

PFAS in Biosolids and Septage



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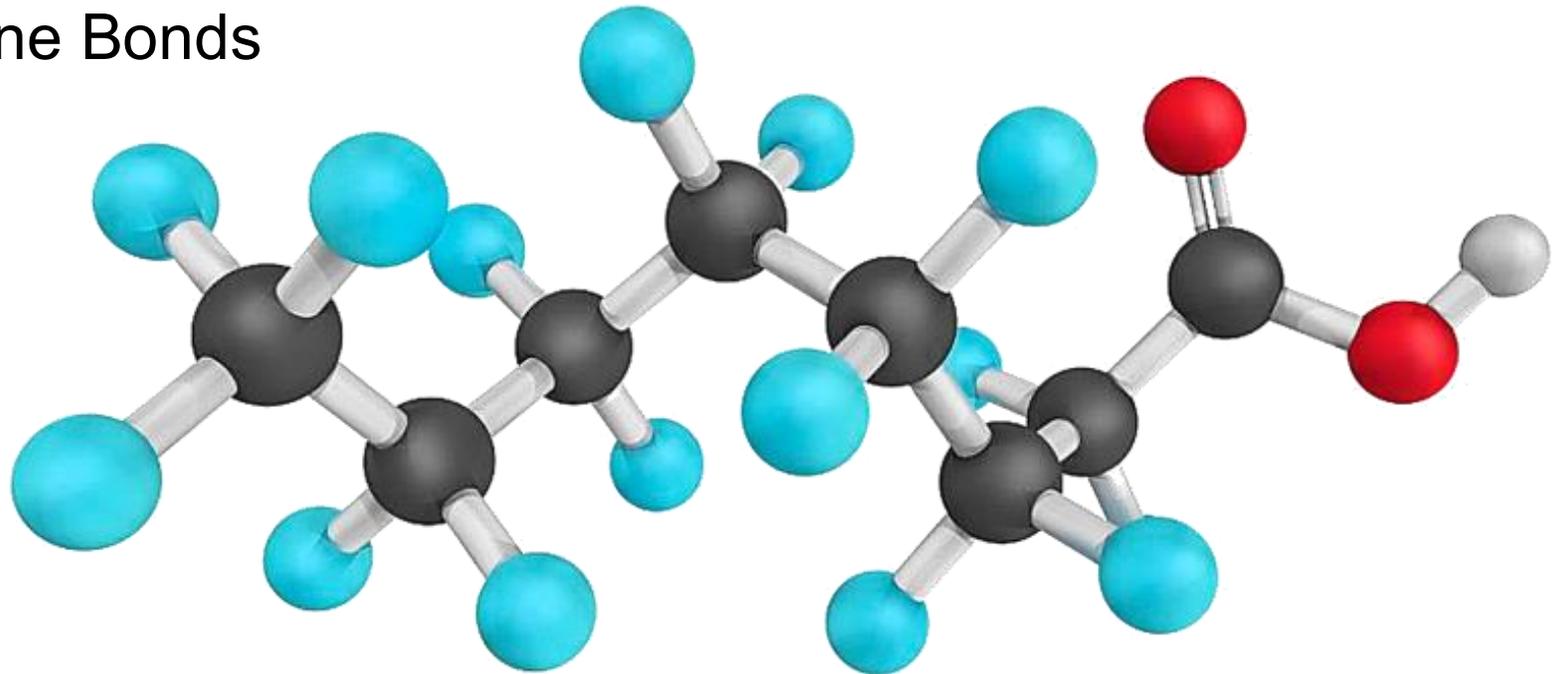
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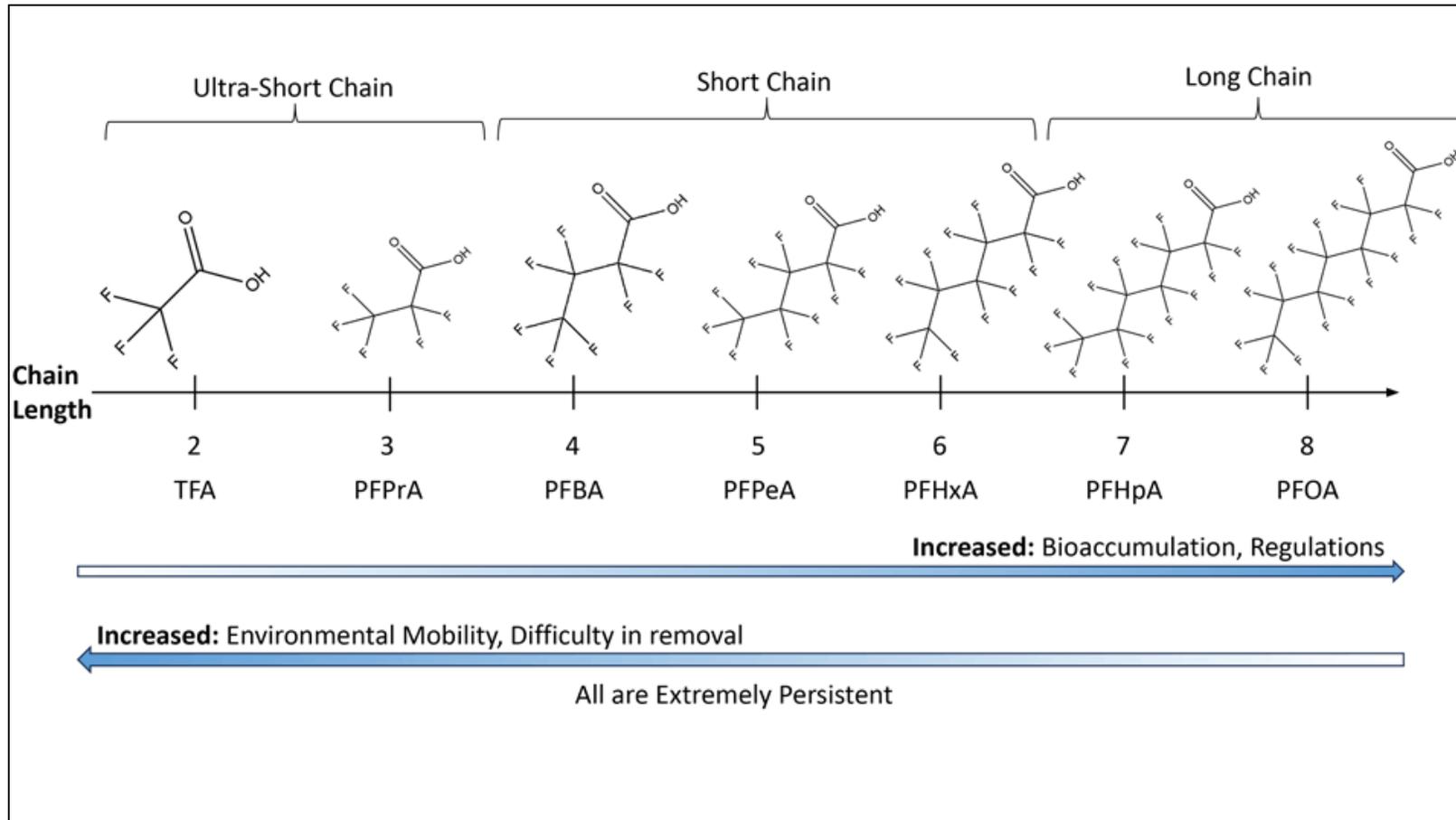
PFAS

