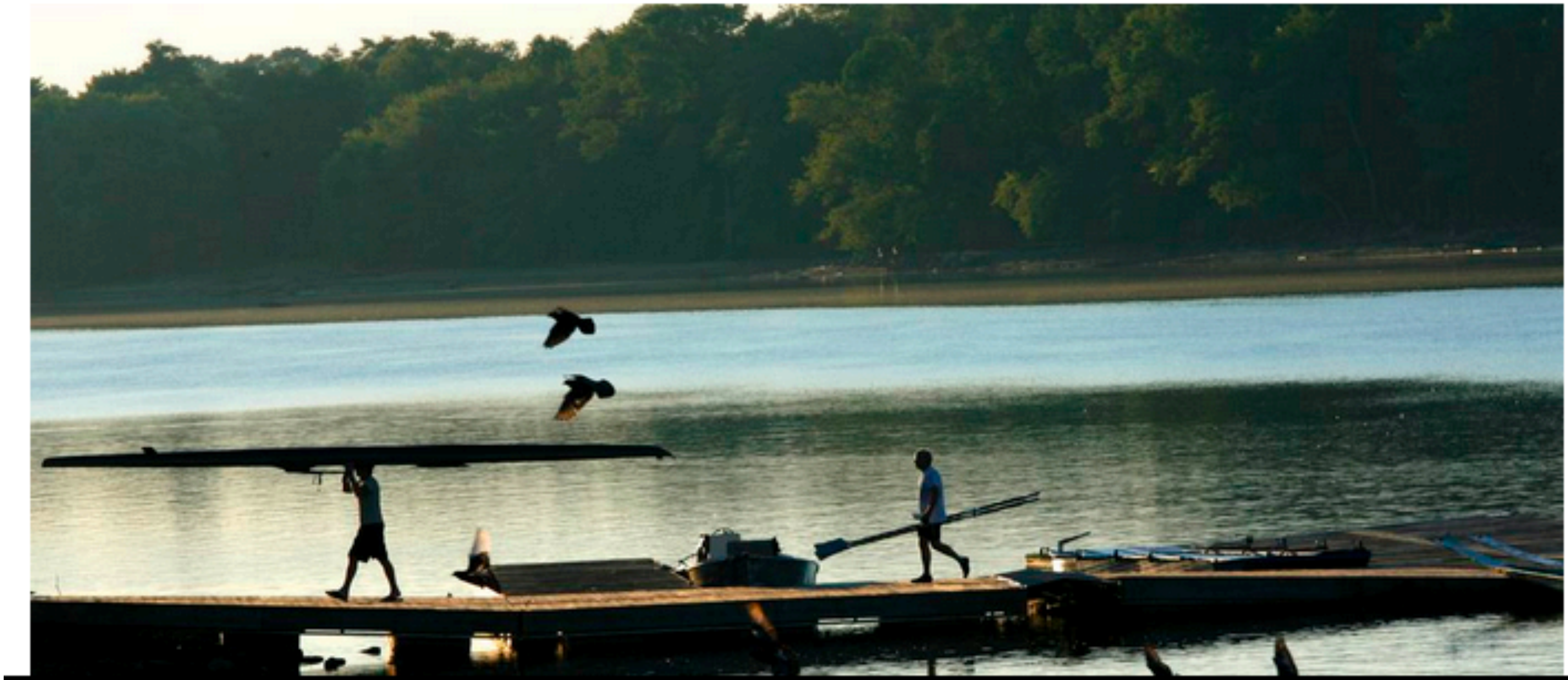
polyfluorinated:



Toxic chemicals can be dumped into Merrimack River, federal and state officials say

By **David Abel** Globe staff, November 5, 2019, 6:41 p.m.

190



Why has it become so important…

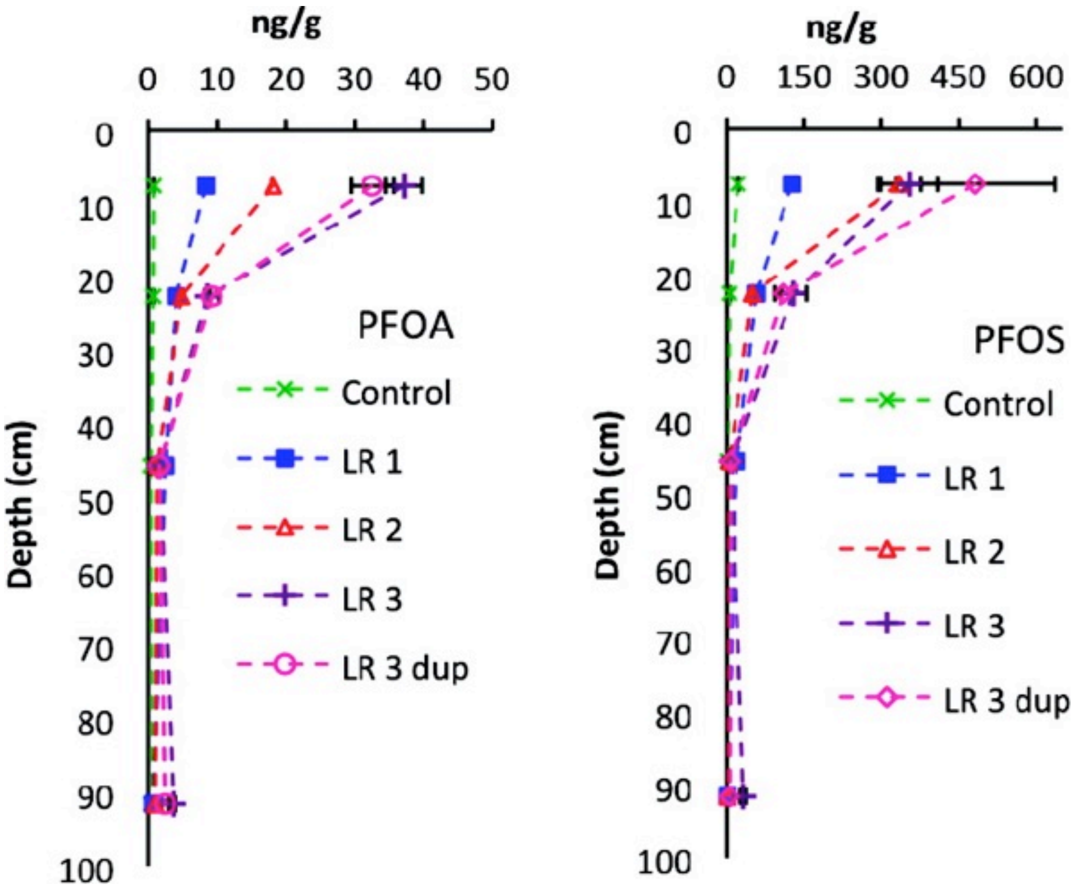
…for biosolids/residuals and wastewater management?

PFAS are in wastewater & biosolids, of course. Wastewater & biosolids mirror modern life.

- Even small-town, purely domestic wastewater has PFAS.
- We are aware because of advances in analytical chemistry: measuring at ppt levels.

Why the concern about PFAS in wastewater & biosolids?

1) PFAS leach in soil some.



Sepulvado et al; *Environ. Sci. Technol.* 2011, 45, 8106-8112

Concentrations of PFOA and PFOS with depth in the long-term plots at various loading rates. Control = 0 Mg/ha, LR 1 = 553 Mg/ha, LR 2 = 1109 Mg/ha, and LR 3 and LR 3 dup = 2218 Mg/ha (on dry weight basis).

Why the concern about PFAS in wastewater & biosolids?

2) PFAS are likely emitted to air from sewage sludge incineration.

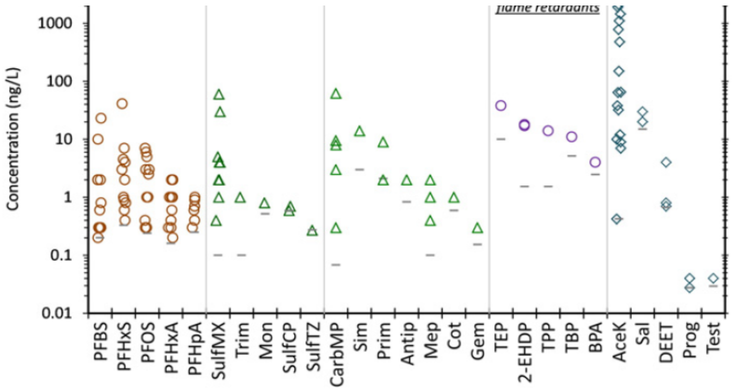
- PFAS destruction requires >1000º C.
- PFAS are not found in ash (Manchester, NH testing)
- Do air emissions controls capture it?
- Testing & research needed & are starting
- Some may worry about downwind plumes & deposition & impacts on groundwater – but SSI's are unlikely to be major emitters, but it's uncertain…

Why the concern about PFAS in wastewater & biosolids?

3) Some are regulating at background levels.

NH MCLs & ambient groundwater quality standards:

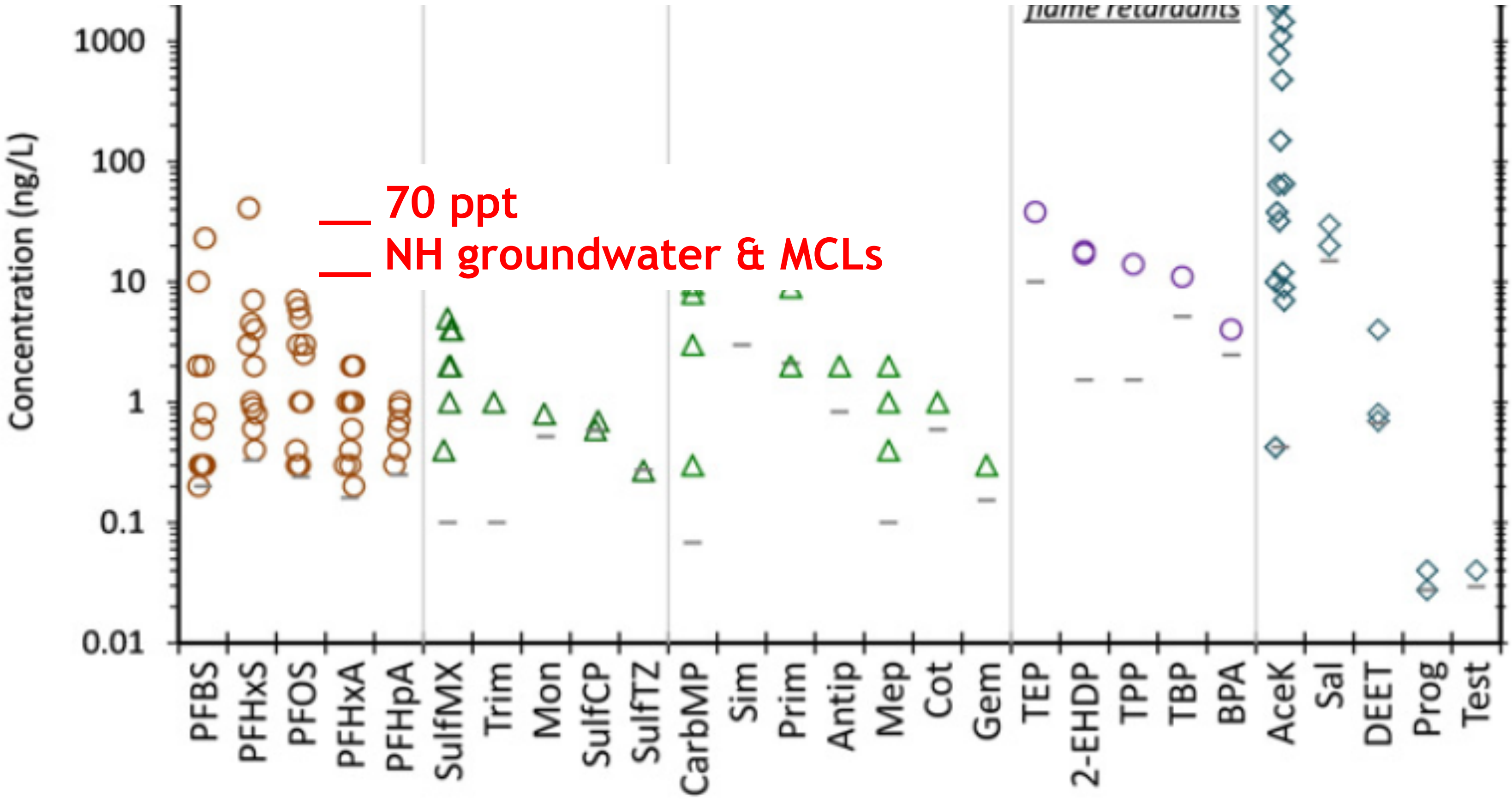
- PFOA 12 ppt
- PFOS 15 ppt
- PFHxS 18 ppt
- PFNA 11 ppt



Effective September 30, 2019.

Estimated cost for 2 years: $267 million (likely an underestimate); no funding provided for municipalities & utilities.

Regulating at background levels? Cape Cod groundwater & drinking water impacted by septic systems



__ 70 ppt

__ NH groundwater & MCLs

* Schaider et al., 2016. Septic systems as sources of organic wastewater compounds in domestic drinking water wells in a shallow sand and gravel aquifer. *Sci. Total Environ.*

4) Landfill disposal of sludge/biosolids is the only other option.

- As land application is challenged in NH & ME, more demand for landfill disposal.
- Sludge/biosolids are wet and organic; landfills cannot manage indefinite quantities.
- Landfill capacity in this region is limited.
- Landfill concerns about PFAS-containing materials, and all biosolids have PFAS.

Measuring PFAS:

In waters: in ppt

1 ppt = 1 second in ~31,700 years

In soils/solids: in ppb

1 ppb = 1 second in 31.7 years

Analytical methods:

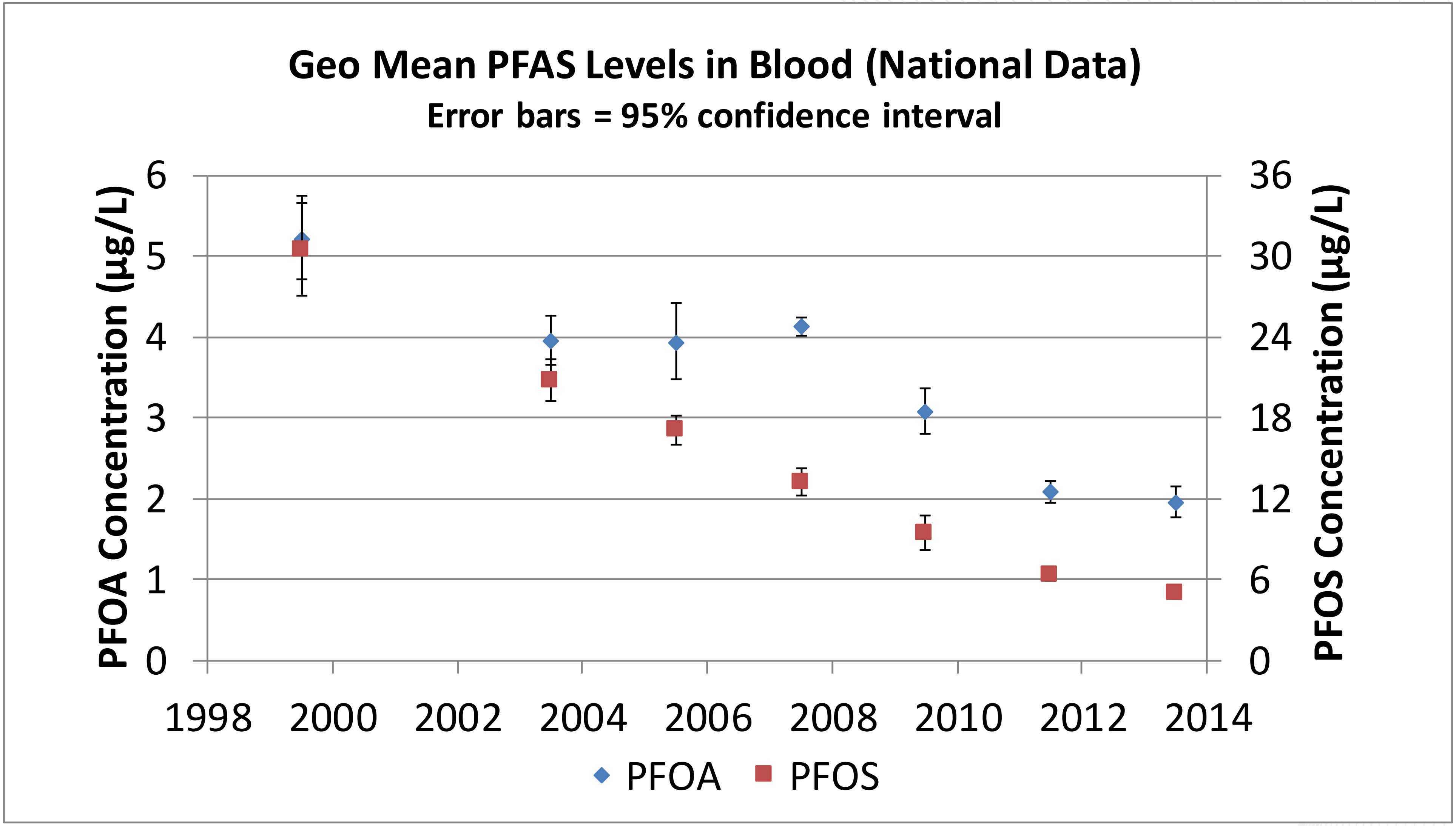
- EPA Method 537.1 (Nov. 2018) – for drinking water only
- DoD guidance for other matrices – is
- Draft EPA SW method for non-drinki
- 2020 draft EPA SW method for solid

Be skeptical of PFAS data.

the level of PFAS health risk?

There is debate. That is not ours to figure out. But we track & comment to ensure no rush to judgment without good science.

The most cost-effective strategy for persistent & proven toxic CECs is to phase out their use.



Data in part reflect PFOA/PFOS half-lives in humans

There are 2 major sources of PFAS

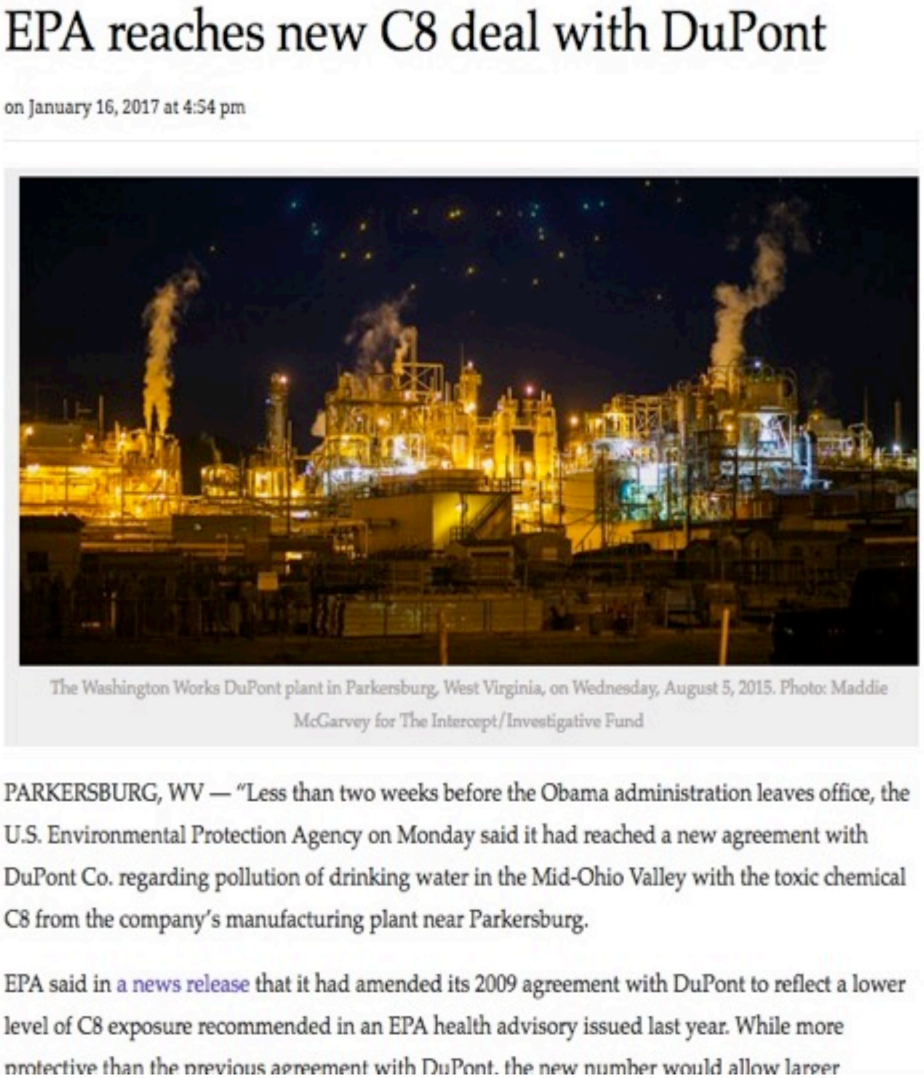
in the environment:

- industrial discharges
- fire-fighting (including training, e.g. at military sites)

Major sources of PFAS in the environment:

Cottage Grove, MN

Parkersburg, WV



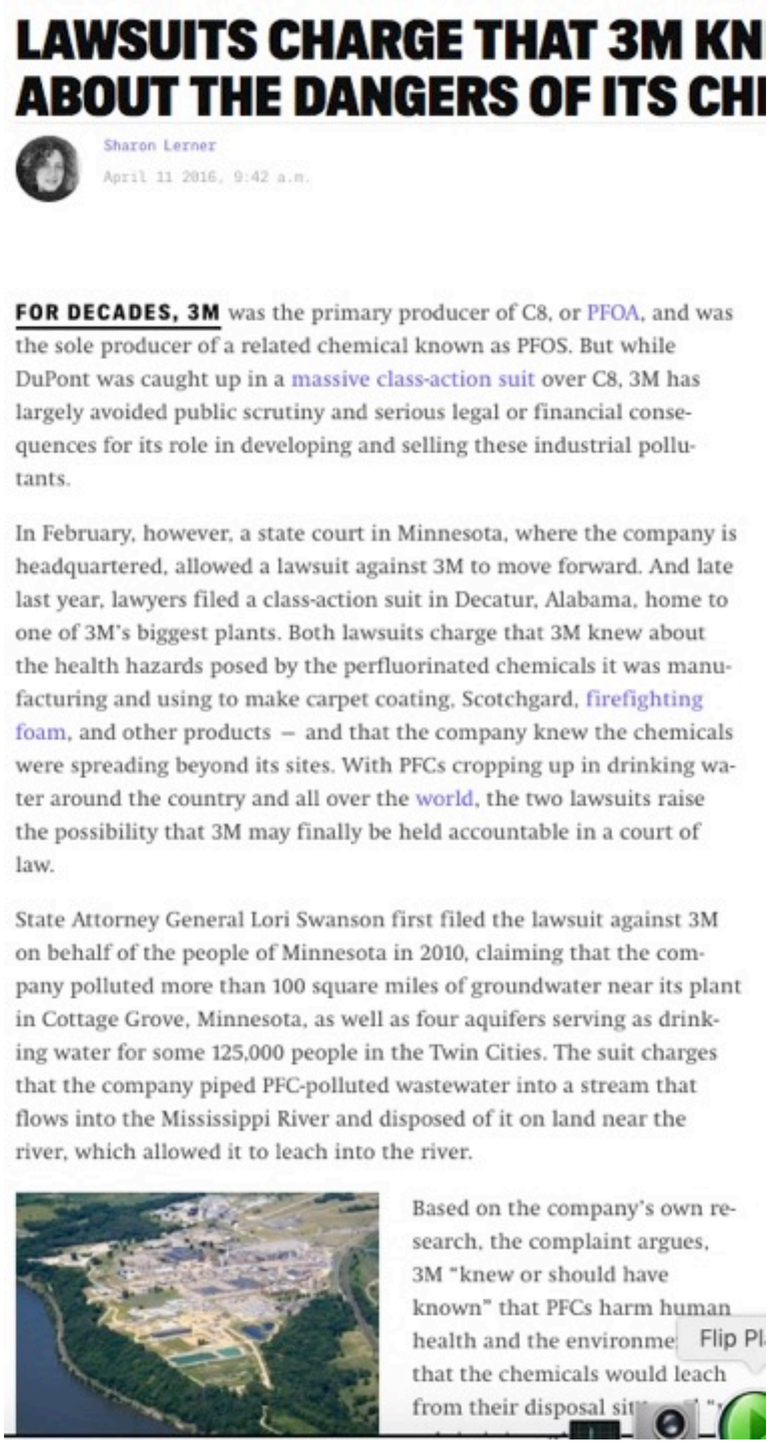
EPA reaches new C8 deal with DuPont

on January 16, 2017 at 4:54 pm

The Washington Works DuPont plant in Parkersburg, West Virginia, on Wednesday, August 5, 2015. Photo: Maddie McGarvey for The Intercept/Investigative Fund

PARKERSBURG, WV — "Less than two weeks before the Obama administration leaves office, the U.S. Environmental Protection Agency on Monday said it had reached a new agreement with DuPont Co. regarding pollution of drinking water in the Mid-Ohio Valley with the toxic chemical C8 from the company's manufacturing plant near Parkersburg.

EPA said in a news release that it had amended its 2009 agreement with DuPont to reflect a lower level of C8 exposure recommended in an EPA health advisory issued last year. While more protective than the previous agreement with DuPont, the new number would allow larger



LAWSUITS CHARGE THAT 3M KN ABOUT THE DANGERS OF ITS CHI

Sharon Lerner

April 11 2016, 9:42 a.m.

FOR DECADES, 3M was the primary producer of C8, or PFOA, and was the sole producer of a related chemical known as PFOS. But while DuPont was caught up in a massive class-action suit over C8, 3M has largely avoided public scrutiny and serious legal or financial consequences for its role in developing and selling these industrial pollutants.

In February, however, a state court in Minnesota, where the company is headquartered, allowed a lawsuit against 3M to move forward. And late last year, lawyers filed a class-action suit in Decatur, Alabama, home to one of 3M's biggest plants. Both lawsuits charge that 3M knew about the health hazards posed by the perfluorinated chemicals it was manufacturing and using to make carpet coating, Scotchgard, firefighting foam, and other products — and that the company knew the chemicals were spreading beyond its sites. With PFCs cropping up in drinking water around the country and all over the world, the two lawsuits raise the possibility that 3M may finally be held accountable in a court of law.

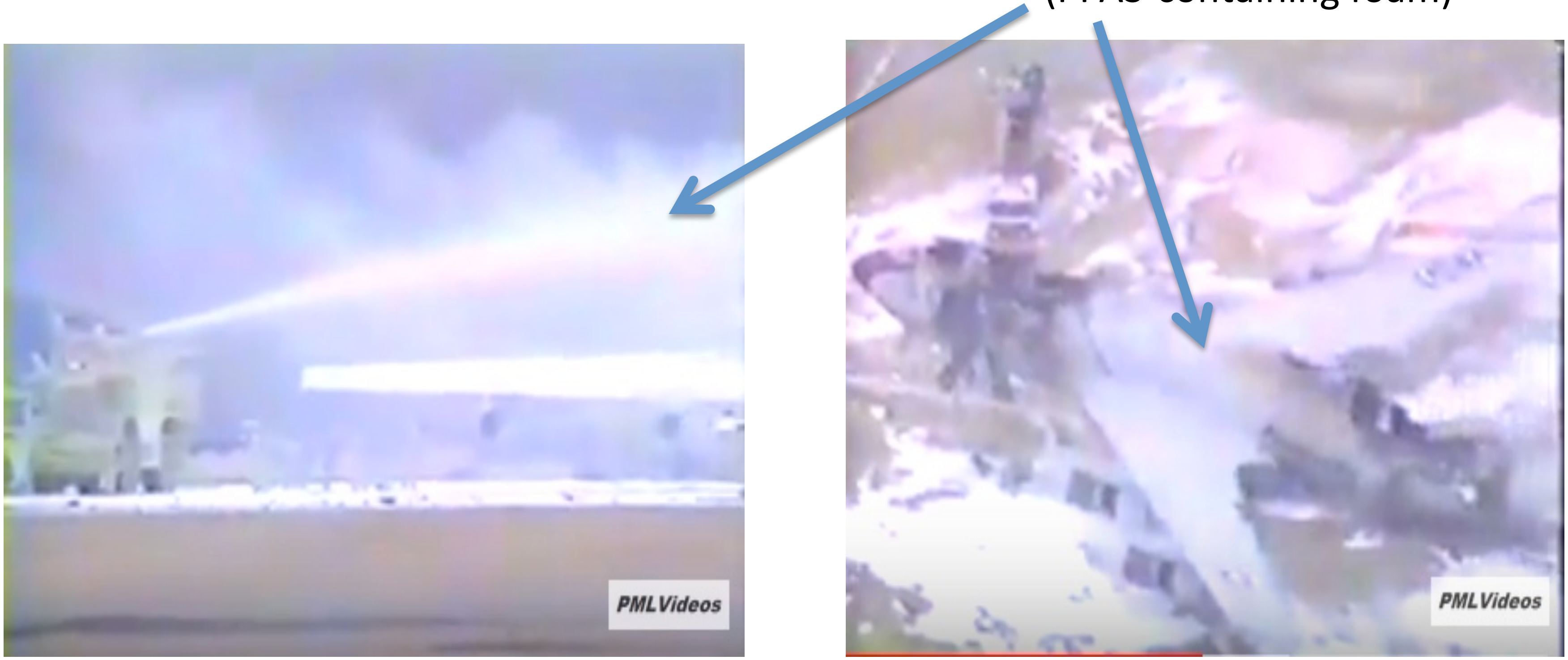
State Attorney General Lori Swanson first filed the lawsuit against 3M on behalf of the people of Minnesota in 2010, claiming that the company polluted more than 100 square miles of groundwater near its plant in Cottage Grove, Minnesota, as well as four aquifers serving as drinking water for some 125,000 people in the Twin Cities. The suit charges that the company piped PFC-polluted wastewater into a stream that flows into the Mississippi River and disposed of it on land near the river, which allowed it to leach into the river.

Based on the company's own research, the complaint argues, 3M "knew or should have known" that PFCs harm human health and the environme

that the chemicals would leach from their disposal sit

Major source of PFAS in the environment:

AFFF, Pease AFB, NH



All the white is AFFF
(PFAS-containing foam)

https://www.youtube.com/watch?v=8W_zJfJGhSI&feature=youtu.be

Data: PFAS contamination at industrial sites

EXAMPLE: Wolverine Worldwide Kent County tannery dump sites, Rockford, MI

Date of discovery: 2017

Results (PFOS/ PFOA) or Range above EPA LHAs: House Street Area Testing Results as of 12/20/18 as reported by Wolverine:

- -Wolverine has sampled 689 homes
- -38 homes over 70 PPT (PFOA+PFOS)
- -392 had detection of PFOA/PFOS
- -Highest concentration is **76,000 PPT** (PFOA+PFOS)

Suspected source: This area consists of a former licensed disposal facility owned and operated by Wolverine… and several unregulated dump sites across three townships in northern Kent County.

https://www.ewg.org/research/update-mapping-expanding-pfas-crisis

*Data: PFAS at firefighting & training sites

EXAMPLE: Battle Creek Air National Guard Base, MI
Date of discovery: 2018
Results (PFOS/ PFOA) or Range above EPA LHAs: On-base groundwater:
- -PFOA: **21,500 ppt**
- -PFOS: **55,000 ppt**
- -PFHxS: **38,400 ppt**

Two contaminated private wells (drinking water): -PFOS+PFOA: high of 411 ppt
Other Results PFAS or Range above EPA LHAs: On-Base water wells show presence of 13 PFAS compounds – Highest results: PFHxS=38,400 ppt
Suspected source: Firefighting foam used at Battle Creek ANGB

EXAMPLE: Travis Air Force Base, CA
Date of discovery: 2018
Results (PFOS/ PFOA) or Range above EPA LHAs:
- -PFOA + PFOS = **712,000 ppt**
- - PFOA = **88,000 ppt**
- - PFOS = **690,000 ppt**

Other Results PFAS or Range above EPA LHAs: PFBS = 140,000 ppt
Suspected source: Firefighting foam

https://www.ewg.org/research/update-mapping-expanding-pfas-crisis

PFAS
ambient background:

includes most wastewater & biosolids and other residuals (e.g. compost, paper mill residuals), septic (onsite) systems, solid waste management activities

Typical biosolids are part of "ambient background" levels of PFAS.

There are a few cases of large industrial inputs to solid waste facilities & sewers; those are industry point sources – not typical.

Sources of PFAS to the Environment

RMIT UNIVERSITY

Industry

Defense

Airports

Point Source

Domestic Environment

WWTPs

Landfill

"Ambient Background"

Source: Dr. Bradley Clarke, RMIT, Per- and polyfluoroalkyl substances (PFAS) in Australia, Dec. 2017 slide presentation to Water Research Australia

Data…
PFAS are showing up in various waters & soils:

drinking water

groundwater

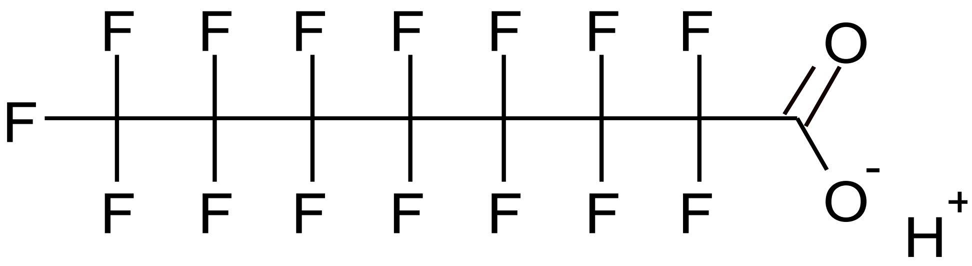
surface water

wastewater

landfill leachate

Compare the following data to the 10,000s of ppt at industrial & fire-fighting sites.

PFOA



Data…
PFAS are showing up in various waters:

drinking water

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surface water

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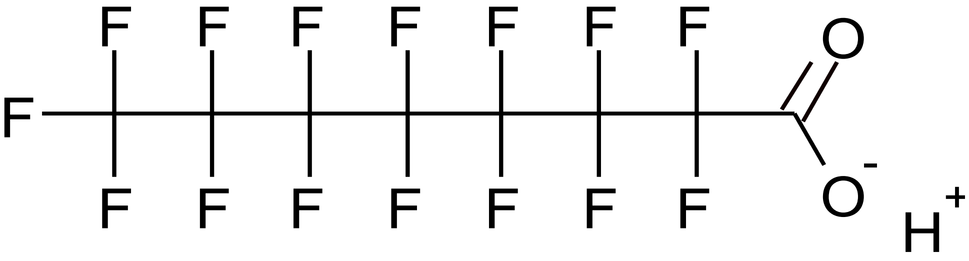
landfill leachate

DATA following are ng/L (ppt)

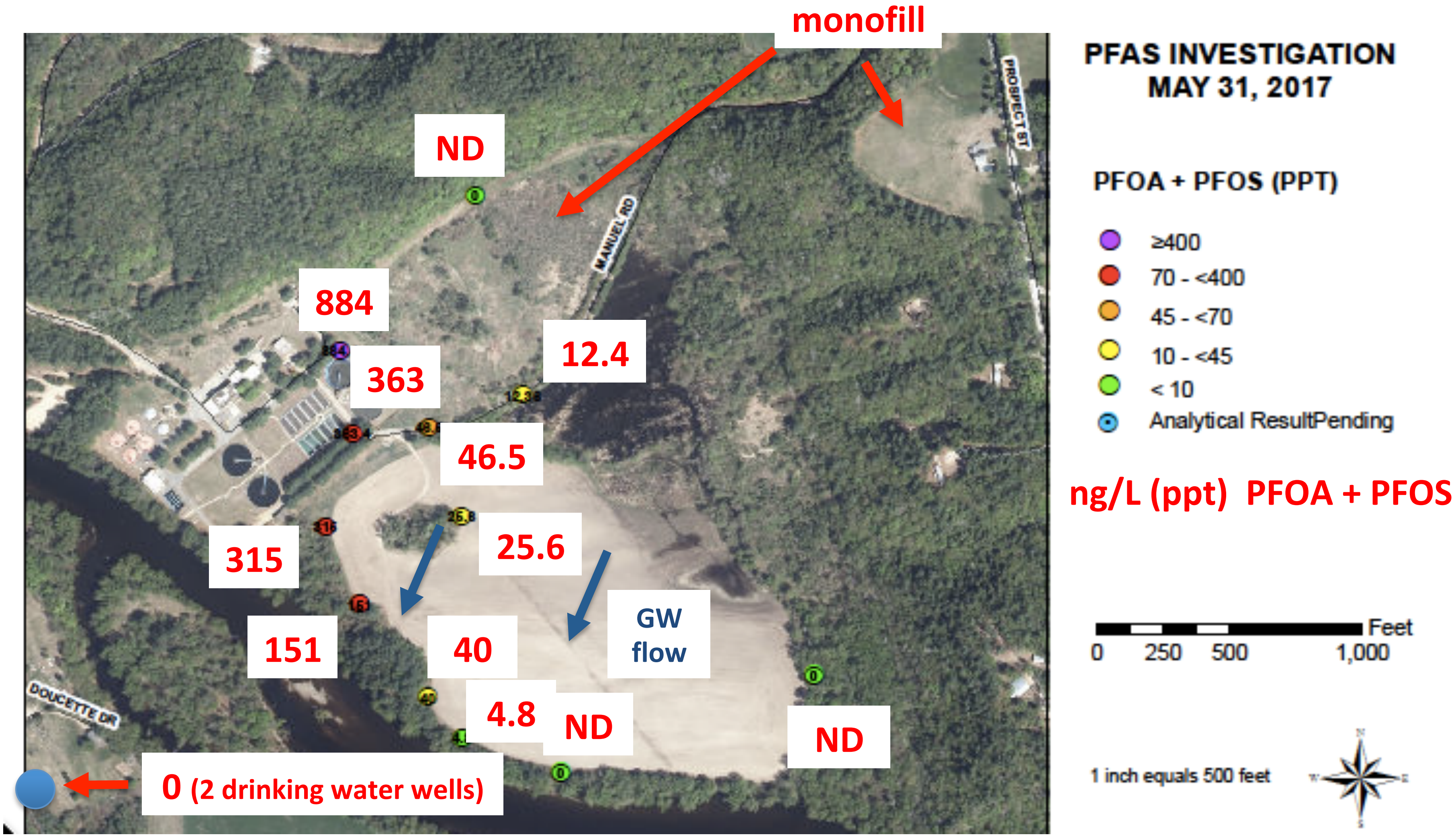
Compare to 70 ppt
for PFOA + PFOS (EPA PHA)

PFOA



Monitoring well testing at sludge monofill

- Monofill used in 1980s. Since ~1996, all biosolids from WWTP (11.5 MGD) have been land applied, some on farm field shown.
- Likely a worst-case scenario? But nothing like a firefighting site!