- *Per- and Polyfluoroalkyl Substances (PFAS)*
- *Depending on definition, over 10,000 different analytes*
 - Strong Carbon-Fluorine Bonds





Chain Length



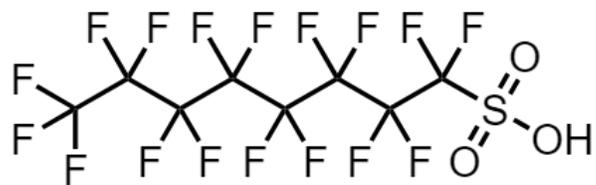
- *PFAS chain length influences their environmental mobility and bioaccumulation in the environment*
- *Long chain PFAS tend to bioaccumulate more and have a larger potential for causing health impacts*



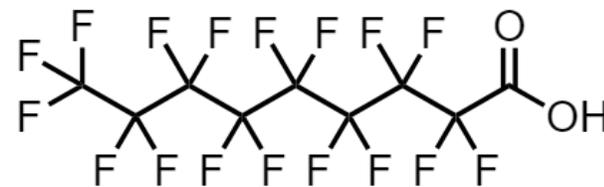
Per- and polyfluoroalkyl substances (PFAS)

European Union 2023 Maximum Level (ppb)

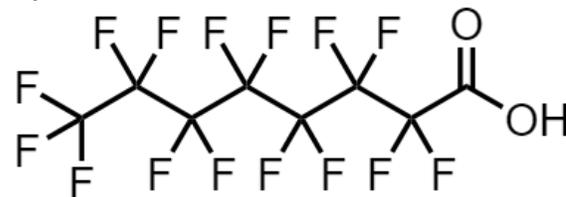
Product	PFOS	PFOA	PFNA	PFHxS	Sum of Four
Meat of Bovine, Pig, or Poultry	0.30	0.80	0.20	0.20	1.3



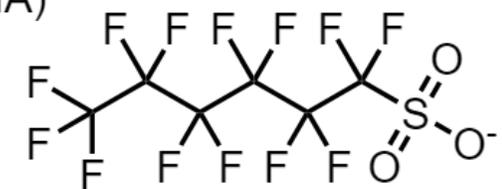
perfluorooctanesulfonic acid (PFOS)



perfluorononanoic acid (PFNA)



perfluorooctanoic acid (PFOA)



perfluorohexane sulfonate (PFHxS)



PFAS Development

1930s



Teflon accidentally discovered in 1938

1940s



DOD Research (Uranium Enrichment)

1950s



Consumer products

1960s



Aqueous Film Forming Foam (AFFF) is developed

Electrochemical Fluorination

11-29-1948 3M Application for Patent

“electrolyzing a liquid hydrogen fluoride(HF) solution containing a fluorinatable organic starting compound, at an electrolyzing potential which is insufficient to generate free fluorine under the existing conditions, but which is sufficient to cause the production of fluorine-containing carbon compound products at a useful rate”

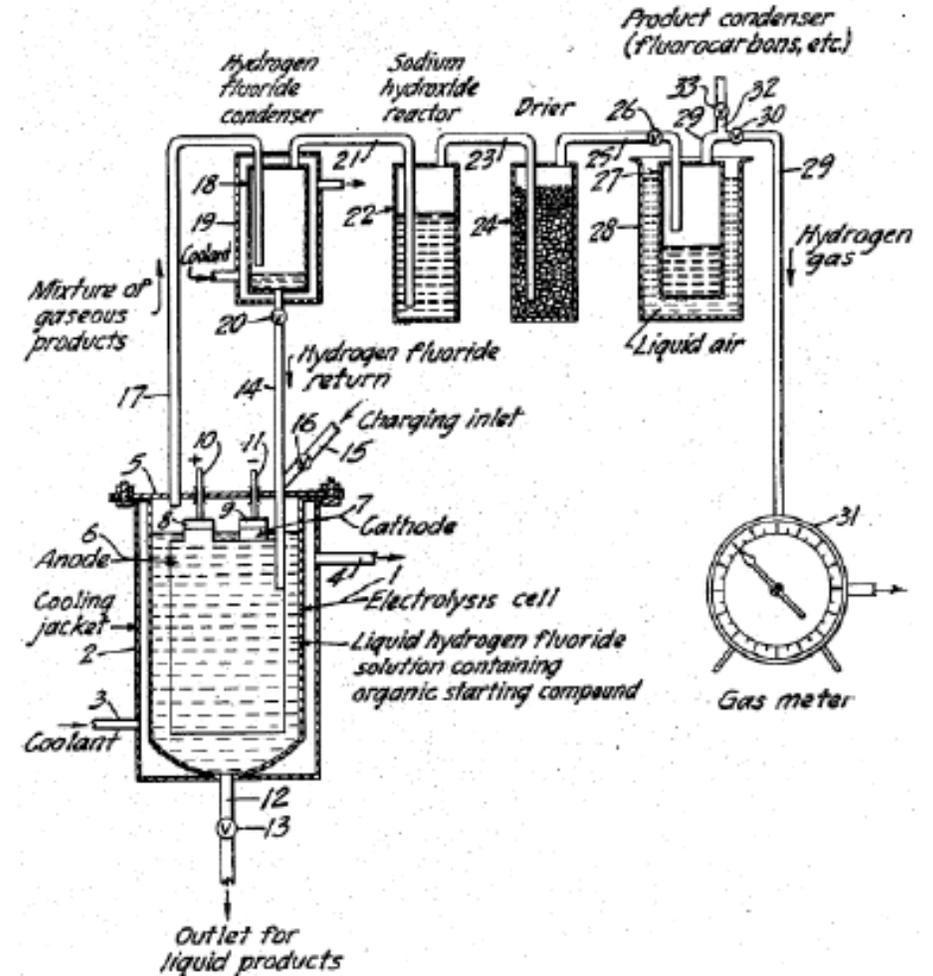
<https://patents.google.com/patent/US2519983A/en>