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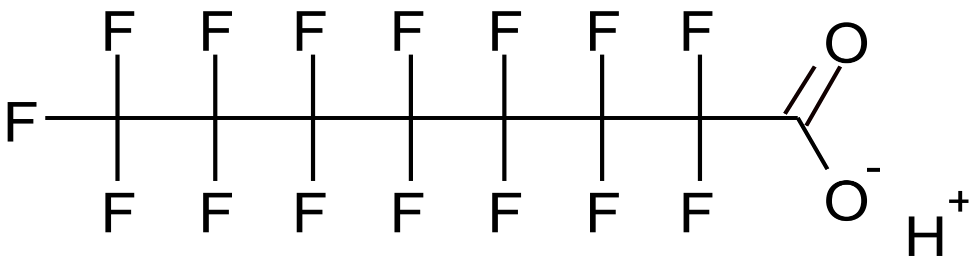
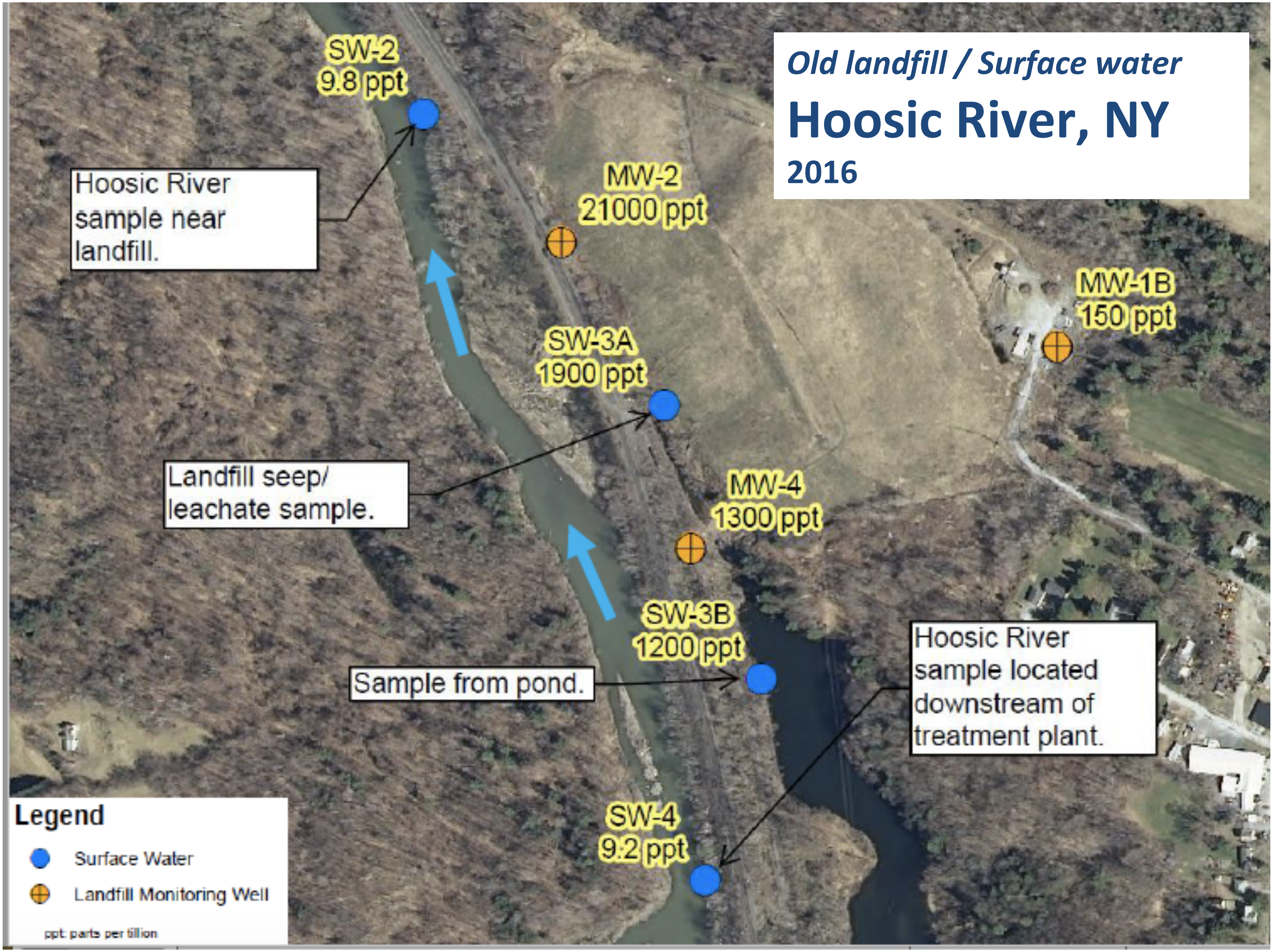


Old landfill / Surface water

Hoosic River, NY

2016



Paper mill residuals composting operation.

Regulatory response in March 2017 drives recycle paper mill residuals to landfill and composting business to laying off workers.

Data…
PFAS are showing up in various waters:

drinking water

groundwater

surface water

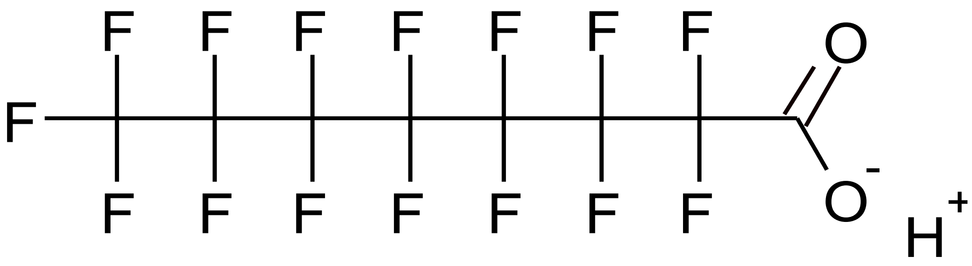
wastewater

landfill leachate

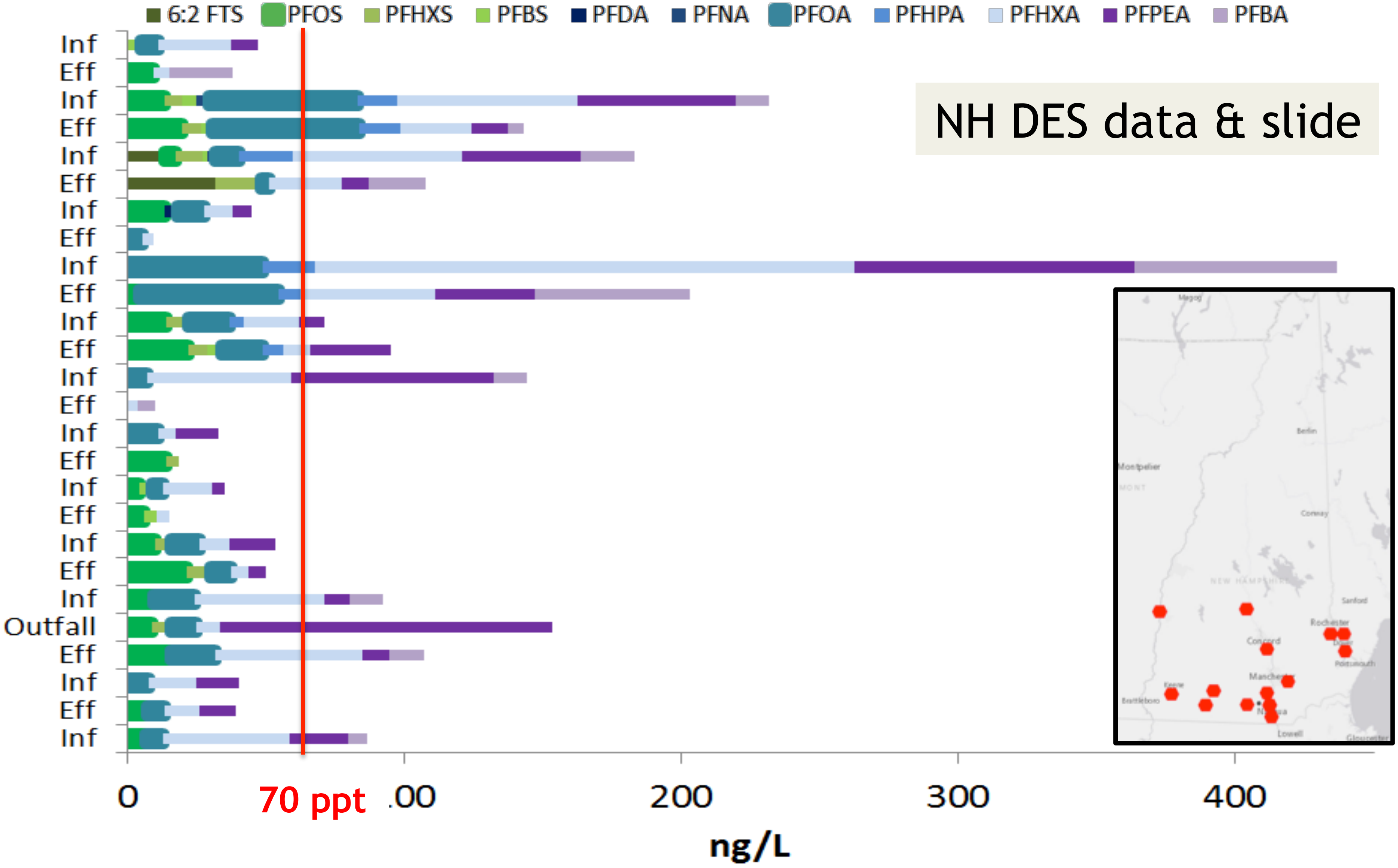
DATA following are ng/L (ppt)

Compare to 70 ppt
for PFOA + PFOS (EPA PHA)

PFOA



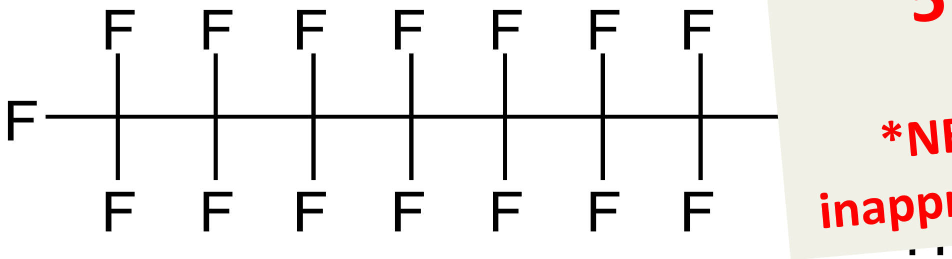
Wastewater Assessments



NH DES data & slide

Data…
PFAS are present in all biosolids, some residuals, & soils…

PFOA



DATA following are ng/g (ppb) dry weight

Compare to:

~72 ppb a NY DEC screening value

2.5 ppb ME PFOA limit*

5.2 ppb ME PFOS limit*

*NEBRA finds these values are inappropriate for use with biosolids.

Recent PFAS test results:

Biosolids, Residuals, & Septage (ng/g, ppb)

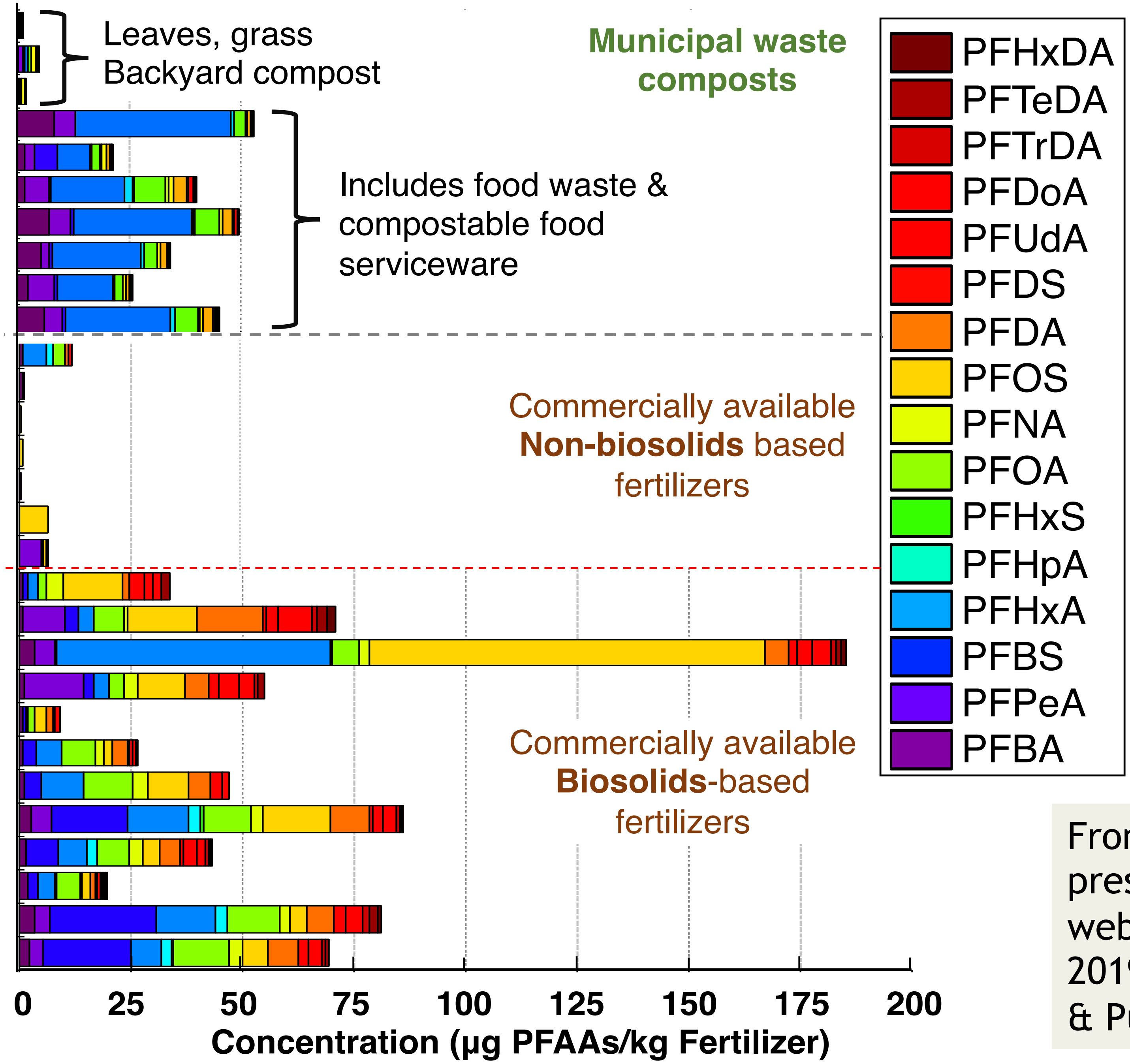
	PFOA*	PFOS*	PFNA*	PFHxS*	PFHpA*	PFDA	Notes
Biosolids products nationwide, 2018	~3 - ~15	~2 - ~ 90	ND - ~4		ND - ~4	< 1 - ~17	7 composts tested by Lazcano, Lee - Purdue
ME biosolids, 2019	0.6 – 46 (mean = 8.5)	3.2 – 120 (mean = 25.4)					55 biosolids sampled, cake & composts
Food waste & compostable foodware compost, 2018	~3 - 12	ND - ~2	ND – ~2	~0.2 - 1	ND - ~3	~1– 3	PFHxA = ~ 9 – 50 7 composts tested by Choi, Lazcano - Purdue
ME septage, 2019	15 – 60	< 10 - 121					7 samples; typical levels > biosolids**
U. S. sewage sludges, 2001	12 – 70 (mean = 34)	308 – 618 (mean = 403)					Venkatesan & Halden, 2013; older sludges = higher PFOA & PFOS
SCREENING							
Modeled PFAS levels in biosolids to avoid impacts to 1 m ground water above 70 ppt (EPA screen)	sum = < 40 – 60: 40 PFOA + 0 PFOS or 0 PFOA + 60 PFOS						Stone Environmental PRZM modeling, 2019, for NEBRA
ME DEP screening level developed for non-agronomic residuals, 2018	2.5	5.2					Applied to biosolids & biosolids soils in 2019

All data are suspect & variable due to there being no approved analytical method other than for drinking water and different lab protocols in use.

* There were 6 PFAS included in the U. S. EPA Unregulated Contaminant Monitoring Rule 3 (UCMR 3) testing of drinking water; the 6th, not shown here, is PFBS.

** Septage may have higher levels than biosolids because it is older, having sat in septic tanks for up to 10 years, reflecting higher uses of PFOA and PFOS prior to the early-2000s phase-out of these 2 PFAS.

ND = not detected



From Kim-Lazcano – presentation for USCC webinar, Jan. 18, 2019. © Kim-Lazcano, & Purdue Univ. data.

A few biosolids are impacted at levels of some concern - when an industry discharges large amounts of PFAS to a sewer:

- Decatur, AL (2000s) – 3M manufacturing facility
- Lapeer, MI (2017) – metal plating industry
- Maine farm (2019) – issue is not municipal biosolids; PFOS is the only concern; paper industry sludge/ash; max soil: 878 ppb PFOS (see NEBRA fact sheet: https://www.nebiosolids.org/pfas-biosolids

<u>Solution</u>:

Apply pretreatment & source control.

Data…
PFAS in…:

drinking water

groundwater

surface water

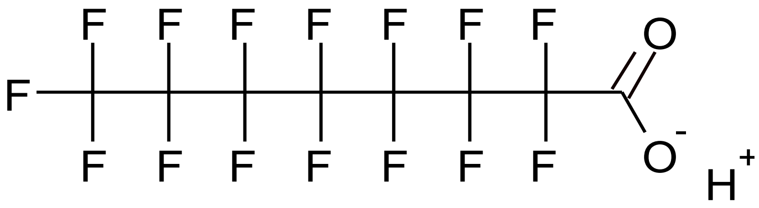
wastewater

landfill leachate

DATA following are ng/L (ppt)

Compare to 70 ppt
for PFOA + PFOS (EPA PHA)

PFOA



Sources of PFAS at Landfills (?)

- Consumer products
- Sewage sludge (or treated biosolids)
- Industrial wastes
- Auto shredder residue
- Debris from fire cleanup
- Discarded AFFF
- Other sources

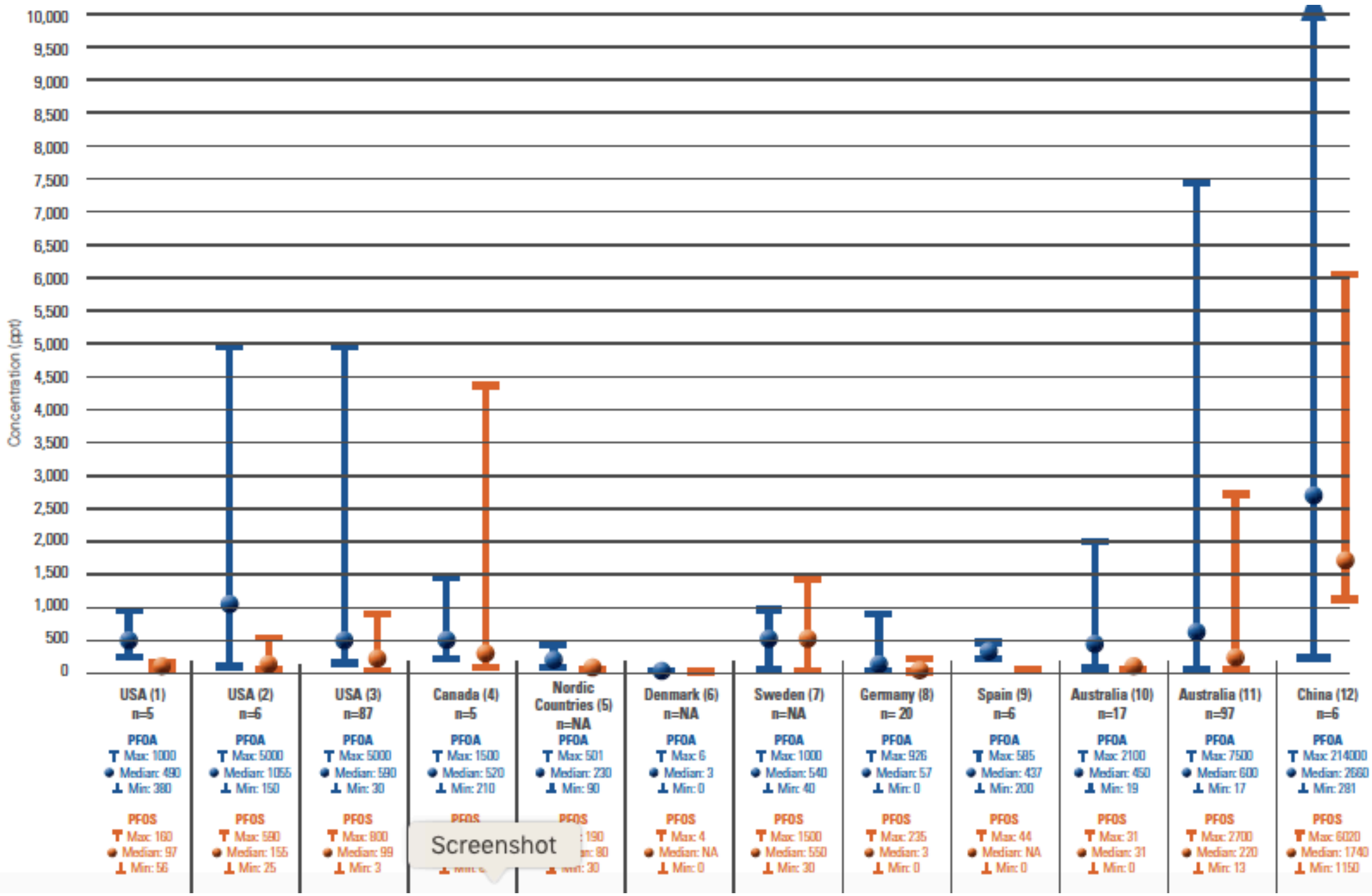
Landfill leachate PFAS concentrations (ng/l or ppt)

(adapted from MI Waste & Recycling Association, Table 4.3, https://www.michiganwasteandrecyclingassociation.com/

Location	PFOA	PFOS	Notes
Michigan	16 – 3,200	9 – 960	32 MI landfills & MiWaters data (see report link above)
Vermont	80 – 2,800	23 - 300	11 analyses of 9 samples in 2018
United States	30 – 5,000	3 – 800	
Europe	ND – 1,000	ND – 1,500	
Australia	17 – 7,500	13 – 2,700	
China	281 – 214,000	1,150 – 6,020	
STANDARDS			
VT screening levels for landfill leachate, 2018	120,000	1,000	guidance only
MI EGLE surface water limit (2015)	420	12	if source of drinking water; limits are being used to screen wastewater effluent
Canada Health (2018) drinking water	200	600	
U.S. EPA drinking water screening value (2016)	70		applies to the sum of 2 PFAS

Landfill leachate PFAS concentrations (ng/l or ppt)

(from MI Waste & Recycling Association, Figure 2.1, https://www.michiganwasteandrecyclingassociation.com/)



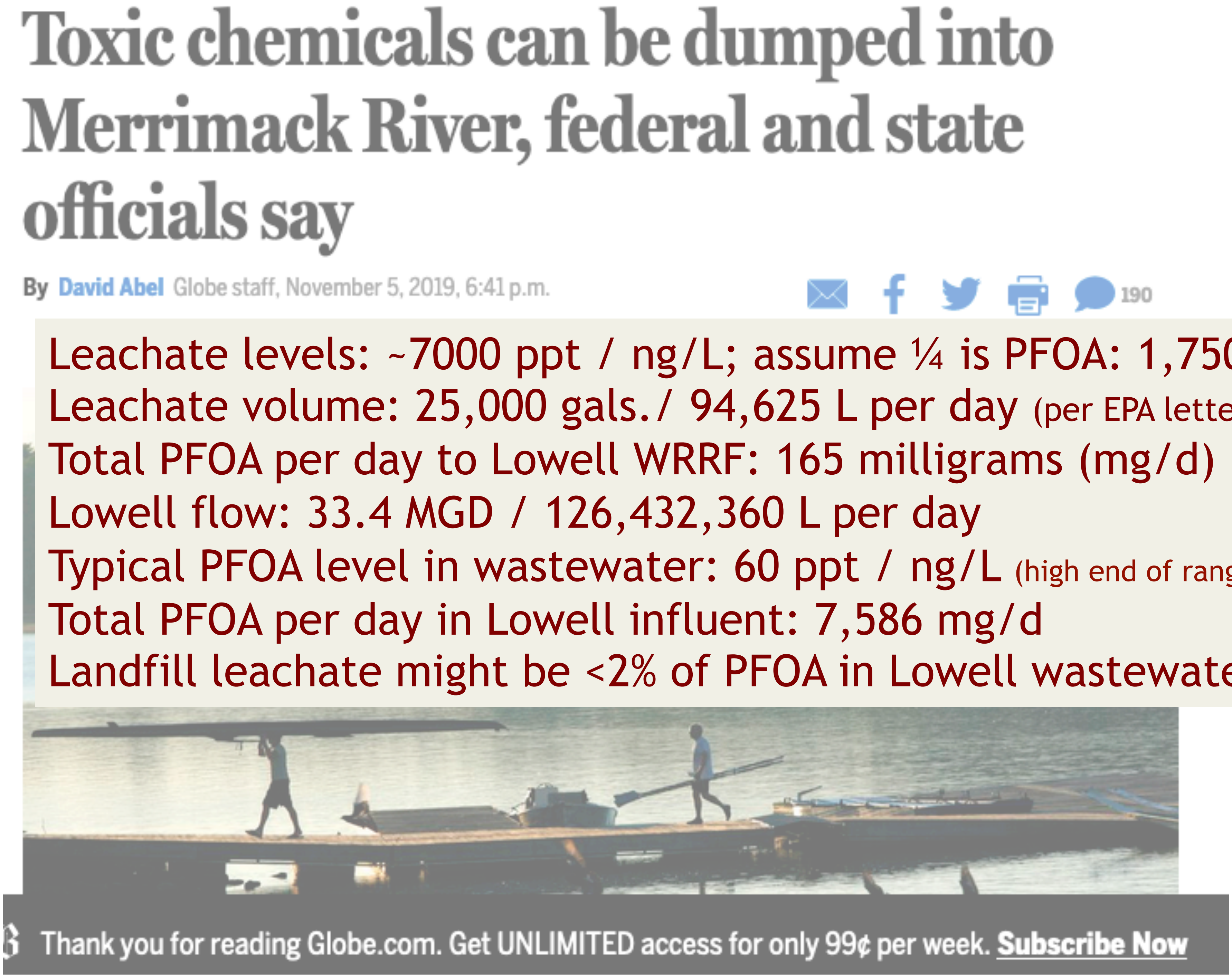
Conclusions for wastewater utilities

(from MI Waste & Recycling Assoc.https://www.michiganwasteandrecyclingassociation.com/

"a. leachate provides a relatively minor contribution to the overall PFOA and PFOS concentration/mass in most WRRF influent because of the relatively low leachate discharge volumes;

"b. non-leachate sources of PFOA and PFOS significantly contribute to WRRF influent and at higher volumes. It is noteworthy that the WRRF influent that have no landfill leachate contribution show a similar concentration range for PFOA and PFOS as WRRF influent that has leachate contribution; and

"c. although reduction of landfill leachate concentrations of PFOA and PFOS to the WRRF influent could be beneficial to meeting WQS in the WRRF effluent, the impact may be minor in most cases since leachate typically contributes a relatively small volume to the overall WRRF influent."



Toxic chemicals can be dumped into Merrimack River, federal and state officials say

By **David Abel** Globe staff, November 5, 2019, 6:41 p.m.

Leachate levels: ~7000 ppt / ng/L; assume ¼ is PFOA: 1,750
Leachate volume: 25,000 gals./ 94,625 L per day (per EPA letter)
Total PFOA per day to Lowell WRRF: 165 milligrams (mg/d)
Lowell flow: 33.4 MGD / 126,432,360 L per day
Typical PFOA level in wastewater: 60 ppt / ng/L (high end of range)
Total PFOA per day in Lowell influent: 7,586 mg/d
Landfill leachate might be <2% of PFOA in Lowell wastewater.

Biosolids compost for my raspberries… still using it, even though I know it has PFAS in it. The benefits outweigh the risks :)

Thank you.

Ned Beecher, MS • NEBRA • Tamworth, NH

November 12, 2019

EBC New England • Framingham, MA

Estimating Total Mass of PFAS in Landfill Leachate

- Lang et al (2017) published PFAS measurements in landfill leachate (*Environ. Sci. Technol.* **51**:2197–2205)
  - 70 PFAS / 95 samples / 18 landfills
  - Estimate 563 – 638 kg of PFAS in leachate per year in the U.S.

Ballpark Estimate of PFAS in Sludge & Biosolids

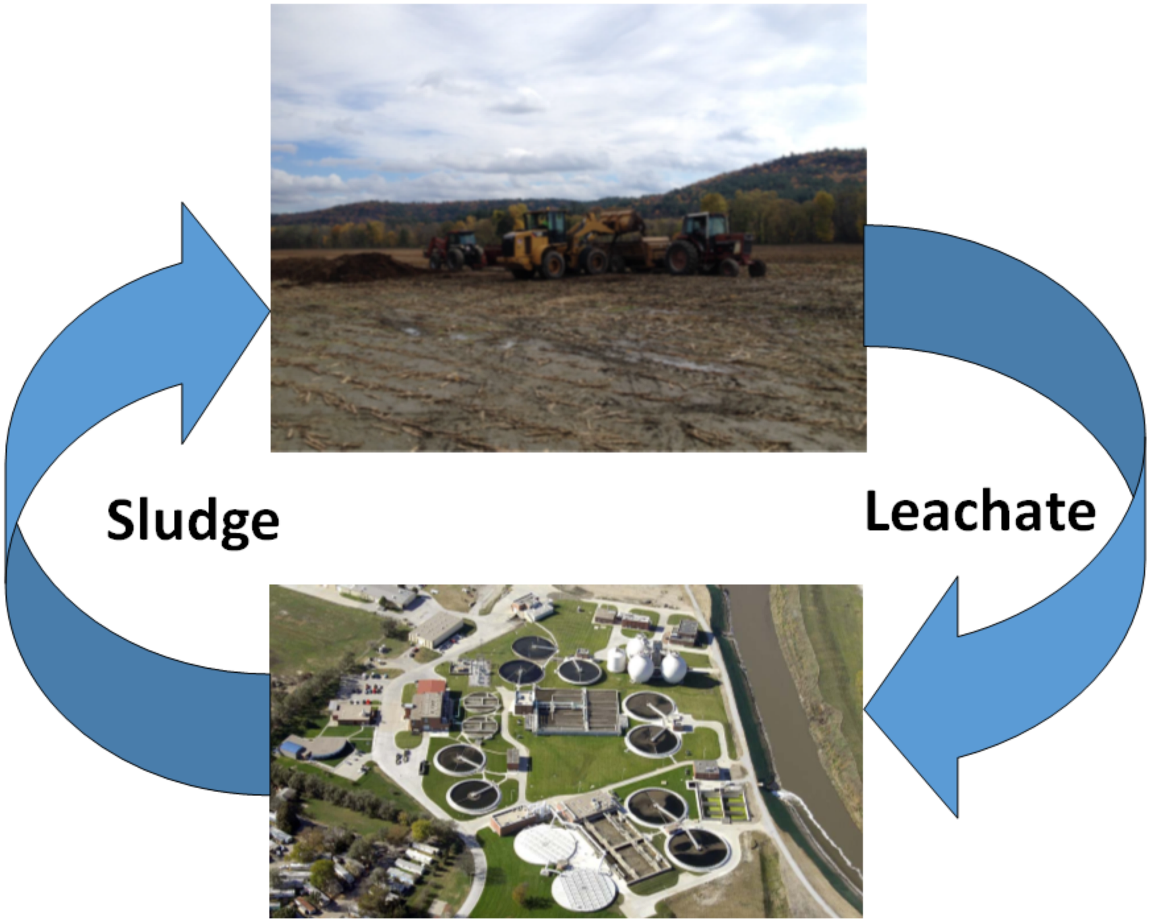
Assume

- 7.2 million dry tons of sewage sludge (NEBRA et al., 2007)
- PFAS content ~100 ppb (µg/kg summed)

Find

- ~700 kg/year of PFAS in sewage sludge
- Comparable total mass to what’s in leachates

PFAS Relationship Between Landfills and Wastewater Treatment Plants (WWTPs)



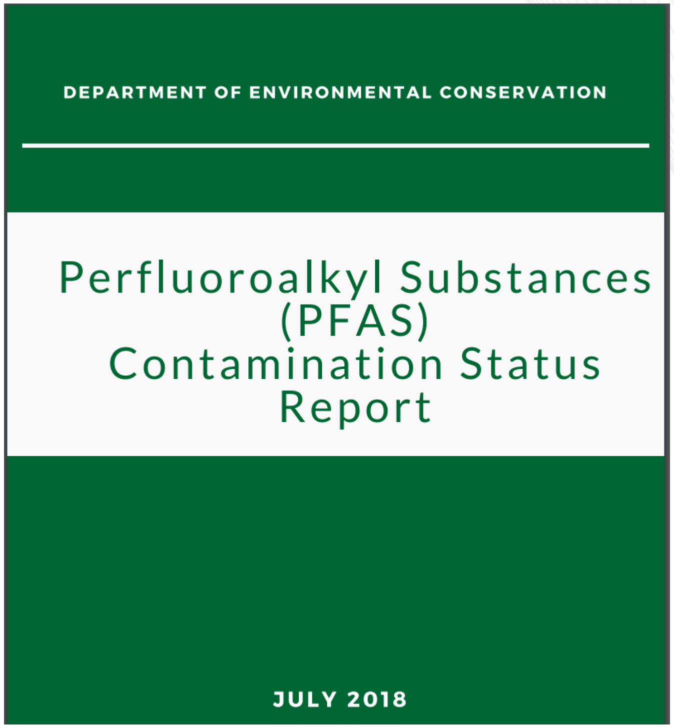
Sludge

Leachate

Do PFAS cycle between landfills and WWTPs?

Leachate and Sludge Data

- VT DEC (1) investigated PFAS in landfill leachate and WWTP sludge (and WWTP influent/effluent)
  - 29 PFAS
  - 5 landfills
    - 1 active
    - 4 closed
  - 6 WWTPs

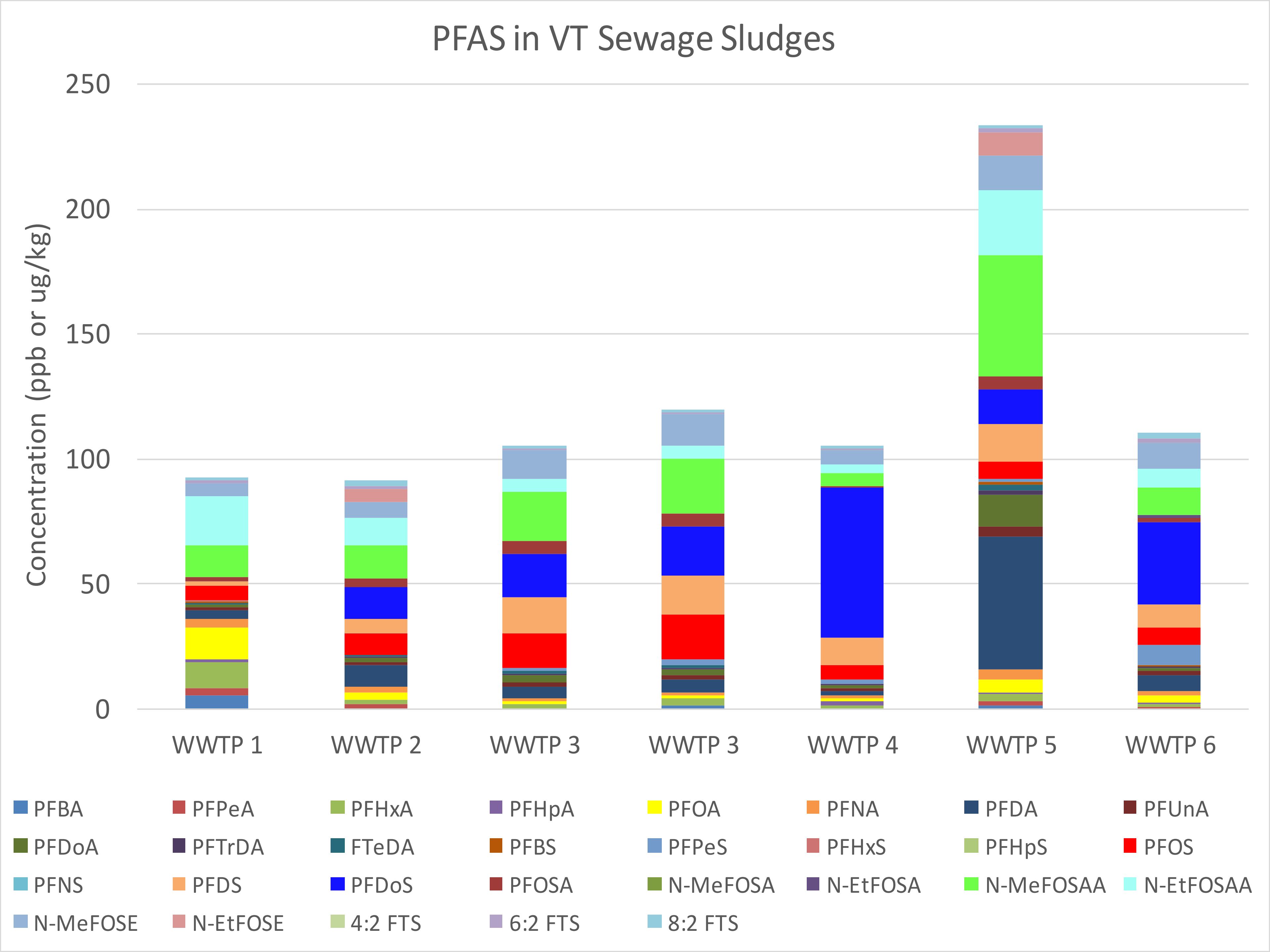


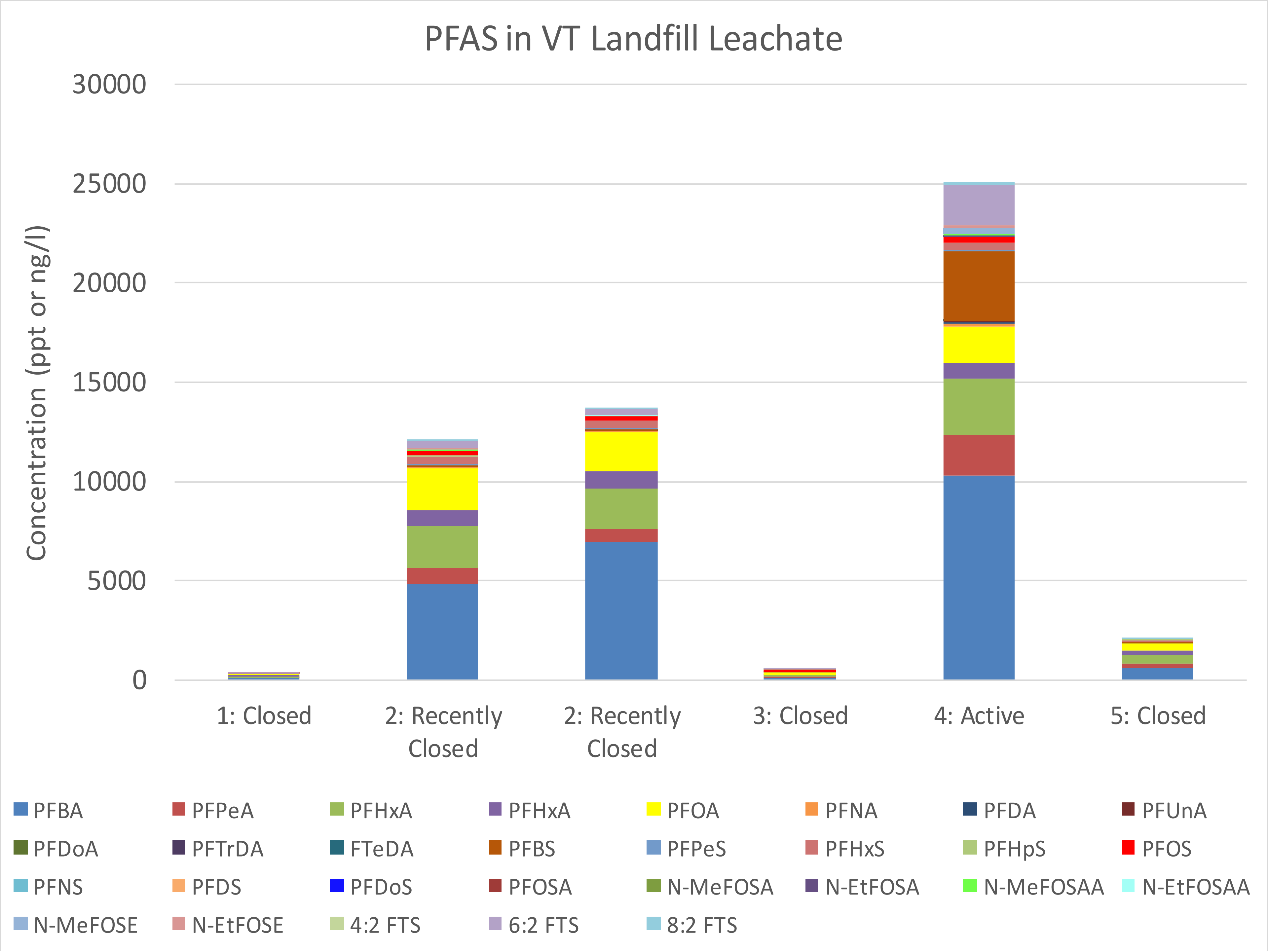
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

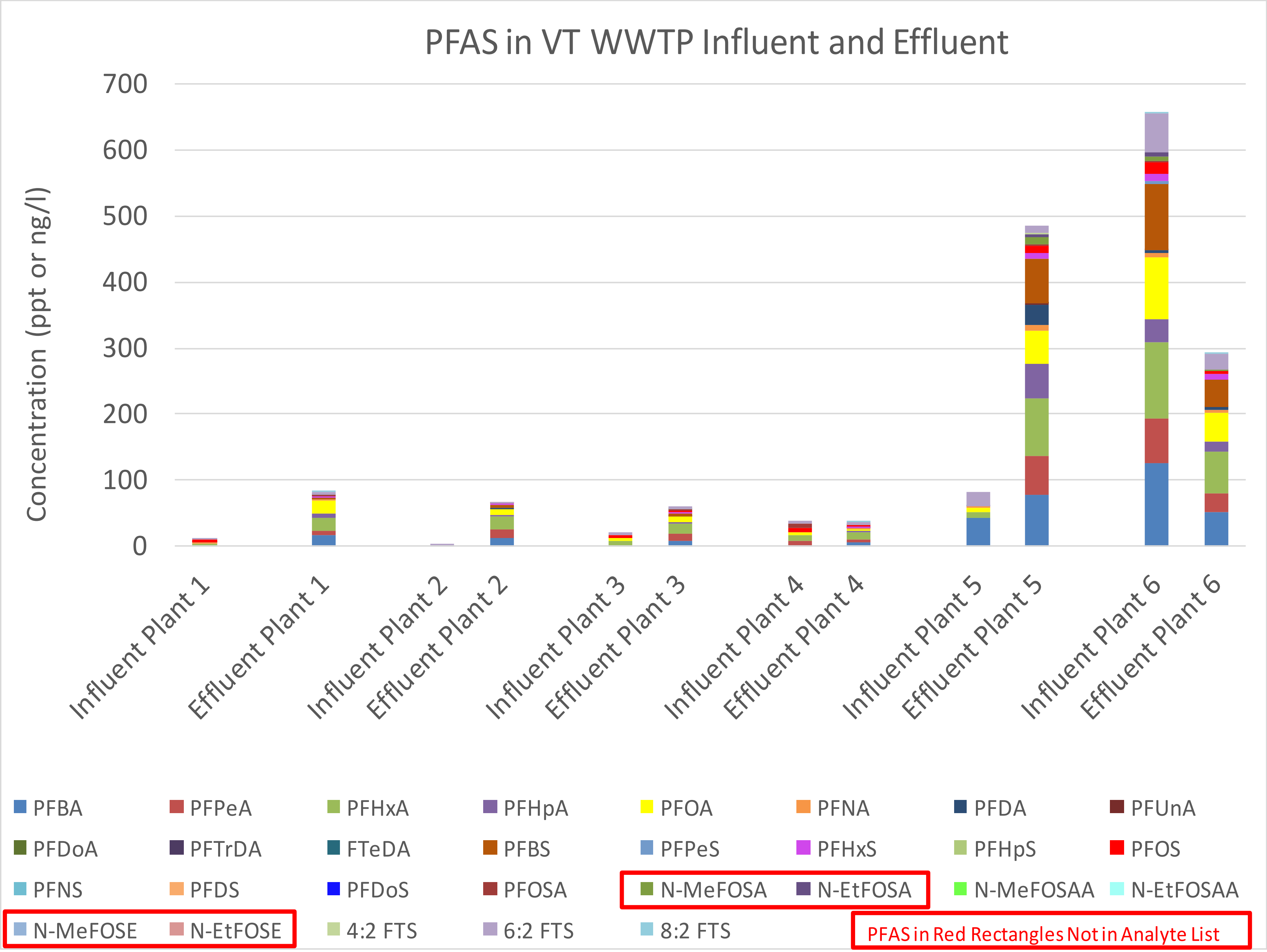
Perfluoroalkyl Substances (PFAS) Contamination Status Report

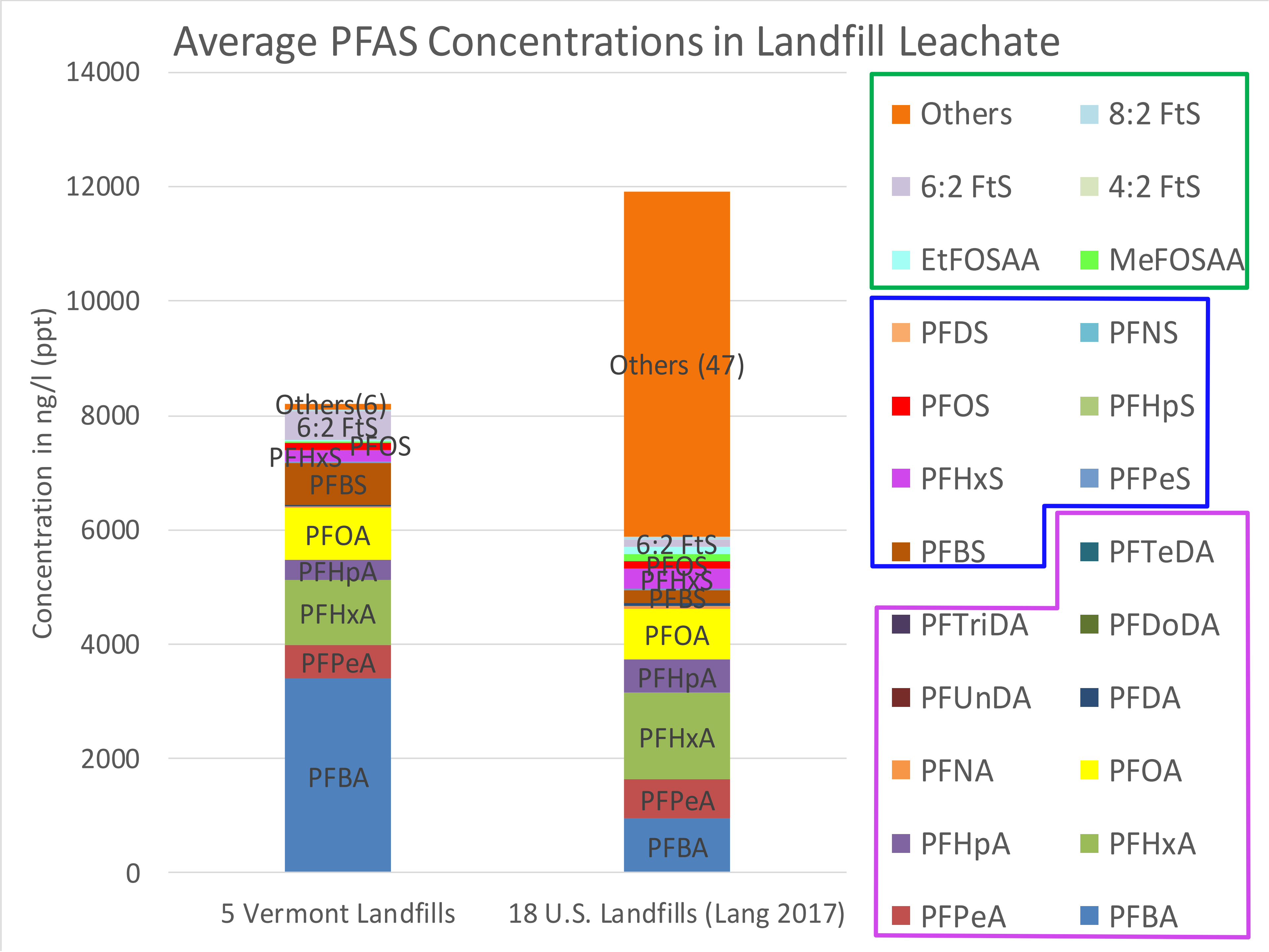
JULY 2018

(1) Weston and Sampson, Letter report to John Schmeltzer, Vermont Department of Environmental Conservation, May 3, 2018


PFAS in VT Sewage Sludges
Concentration (ppb or ug/kg)
250
200
150
100
50
0
WWTP 1
WWTP 2
WWTP 3
WWTP 3
WWTP 4
WWTP 5
WWTP 6
PFBA
PFPeA
PFHxA
PFHpA
PFOA
PFNA
PFDA
PFUnA
PFDoA
PFTrDA
FTeDA
PFBS
PFPeS
PFHxS
PFHpS
PFOS
PFNS
PFDS
PFDoS
PFOSA
N-MeFOSA
N-EtFOSA
N-MeFOSAA
N-EtFOSAA
N-MeFOSE
N-EtFOSE
4:2 FTS
6:2 FTS
8:2 FTS

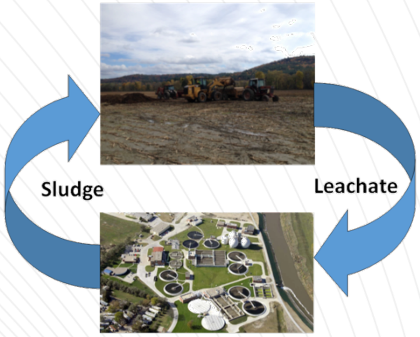

PFAS in VT Landfill Leachate
Concentration (ppt or ng/l)
30000
25000
20000
15000
10000
5000
0
1: Closed
2: Recently Closed
2: Recently Closed
3: Closed
4: Active
5: Closed
PFBA
PFPeA
PFHxA
PFHxA
PFOA
PFNA
PFDA
PFUnA
PFDoA
PFTrDA
FTeDA
PFBS
PFPeS
PFHxS
PFHpS
PFOS
PFNS
PFDS
PFDoS
PFOSA
N-MeFOSA
N-EtFOSA
N-MeFOSAA
N-EtFOSAA
N-MeFOSE
N-EtFOSE
4:2 FTS
6:2 FTS
8:2 FTS


PFAS in VT WWTP Influent and Effluent
Concentration (ppt or ng/l)
700
600
500
400
300
200
100
0
Influent Plant 1
Effluent Plant 1
Influent Plant 2
Effluent Plant 2
Influent Plant 3
Effluent Plant 3
Influent Plant 4
Effluent Plant 4
Influent Plant 5
Effluent Plant 5
Influent Plant 6
Effluent Plant 6
PFBA
PFPeA
PFHxA
PFHpA
PFOA
PFNA
PFDA
PFUnA
PFDoA
PFTrDA
FTeDA
PFBS
PFPeS
PFHxS
PFHpS
PFOS
PFNS
PFDS
PFDoS
PFOSA
N-MeFOSA
N-EtFOSA
N-MeFOSAA
N-EtFOSAA
N-MeFOSE
N-EtFOSE
4:2 FTS
6:2 FTS
8:2 FTS
PFAS in Red Rectangles Not in Analyte List



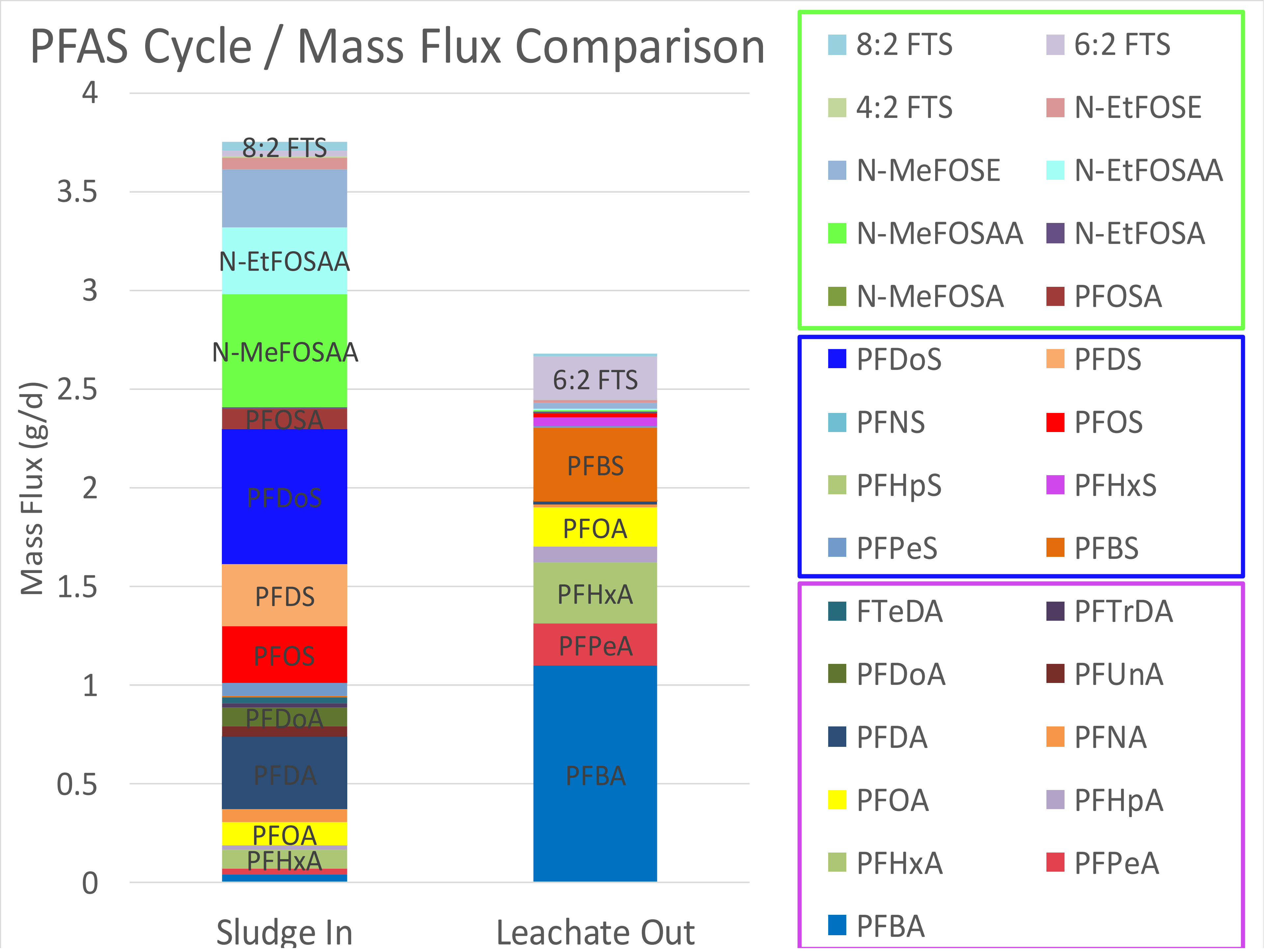
Average PFAS Concentrations in Landfill Leachate

PFAS Cycle/Comparison

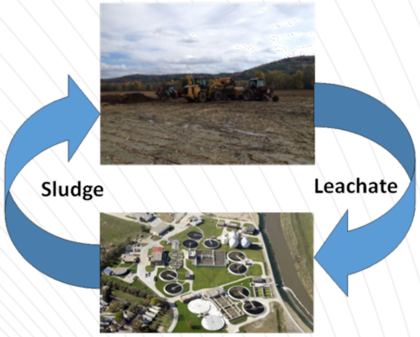


- Case study very rough examination of an active landfill
  - Leachate generation ~ 30,000 gal/d
  - Sludge acceptance ~ 270,000 lb/day (wet)
  - Sludge water content 75%
  - Average PFAS concentration in sludge
  - Landfill-specific PFAS concentration in leachate

PFAS Cycle / Mass Flux Comparison

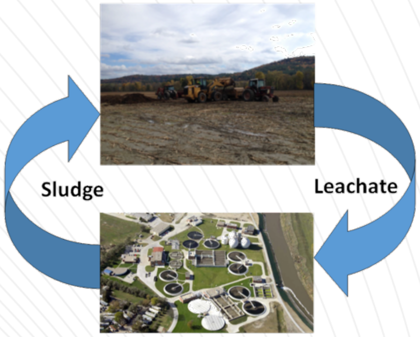


Observations



- Estimates of PFAS fluxes into (sludge) and out of (leachate) the landfill are similar in magnitude, but the PFAS distributions differ markedly
    - Long-chain PFAS, especially sulfonic acids, may sequester in the landfill
    - Short-chain compounds are prevalent in leachate, and appear to come from sources other than sludge
- PFAS cycling may not be significant at the compound level, and the overall PFAS balance appears to be much more complex
- Comparing PFAS data can be challenging due to varying analyte lists and lack of consistent analytical methods, data quality.

Additional Questions



- What fraction of WWTP loading comes from landfill leachate? (Mostly minimal, as discussed above.)
- What are the specific sources of PFAS found in leachate?
- What fractions of the PFAS in leachate are due to landfill gas condensate?
- Can leachate be treated in a cost-effective manner?
- Are air emissions of PFAS important?

Biosolids compost for my raspberries… still using it, even though I know it has PFAS in it. The benefits outweigh the risks :)

Thank you.

Ned Beecher, MS • NEBRA • Tamworth, NH

November 12, 2019

EBC New England • Framingham, MA

An Overview of PFAS Occurrence at Landfills

Arie Kremen, Ph.D.

Client Manager

Tetra Tech

An Overview of PFAS Occurrences at Landfills

EBC Solid Waste Management Program – Impact of PFAS on Solid Waste Operations

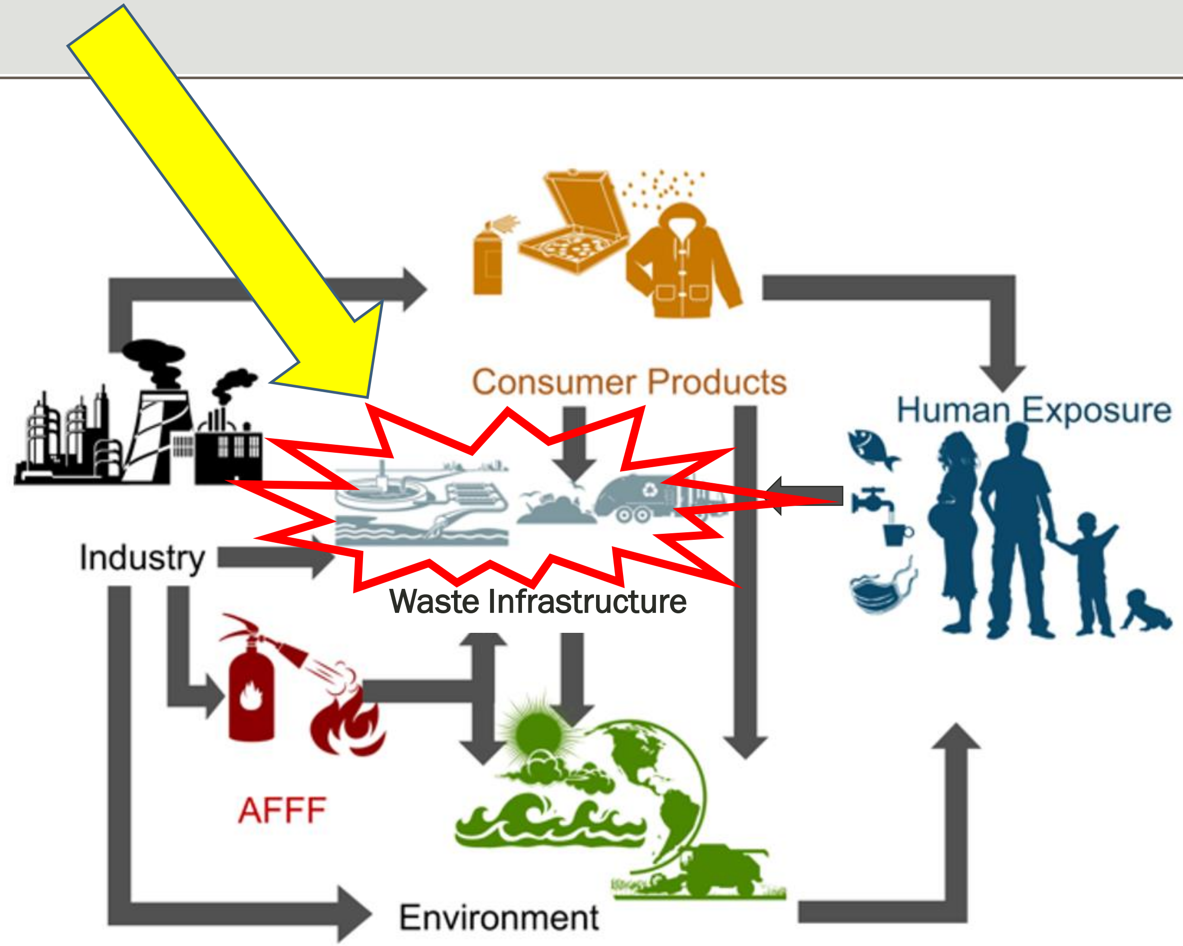
complex world | CLEAR SOLUTIONS™

Overview of PFAS Occurrences at Landfills

Environment	Materials	Equipment
Groundwater	Solid Waste	Operations equipment
Surface water	Leachate	Hand and stationary tools
Stormwater	Landfill Gas	Personal Protective Equipment
Ambient air	Cover Material	Sampling equipment
Soil	Construction Materials	Food packaging

PFAS are ubiquitous and are present in all aspects of landfill operations.

Potential Major Exposure Pathways



Source: Sunderland et al. (2019)

Attempts at a PFAS Mass Balance

Inputs

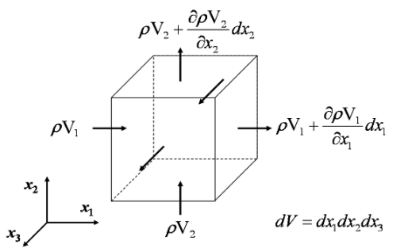
- Waste*
- Biosolids*
- Cover material*

Outputs

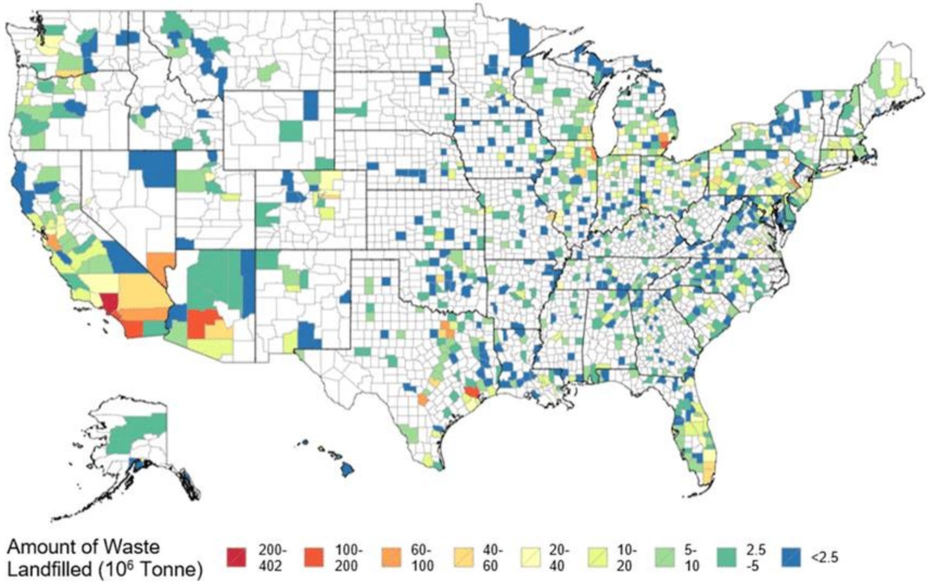
- Leachate*
- ~~Surface water~~
- Surface emissions
- Landfill gas

} *

$$\begin{bmatrix}Rate\ of\\ Accumulation\end{bmatrix} = \begin{bmatrix}Rate\\ in\end{bmatrix} - \begin{bmatrix}Rate\\ out\end{bmatrix} + \begin{bmatrix}Rate\ of\\ Generation\end{bmatrix}$$

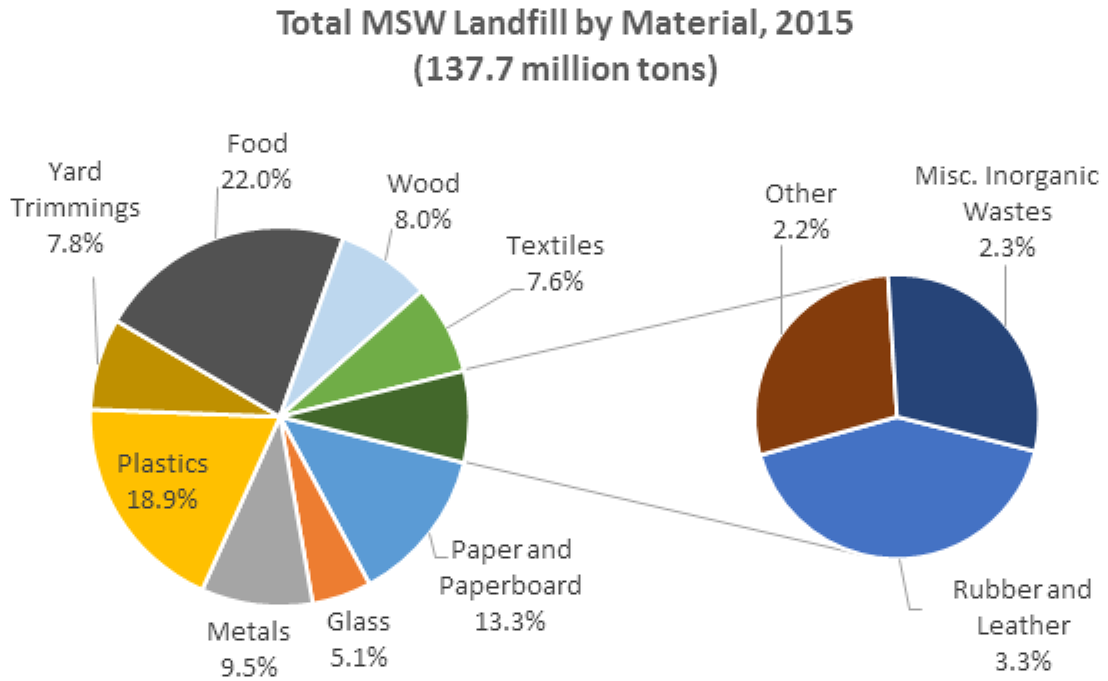


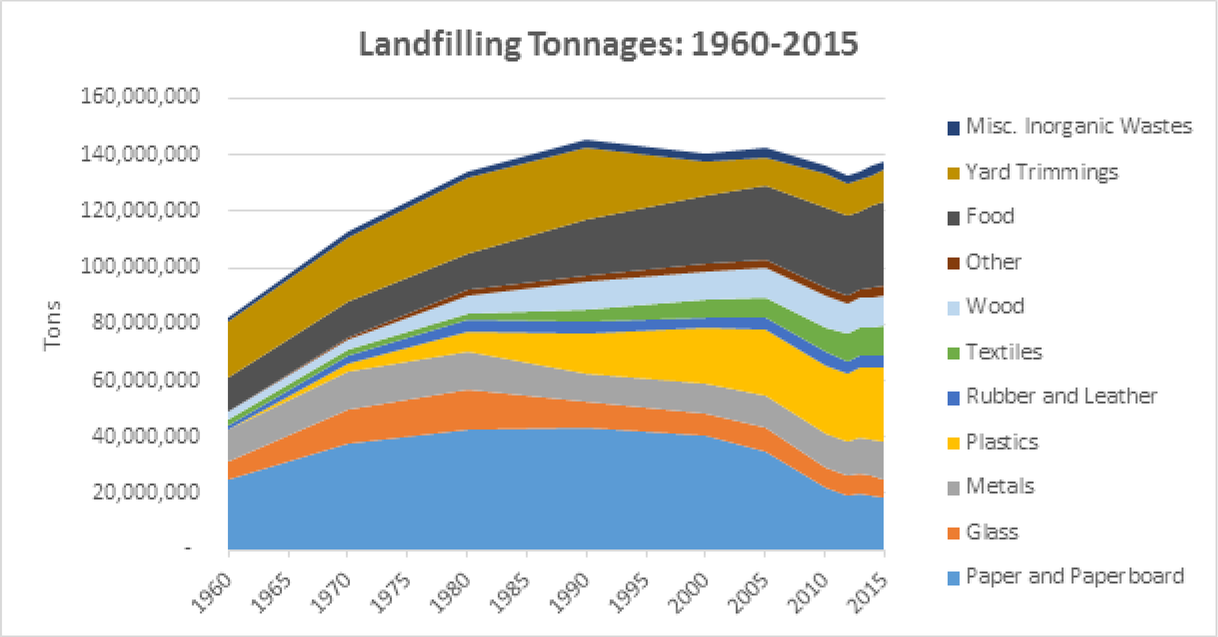
Control Volume: US MSW Landfills



Source: Powell et al. (2016)

Landfilled MSW Composition & Tonnage





Source: USEPA (2018)

Main Source Quantification: MSW

MSW Component	PFAS Content
Compost w/o packaging material	2.4-7.6 ng/kg
Compost w/packaging material	28.7-75.9 ng/kg
Bulky Waste	500 ng/g
C&D waste	800 ng/g
ASSUME (‘Fermi Approximation’)	1, 10, 100, and 1,000 ng/g

Based on annual amount of landfilled waste of 137.7 million tons:

MSW PFAS content	Estimated Amount PFAS landfilled
1 ng/g	124.9 kg/yr
10 ng/g	1,249.2 kg/yr
100 ng/g	12,492 kg/yr
1,000 ng/g	124,920 kg/yr

Challenging sampling and analysis matrix

Release Potential from Landfill Leachate

National Release Potential (Lang et al., 2017)

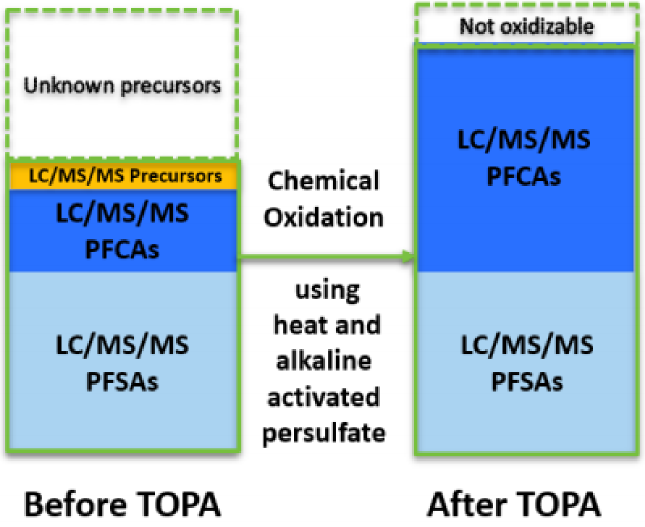
Climate	Wet		Temperate		Arid		Total (kg/yr)
Landfill Age	<10 yr (n=14)	>10 yr (n=12)	<10 yr (n=2)	>10 yr (n=6)	<10 yr (n=2)	>10 yr (n=4)	
PFAS (ng/l)	15,000	11,000	7,000	11,000	29,000	15,000	
	±16,000	±12,000	±1,000	±9,000	±1,000	±16,000	
Leachate	12,700 Mgal/yr		3,450 Mgal/yr		30 Mgal/yr		
Loading (kg/yr)	625.0		117.5		2.5		745.0

Note:

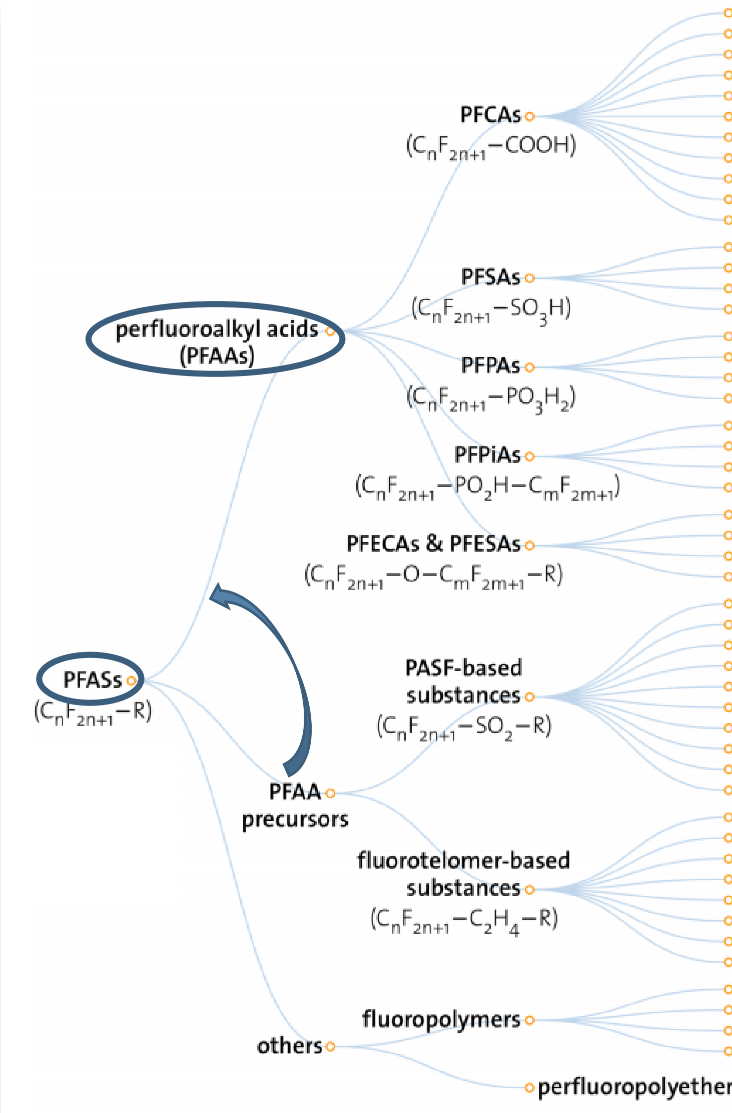
- Total of 70 quantifiable PFAS (ΣPFAS)
- Excludes oxidizable precursors
- Relied on averages, as standard deviations are too large

Precursors of Perfluoroalkyl Acids (PFAA)

- The PFAS group consists of
  - PFAA precursors
  - PFAA, including PFOS and PFOA
  - Others
- PFAA are non-degradable, and are considered ‘terminal PFAS’;
- PFAA precursor quantification is limited due to a lack of analytical standards;
- Total Oxidizable Precursor Assay (TOPA) is used to determine the presence of PFAA precursors in a sample (not commercial);



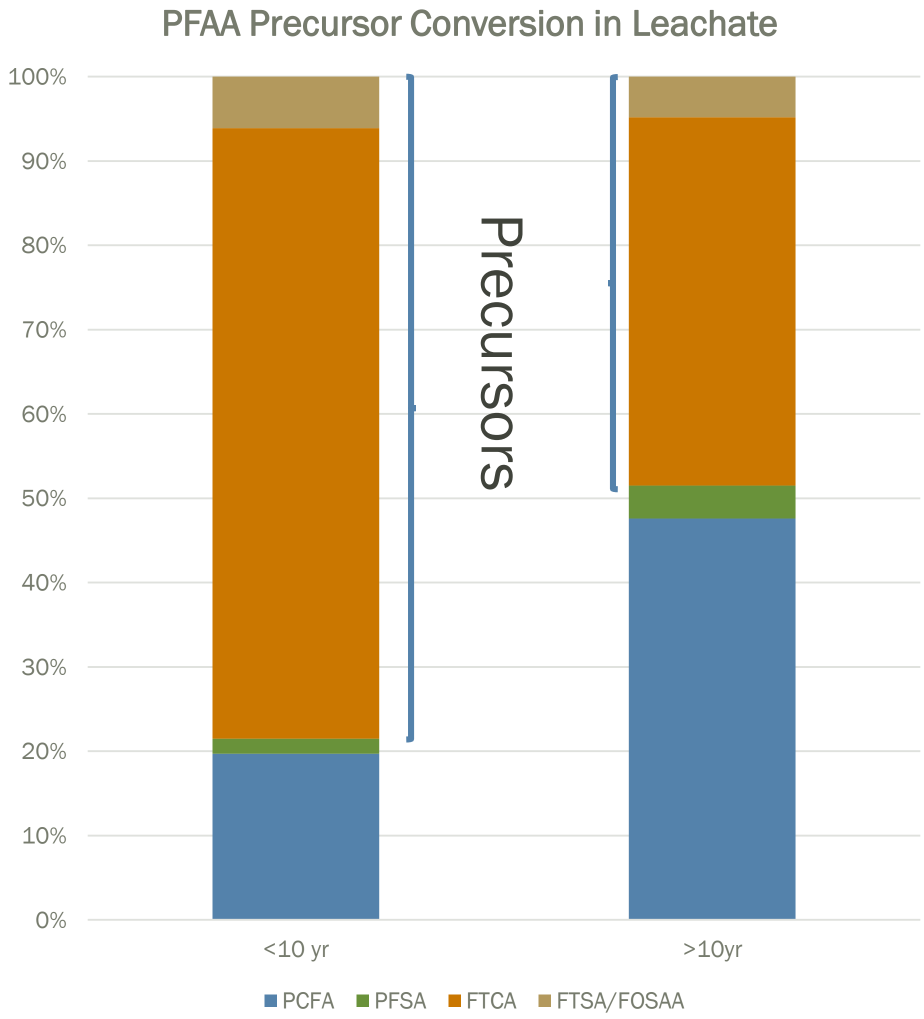
Source: Chiang (n.d.)