Patent US2519983

Aug. 22, 1950

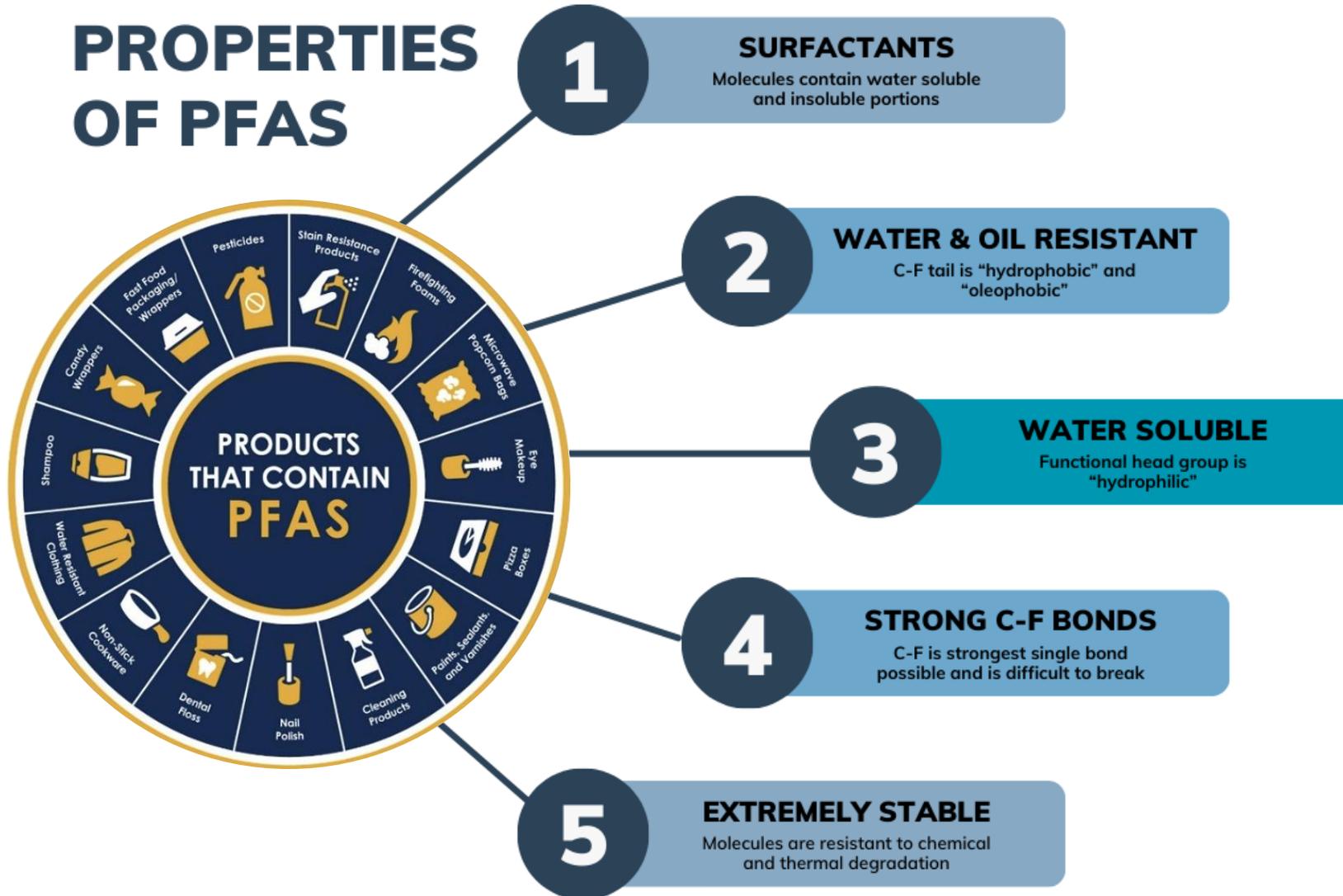
J. H. SIMONS
ELECTROCHEMICAL PROCESS OF MAKING FLUORINE-CONTAINING
CARBON-COMPOUNDS
Filed Nov. 29, 1948

2,519,983





PROPERTIES OF PFAS



- Carpeting
- Waterproof clothing
- Waterproof/greaseproof food packaging
- Cosmetics
- Stabilize emulsions
- Metal plating
- Firefighting foams
- Non-stick cookware



So Why The Concern?

- Don't Break Down Easily
- Long half-life in humans (PFOA, PFOS)

Article | [Open access](#) | Published: 06 July 2024

Reasons why life on Earth rarely makes fluorine-containing compounds and their implications for the search for life beyond Earth