Leachate PFAA Precursor Estimate

- Precursor content decreased from 78.5% to 48.5% in LFs > 10 yrs
    - PFAS content is underestimated
    - Treatment to increase PFAS content
- PFAA precursor oxidation increases leachate PFAS content
- Additional oxidation during leachate treatment
- PFAA conversion estimate:

745.0 kg/yr × 2 = 1,490 kg/yr



Source: Lang et al. (2017)

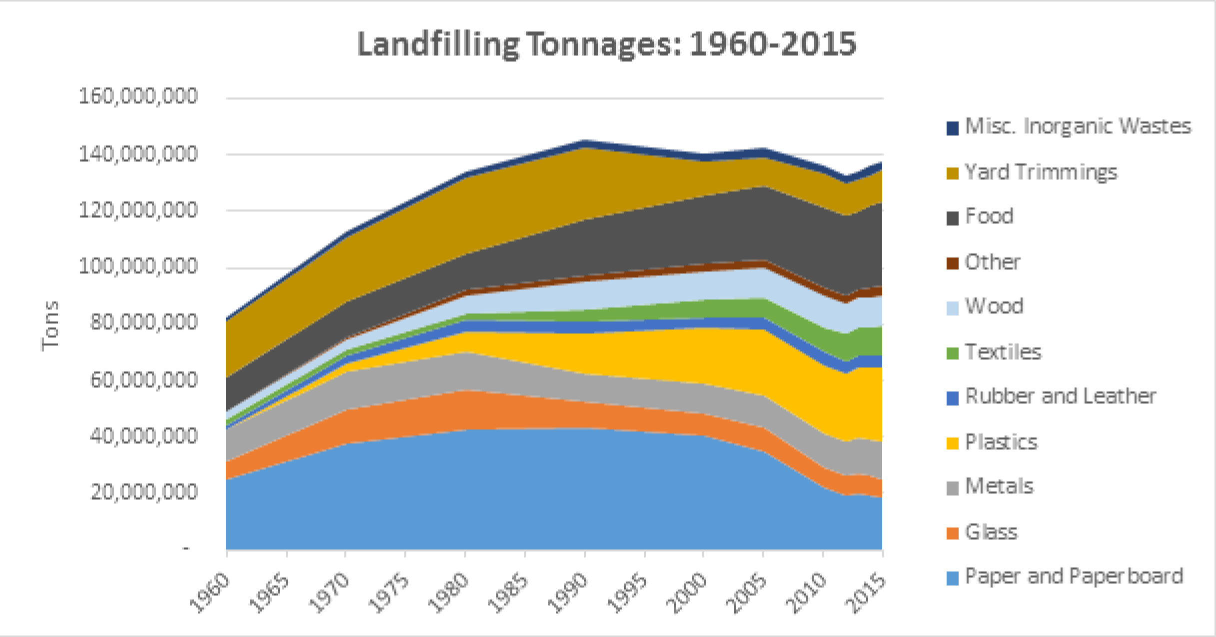
National Inventory of PFAS in US Biosolids (2001 EPA Survey)

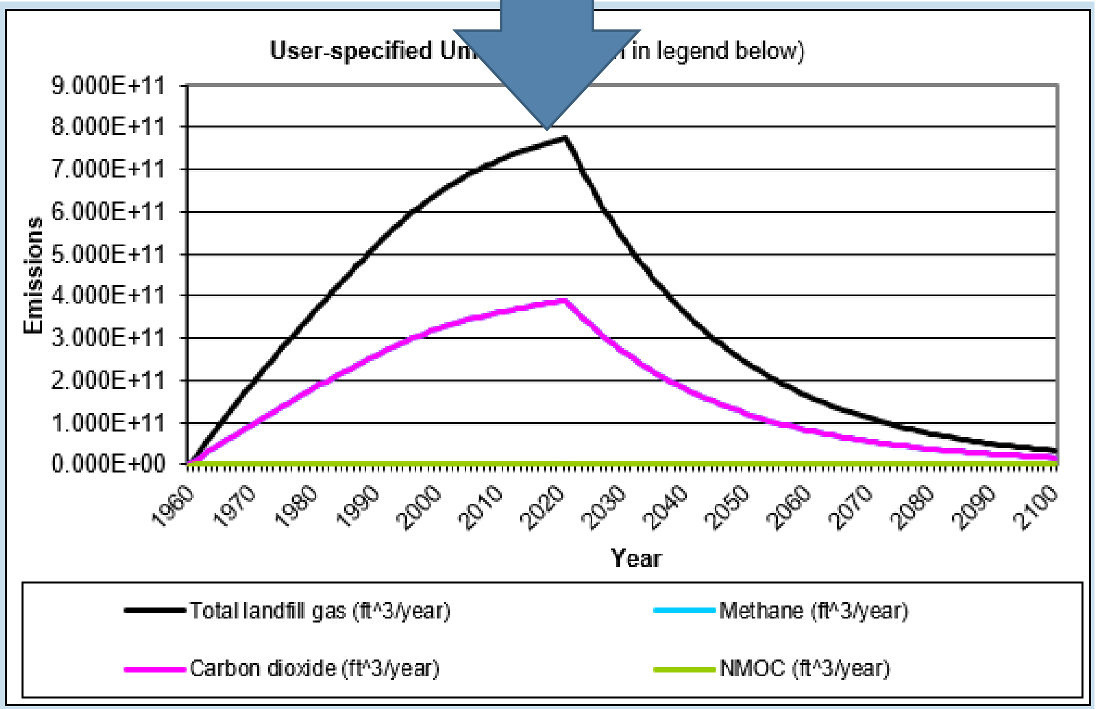
Compound	Concentration (ng/g-dw)	Detection Frequency	Estimated Annual Load (kg/year)				
			Biosolids Production	Land Application	Landfill	Incineration	%landfilled
PFBA	2.0 (1.2-3.2)	80%	10.0-12.5	5.0-7.5	1.7-2.1	2.0-2.5	
PFPeA	3.5 (1.8-6.7)	100%	17.7-22.2	8.8-13.3	3.0-3.8	3.5-4.4	
PFHxA	6.2 (2.5-11.7)	100%	31.8-39.9	15.9-23.9	5.4-6.8	6.4-8.0	
PFHpA	3.4 (1.2-5.4)	80%	17.4-21.8	8.7-13.1	3.0-3.7	3.5-4.4	
PFOA	**34.0 (11.8-70.3)**	**100%**	**172-215**	**85.8-129**	**29.3-36.6**	**34.3-43.1**	6.3%
PFNA	9.2 (3.2-21.1)	100%	47.2-59.1	23.5-35.5	8.0-10.0	9.4-11.8	
PFDA	26.1 (6.9-59.1)	100%	133.0-167.0	66.6-100.0	22.7-28.4	26.7-33.4	
PFUnDA	11.7 (2.8-38.7)	100%	59.9-69.7	29.9-45.1	10.2-12.8	12.0-15.0	
PFDoDA	10.9 (4.5-26.0)	100%	55.6-69.7	27.8-41.8	9.4-11.9	11.1-13.9	
PFBS	3.4 (2.5-4.8)	60%	17.6-22.0	8.8-13.2	3.0-3.7	3.5-4.4	
PFHxS	5.9 (5.3-6.6)	100%	29.9-37.5	15.0-22.5	5.1-6.4	6.0-7.5	
PFOS	**403 (308-618)**	**100%**	**2,052-2,575**	**1,026-1,545**	**349-438**	**410-515**	74.6%
PFOSA	20.7 (2.2-68.1)	100%	105-132	52.7-79.3	17.9-22.5	21.1-26.4	
Source: Venkatesan and Halden (2013)			**2,749-3,443**		**467.7-586.7**		**17.0%**

LFG Generation (not Recovery) Potential Estimate

LandGEM, using ‘Inventory Conventional’ settings:

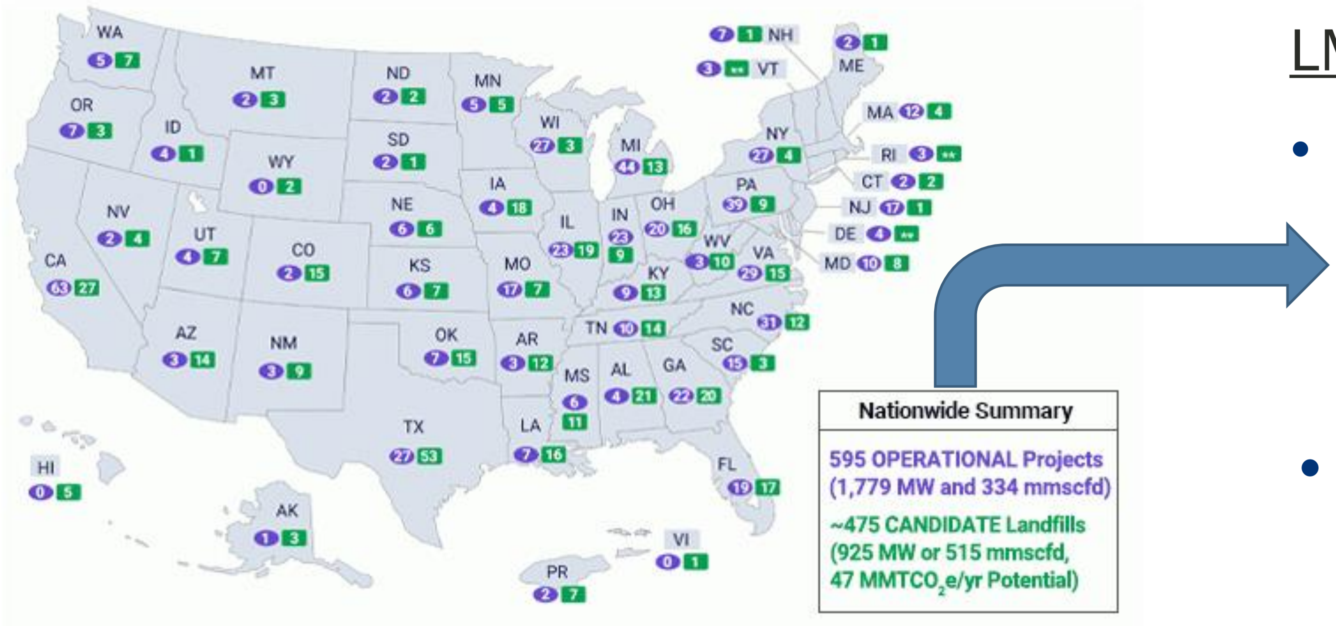
- Methane generation rate: $k=0.05\ yr^1$
- Specific methane generation capacity: $L_0=100\ m^3/Mg$





$7.719\times10^{11}\ ft^3/yr$

PFAS Emission Potential with LFG



Nationwide Summary

595 OPERATIONAL Projects (1,779 MW and 334 mmscfd)

~475 CANDIDATE Landfills (925 MW or 515 mmscfd, 47 MMTCO$_2$e/yr Potential)

<u>LMOP data</u>

- Recoverable LFG potential:

Operational:	334 mmscfd
Candidates:	515 mmscfd
Total:	849 mmscfd

- Assume 60% collection efficiency

Generation:	1,415 mmscfd
	5.165×10^{11} ft^3/yr

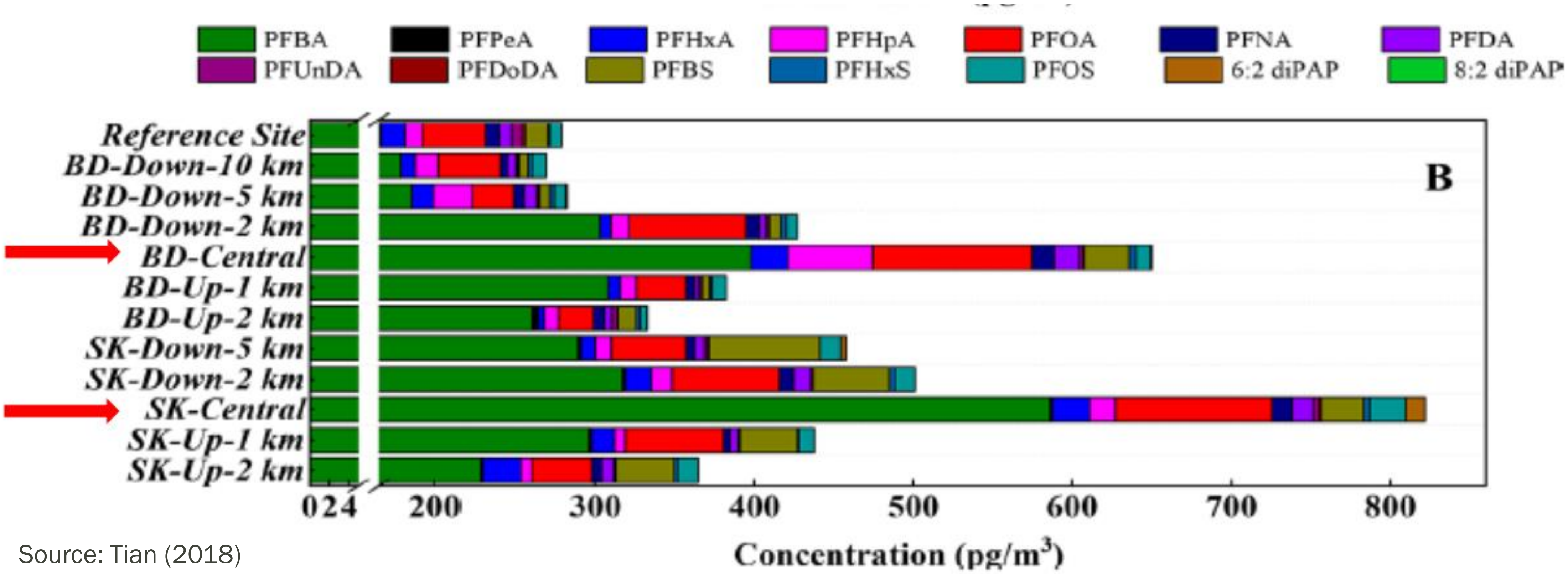
Source/Model	ft^3/yr	m^3/yr	Average
LandGEM	7.719×10^{11}	0.219×10^{11}	0.183×10^{11}
LMOP	5.165×10^{11}	0.146×10^{11}	

PFAS Potential to Emit with LFG

ΣPFAS in LFG: 650-850 pg/m^3, assume 1,000 pg/m^3

NEGLIGIBLE

Annual Emission Potential: 0.185×10^{11} m^3/yr × $1{,}000 \times 10^{-15}$ kg/m^3 = 0.02 kg/yr



Source: Tian (2018)

PFAS Input with Cover Material

Input with Cover Material

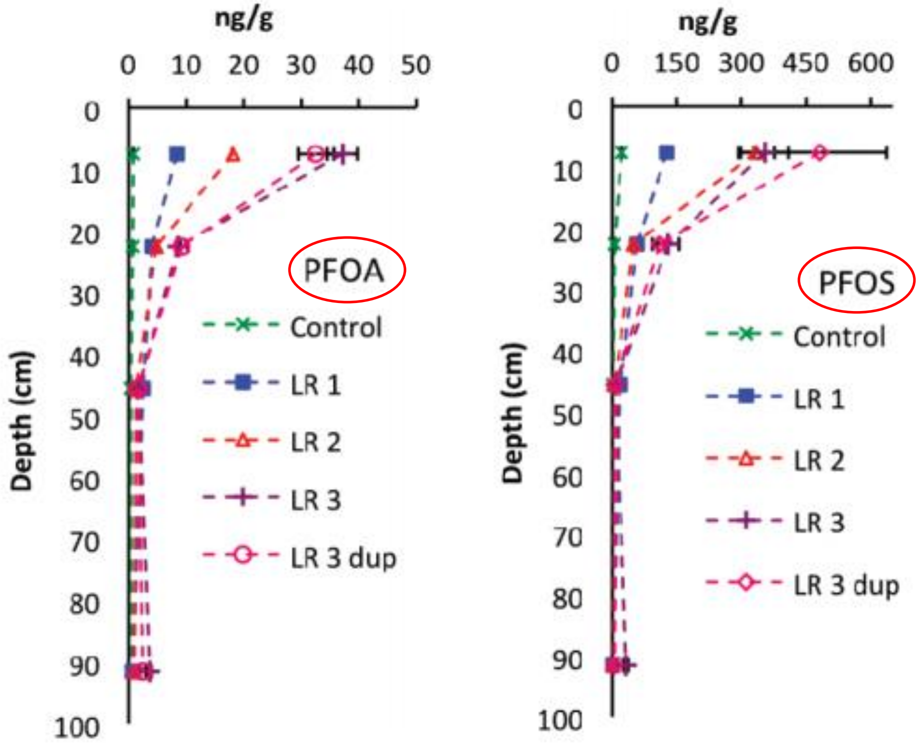
- Estimate cover as 20% of landfilled MSW

$$\Sigma PFAS = 25\ ng_{PFOA}/g_{soil} + 200\ ng_{PFOS}/g_{soil}$$
$$= 225\ ng/g$$
$$M_{PFAS} = 0.2 \times 140 x 10^6\ ton/yr \times 225\ ng/g$$
$$= \ldots$$
$$= 40.7\ kg/yr$$

PFAS leaching from Soils (Source: McLachlan et al., 2019)

- PFAS leaching occurred within 49-120 days
- Soil/water partitioning $k_d \approx 0.5$
  - Leached – 20.3 kg/yr (➔ leachate)
  - Adsorbed – 20.3 kg/yr (immobilized)

PFOA and PFOS in Soils from Land Application of Biosolids



Source: Sepulvado et al. (2011)

Annual Flux Summary by Stream (kg/yr)

			Input	Output	
Waste	~~1 ng/g~~	~~124.9~~			
	10 ng/g	1,249.2	1,249.2		
	~~100 ng/g~~	~~12,492.0~~			
	~~1,000 ng/g~~	~~124,920.0~~			
Biosolids	467.7 – 586.7		527.2		
Cover			20.3		
Leachate				745.0	
Precursors			745.0		
Landfill Gas				0.02	
Total Fluxes			2,541.7	745.0	29.3%
Net Flux			1,796.7		

Summary & Conclusions

- On a national basis, landfills appear to sequester PFAS
- The largest inputs of PFAS are
  - Solid waste
  - Biosolids
  - Precursors (internal source)
- Leachate is the predominant pathway for PFAS removal, about 30%
- LFG recovery and emissions appear to have little-to-no impact
- Review of additional data and papers to validate the finding
- Use of impacted cover soil – by itself – appears to be net neutral
- Role of precursors requires greater focus
- Need for larger sample size, better spatial and temporal resolution
- Need for standardizing sampling and analytical techniques

Questions? Comments?

thank you!

Arie P. Kremen, PhD
arie.kremen@tetratech.com
(w) 845.695.0213

Treatment Technologies for PFAS in Landfill Leachate

Ivan Cooper

Principal

Civil & Environmental Consultants, Inc.

Leachate Treatment for PFAS

ENVIRONMENTAL BUSINESS COUNCIL

FRAMINGHAM, MASSACHUSETTS

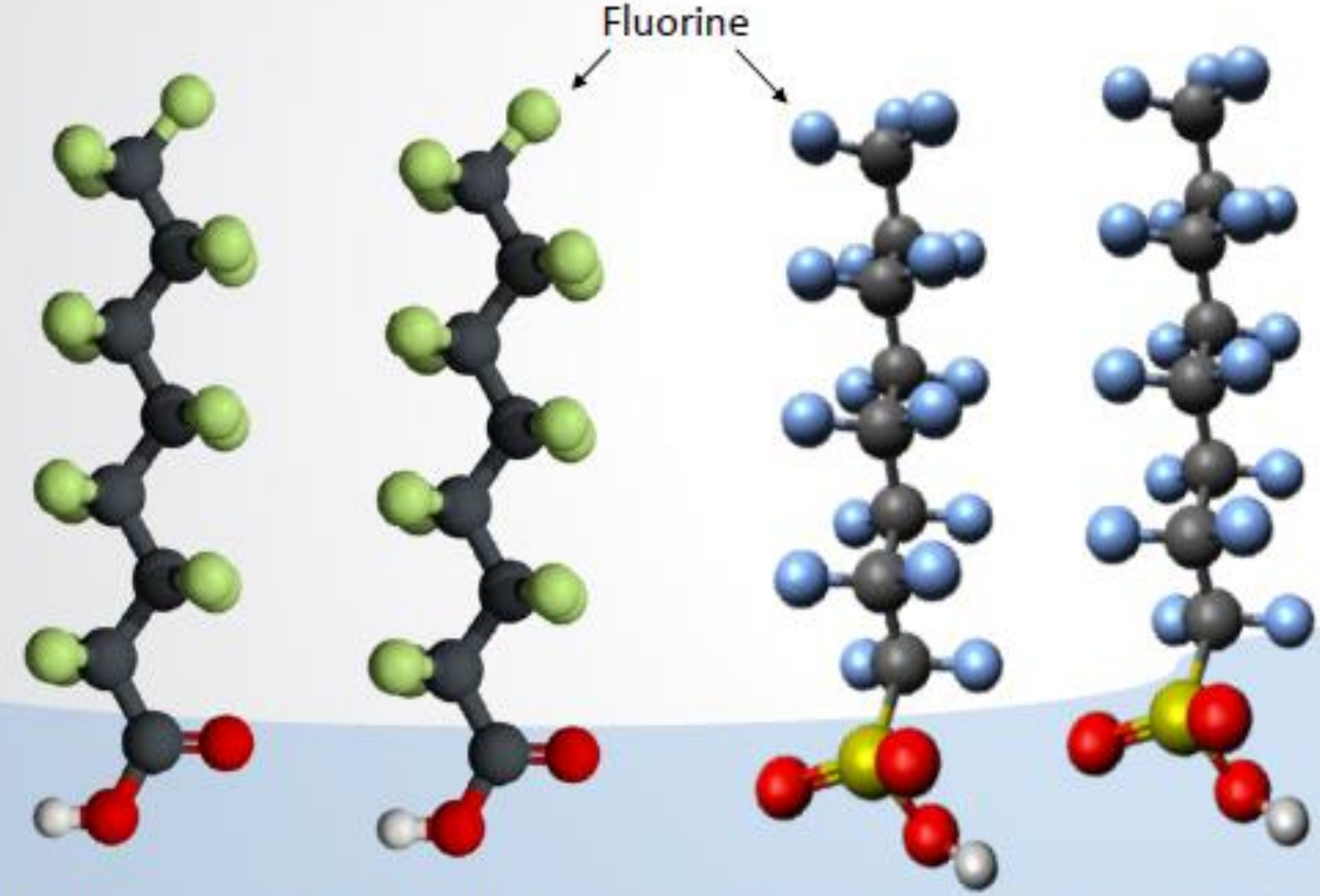
NOVEMBER 12, 2019

Ivan A. Cooper, PE, BCEE
Civil & Environmental Consultants, Inc.
Charlotte NC

Agenda

- **Emerging Contaminants –**
  - PFAS
- **Treatment Technologies**
  - Activated Carbon
  - Ion Exchange
  - Reverse Osmosis
  - Innovative Technologies
    - Advanced Remediation Catalysis (ARC)
    - Advanced Reduction Processes (ARP)
    - Non-Thermal Plasma Reduction
    - Advanced Oxidation – Persulfate; Nano-ZVI
    - Electro-Oxidation/Transmembrane Systems
    - Others?
- **Summary**

Per- and Polyfluoroalkyl Substances (PFAS) - What Are They?



Perfluorooctanoic acid (PFOA)

Perfluorooctanesulfonic acid (PFOS)

- ➢ A class of man-made chemicals
  - Chains of carbon (C) atoms surrounded by fluorine (F) atoms
    - – Water-repellent (hydrophobic)
    - – Stable C-F bond
  - Some PFAS include oxygen, hydrogen, sulfur and/or nitrogen atoms, creating a polar end

EPA , 2018

PFAS –Why Important?

- **Thousands of Fluorinated Compounds in class**
- **Short-chained (C_4-C_7) carboxylates or sulfonates are present at greater abundance relative to longer-chain homologs ($\geq C_8$).[1]**
  - Leachate tests showed Perfluoroalkyl carboxylates (2,800 ng/L max) followed by Perfluoroalkyl sulfonates (2,300 ng/L max).
  - Water soluble responsible for presence in leachate and potential release to the environment.
- **Linked to many health impacts, linked to cancer**
  - Example – 50,000 people sued DuPont in Parkersburg WV for PFOA in drinking water from plant making Teflon[2]
  - Current estimates are 15 million people have contaminated drinking water in US
  - Found in virtually every persons blood, US and worldwide

1.Huset et al., 2011
2. Environmental Working Group, 2018

Where PFAS is Used?

	Product Uses/Sources
Fluoropolymer coatings Plastics/polymers Oil, stain, water repellent (, Stainmaster® carpets, Scotch Gard™ and Gore-Tex®) Surfactants used in firefighting foams Mist suppressants for metal plating operations Photomicrolithography process to produce semiconductors Photography and film products 	Some grease-resistant paper Fast food containers/wrappers (27 fast food chains) Microwave popcorn bags Pizza boxes Candy wrappers Non-stick cookware such as Teflon™-coated pots/pans Used on carpets, upholstery, and other fabrics Water-resistant clothing - Hush Puppy Shoes (Wolverine Worldwide) Adhesives Aviation hydraulic fluids Cleaning products Personal care products such as shampoo, dental floss, and cosmetics (nail polish, eye makeup) Paints, varnishes and sealants

PFAS Found in Food 20 years ago!

- **3M Commissioned Study reported in 2001 – PFOA and PFOS in beef, pork, chicken, milk, green beans, eggs, bread, and others in 6 cities in US southeast**
  - Levels from 500 to 14,700 ppt
- **FDA study 2019 – PFAS in meat, seafood, dairy, sweet potatoes, pineapples, leafy greens, chocolate cake with icing –**
  - **17,640 parts per trillion (ppt) of perfluoro-n-pentanoic acid (PFPeA) in chocolate cake with icing**.
  - If regulated at same level as proposed NY drinking water guidelines of 10 ppt, cake would contaminate thousands of gallons of water.

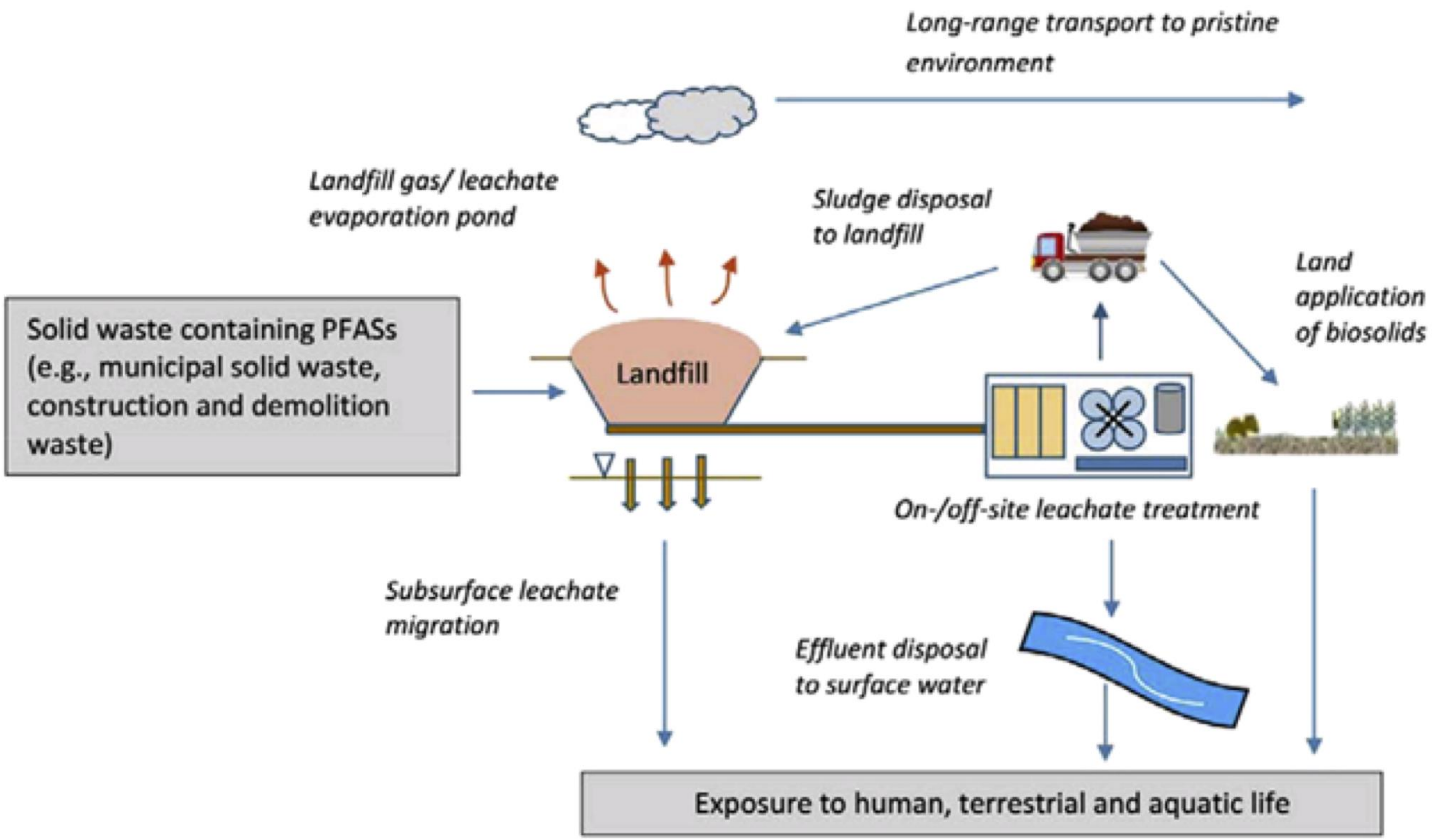
Drinking Water Standards

Parts per Trillion - As of October 2019										
		PFOS	PFOA	PFNA	PFHxS	PFHpA	PFBS	PFDA	PFHxA	GenX
USEPA	Health Advisory	**70 sum**		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
ATSDR	Tox Values	**7**	**11**	**10**	**70**	**NA**	**NA**	**NA**	**NA**	**NA**
NY	Recommended MCL	**10**	**10**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
NJ	MCL or Proposed	**13**	**14**	**13**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
VT	Health Advisory/ Emergency Rules	**20 sum of five**				**NA**	**NA**	**NA**	**NA**	**NA**
MA	Current ORSG	**20 proposed sum of six**					**NA**	**NA**	**NA**	**NA**
CT	Water Board Notification Levels	**70 sum of five**				**NA**	**NA**	**NA**	**NA**	**NA**
CA	Regulatory Standard	**6.5**	**5.1**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
MI	Health Based	**16**	**8**	**6**	**51**	**NA**	**420**	**NA**	**400,000**	**370**
MN	Drinking Water Guidelines	**70**	**38**	**NA**	**47**	**NA**	**NA**	**NA**	**NA**	**NA**
NH	Regulatory Standards	**12**	**15**	**23**	**85**	**NA**	**NA**	**NA**	**NA**	**NA**
NC	Guidance/Goals	**70 sum**		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**140**
Other States	EPA Values	**70 sum**		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

PFAS

- Lined landfills = leachate; unlined C&D landfills = groundwater; Soluble in water
- Readily bind to solids, but hard to predict
- Very Stable and persistent (3M in Minnesota, DuPont primary suppliers – now banned)
- Not treatable by conventional technology
- In 1/3 drinking water supplies in US, dust/ambient air, food
- High human toxicity, possibly human carcinogen, bioaccumulative
- Found in many landfill leachates (Canada study on 28 landfills– found in all leachates)
- Lab data difficult – Sampling protocol, Lab techniques, high variability, poor confidence?

PFAS Landfill Cycle



Long-range transport to pristine environment

Landfill gas/ leachate evaporation pond

Sludge disposal to landfill

Land application of biosolids

Solid waste containing PFASs (e.g., municipal solid waste, construction and demolition waste)

Landfill

On-/off-site leachate treatment

Subsurface leachate migration

Effluent disposal to surface water

Exposure to human, terrestrial and aquatic life

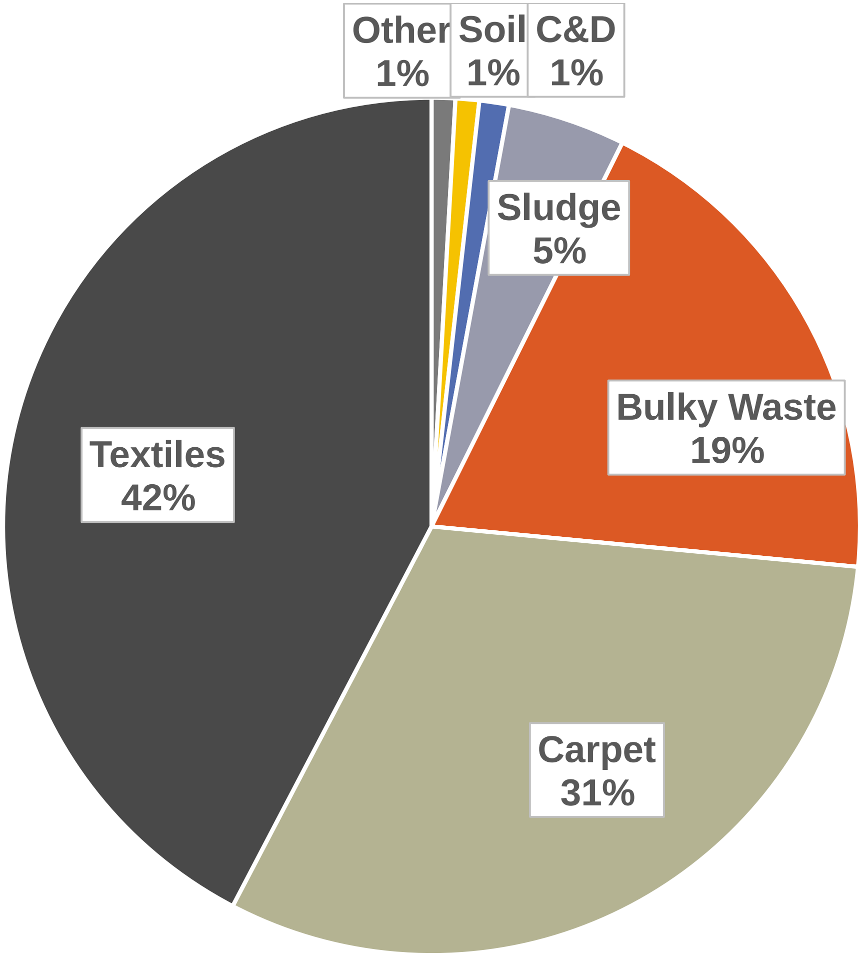
PFAS Impacts on Landfills

- POTW – Plants may put limits on leachate; likely during re-permitting
- PFAS found in all waste types and hard to limit amount entering landfills
- PFAS will be discharged in leachate
- Low levels make analysis difficult and expensive
- Low level limits likely, but unclear at this time
- Cost of sampling, analysis, and leachate management will go up
- Start seeing in state and local permits
  - VT, MI, others?