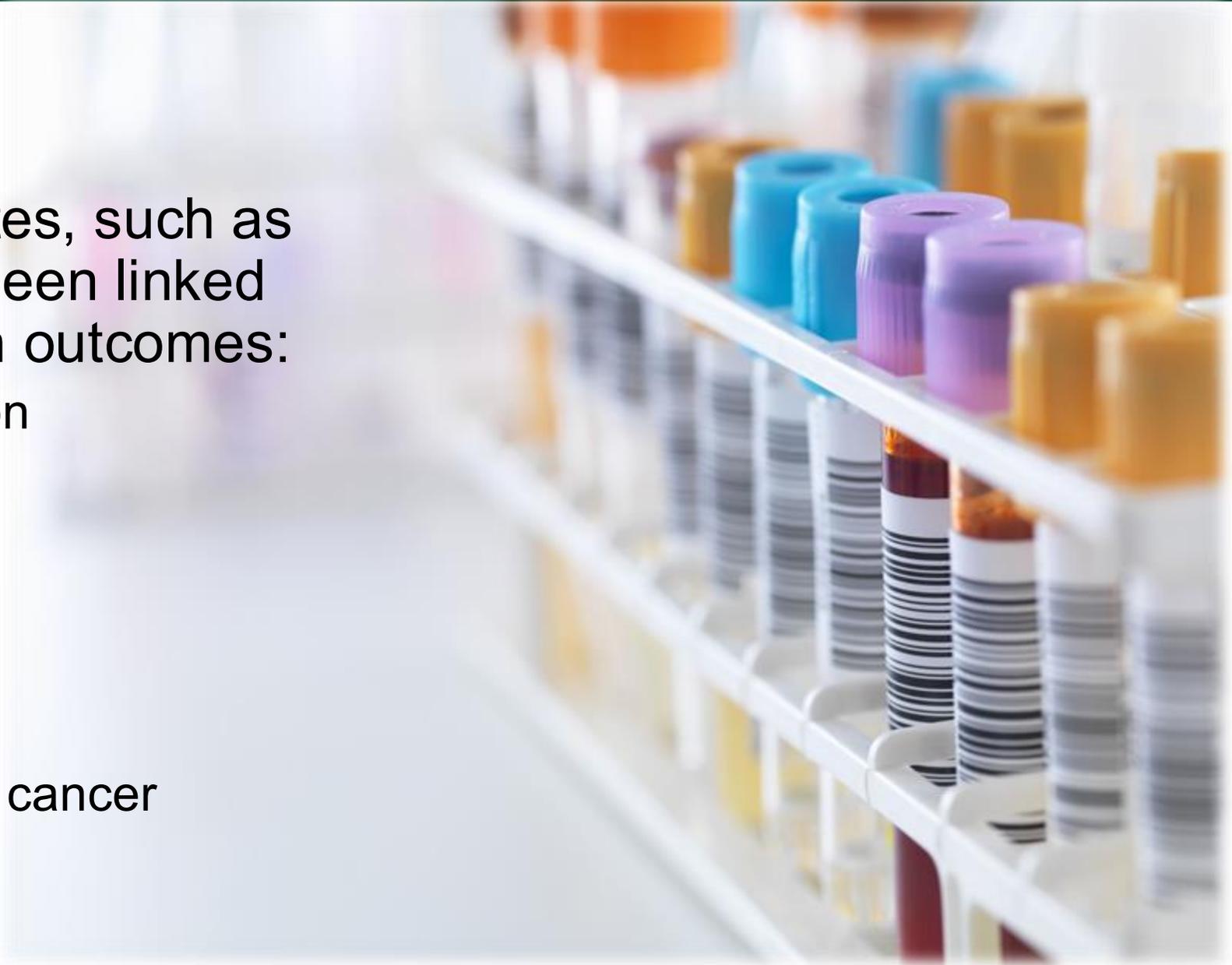
[Janusz J. Petkowski](#) , [Sara Seager](#) & [William Bains](#)

[Scientific Reports](#) **14**, Article number: 15575 (2024) | [Cite this article](#)



PFAS and Health

- Some well-studied analytes, such as PFOA and PFOS, have been linked to negative human health outcomes:
 - Liver and thyroid malfunction
 - Immunological disruption
 - Cardiovascular effects
 - Developmental effects
 - Reduced fertility
 - Higher cholesterol
 - Developing certain types of cancer

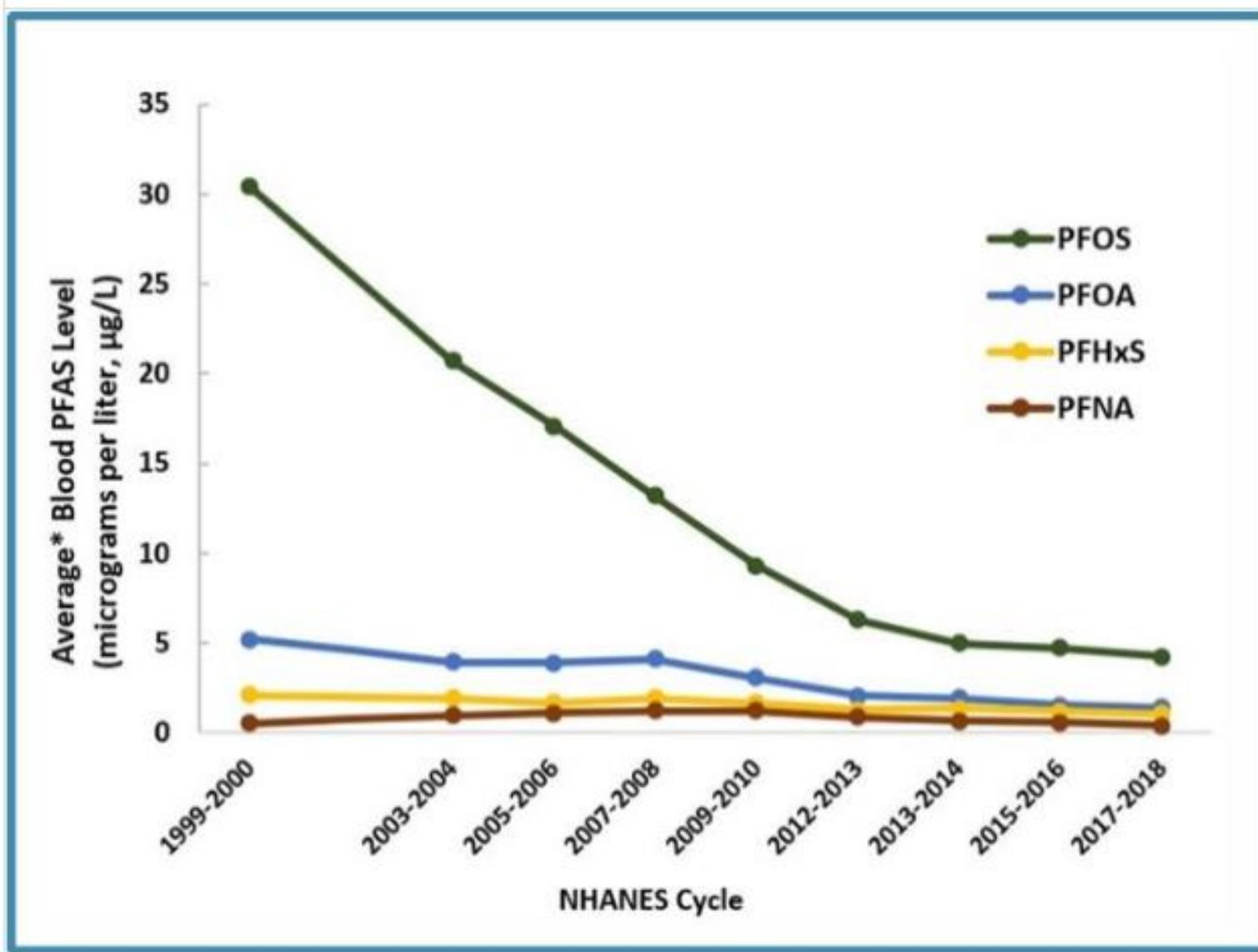




Exposure to PFAS Chemicals

- Drinking contaminated water
- Eating fish caught from water contaminated by PFAS
 - “Eat Safe Fish” Guidelines
- Incidental swallowing of contaminated soil or dust
- Eating food packaged in materials containing PFAS
- Using some consumer products
- PFAS absorption through skin is typically not a concern

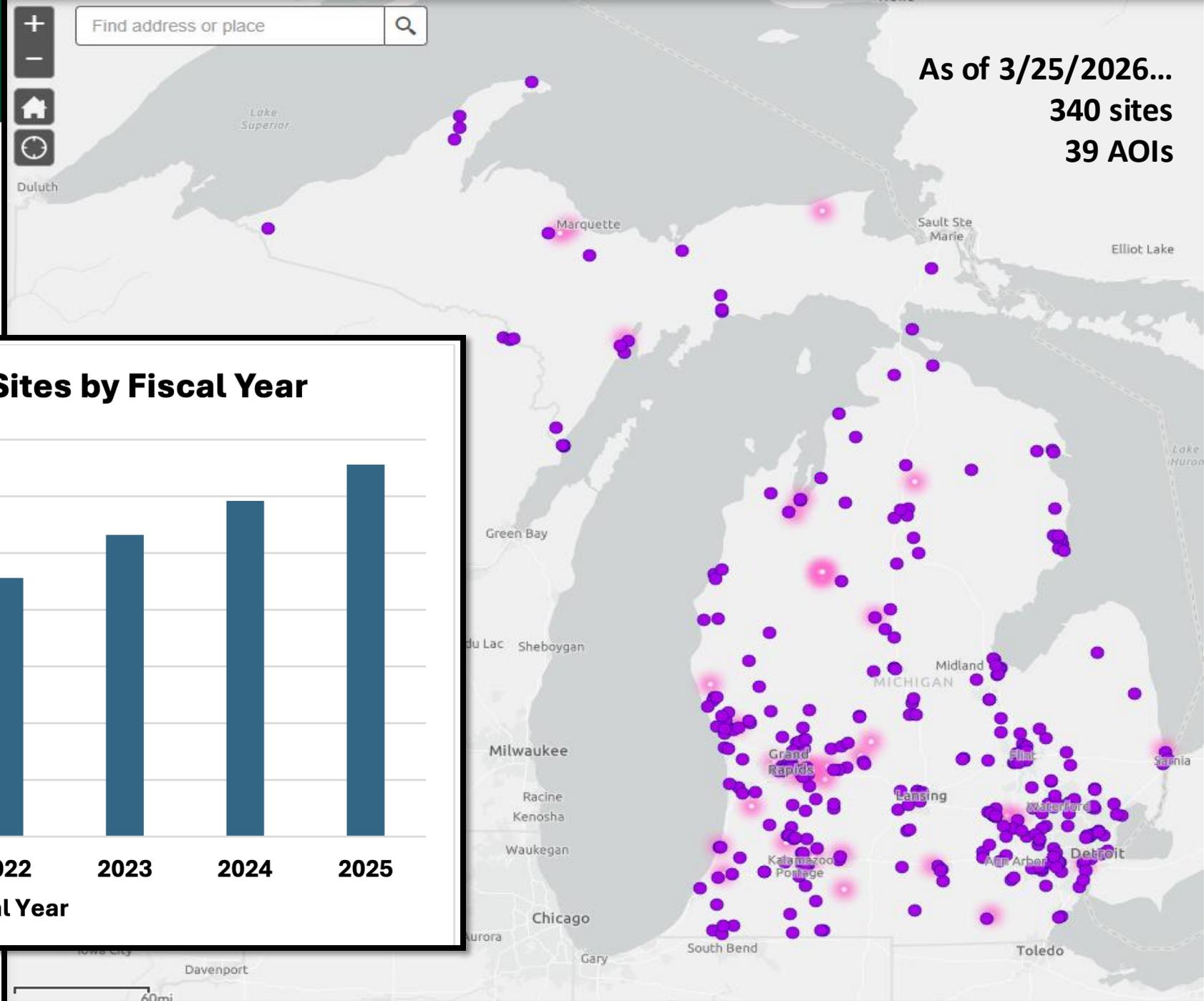




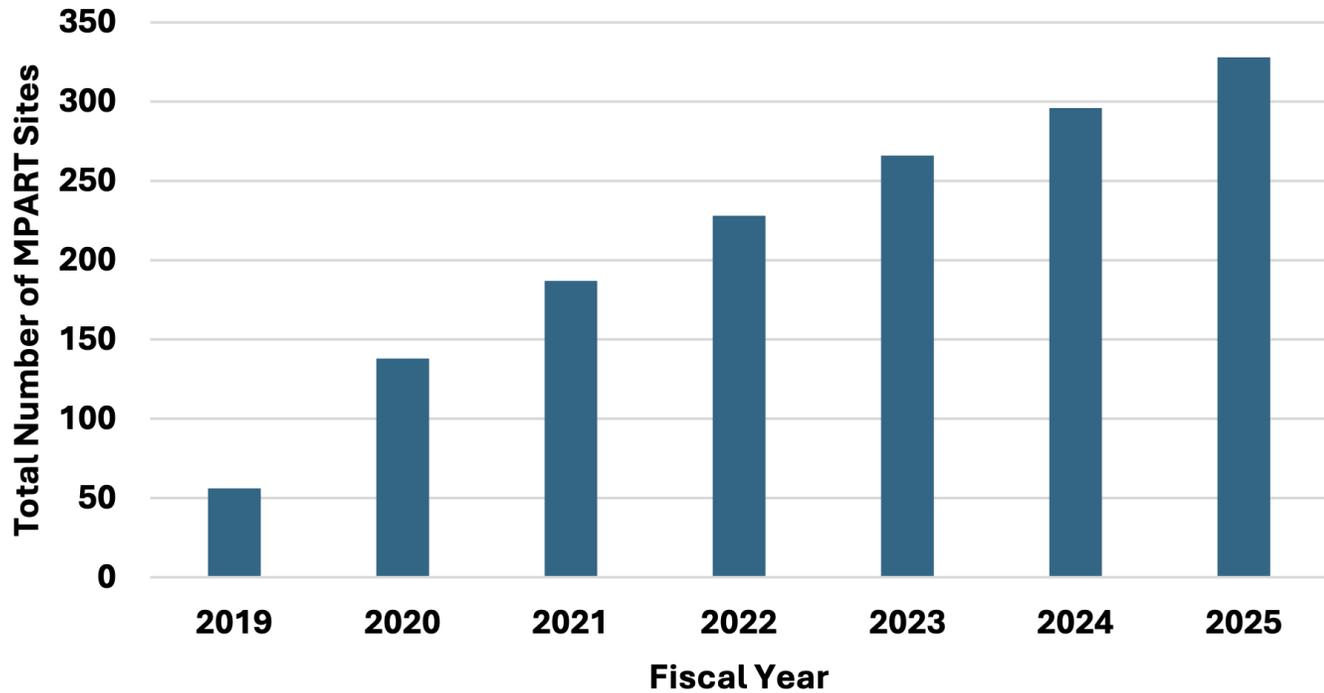
Blood levels of the most common PFAS in people in the United States 2000-2018

Map navigation controls: zoom in (+), zoom out (-), home, and refresh. A search bar contains the text "Find address or place" and a search icon.