Usage	Aqueous film-forming foams (AFFF)	Military installations, airports, hangars, fire training areas, refineries
	Metal plating (mist suppressants)	Industrial facilities, water discharges
	Photolithographic chemicals	Manufacturing and processing
	Coatings that resist heat, oil grease, stains: Scotchgard, Gore-Tex, Teflon, food packaging, fabrics, carpet	Households and production facilities

US Military had largest stockpile of AFFF:
11 million L,
29% of US stocks
in 2004

PFAS Mass Loading

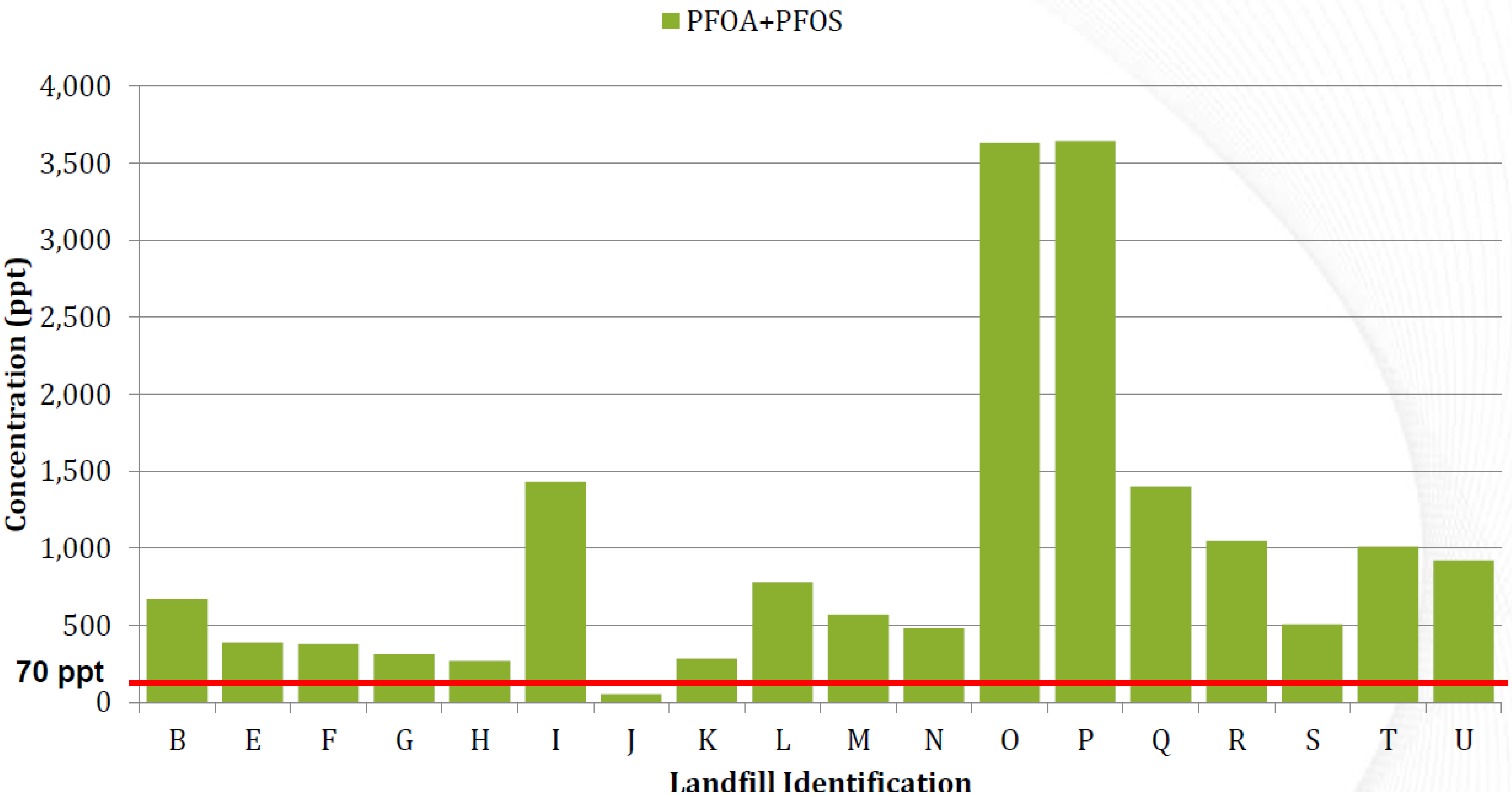


Recent LF Waste Study (Biased)

95% of tested waste contained PFAS

Excluded MSW

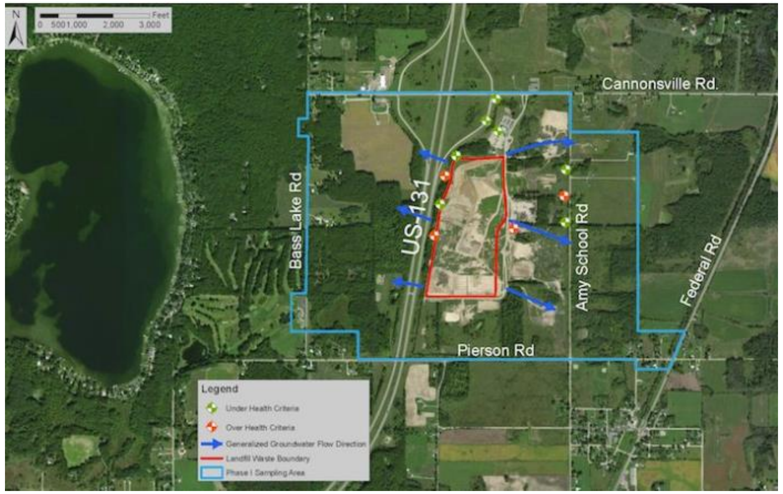
PFAS in Landfill Leachate



Lang et al, National Estimate PFAS Release to US Municipal Landfill Leachate, 2017

Site Example – Wolverine Dump Sites, Michigan

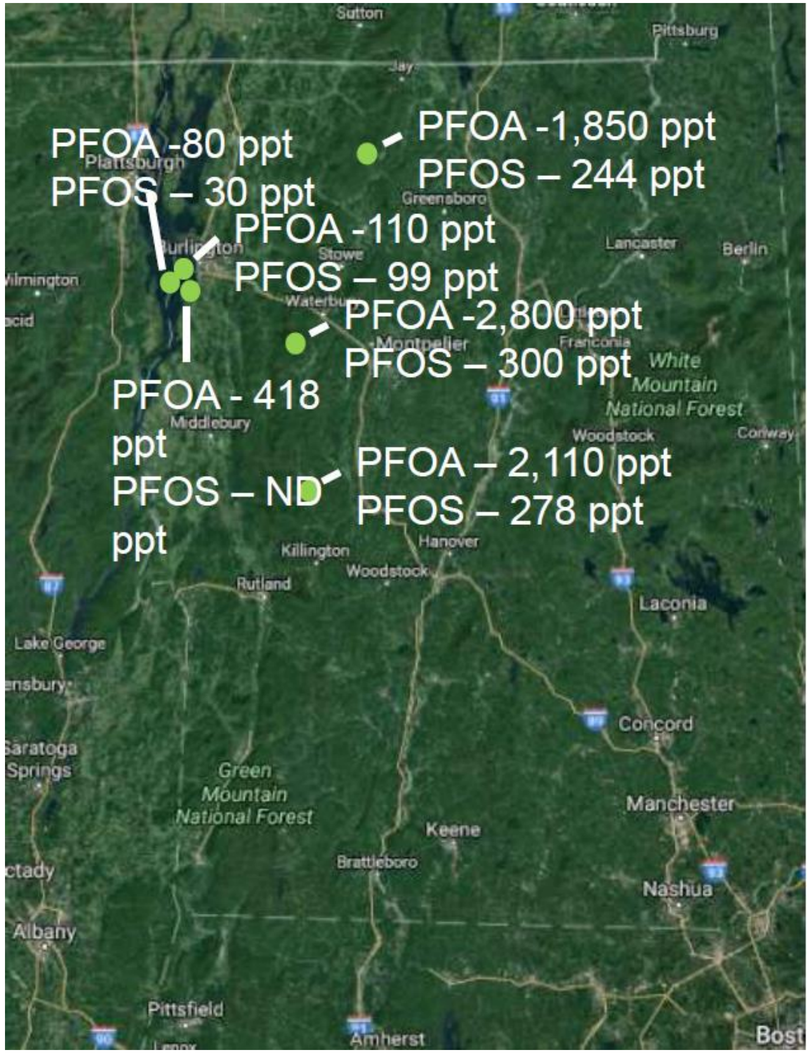
- Wolverine Worldwide dumped PFAS wastes in several Michigan landfills
- Wolverine World Wide tannery waste dumped into Northeast Gravel mine and landfill daily between 1970 and 1979. Keeler Brass also dumped electroplating wastes.
- A well near the Wolverine Gravel dump less than 10 miles away has almost 59,000 ppt PFAS, now a Superfund site
- Central Sanitary landfill, located in the Montcalm County village of Pierson, recently tested at concentrations above 70 parts-per-trillion.
- Kent County MI Landfill also has high concentrations PFAS
- Michigan very active in landfill identification and leachate for PFAS



Gallery: Wolverine tannery waste buried under golf course

Vermont Landfill Leachate

(Vermont DEC, May 2018)



PFOA
High – 2,800 ppt
Low – 80 ppt

PFOS
High – 300 ppt
Low – Non-detect

Transborder implication – data and evaluations to the Gouvernement du Quebec Ministere de l'Environnement.

1,000 feet to Lake Memphremagog – water supply to Quebec.

Vermont Guidelines, May 2018

PFAS Analyte:	Landfill Leachate concentration requiring no restrictions	Landfill Leachate concentration which may require restrictions	Landfill Leachate concentration requiring pretreatment
PFOA	0.120 mg/L (120,000 ppt)	0.120 mg/L to 1.2 mg/L	>1.2 mg/L
PFOS	0.001 mg/L (1,000 ppt)	0.001 mg/L to 0.010 mg/L	>0.010 mg/L

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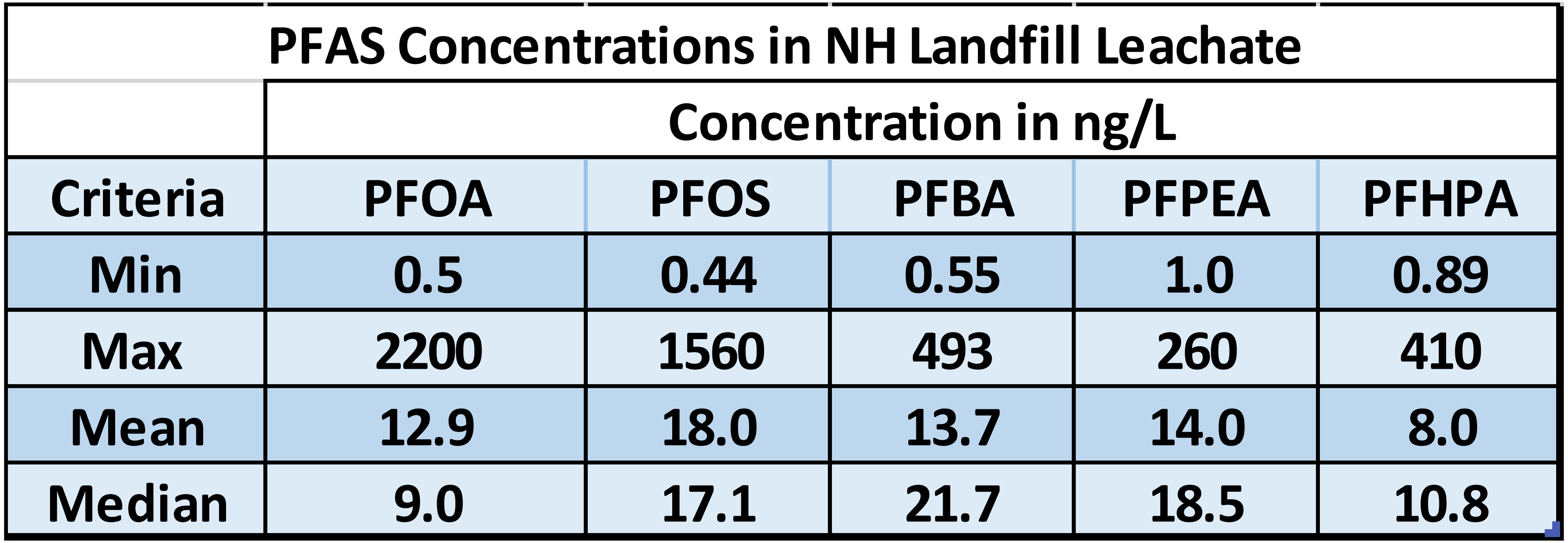
Vermont PFAS in Closed Landfills

(Vermont DEC, May 2018)

ppt	MSW LF 1	MSW LF 2	MSW LF 3	MSW LF 4	MSW LF 5	MSW LF 6	Paper Sludge LF	C&D LF
Sample Date	10/17	10/17	9/16	9/16	10/16	12/16	10/16	10/16
PFOA	11.3	44.9	8.43	14	2	8.99	18	900
PFOS	ND	37	4.98	5	ND	ND	11	140
TOTAL	11.3	81.9	13.41	19	2	8.99	29	1040

PFAS in NH Landfills



PFAS Concentrations in NH Landfill Leachate					
	Concentration in ng/L				
Criteria	PFOA	PFOS	PFBA	PFPEA	PFHPA
Min	0.5	0.44	0.55	1.0	0.89
Max	2200	1560	493	260	410
Mean	12.9	18.0	13.7	14.0	8.0
Median	9.0	17.1	21.7	18.5	10.8

PFAS in Landfill Leachate
Nationwide - 20 Billion Gals/yr - 1900 Landfills *

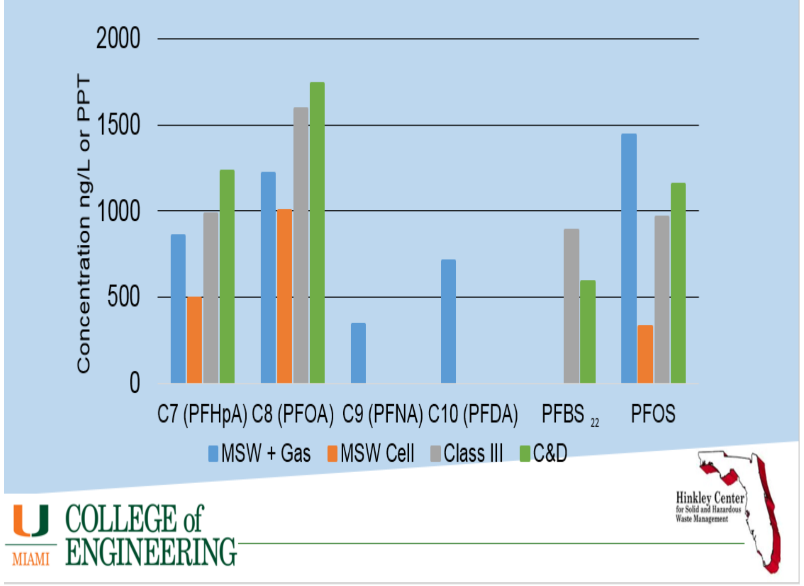
▶ Main Typical PFAS*:

- ▶ Typical Concentrations: 0.1 to 10 ppb *
- ▶ **PFOA** perfluorooctanoic acid
- ▶ **PFHxA** perfluorohexanoic acid
- ▶ **5:3 FTCA** fluorotelomer carboxylic acids

* Ref. Lang, Johnsie PFAS in MSW Landfill Leachate 2016 Thesis UNC

▶ Other PFAS:

- ▶ Typical Concentrations: 0.2 to 1.5 ppb
- ▶ PFOS
- ▶ PFBS
- ▶ PFHpA
- ▶ PFNA
- ▶ PFDA



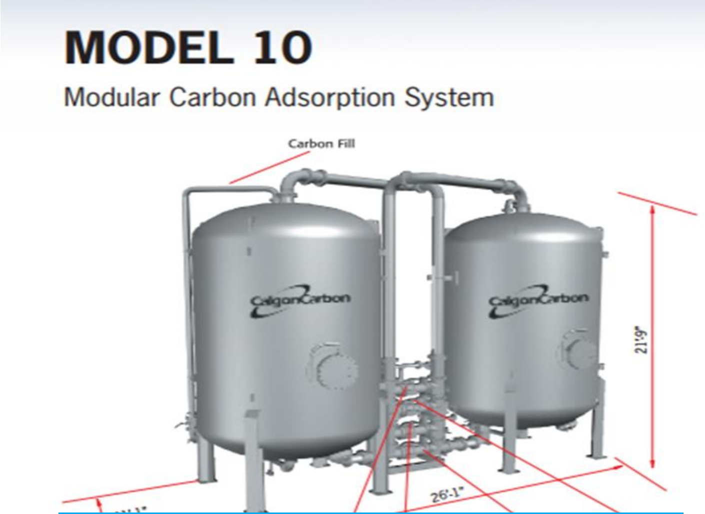
Primary Source: Carpets and Clothing

PFAS Treatment Technologies

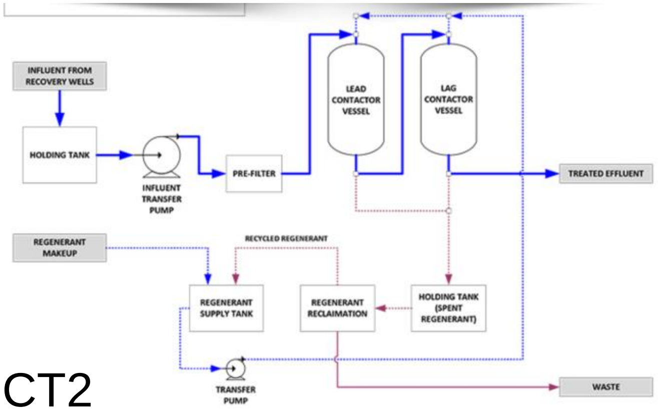
- Activated Carbon
- Ion Exchange
- Reverse Osmosis
- Deep Well Injection
- Innovative Technologies
  - Advanced Remediation Catalysis (ARC)
  - Advanced Reduction Processes (ARP)
  - Non-Thermal Plasma Reduction
  - Advanced Oxidation – Persulfate; Nano-ZVI
  - Plasma Arc
  - Etc
  - Etc
  - Etc

PFAS Remediation Options for Pump & Treat

Membrane Filtration



Carbon Adsorption



ECT2

Methanol/Brine
Regenerable Resin

Single-Use Resin

Types/Forms of Activated Carbon

Raw Materials


Wood


Coconut Shell


Peat/Lignite

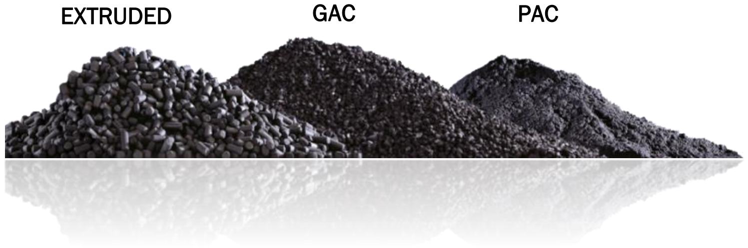

Bituminous Coal

Raw Material dictates:

- **Ash impurities**
- **Density**
- **Hardness**
- **Transport pore structure**
- **Adsorption kinetics**

Wood ≠ Coconut ≠ Lignite ≠ Bit. Coal

Forms of Activated Carbon



Extruded: Typically, vapor phase

Low Pressure Drop /Slow Kinetics

Usually, 3 or 4 mm diameter

GAC: Liquid Phase (12x40, 8x30)

Vapor Phase (4x8, 4x10)

PAC: Typically, Liquid Phase 65-85% < 325 U.S. Mesh (0.045 mm) or finer

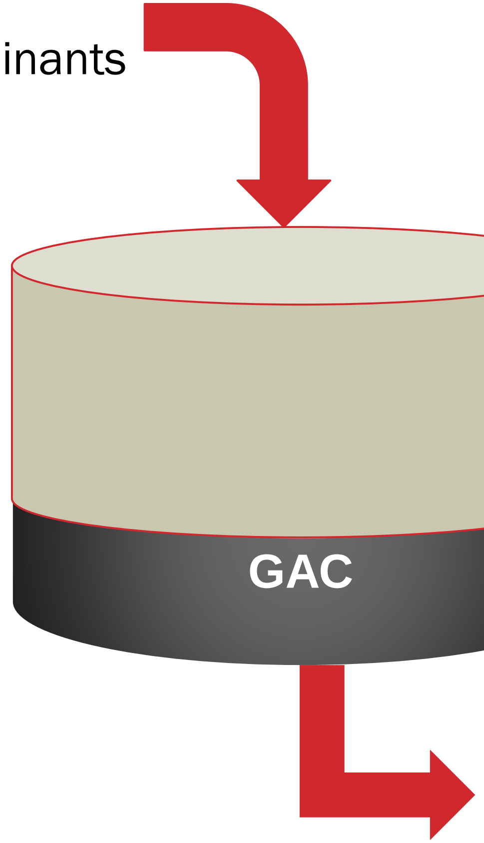
(Smaller particles have faster kinetics, but are more challenging to remove)

GAC Adsorption

- With GAC, adsorption occurs on the surface of the interior graphite platelets which are the solid part of the porous structure of the granules
- Adsorption is an equilibrium process and capacity is concentration dependent
- Exhausted GAC can often be sent to a reactivation furnace to destroy the adsorbates and produce a reusable product – air emissions?

Activated Carbon

- **Granular Activated Carbon (GAC) Well Demonstrated**
  - Bituminous GAC – increasing full scale installations
  - Competing Organics fill absorption sites
  - Needs high quality leachate treatment before GAC



Influent

Bulk solution + Contaminants

Effluent

Treated Solution

General Comments:

Typically operate downflow

Typically Empty Bed Contact Time (EBCT) is in **minutes**

Typical Superficial Velocities:
2-5 gpm/ft^2

Isotherm testing initially done for feasibility

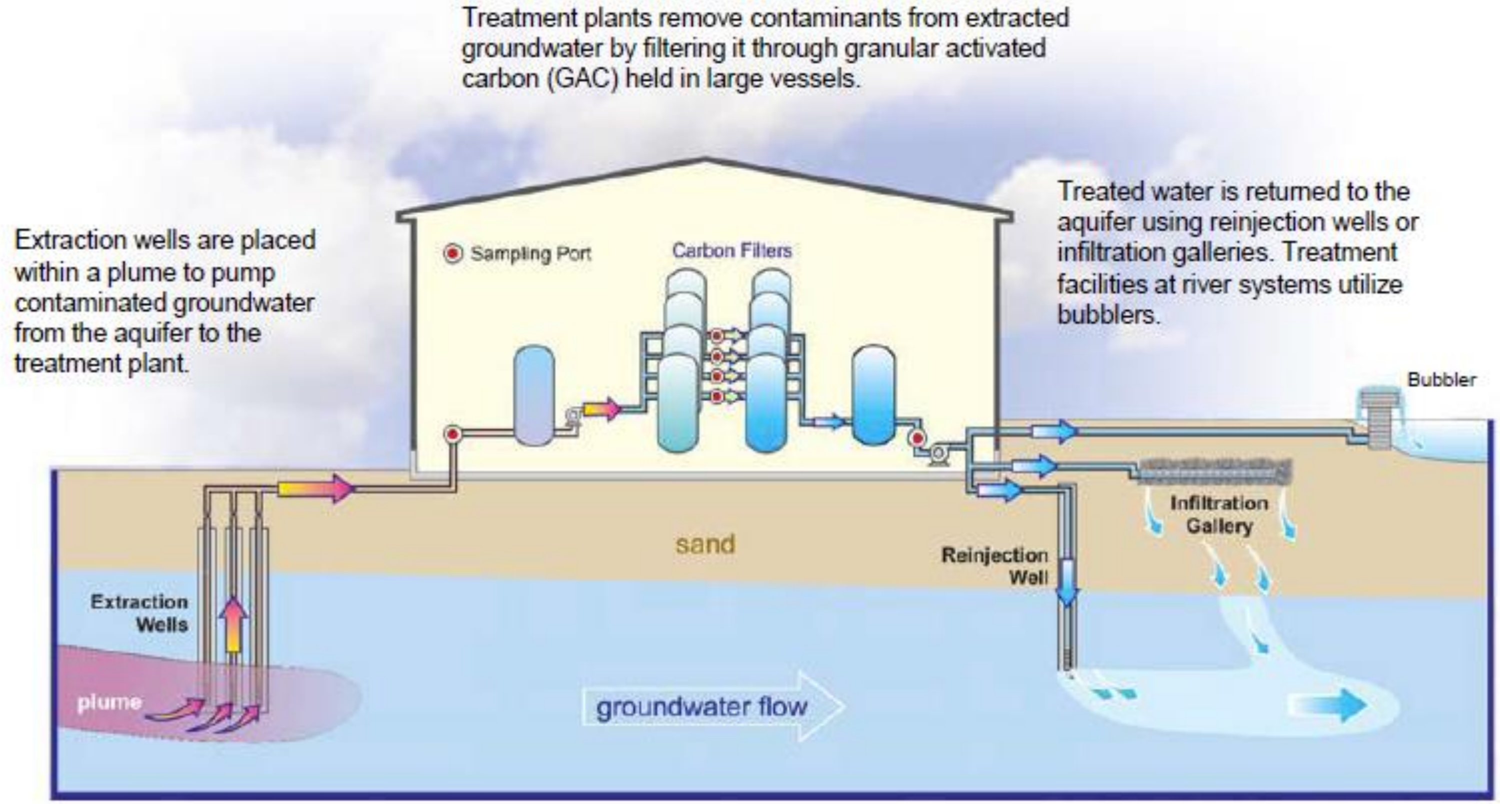
Accelerated Column Test (ACT)/Rapid Small Scale Column Test (RSSCT) or pilot performed to validate system design

Some usage rates/performance can be computer modeled in water

GAC can be reactivated once it has been used

GAC Perfluorinated Compound Adsorption

- GAC has been in use at Minnesota sites for groundwater treatment for many years in this service
- Spent GAC can be successfully reactivated from this service for a minimum of waste generation
- As is typical of GAC adsorption, smaller and lower formula weight compounds tend to adsorb less strongly than larger, heavier compounds with similar structures.



Treatment plants remove contaminants from extracted groundwater by filtering it through granular activated carbon (GAC) held in large vessels.

Extraction wells are placed within a plume to pump contaminated groundwater from the aquifer to the treatment plant.

Treated water is returned to the aquifer using reinjection wells or infiltration galleries. Treatment facilities at river systems utilize bubblers.

Courtesy USAF – Jt. Base Cape Cod

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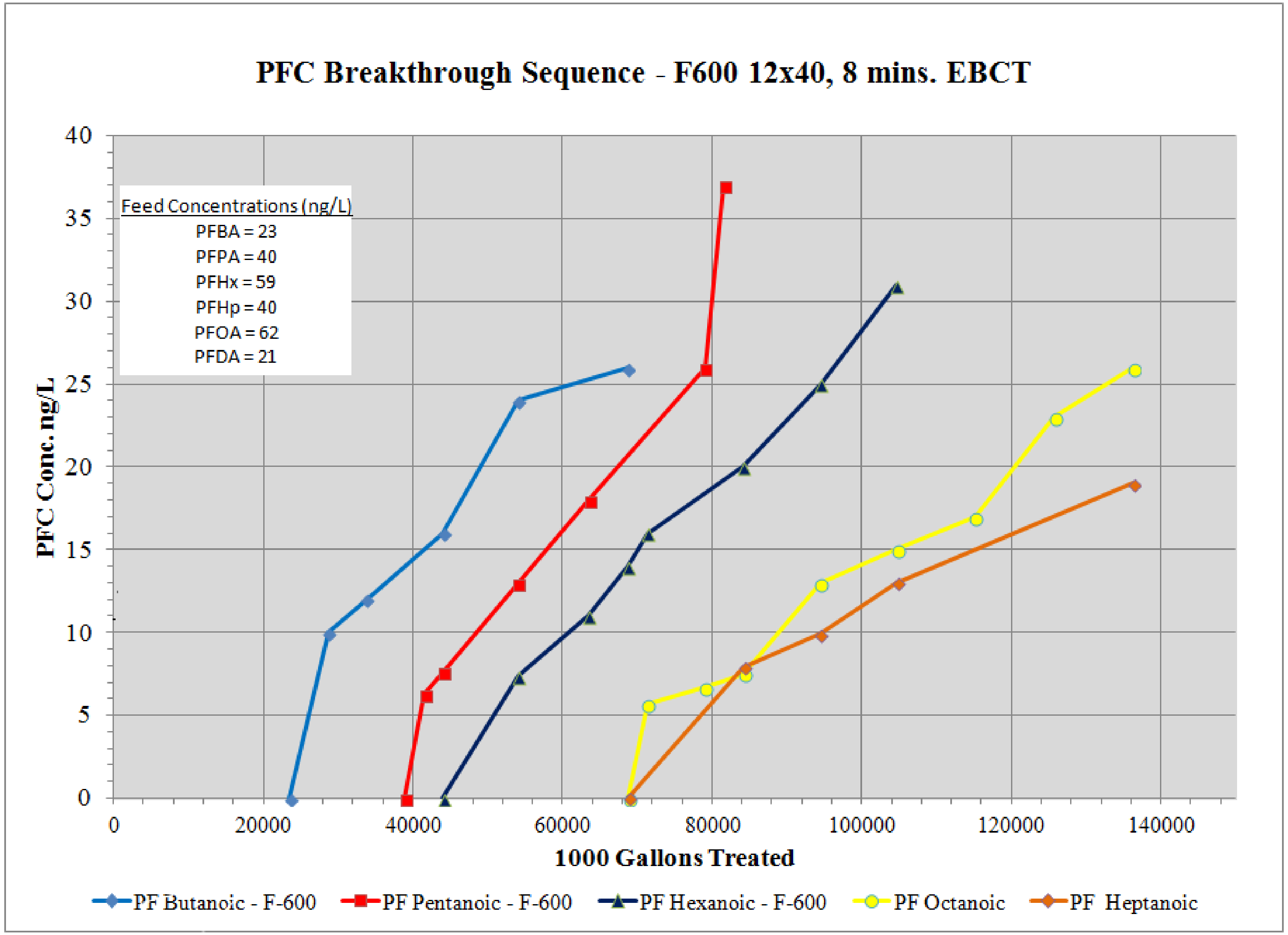
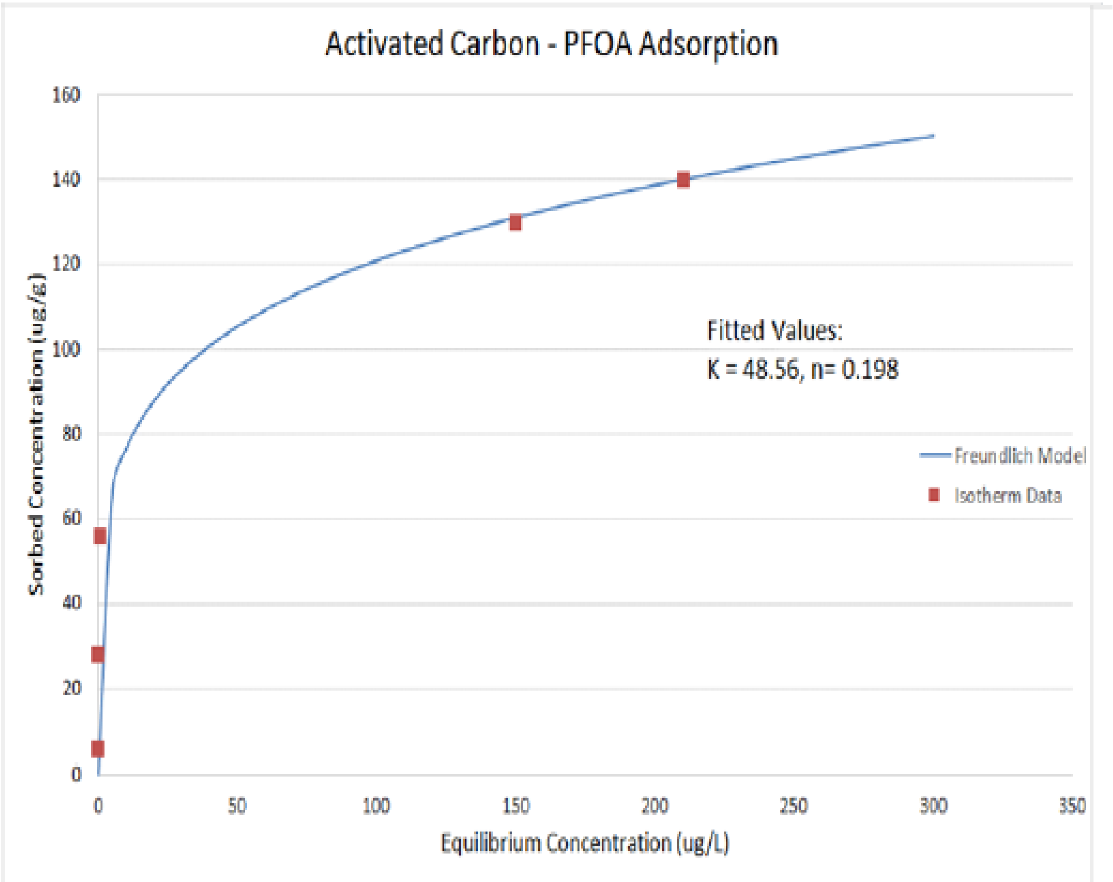
GAC Perfluorinated Compound Relative Activated Carbon Breakthrough Time versus PFAS congeners

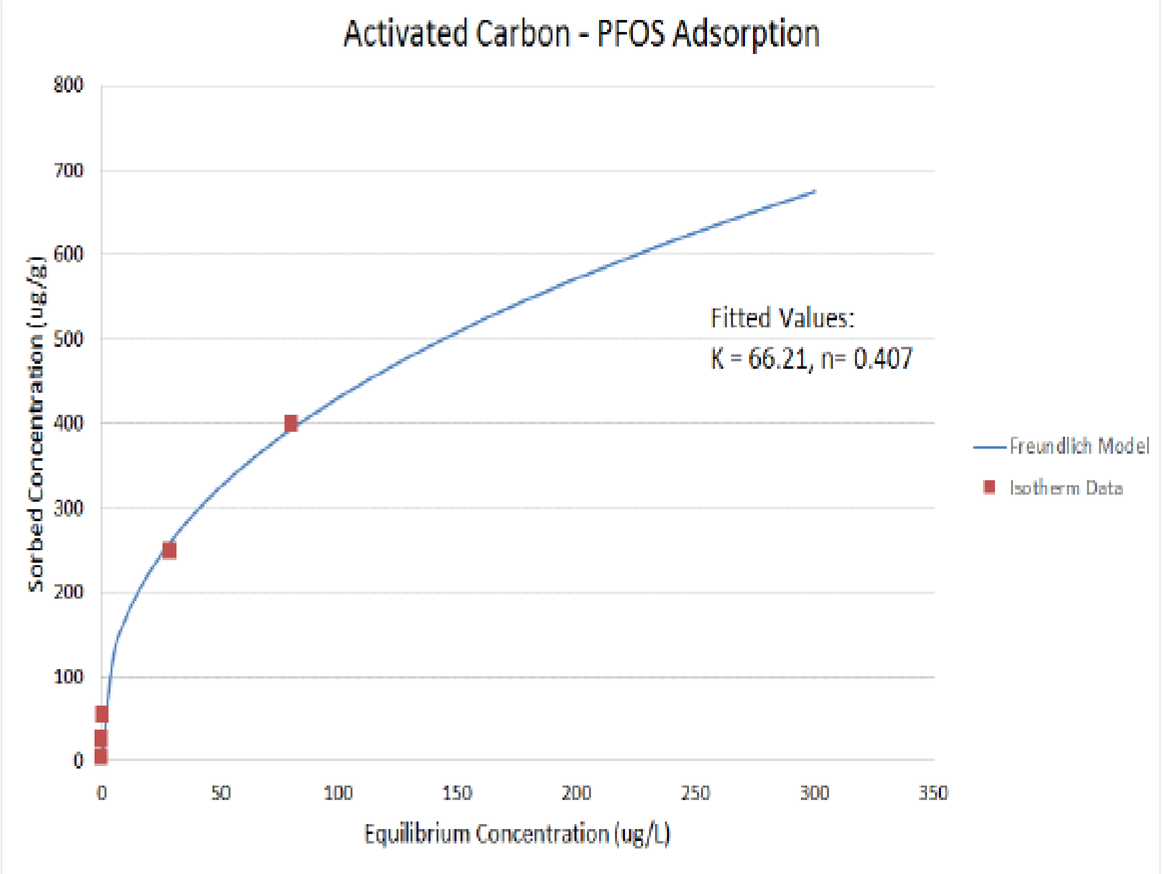


GAC PFAS Adsorption



Activated Carbon - PFOA Adsorption

Fitted Values:
K = 48.56, n= 0.198

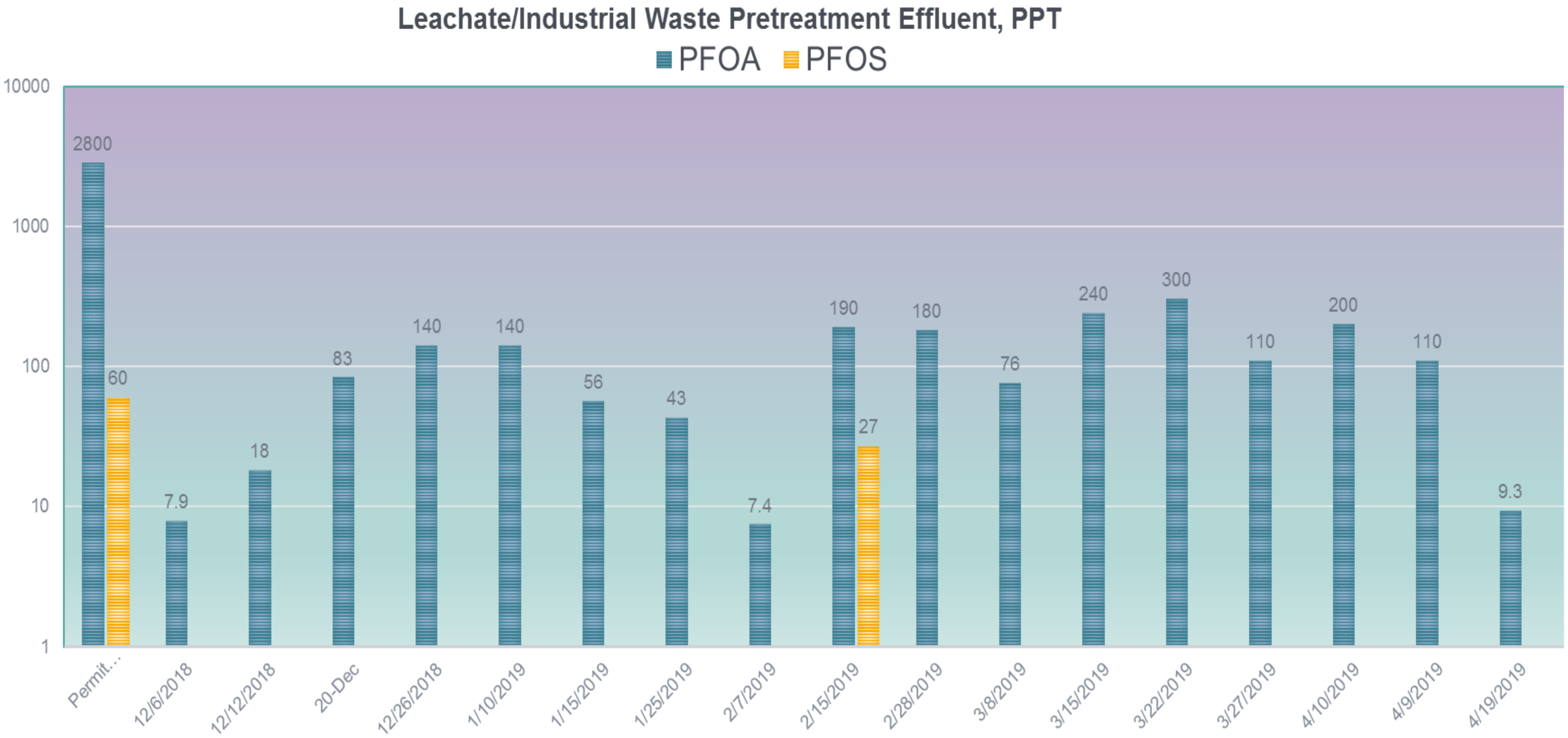


Activated Carbon - PFOS Adsorption

Fitted Values:
K = 66.21, n= 0.407

So absorption characteristics depend on type of PFAS!! – See vertical scale on both graphs.

GAC Actual Performance on Wastewater/Leachate

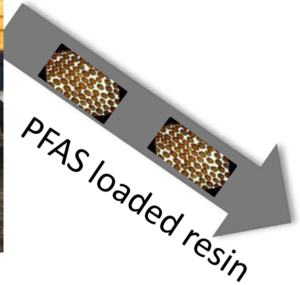


Note: Limited information on design, influent, operating conditions,

IX - Single-Use Selective Resin + Incineration

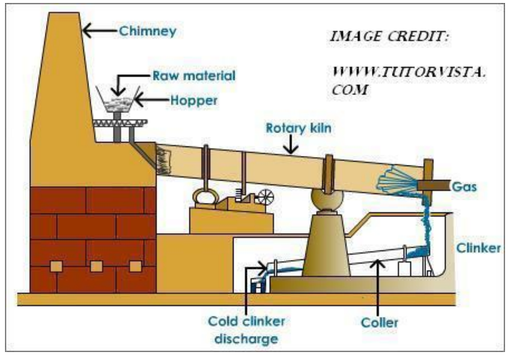
PFAS in water

PFAS –free water



PFAS loaded resin

Cement Kiln Incineration
1400°C to 2000°C



Complete Destruction of PFAS

Short Contact Time ~3 mins
Simple & Effective - Operator Preferred.