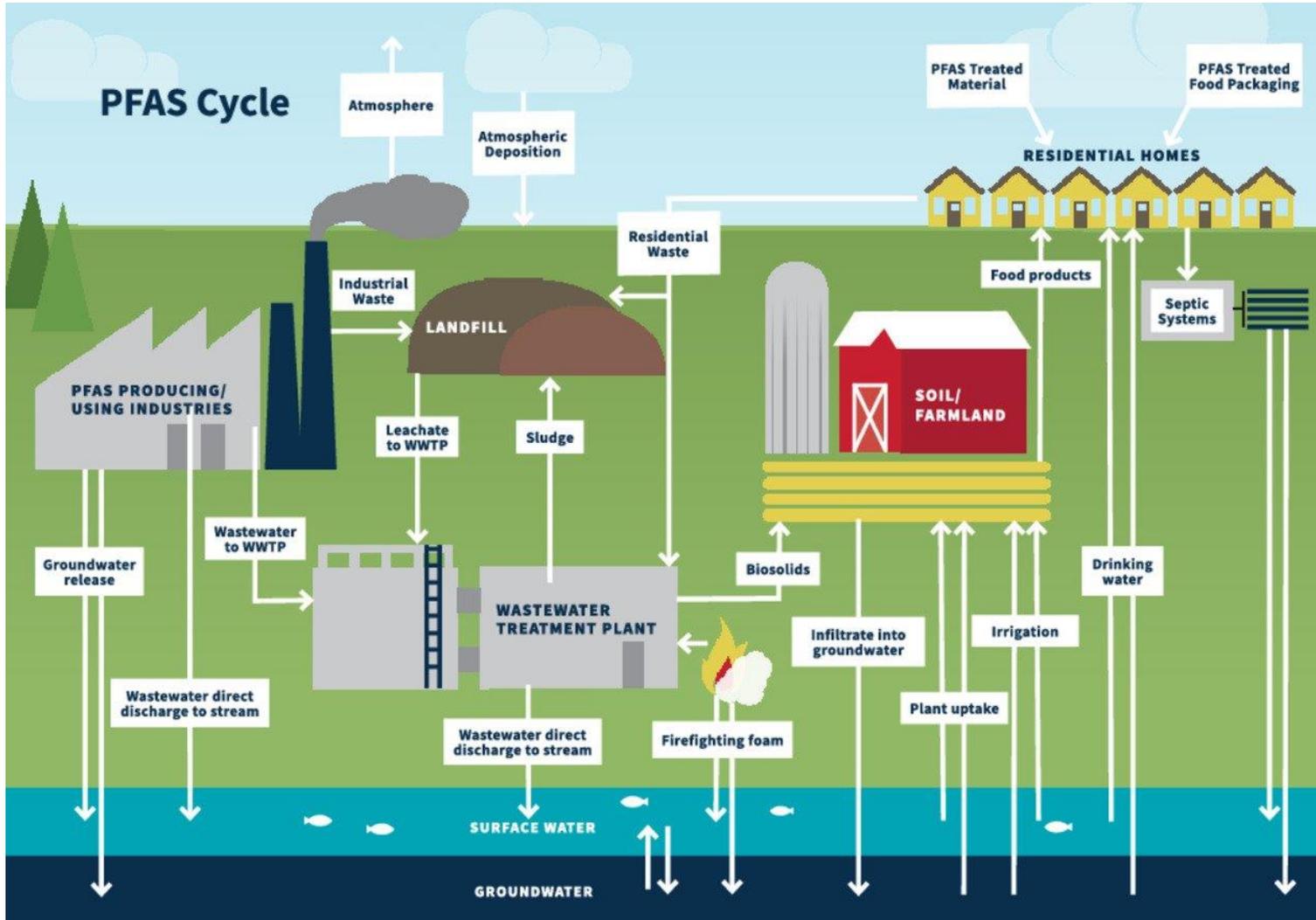
As of 3/25/2026...
340 sites
39 AOIs



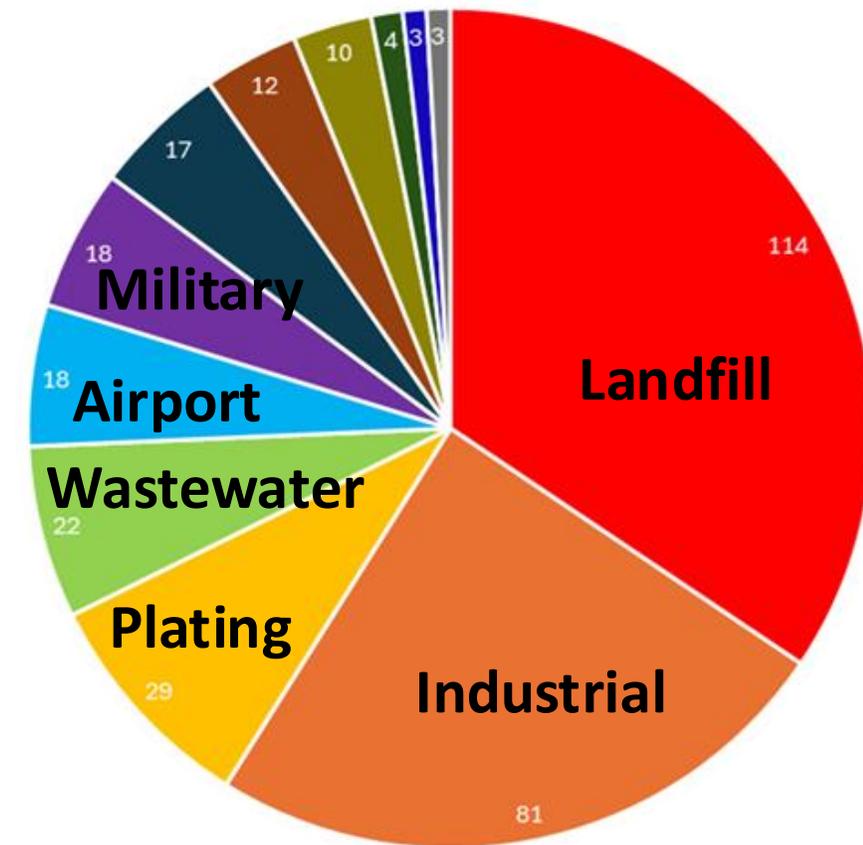
Total Number of MPART Sites by Fiscal Year