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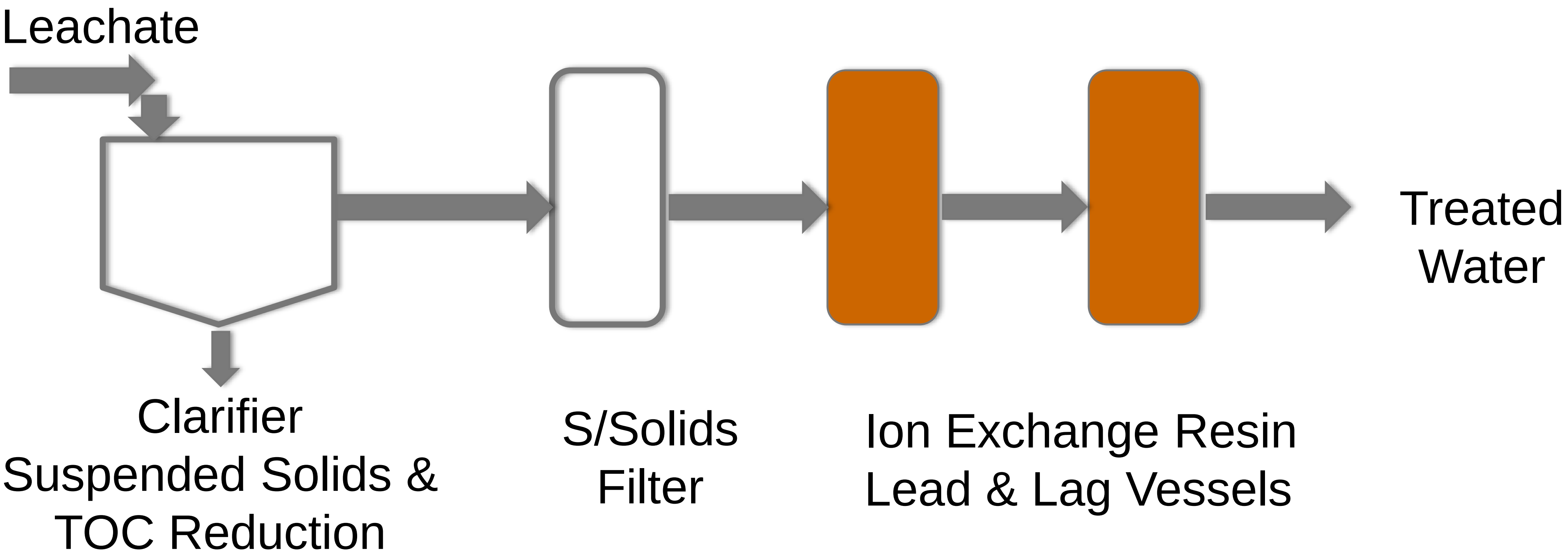
General Process Flow Scheme Using Ion Exchange



Leachate

Clarifier
Suspended Solids &
TOC Reduction

S/Solids
Filter

Ion Exchange Resin
Lead & Lag Vessels

Treated
Water

Selective IX Capacity in leachate : Expect 10,000 to 20,000 BV

IX - Ion Adsorption

- **Many competing constituents**
  - Constituents Slows transport kinetics (speed that constituents adsorb)
  - Limits adsorption capacity (how much PFAS can be adsorbed)
  - Background organics
  - Anions (chlorides, sulfates)
  - May be restricted to batch treatment given limitations

Must Consider Negative Impact of Leachate Chemistry on GAC & IX

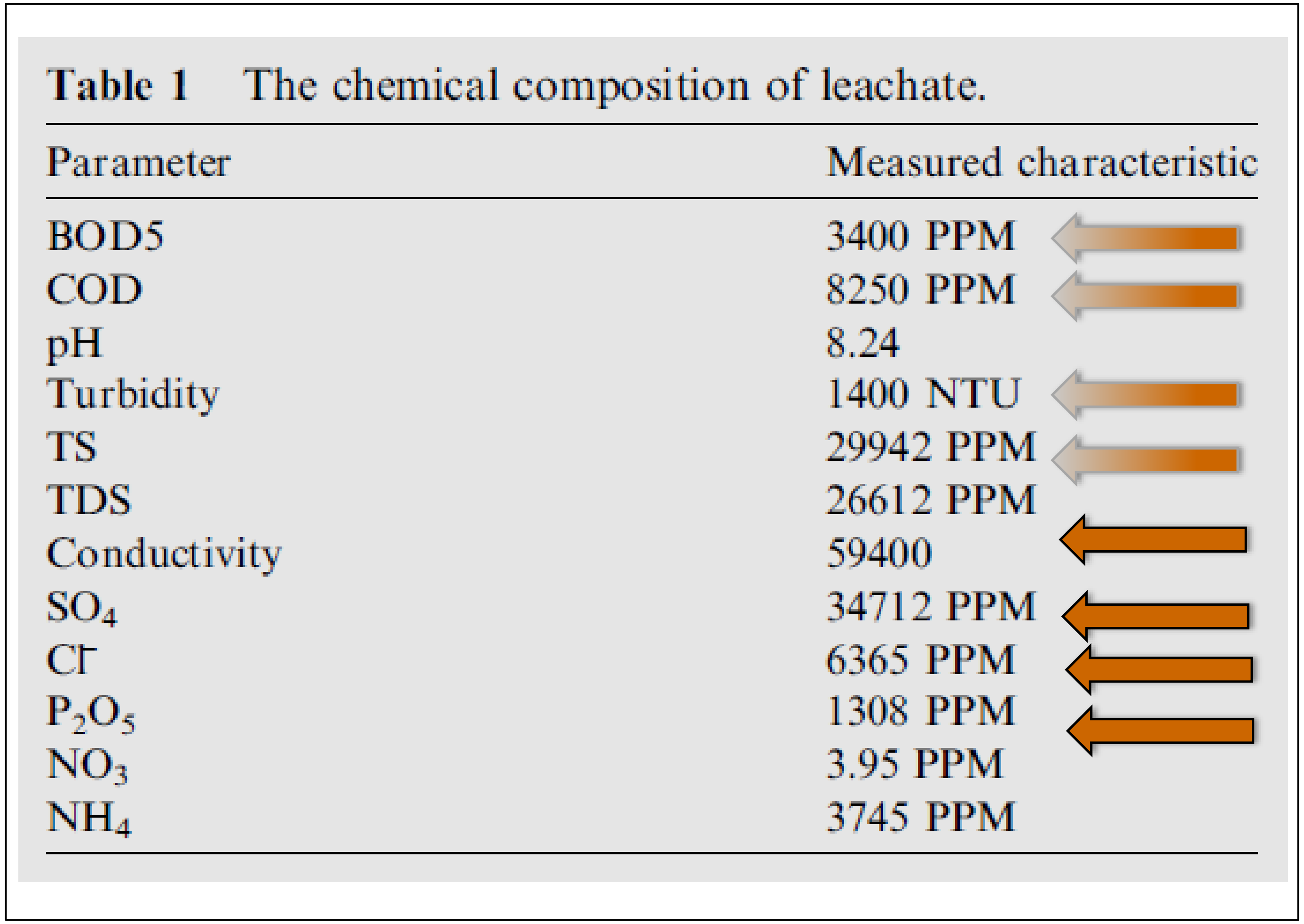


Table 1 The chemical composition of leachate.

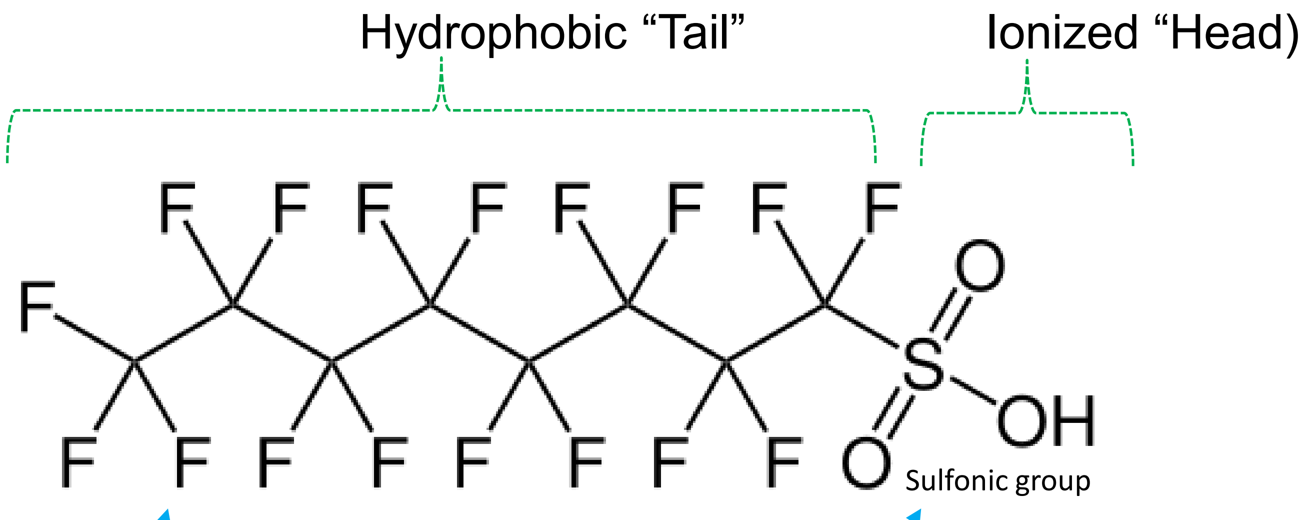
Parameter	Measured characteristic
BOD5	3400 PPM
COD	8250 PPM
pH	8.24
Turbidity	1400 NTU
TS	29942 PPM
TDS	26612 PPM
Conductivity	59400
SO_4	34712 PPM
Cl^-	6365 PPM
P_2O_5	1308 PPM
NO_3	3.95 PPM
NH_4	3745 PPM

Some constituents interfere more than others!!

Ref. Raghab,Safaa, Treatment of Municipal Solid Waste Landfill HBRC Journal 2013 Vol 9 187-192

Superior Dual Removal Mechanisms for IX vs GAC

PFOS – Perfluoroalkyl Sulfonic Acid



GAC

removes by adsorption
using hydrophobic “Tail”

Selective IX Resins

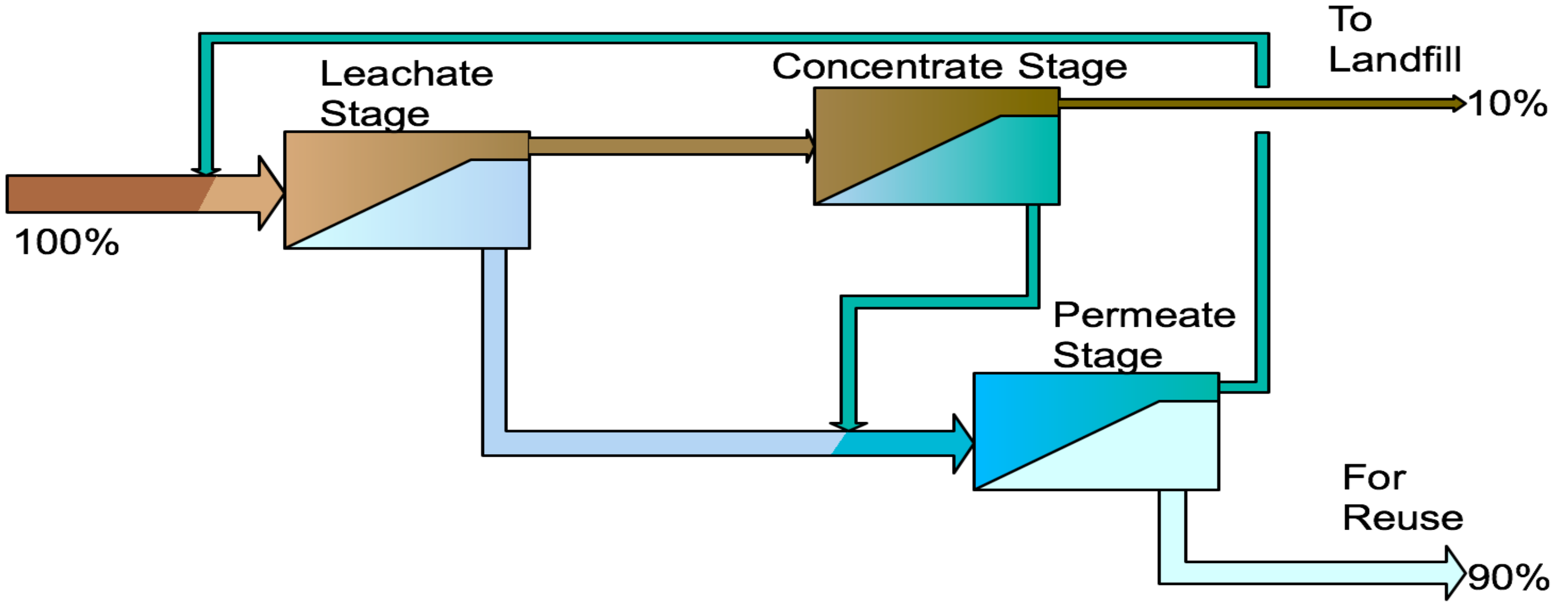
removes by both ion exchange and
adsorption using both “Head” & “Tail”

Reverse Osmosis

- **Should work effectively**
- **Membrane Based Separation Process.**
- **Separates Water from Organic and Inorganic Compounds.**
- **Effluent for reuse or disposal.**
- **What to do with Reject???**
- **If recirculation is allowed, returns the contaminants to the landfill where they were originally deposited.**
- **Solidification – Lime, others?**
- **Evaporation – Crystallization**
  - Heat needed
  - Air Emissions

Reverse Osmosis

- **Membrane Based Separation Process.**
- **Separates Water from Organic and Inorganic Compounds.**
- **If recirculation is allowed, returns the contaminants to the landfill where they were originally deposited.**
- **Effluent for reuse or disposal.**



Second Stage to reduce reject volume – or Evaporation

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Reverse Osmosis - PFAS Expected Removal from Leachate (µg/l concentrations) - Additional Information

Compound (ng/l)	Leachate	RO 1 Permeate	RO 2 Permeate	Rejection
Perfluorobutanesulfonic acid (PFBS)	280	<2	<1.9	>99.3%
Perfluorobutanoic acid (PFBA)	1100	5	<1.9	>99.8%
Perfluoroheptanoic acid (PFHpA)	480	<2	<1.9	>99.6%
Perfluorohexanesulfonic acid (PFHxS)	690	<2	<1.9	>99.7%
Perfluorohexanoic acid (PFHxA)	2100	7.8	<1.9	>99.9%
Perfluorooctanesulfonic acid (PFOS)	200	<2	<1.9	>99.1%
Perfluorooctanoic acid (PFOA)	820	2.5	<1.9	>99.8%
Perfluoropentanoic acid (PFPeA)	880	2.7	<1.9	>99.8%
Total	6550	18	0	>99.9%

Source, Rochem 2018

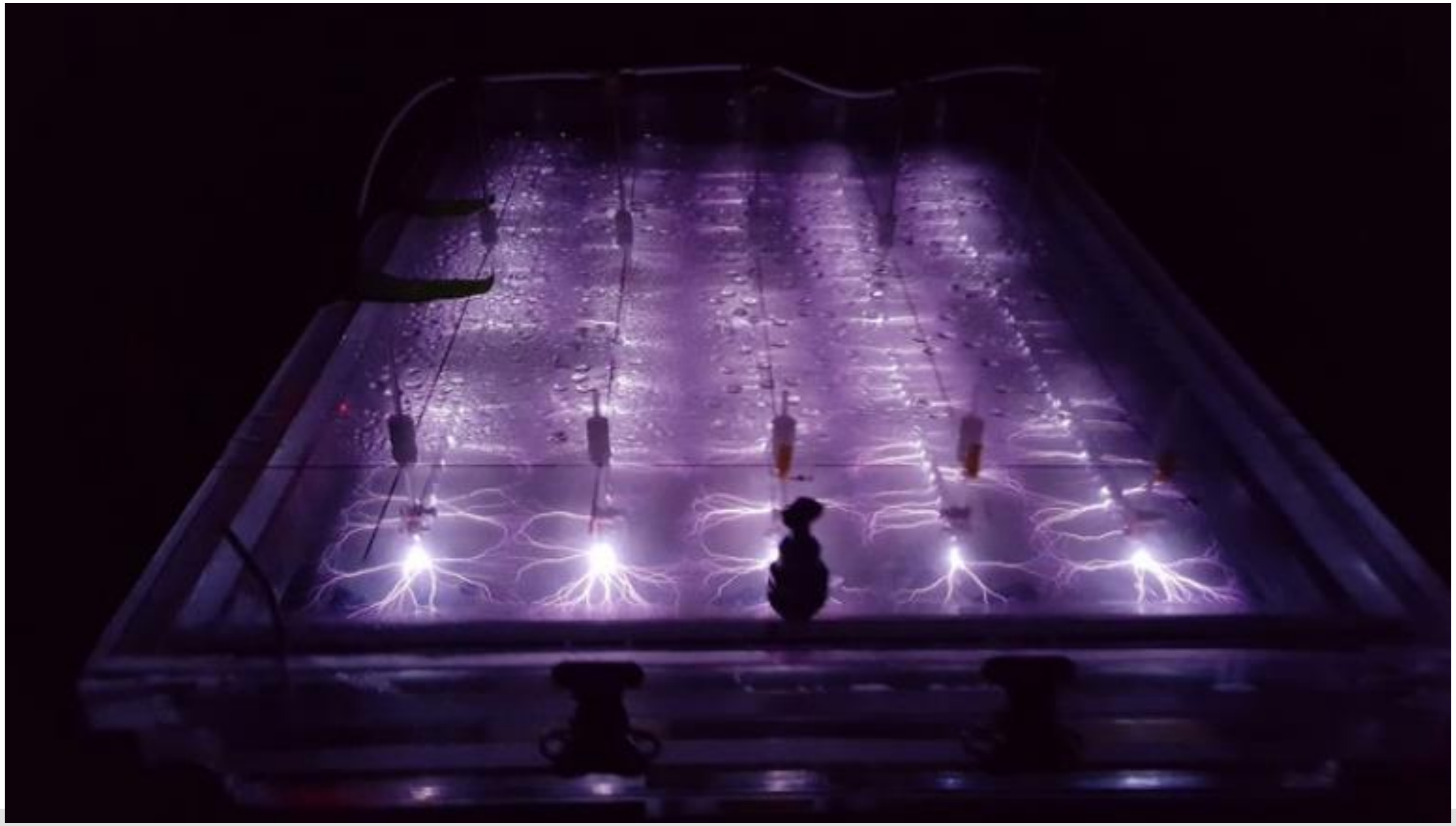
Treatment Technology Status

Field Implemented	Limited Application	Developing
• Full Scale Operation • Multiple Sites • Multiple Designers • Well Document by Peers	• Limited Sites • Limited Number of Designers • No Peer Review Literature	• Laboratory research • Bench Scale Studies • No Field Demonstrations

Limited Application and Developing Technologies

Developing Technologies	Limited Application Technologies
• PerfluorAd (Cornelsen) – Liquid PerfluorAd changes solubility of PFAS for adsorption and removal	• Electrochemical Oxidation Converted into PFAAs during bio or chemical oxidation processes?
• Chemical Oxidation	• Electrochemical + Membrane Concentration or Bio
• Ozone	• Deep Well Injection
• Perozone	• Plasma (several in Australia)
• Heat-Activated Persulfate	• Advance Oxidation (AOP)
• Cavitation Oxidation	• Zero Valent Iron (ZVI) reduction + Bio Treatment
• Hydrated Ion (ARC)	• Chemical Oxidation + Bio Treatment
• Thermal Decomposition	• Non-Thermal Plasma
• Solvated Electron Reduction	• Hydrothermal
• Electron Beam	• ScisoR® – Smart Combined In-situ oxidation and reduction
• Absorbents – Protein-Based – Waste Oil based (Flinders Univ – Australia) or Polymer Based, Cationic Hydrophobic	• PRB – Funnel & Gate + Additional treatment
• Boron Doped Diamond Electro-Oxidation- MSU	
• Nanoporpous Nets - metal organic frameworks or MOFs	

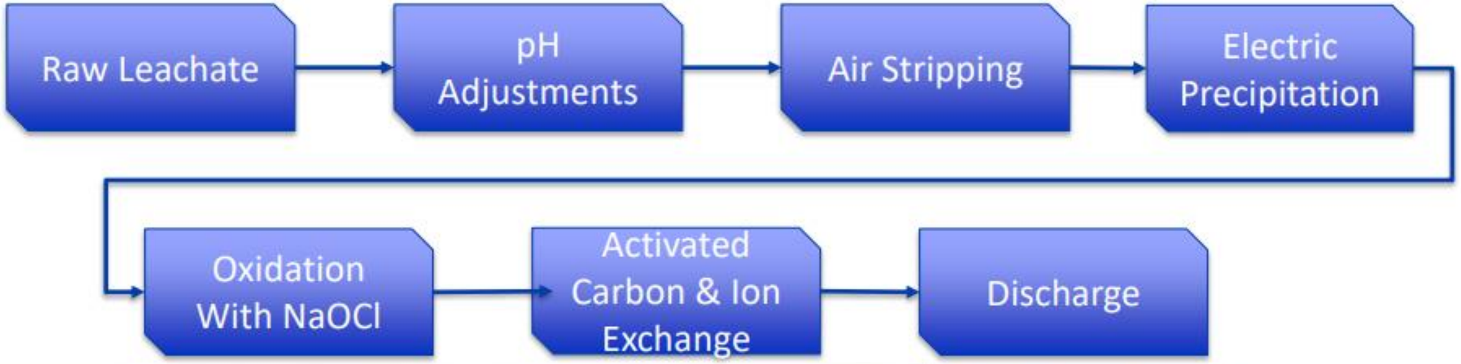
Enhanced Contact Plasma Reactor



A plasma reactor is demonstrated at Wright-Patterson Air Force Base, Ohio, Sept. 25, 2019 to degrade and destroy perfluorooctane sulfonate and perfluorooctanoic acid, better known as PFOS and PFOA, in sample groundwater. The test was the first field demonstration of the Enhanced Contact Plasma Reactor, conducted under an Air Force Civil Engineer Center contract with primary contractor, Clarkson University and teaming partner, GSI Environmental. (U.S. Air Force courtesy photo by Clarkson University)

Electro Coagulation – HTX Technology as a service

Electro-Coagulation Demonstration

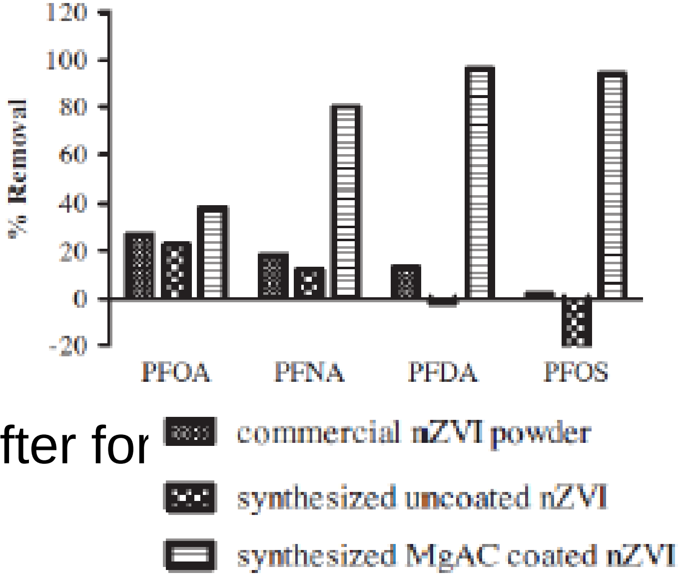


Raw Leachate → pH Adjustments → Air Stripping → Electric Precipitation → Oxidation With NaOCl → Activated Carbon & Ion Exchange → Discharge

Ref. Michael Cook, Burns & McDonnell, RAM/SWANA Conf Oct 2018

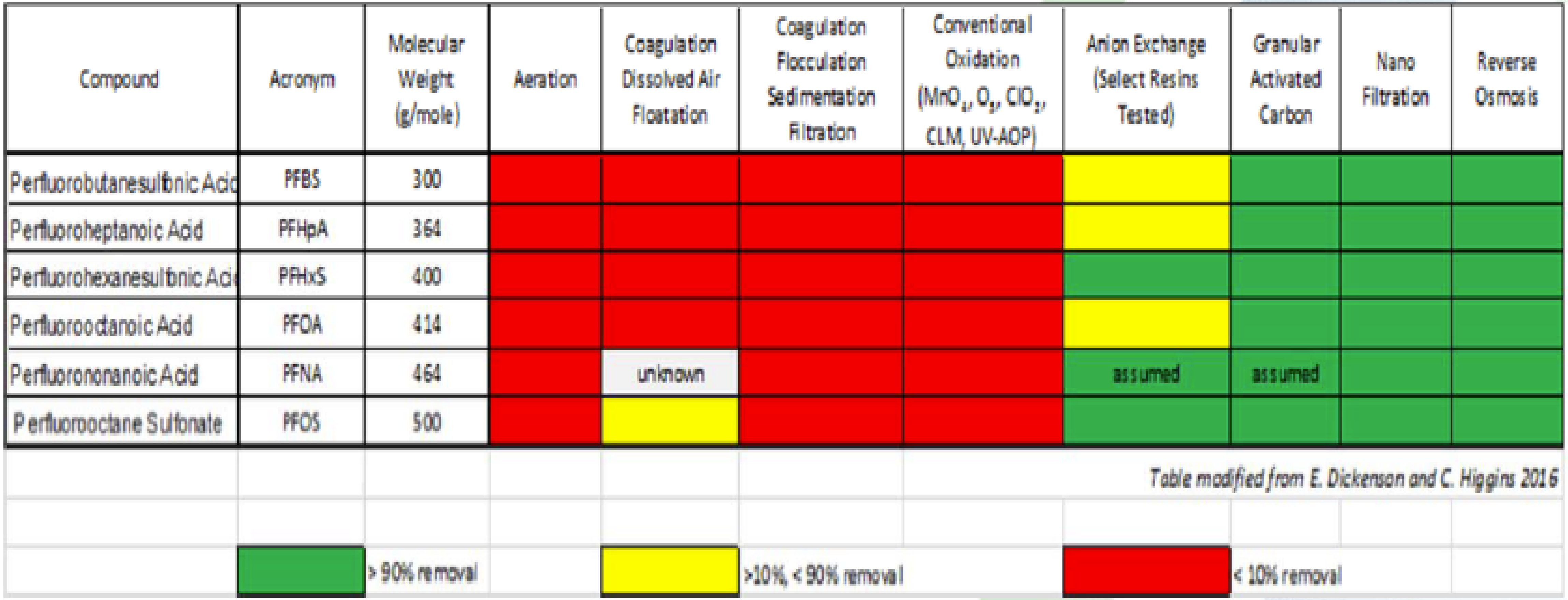
Other Innovative Technologies

- **Various studies of advanced oxidation / reduction: all on bench scale**
  - Ozone, perozone, heat-activated persulfate, cavitation oxidation, non-thermal plasma, electrochemical oxidation, solvated electron reduction, zero valent iron (ZVI) reduction
- **Advanced Reduction Processes (ARP)**
  - Catalytic generation of reductants using sulfite
- **Electro-Oxidation –**
  - Reported 96 - 99% removal for Perfluorooctanoic acid (PFOA), Per sulfonate (PFOS), Perfluorononanoic acid (PFNA) - RO before or after for polishing?



- **Plasma – Limited sites - application in Australia**
- **Most Have Limited Bench-Scale Evaluations**

Summary of Water Treatment Options for Various PFAS Compounds



Compound	Acronym	Molecular Weight (g/mole)	Aeration	Coagulation Dissolved Air Floatation	Coagulation Flocculation Sedimentation Filtration	Conventional Oxidation (MnO$_4$, O$_3$, ClO$_2$, CLM, UV-AOP)	Anion Exchange (Select Resins Tested)	Granular Activated Carbon	Nano Filtration	Reverse Osmosis
Perfluorobutanesulfonic Aci	PFBS	300	🟥	🟥	🟥	🟥	🟨	🟩	🟩	🟩
Perfluoroheptanoic Acid	PFHpA	364	🟥	🟥	🟥	🟥	🟨	🟩	🟩	🟩
Perfluorohexanesulfonic Aci	PFHxS	400	🟥	🟥	🟥	🟥	🟩	🟩	🟩	🟩
Perfluorooctanoic Acid	PFOA	414	🟥	🟥	🟥	🟥	🟨	🟩	🟩	🟩
Perfluorononanoic Acid	PFNA	464	🟥	unknown	🟥	🟥	🟩 assumed	🟩 assumed	🟩	🟩
Perfluorooctane Sulfonate	PFOS	500	🟥	🟨	🟥	🟥	🟩	🟩	🟩	🟩

Table modified from E. Dickenson and C. Higgins 2016

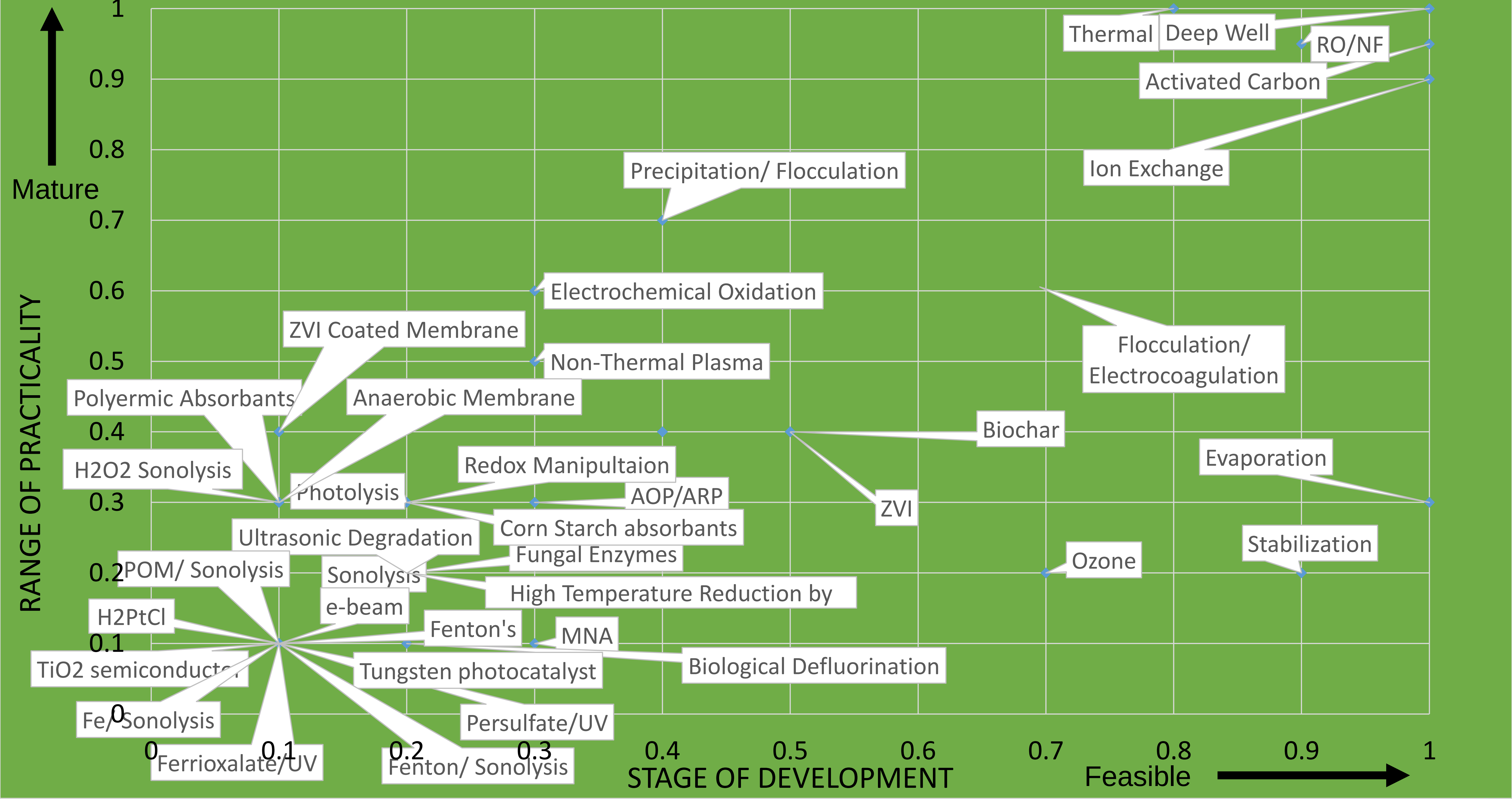
🟩 > 90% removal

🟨 >10%, < 90% removal

🟥 < 10% removal

E. Dickenson and C. Higgins, "Treatment Mitigation Strategies for Poly- and Perfluoroalkyl Substances," Water Research Foundation, 2016.

DEVELOPMENT AND PRACTICALITY OF TREATMENT TECHNOLOGIES



Treatment Technologies – Pretreatment?

Contaminant	Biological Treatment	Activated Carbon[1]	Ion Exchange [1]	Reverse Osmosis[2]	Electro Oxidation	AOP	ARC
COD/Ammonia	Yes	Possible	Possible	Possible – Reject	Yes	Possible	Possible
I,4 Dioxane	Possible	OK	OK	OK – Reject	OK	OK	OK
DON and rDON	Possible	OK	Possible	OK – Reject	Possible	Possible	Possible
PPCP	Possible	OK	OK	OK – Reject	OK	OK	OK
Nanoparticles /Microplastics	No	No	No	Yes – Reject	No	No	No
UV Absorbing	No	Possible	No	Yes <500 nm, Reject	Possible	No	Possible
PFAS	No	OK	OK	OK – Reject	Possible	Possible	OK

1. **Residuals from spent activated carbon or ion exchange requires replacement and disposal**
2. **RO reject flow requires management by concentration, evaporation, solidification, deep well injection, or other means.**

Thank You !!!

- **Ivan A. Cooper, PE, BCEE**
- **Civil and Environmental Consultants, Inc.**
- **icooper@cecinc.com**
- **Direct: (980) 260-2110**
- **Mobile: (980) 238-0373**

The Impact of PFOAs in Landfill Leachate on POTWs in Michigan

Richard Burns

Senior Vice President

NTH Consultants, Ltd.

Michigan Landfill Leachate PFAS Impact on WWTP Influent

Project Timeline (Fall 2017 to Summer 2019)

FALL 2017
MDEQ (EGLE) Mandate

WINTER 2018
MWRA's Common Interest Agreement

WINTER 2018
EGLE's approval of MWRA's statewide approach

SPRING/SUMMER 2018
Scope Development

NOV. 2018-MAR. 2019
Data collection / evaluation / interpretation

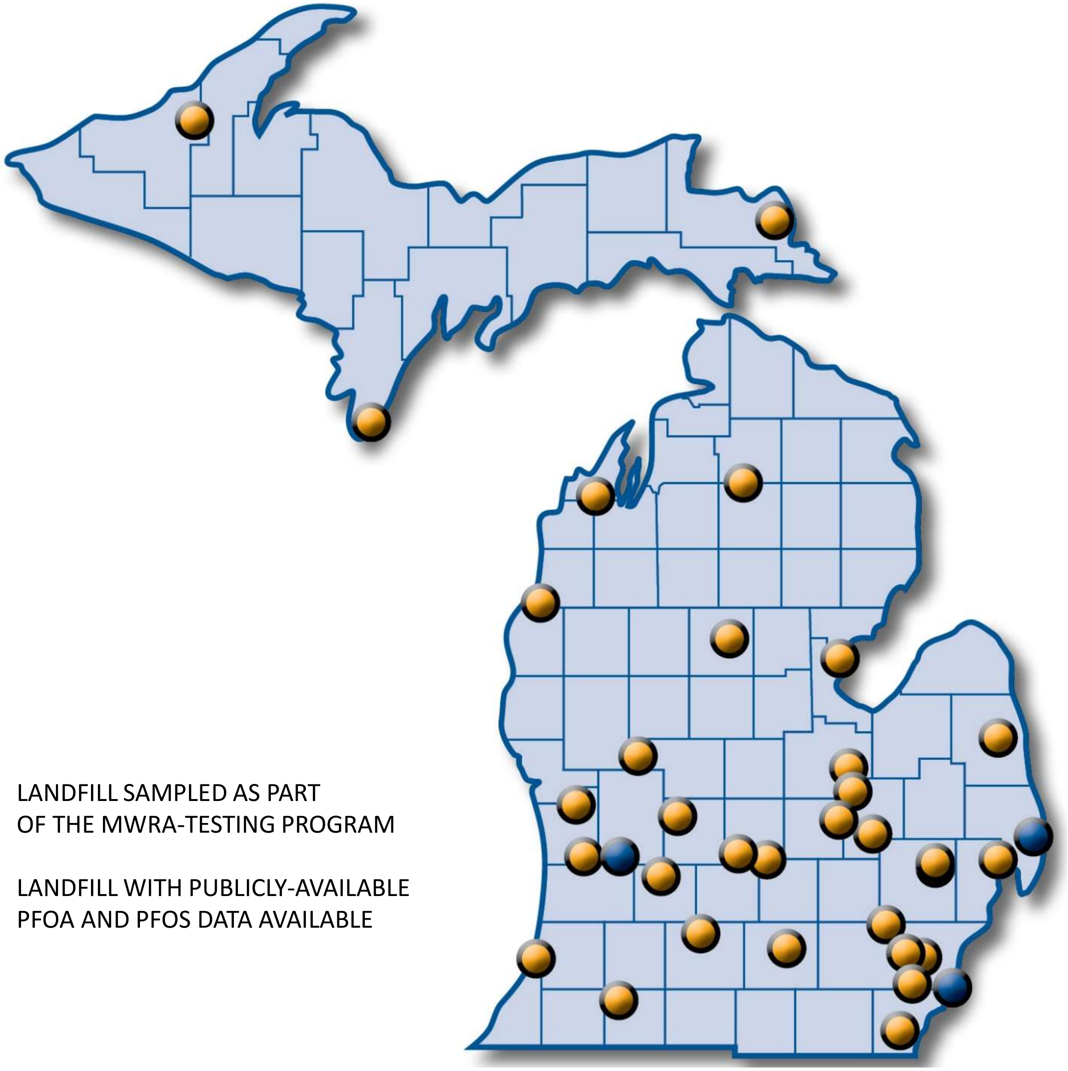
Project expansion from data report to research project

Two separate reports prepared

March 2019
Report(s) issued to MDEQ/EGLE

Spring /Summer 2019
Follow up activities. Discussions between WRRFs, EGLE, and MWRA

Solid Waste Disposal Facilities Included



● LANDFILL SAMPLED AS PART OF THE MWRA-TESTING PROGRAM

● LANDFILL WITH PUBLICLY-AVAILABLE PFOA AND PFOS DATA AVAILABLE

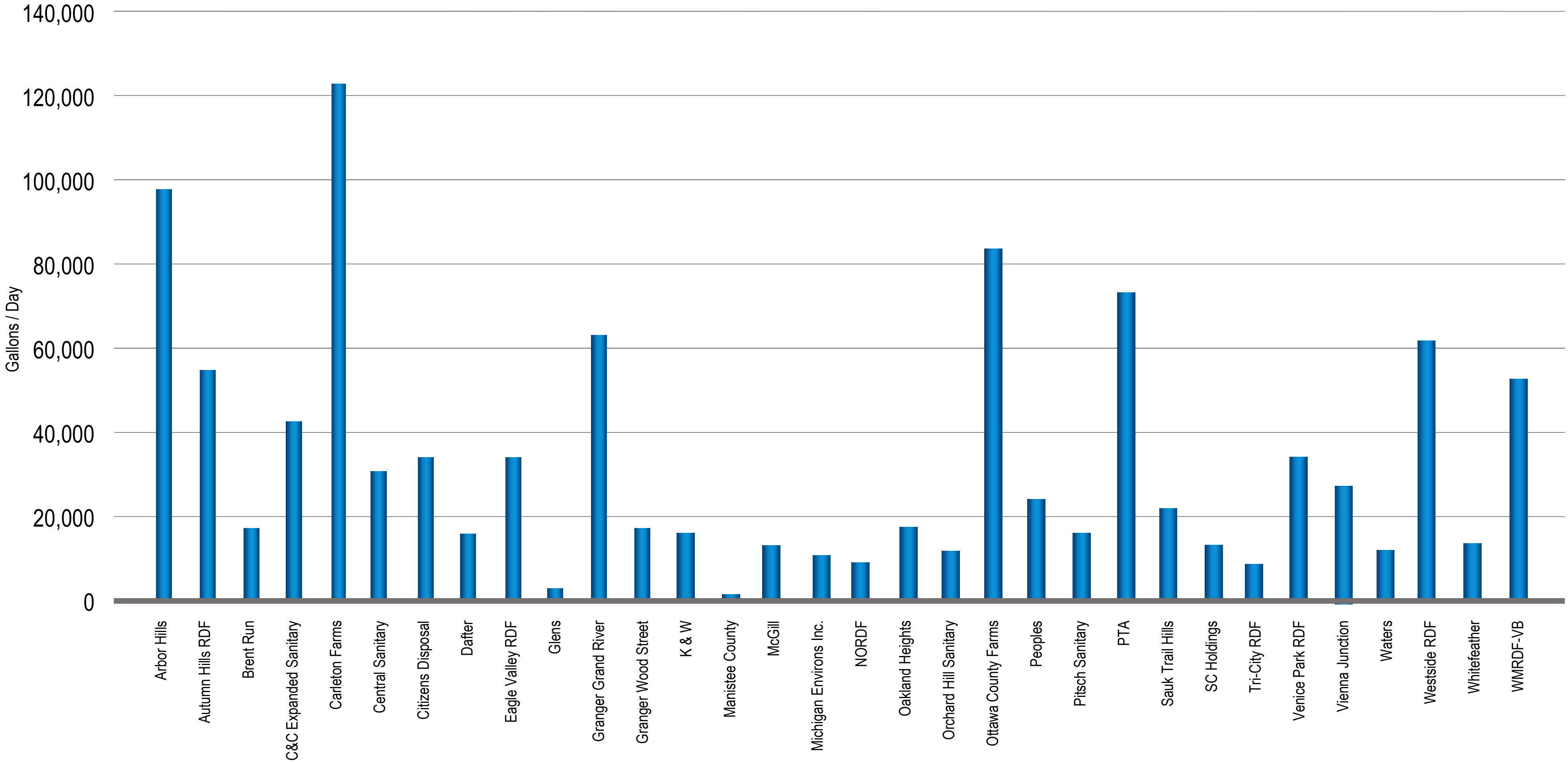
Advanced Disposal Services Arbor Hills Landfill, Inc.
Autumn Hills Recycling and Disposal Facility
Brent Run Landfill
C&C Expanded Sanitary Landfill
C&C Expanded Sanitary Landfill
Carleton Farms Landfill
Central Sanitary Landfill, Inc.
Citizens Disposal
Dafter Sanitary Landfill
Eagle Valley Recycle and Disposal Facility
Glens Sanitary Landfill
Granger Grand River Landfill
Granger Grand River Landfill
K&W Landfill
Manistee County Landfill, Inc.
Michigan Environs Inc.
Northern Oaks
Oakland Heights Development, Inc.
Orchard Hill Sanitary Landfill
Ottawa County Farms Landfill
Peoples Landfill, Inc.
Pine Tree Acres, Inc.
Pitsch Sanitary Landfill
Recycling and Disposal Facility
Republic Services of Pinconning (Whitefeather)
Riverview Land Preserve
Sauk Trail Hills Landfill
SC Holdings
Smith's Creek Landfill
South Kent Landfill
Tri-City Recycling and Disposal Facility
Venice Park Recycling and Disposal Facility
Vienna Junction Industrial Park Sanitary Landfill
Waters Landfill
Westside Recycling and Disposal Facility
Woodland Meadows RDF - Van Buren