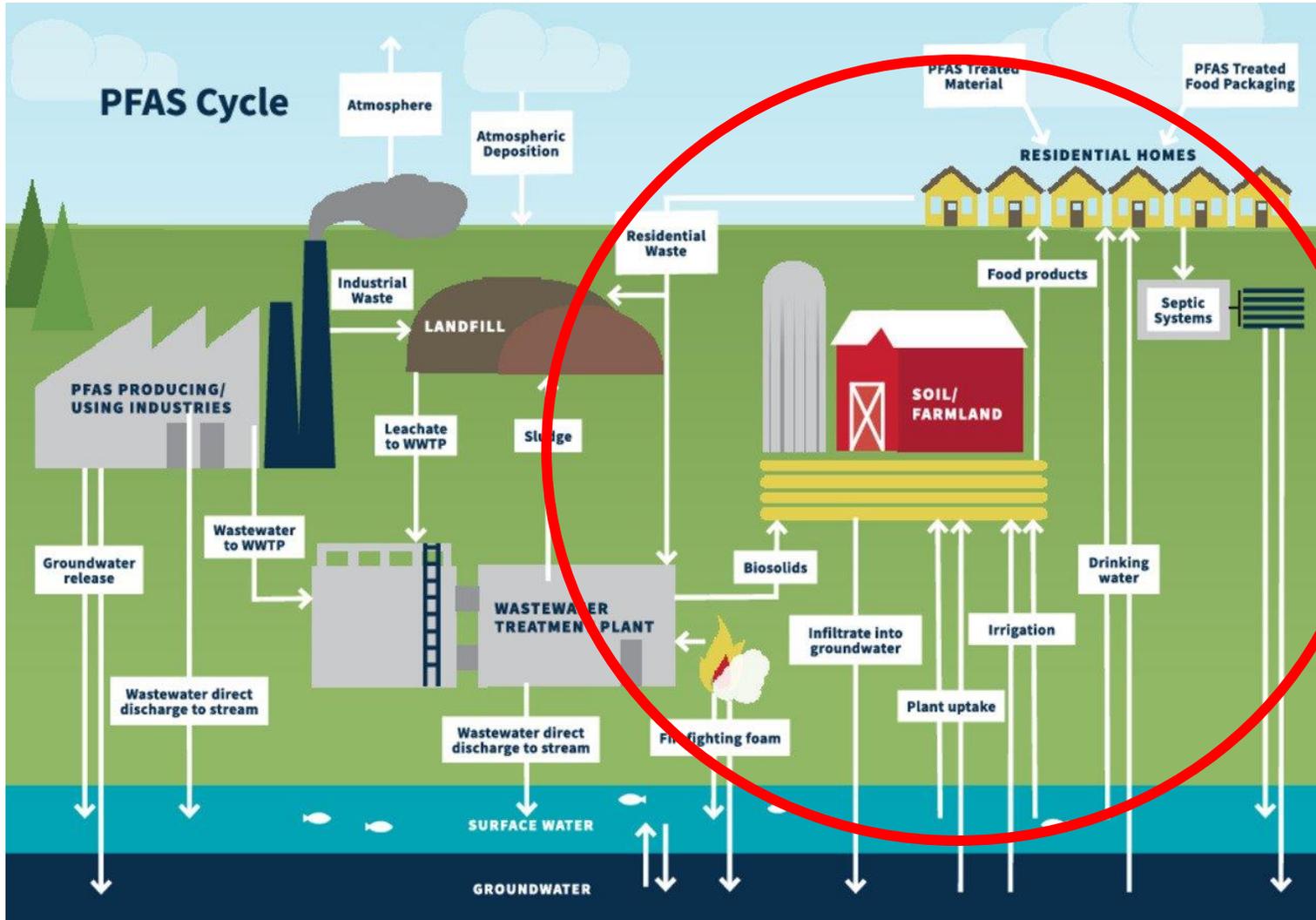


(MPART, 2025)



Identified PFAS Source







Interpreting PFAS Results

1 ppm = 1mg/L



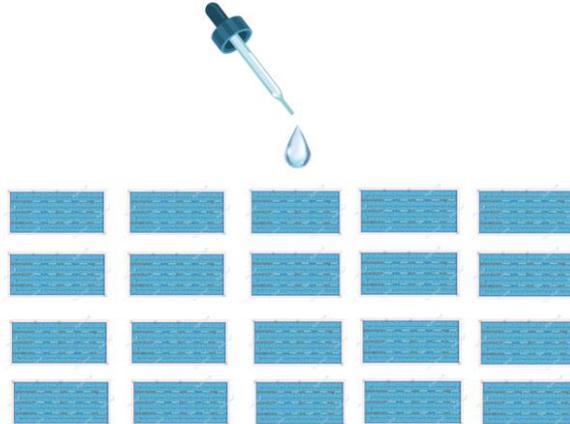
10-gallon aquarium

1 ppb = 1µg/L



10,000-gallon pool

1 ppt = 1ng/L



20 Olympic Swimming Pools

Units of Measure

parts per million	parts per billion	parts per trillion
1 ppm	1 ppb	1 ppt
= 1 milligram/kilogram mg/kg	= 1 microgram/kilogram µg/g	= 1 nanogram/kilogram ng/kg
= 1 milligram/liter mg/L	= 1 microgram/liter µg/L	= 1 nanogram/liter ng/L

Solids –
soils,
food, etc.

Liquids –
water,
milk, etc.



What are Biosolids?