Leachate Sampling and Laboratory Testing Program

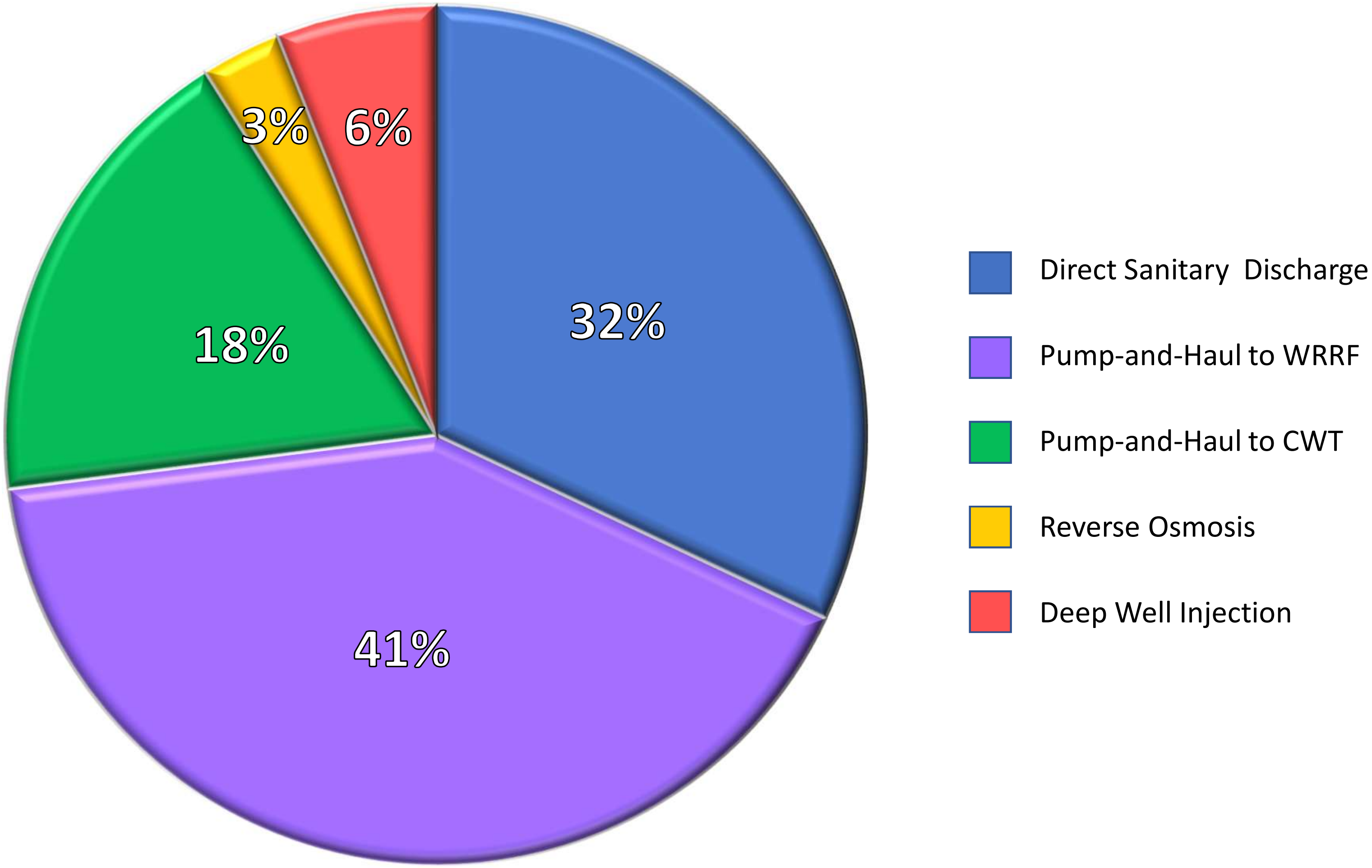
Sample Shipment – Sealed Cooler Prepared for Shipment

- **Samples collected using MDEQ/EGLE draft PFAS protocol**
- **Test America-San Francisco completed analyses per Method 537 (modified)**
- **All results provided by mid-January 2019**
- **No statistical outliers present in data set**

Leachate Volumes Per MWRA Landfill



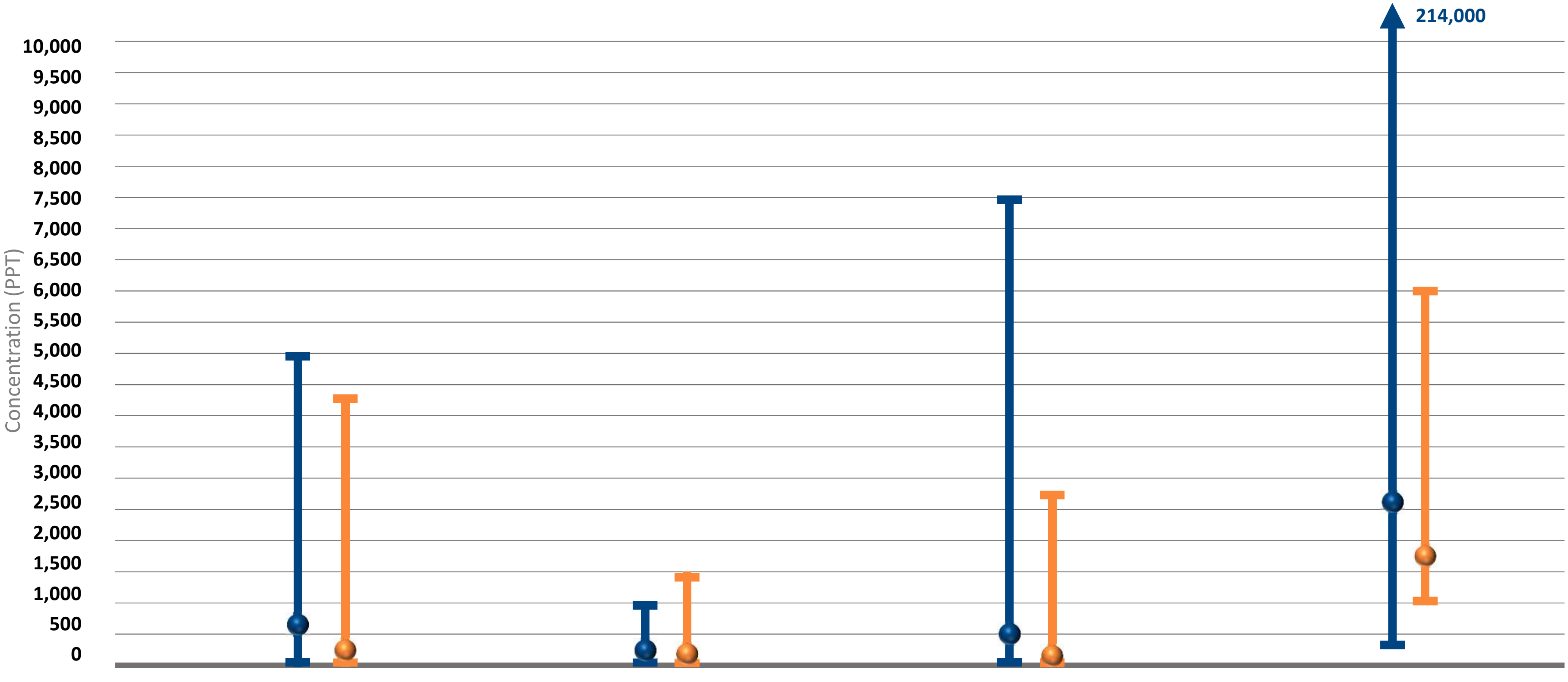
Leachate Disposal Methods



WATER RESOURCE RECOVERY FACILITY (WRRF) SUMMARY

<table>
<tr><th colspan="4">Summary of WRRF PFOA/PFOS With Influent Data Evaluated in This Study</th></tr>
<tr><td>WRRFs with PFOA/PFOS data that manage MWRA-member landfill leachate</td><td>Total WRRFs with PFOA/PFOS data that manage leachate from other active Type II Landfills</td><td>WRRFs with PFOA/PFOS data that do not manage Leachate from active Type II Landfills</td><td>Total WRRFs with PFOA/PFOS data included in this Study</td></tr>
<tr><td>11</td><td>7</td><td>16</td><td>34</td></tr>
</table>

WORLD-WIDE LEACHATE PFOA & PFOS CONCENTRATIONS



N. America

PFOA	PFOS
Max: 5,000	Max: 4,400
Med: 688	Med: 214
Min: 150	Min: 25

Europe

PFOA	PFOS
Max: 1,000	Max: 1,500
Med: 253	Med: 211
Min: 0	Min: 0

Australia

PFOA	PFOS
Max: 7,500	Max: 2,700
Med: 525	Med: 126
Min: 17	Min: 0

China

PFOA	PFOS
Max: 214,000	Max: 6,020
Med: 2,660	Med: 1,740
Min: 281	Min: 1,150

STATEWIDE PFOA AND PFOS
MWRA TYPE II LANDFILL LEACHATE CONCENTRATIONS (abbreviated)

MWRA Participating Landfill Designation	Average Leachate Volume GPD	PFOA (ppt)	PFOS (ppt)	"PFOA Daily Mass (lb/day)"	"PFOS Daily Mass (lb/day)"
Arbor Hills Landfill	98,400	3200	220	0.0026	0.00018
Autumn Hills RDF	54,800	1300	380	0.0006	0.00017
Brent Run Landfill	16,400	540	110	0.0001	0.00002
C&C Expanded Sanitary Landfill	42,000	1300	450	0.0004	0.00015
Carleton Farms Landfill	123,300	1800	250	0.0018	0.00026
Central Sanitary Landfill	30,100	2500	470	0.0006	0.00012
Citizen's Disposal Inc.	32,900	1100	180	0.0003	0.00005
Dafter Sanitary Landfill	16,500	680	130	0.0001	0.00002
Eagle Valley RDF	32,900	490	170	0.0001	0.00005
Glens Sanitary Landfill	3,800	770	210	0.00002	0.00001
Summary Statistics	minimum	16	9	0.000016	0.000007
	maximum	3200	960	0.003	0.0004
	median	1000	220	0.0001	0.00005
	average	1186	287	0.0004	0.0001
	n	39	39	33	33

Michigan Compared to Other Regions

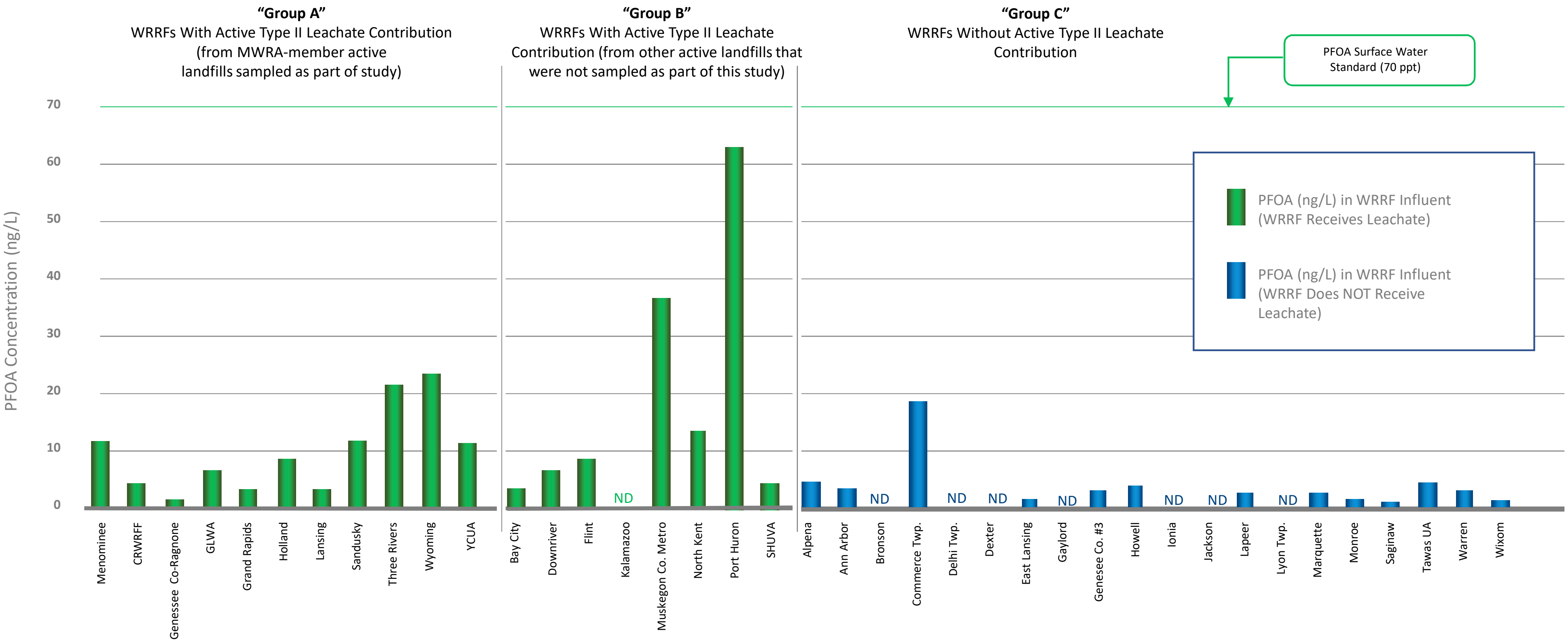
Region	PFOA (ppt)	PFOS (ppt)
Michigan	16 to 3,200	9 to 960
United States	30 to 5,000	3 to 800
Europe	ND to 1,000	ND to 1,500
Australia	17 to7,500	13 to 2,700
China	281 to 214,000	1,150 to 6,020
Worldwide Range	**ND to 214,000**	**ND to 6,020**

Current EGLE/EPA PFOA & PFOS Criteria

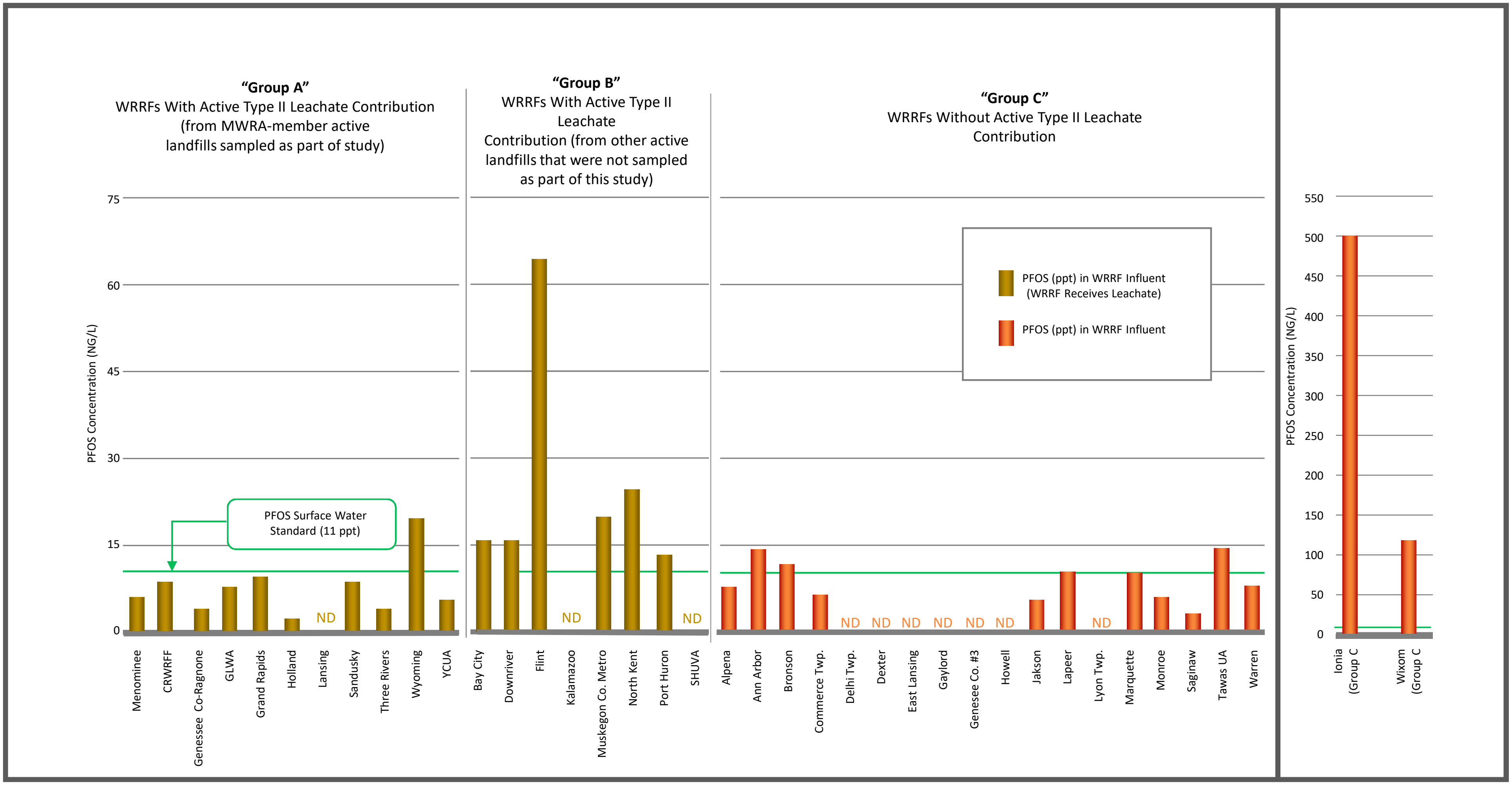
Chemicals	Human Non-Cancer Value (Non-Drinking Water)	Human Non-Cancer Value (Drinking Water)
PFOS	12 ppt	11 ppt
PFOA	12,000 ppt	420 ppt

Note: USEPA Health Advisory (HA) = 70 ppt (PFOA+PFOS)

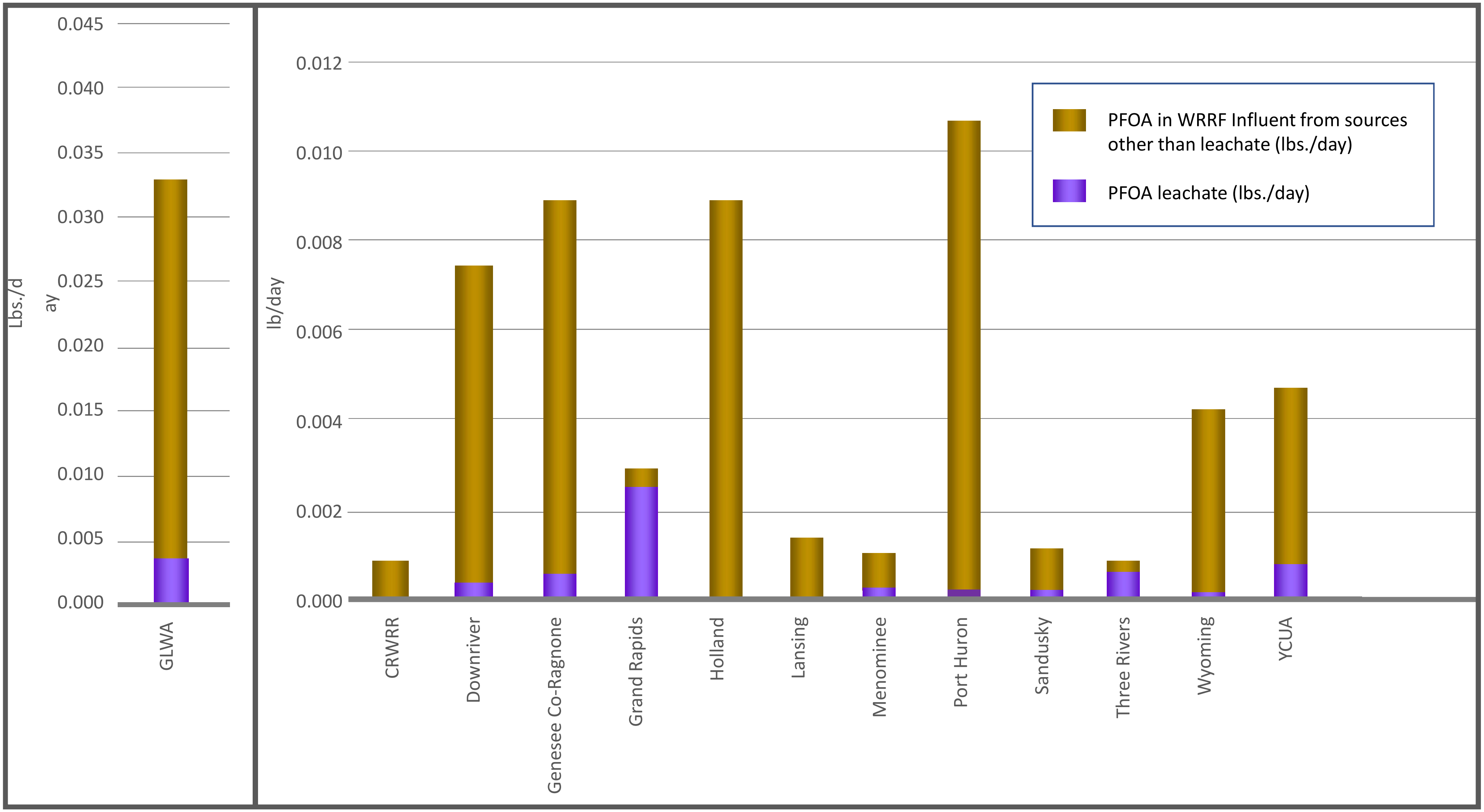
WRRF Overall Influent PFOA Concentrations



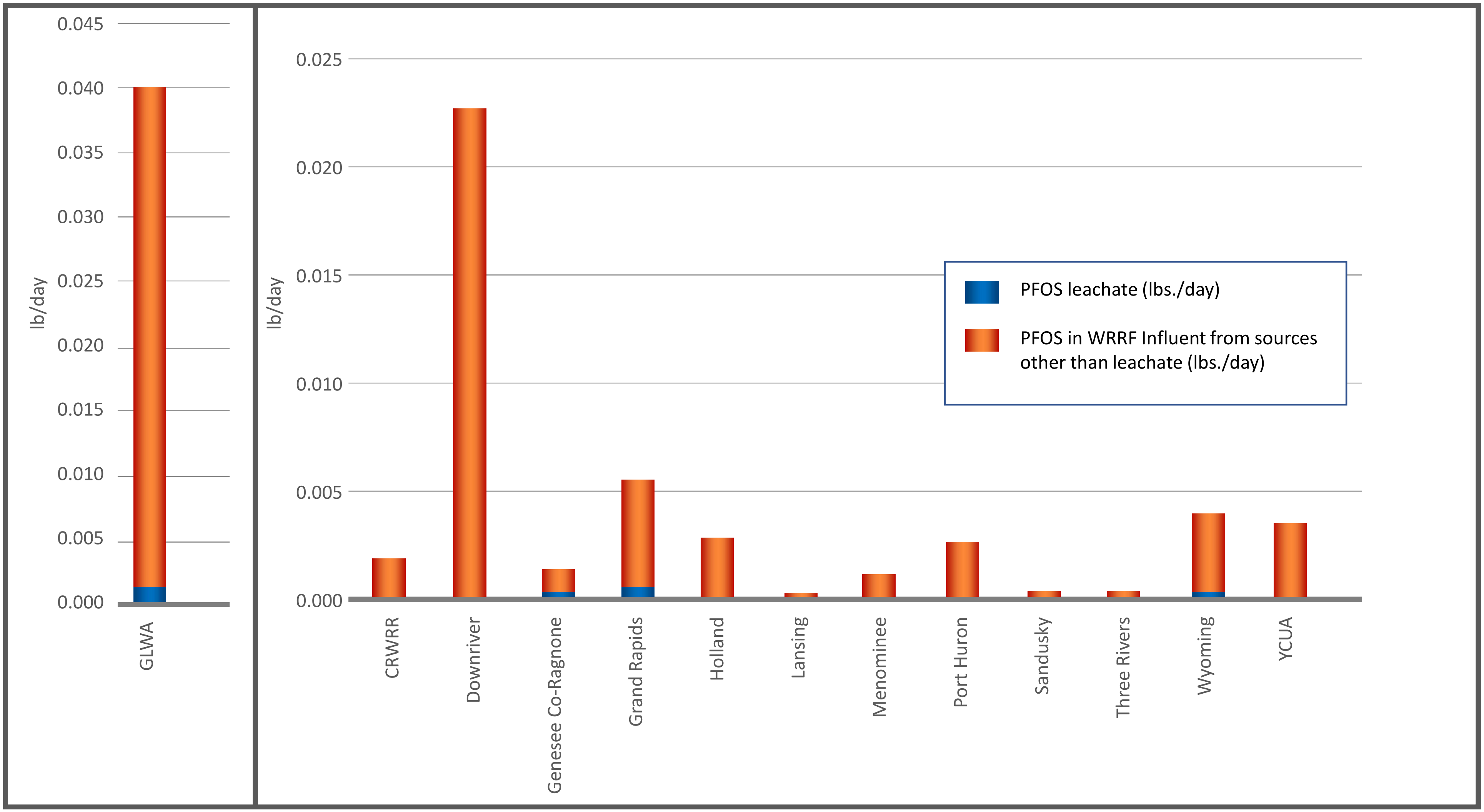
WRRF Overall Influent PFOS Concentrations



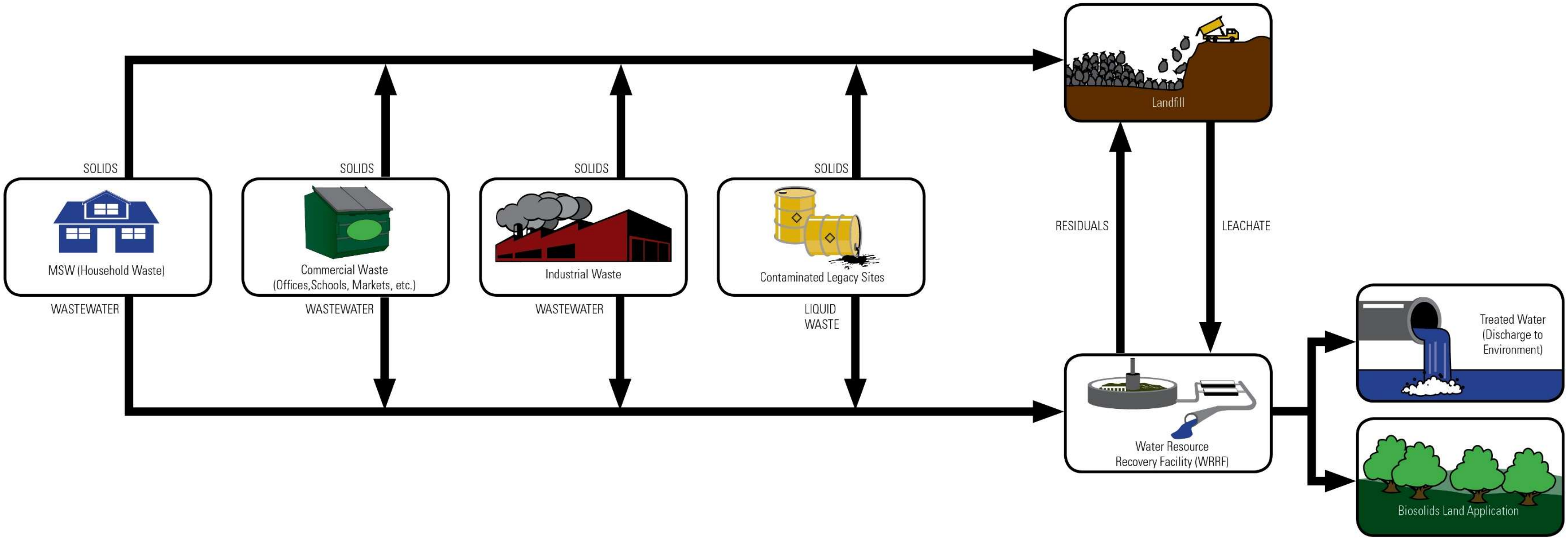
PFOA Mass: Influent Leachate vs. Overall WRRF Influent



PFOS Mass: Influent Leachate vs. Overall WRRF Influent



PFOA & PFOS "CYCLING" WITHIN THE "WASTE ECONOMY"



OVERALL SUMMARY

- **Unsurprisingly, PFOA and PFOS detected in all landfill leachate**
  - Varying concentrations
- **USA and Michigan landfill leachate PFOA and PFOS concentrations similar to other Western countries**
  - China leads all industrial nations.
- **Participating Michigan landfills discharge 1 MGD to WRRFs**
  - Contributing approximately 0.01 lbs./day PFOA and 0.003 lbs./day PFOS
- **WRRF influent approximately 1.4 BGD**
  - With ~ 0.09 lbs./day PFOA and 0.15 lbs./day PFOS

OVERALL SUMMARY (continued)

- State-wide WRRF influent PFOA concentration were below EGLE’s 420 ppt DW WQS
- Approximately two-thirds of WRRF influent PFOS concentrations were below EGLE’s 11 ppt DW WQS
- Landfill leachate appears a relatively minor source of PFOA & PFOS to WRRF influent statewide
- Total mass balance and fate-and-transport not fully-understood
- PFAS management is a societal problem

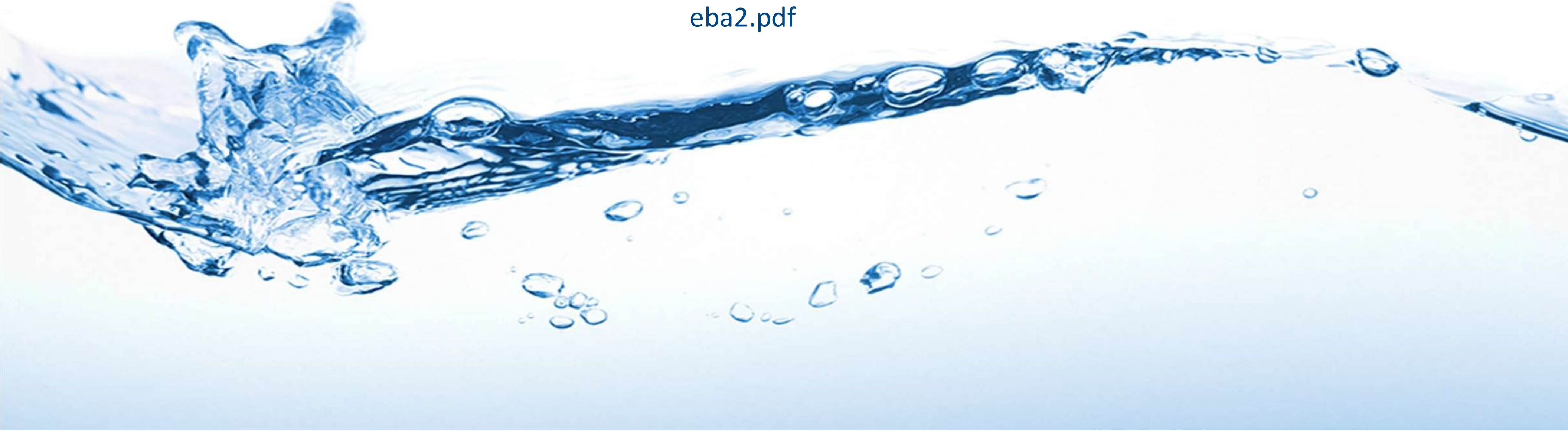
QUESTIONS?

Summary Report

https://docs.wixstatic.com/ugd/6f7f77_b3c62cab66454fea9a66ce6986887da7.pdf

Technical Report

https://docs.wixstatic.com/ugd/6f7f77_5be8751a1f754474ac6e27fc8247eba2.pdf



Removing the Handle from the PFAS Pump

Tiffany Skogstrom, MPH

Outreach & Policy Analyst

Massachusetts Office of Technical Assistance (OTA)

Executive Office of Energy & Environmental Affairs

REMOVING THE HANDLE

OTA
OFFICE OF TECHNICAL ASSISTANCE & TECHNOLOGY

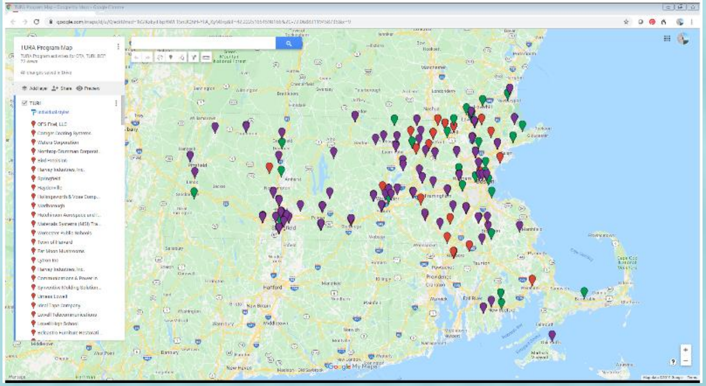
FROM THE PFAS PUMP

Tiffany Skogstrom, MPH
tiffany.skogstrom@mass.gov, 617-626-1086

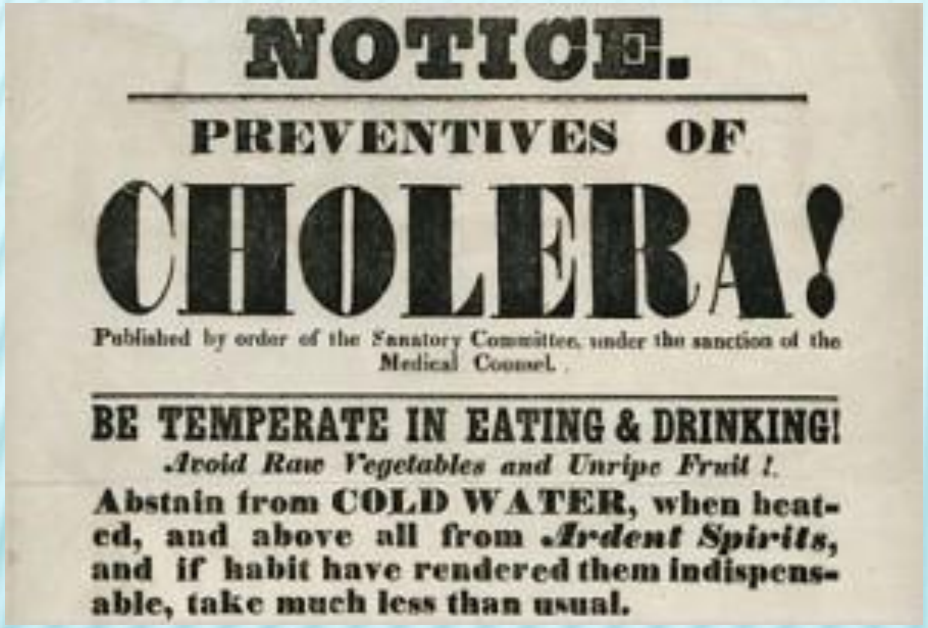
twitter
@Mass_OTA

OFFICE OF TECHNICAL ASSISTANCE (OTA)

- Non-regulatory agency within Executive Office of Energy and Environmental Affairs (EOEEA)
- Provides confidential onsite technical and compliance assistance to manufacturers, businesses, and institutions
- All OTA services are available free of charge to any Massachusetts toxics user
- Some statistics –
  - × More than 3,500 site visits to about 1,500 facilities
  - × Helped in reducing the use of millions of pounds of toxic chemicals, and saving companies millions of dollars in operating costs



TRACKING CHOLERA



NOTICE.

PREVENTIVES OF

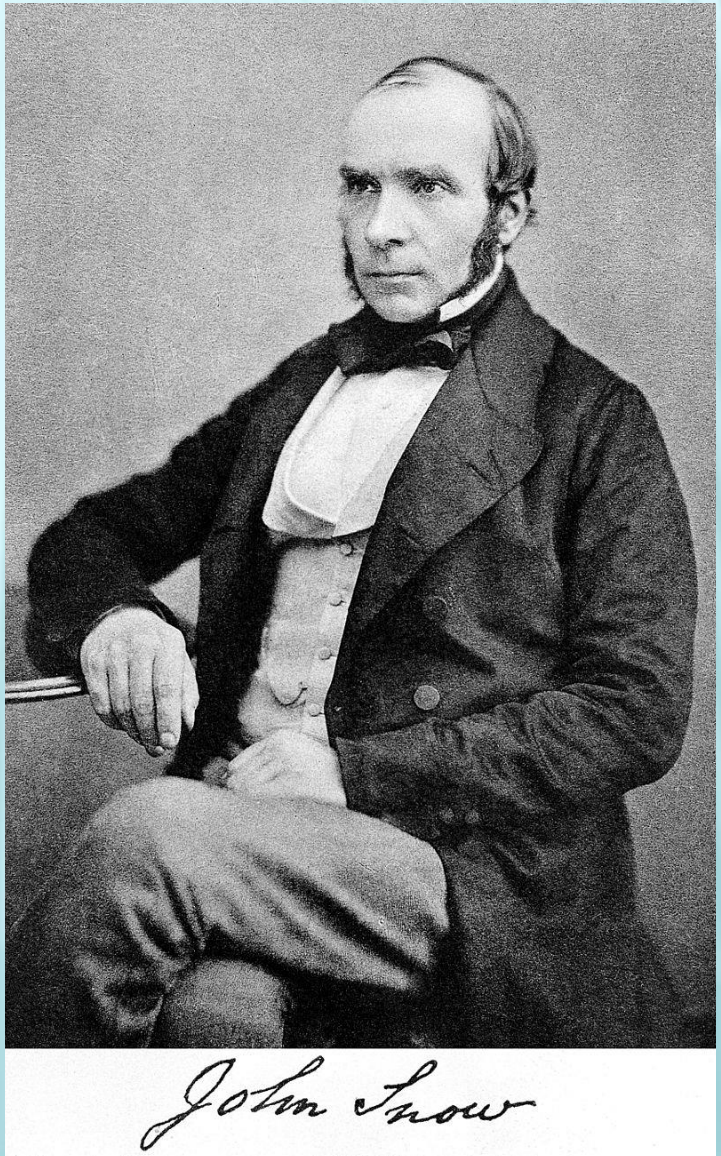
CHOLERA!

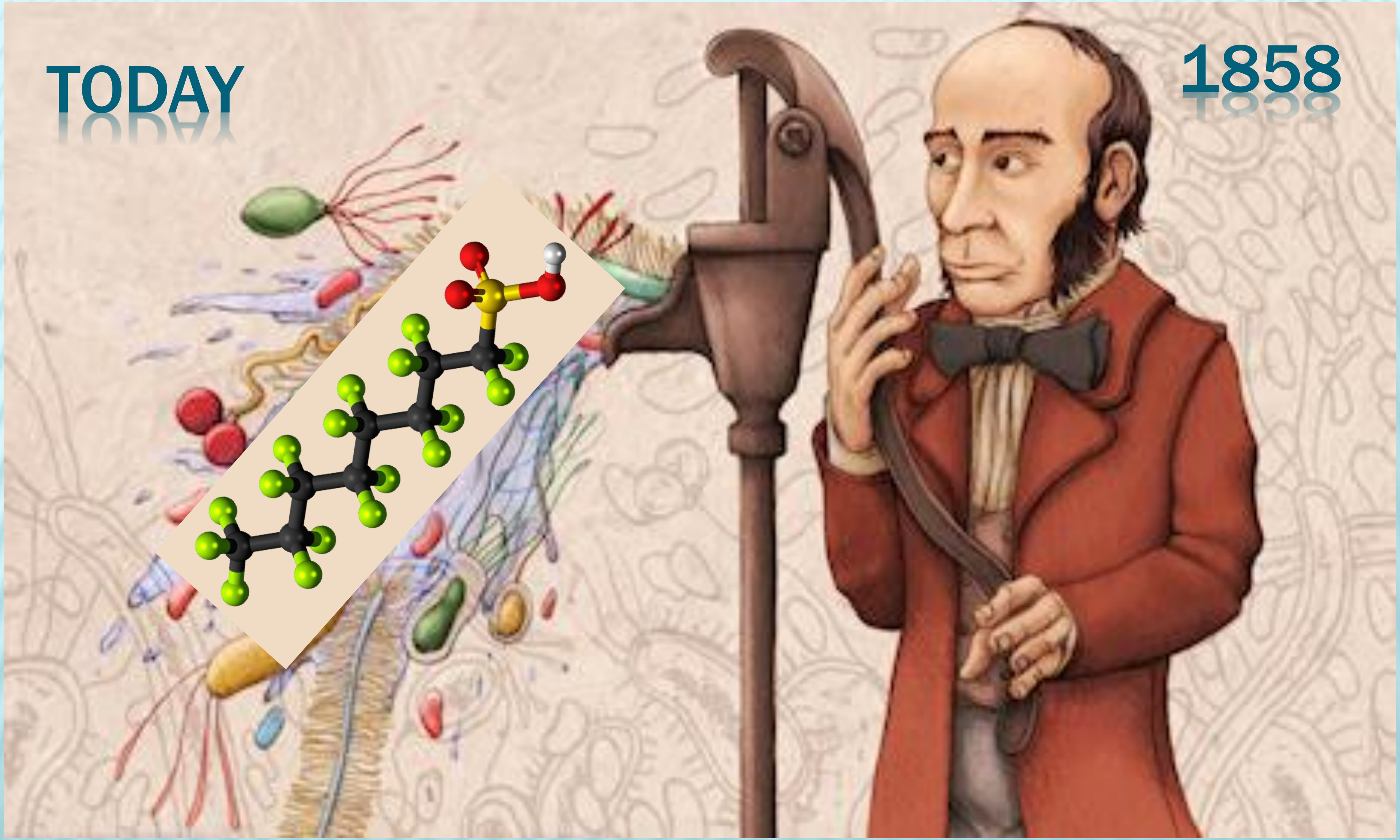
Published by order of the Sanatory Committee, under the sanction of the Medical Counsel.

BE TEMPERATE IN EATING & DRINKING!

Avoid Raw Vegetables and Unripe Fruit !.

Abstain from COLD WATER, when heated, and above all from *Ardent Spirits*, and if habit have rendered them indispensable, take much less than usual.




TODAY
1858

Le Petit Journal

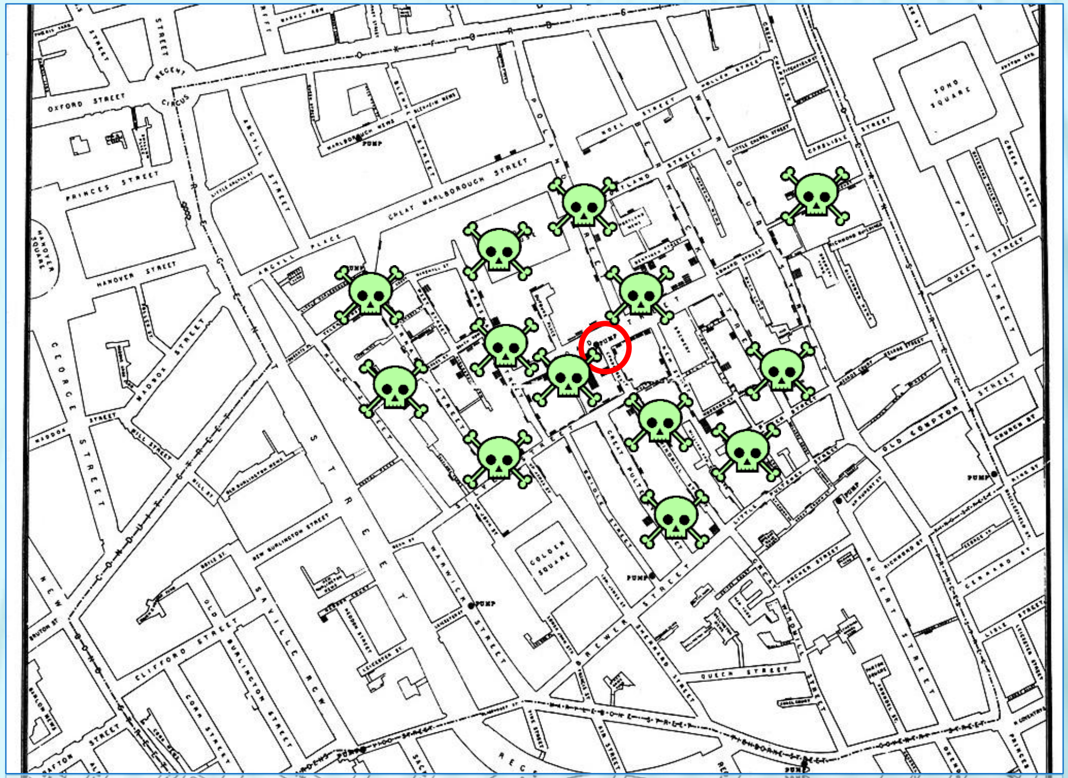
ADMINISTRATION
61, RUE LAFAYETTE, 61
Les manuscrits ne sont pas rendus
On s'abonne sans frais
dans tous les bureaux de poste

5 CENT. SUPPLÉMENT ILLUSTRÉ 5 CENT.
23me Année Numéro 1.150
DIMANCHE 1er DÉCEMBRE 1912

ABONNEMENTS

	SIX MOIS	UN AN
SEINE et SEINE-ET-OISE..	2 fr.	3 fr. 50
DÉPARTEMENTS..........	2 fr.	4 fr. »
ÉTRANGER....	2 50	5 fr. »

LE CHOLÉRA



1858 – MAP THE CHOLERA CASES

TODAY - MAP THE SOURCES

- Fire Training Facilities
- Rug Manufacturers
- Clothing Manufacturers
- Airports
- Etc

EPA Enforcement & Compliance History Online (ECHO) screen shot

PFAS

Airports

Fire Stations

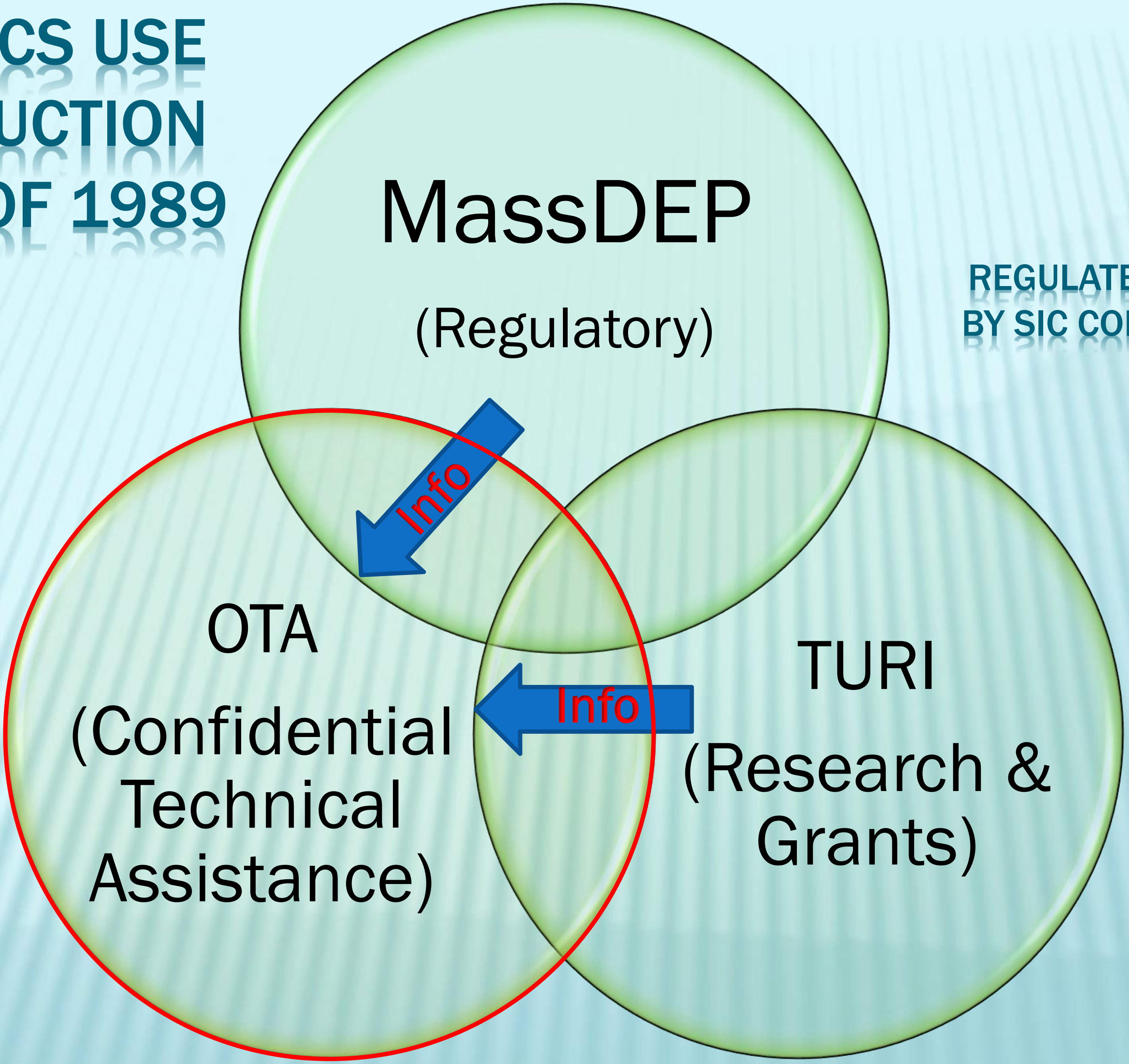
Military Bases

Personal Care Products

Compostable Food Ware

Industry

TOXICS USE REDUCTION ACT OF 1989



MassDEP

(Regulatory)

Info

OTA

(Confidential Technical Assistance)

Info

TURI

(Research & Grants)

REGULATED BY SIC CODE

PROCESS FOR IDENTIFYING COMPANIES

- **Search Online Libraries for SICS / NAICS**
- Visit Company Websites
- Company Familiarity with TURA Program
- Follow the Hottest Trail

IDENTIFY THE INDUSTRIES

SIC Code	Industry
2821	Plastics Materials & Synthetic Resins
3479	Metal Coating & Allied Services
3999	Manufacturing Industries
2295	Coated Fabrics, Not Rubberized
5172	Petroleum Products

NAICS Code	Industry
322220	Paper Bag & Coated & Treated Paper Manufacturing
334419	Other Electronic Component Manufacturing
33599	All Other Miscellaneous Electrical Equipment & Component Manufacturing
335929	Other Communication & Energy Wire Manufacturing

PFAS & TOXICS RELEASE INVENTORY

View Rule

EPA/OCSPP **RIN:** 2070-AK51 **Publication ID:** Spring 2019

Title: •Addition of Certain Per- and Polyfluoroalkyl Substances (PFAS) to the Toxics Release Inventory

Abstract:

Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) created the Toxics Release Inventory (TRI) Program. The TRI Program is a tool EPA may use to understand the releases of Per- and Polyfluoroalkyl Substances (PFAS) by industrial and federal facilities. This information may be helpful to inform decision-making by communities, government agencies, companies and others. Currently, no PFAS chemicals are included on the list of chemicals required to report to TRI; however, the EPA is considering whether to add certain PFAS chemicals. In considering listing, the EPA must determine whether data and information are available to fulfil the statutory listing criteria and the extent and utility of the data that would be gathered. In addition, in considering if TRI will provide useful information to stakeholders, the EPA also will consider if these PFAS are still active in commerce. The process for listing includes notice and comment rulemaking to list PFAS chemicals for reporting prior to adding these chemicals to the TRI for annual reporting.

Agency: Environmental Protection Agency(EPA)
RIN Status: First time published in the Unified Agenda
Major: No
EO 13771 Designation: Not subject to, not significant
CFR Citation: 40 CFR 372
Legal Authority: 42 U.S.C. 11023 et seq.
Legal Deadline: None

Priority: Substantive, Nonsignificant
Agenda Stage of Rulemaking: Prerule Stage
Unfunded Mandates: No

Timetable:

Action	Date	FR Cite
ANPRM	10/00/2019	

Advance Notice of Proposed Rulemaking Expected to be Published in November 2019

NAICS Code	Impacted Industry
31311	Fiber, Yarn, & Thread Mills
314110	Carpet & Rug Mills
324110	Petroleum Refineries
325	Chemical Manufacturing
423220	Home Furnishing Merchant Wholesalers
561740	Carpet & Upholstery Cleaning Services

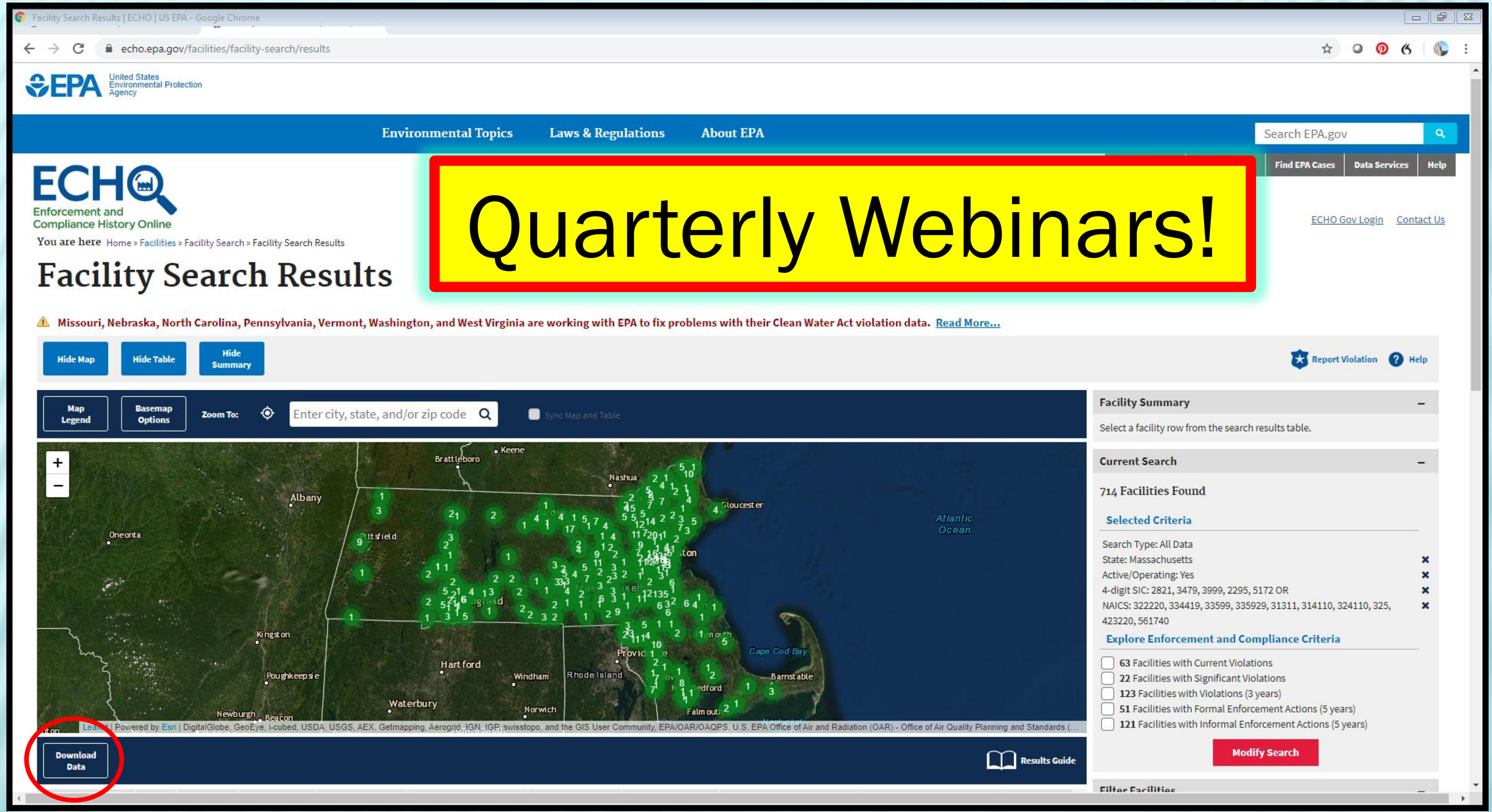
ONLINE LIBRARIES

- A to Z Database
- Mergent Online
- D & B Hoovers

Other Available Databases:

- EPA's Enforcement & Compliance History Online (ECHO)
- Toxics Release Inventory (TRI)

ECHO BY SIC & NAIC CODES



Facility Search Results

Missouri, Nebraska, North Carolina, Pennsylvania, Vermont, Washington, and West Virginia are working with EPA to fix problems with their Clean Water Act violation data. Read More...

Facility Summary

Select a facility row from the search results table.

Current Search

714 Facilities Found

Selected Criteria

Search Type: All Data
State: Massachusetts
Active/Operating: Yes
4-digit SIC: 2821, 3479, 3999, 2295, 5172 OR
NAICS: 322220, 334419, 33599, 335929, 31311, 314110, 324110, 325, 423220, 561740

Explore Enforcement and Compliance Criteria

☐ **63** Facilities with Current Violations
☐ **22** Facilities with Significant Violations
☐ **123** Facilities with Violations (3 years)
☐ **51** Facilities with Formal Enforcement Actions (5 years)
☐ **121** Facilities with Informal Enforcement Actions (5 years)

Modify Search

Quarterly Webinars!

Downloadable Into Excel Files

TOXICS RELEASE INVENTORY TOOLS

Facility Search by State & NAICS

TRI Explorer

You are here: EPA Home » TRI » TRI Explorer » Release Reports » Release Facility Report

Release Reports

Release Facility Report

Year of Data: 2018

Geographic Location: Massachusetts

Chemical: All chemicals

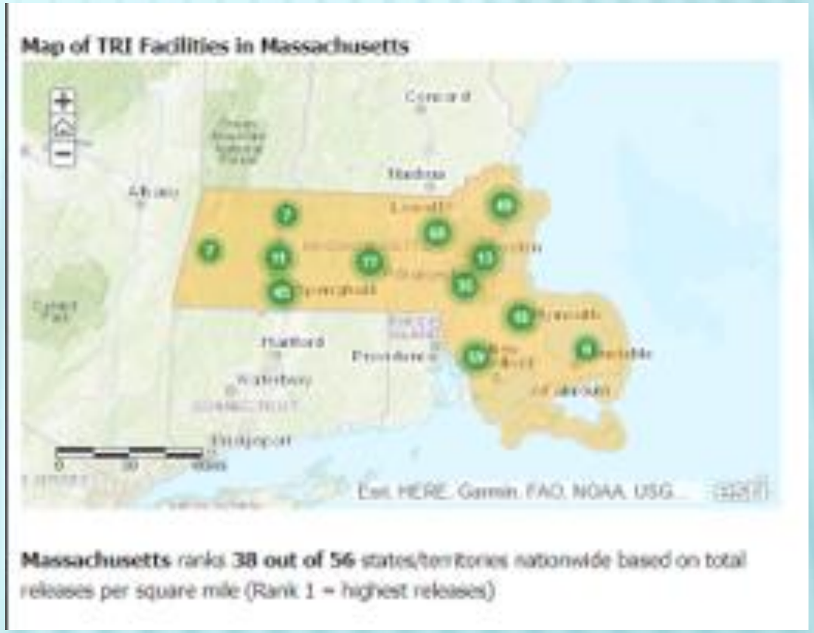
Industry: Change selected industry/industries

Data Set

Report columns to include

☐ TRIF ID
☐ Number of Form Rs
☐ Number of Form As (starting 1995)
☐ Longitude/Latitude
☑ Total On-site Disposal or Other Releases
  Details
  ☐ On-Site Disposal to Class I Wells, RCRA Subtitle C Landfills, and Other On-Site Landfills
  ☐ Other On-Site Disposal or Other Releases
☑ Total Off-site Disposal or Other Releases
  Details
  ☐ Off-Site Disposal to Underground Injection Wells, RCRA Subtitle C Landfills, and Other Landfills
  ☐ Other Off-Site Disposal or Other Releases
☑ Total On- and Off-site Disposal or Other Releases

All TRI Facilities in State



Map of TRI Facilities in Massachusetts

Massachusetts ranks **38 out of 56** states/territories nationwide based on total releases per square mile (Rank 1 = highest releases)

Both Downloadable Into Excel Files

PROCESS FOR IDENTIFYING COMPANIES

- Search Online Libraries for SICS / NAICS
- **Visit Company Websites**
- Company Familiarity with TURA Program
- Follow the Hottest Trail

Facility Criteria

- ✓ Manufactures in MA
- ✓ Process qualifies as non-stick coating, waterproofing, etc

PROCESS FOR IDENTIFYING COMPANIES

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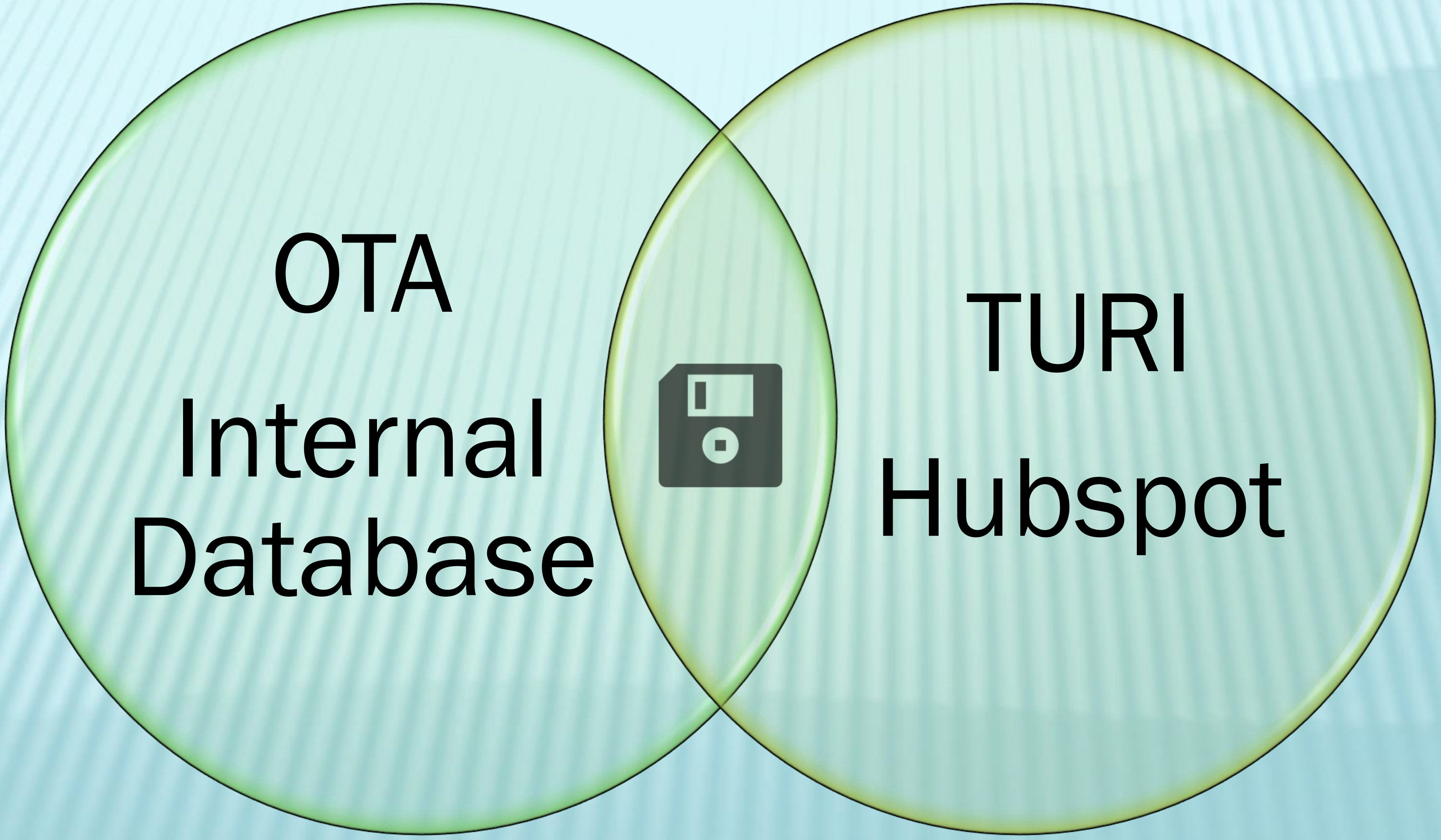
- Visit Company Websites
- **Company Familiarity with TURA Program**
- Follow the Hottest Trail

FAMILIARITY WITH TURA PROGRAM



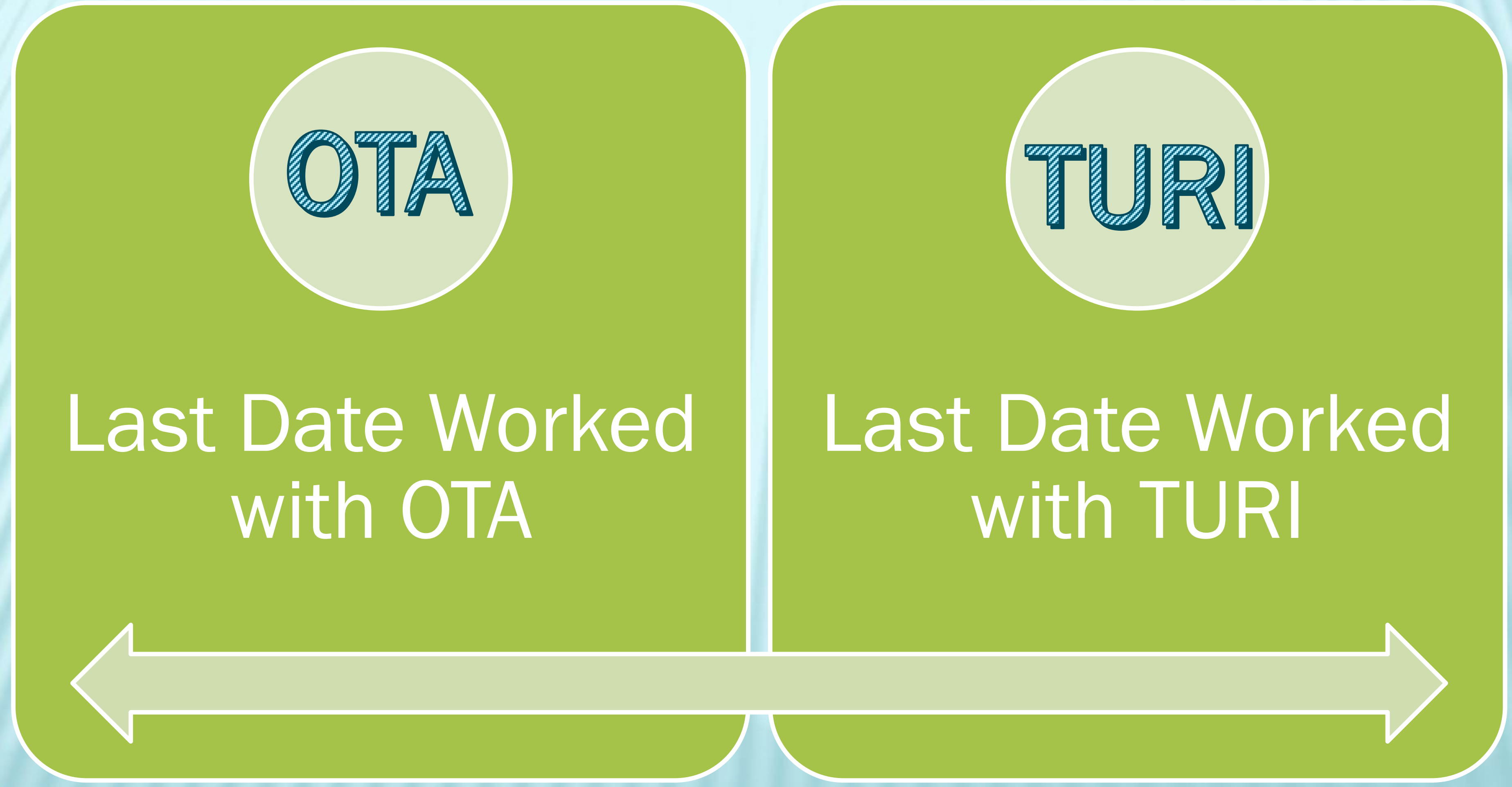
OTA

Internal Database

TURI

Hubspot

FAMILIARITY WITH TURA PROGRAM



OTA

Last Date Worked with OTA

TURI

Last Date Worked with TURI

PROCESS FOR IDENTIFYING COMPANIES

- Search Online Libraries for SICS / NAICS
- Visit Company Websites
- Company Familiarity with TURA Program
- **Follow the Hottest Trail**

OBSTACLES

- Lack of Awareness
- No SDS Listing
- Tainted Incoming Feedstock
- Regrettable Substitution
  - '**Shorter Chain**' is Still a '**Forever Chemical**'
- Fear of Liability
  - Other PFAS Sources = Misplaced Liability
- No Existing Regulations

No Health Data ≠ Safe

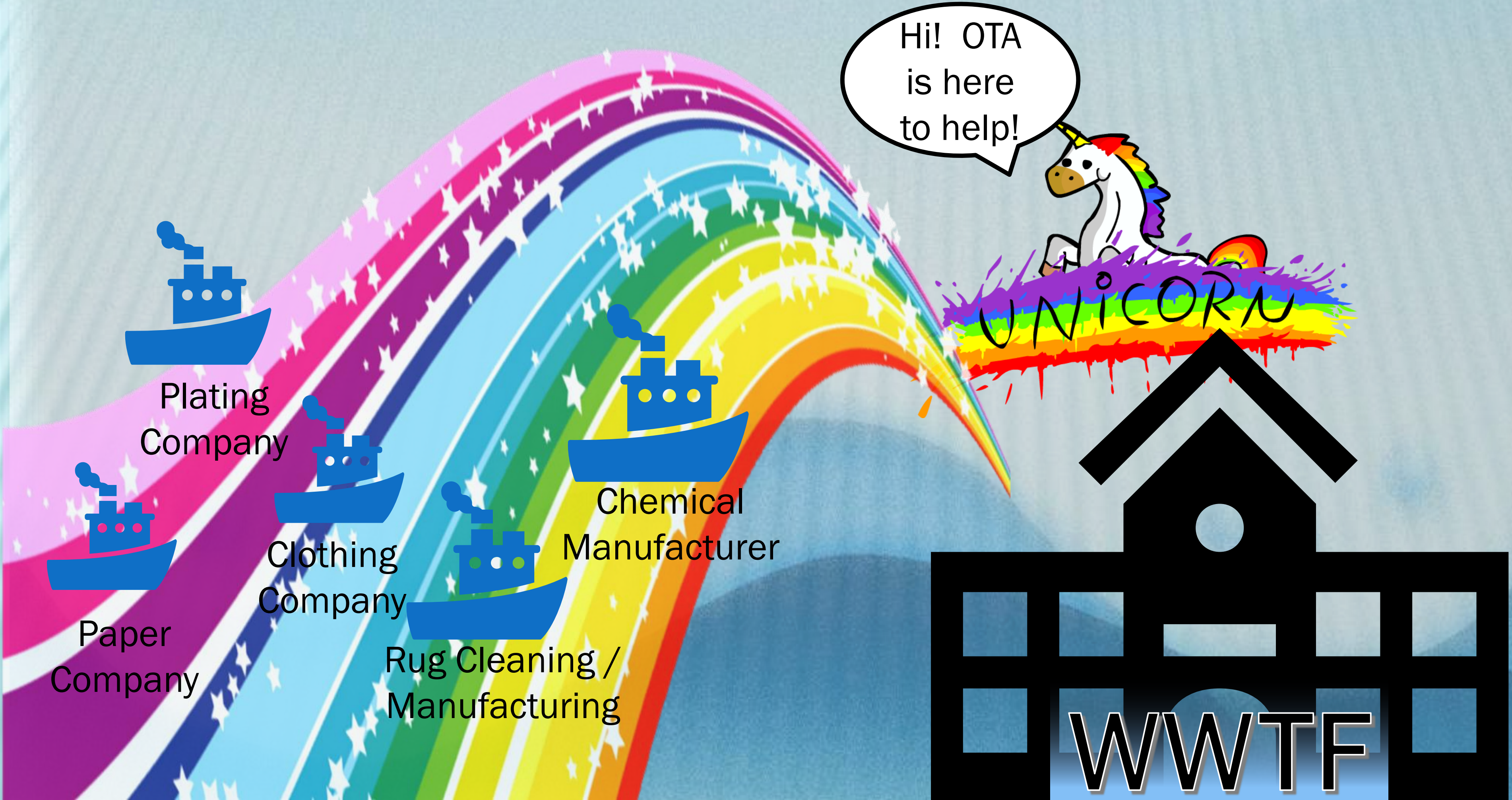
FOLLOW THE HOTTEST TRAIL

Remind company of positive TURA Program experience / OTA confidentiality

Questions to ask:

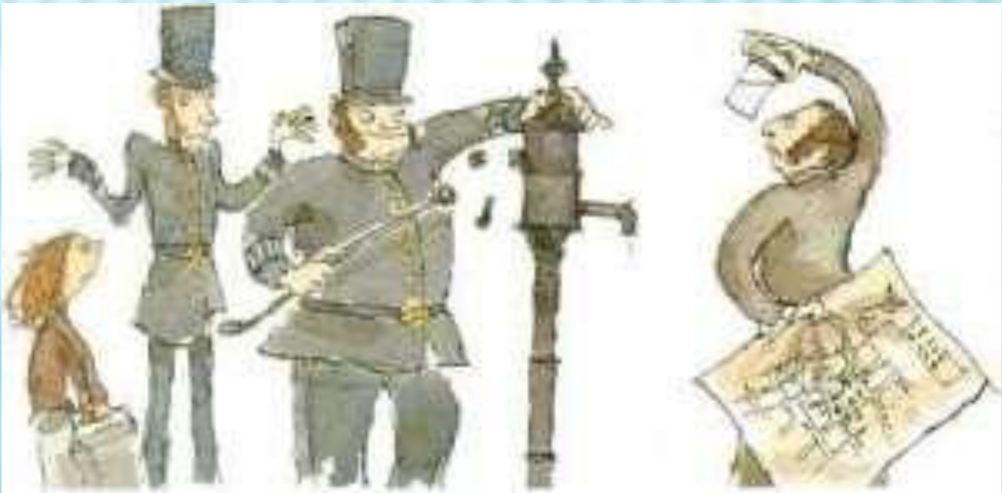
- Are you following the PFAS issue?
- Do you believe you are using PFAS?
- Are you seeking out safer alternatives?
- How can we help you?

HOW OTA HELPS UPSTREAM



REMOVING THE HANDLE FROM THE PFAS PUMP

- Offering Free & Confidential Site Technical Assistance
- Referrals to TURI grants / research / lab
- Identifying Safer Alternatives



USEFUL WEBSITES

- OTA – The MA Office of Technical Assistance
  www.mass.gov/eea/ota
- TURI – The Toxics Use Reduction Institute
  www.turi.org
- EPA Enforcement & Compliance History Online (ECHO)
  https://echo.epa.gov/
- EPA Toxics Release Inventory (TRI) Facility Release Reports
  https://enviro.epa.gov/triexplorer/tri_release.facility
- EPA Toxics Release Inventory (TRI) Analysis Where You Live
  https://www.epa.gov/trinationalanalysis/where-you-live
- TURA Data
  www.turadata.turi.org
- Tier II Data

UPCOMING PFAS EVENT!

NORTHEAST CONFERENCE

THE SCIENCE OF PFAS:

Public Health & The Environment

Tuesday, March 31, 2020 – Wednesday, April 1, 2020

Sheraton Framingham Hotel & Conference Center
Framingham, MA

WWW.NEWMOA.ORG

THANK YOU!

OTA

OFFICE OF TECHNICAL
ASSISTANCE & TECHNOLOGY

FOR MORE INFORMATION:

Tiffany Skogstrom, MPH
tiffany.skogstrom@mass.gov, 617-626-1086

twitter
@Mass_OTA

Moderated Discussion

Moderator: Debra Darby, *Darby Marketing*

Panelists:

- **Ivan Cooper,** *CEC*
- **Arie Kremen,** *Tetra Tech*
- **Tiffany Skogstrom,** *Massachusetts OTA*