- *Biosolids are nutrient-rich, organic solid, semisolid, or liquid residues coming from wastewater treatment plants*
 - *Go through several treatment processes to reduce pathogens and vector (flies, mosquitos and rodents) attraction*
 - *These treatment processes do not remove PFAS chemicals*
- *Come in various forms*
 - *Liquid, dewatered cake, slurry, composted materials, or dried pellets.*





Class A, EQ standards vs Class B Biosolids

Class B

- Treatment processes significantly reduce pathogens (not eliminate)
- May not be applied to lands with high potential for human exposure
- Annual PFAS monitoring in MI biosolids used for land application

Class A

- Designed to further reduce the risk from pathogens present
- Fewer additional requirements for land application
- Annual PFAS monitoring in MI biosolids used for land application

Class A EQ

- Meets both Class A and Exceptional Quality standards for the level of pathogen reduction, stringent pollutant limits, and vector attraction standards
- Can be sold directly to the public for use in home gardens or on lawns
- Quarterly PFAS monitoring in MI biosolids used for land application



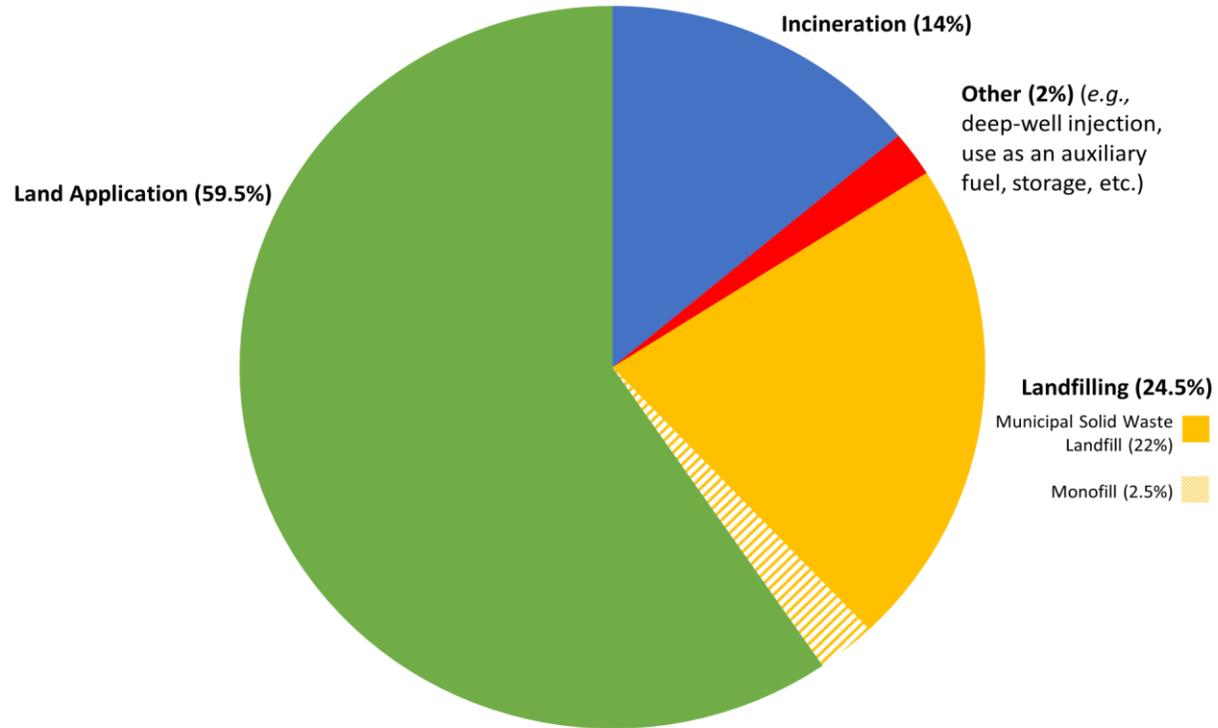
Disposal Options for Biosolids



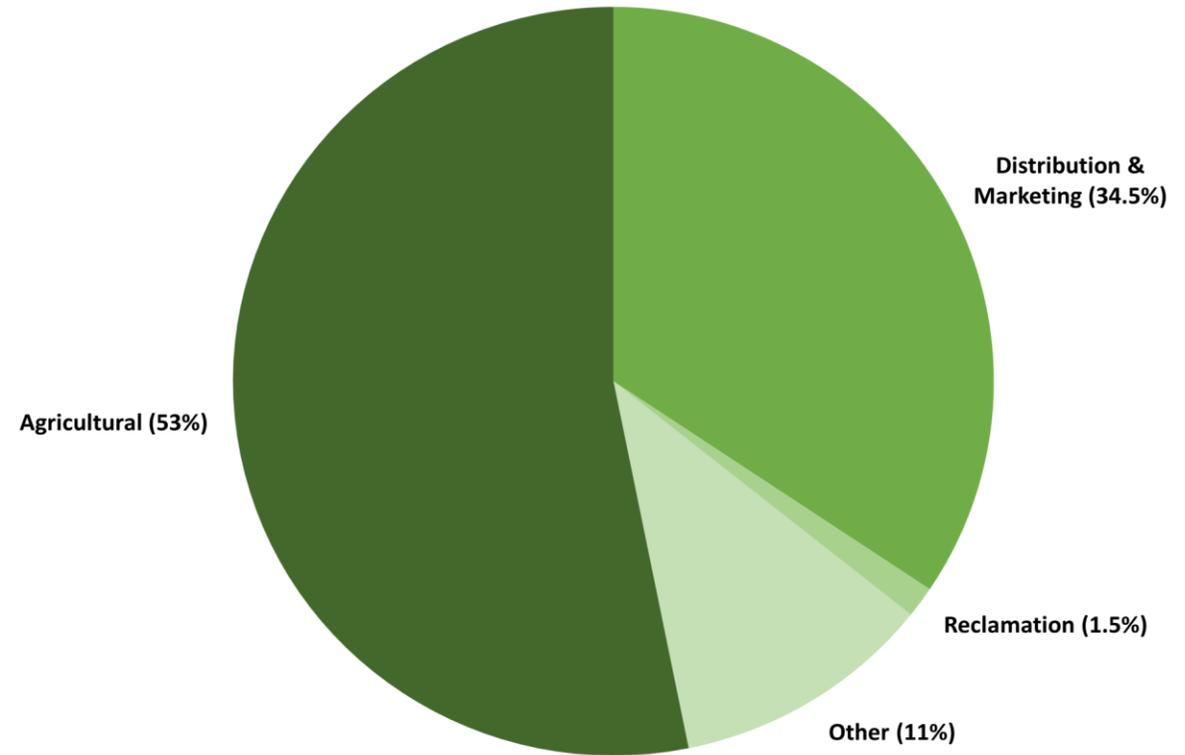


Fate of Biosolids in the United States

Sewage Sludge Use & Disposal from 2024 Biosolids Annual Reports



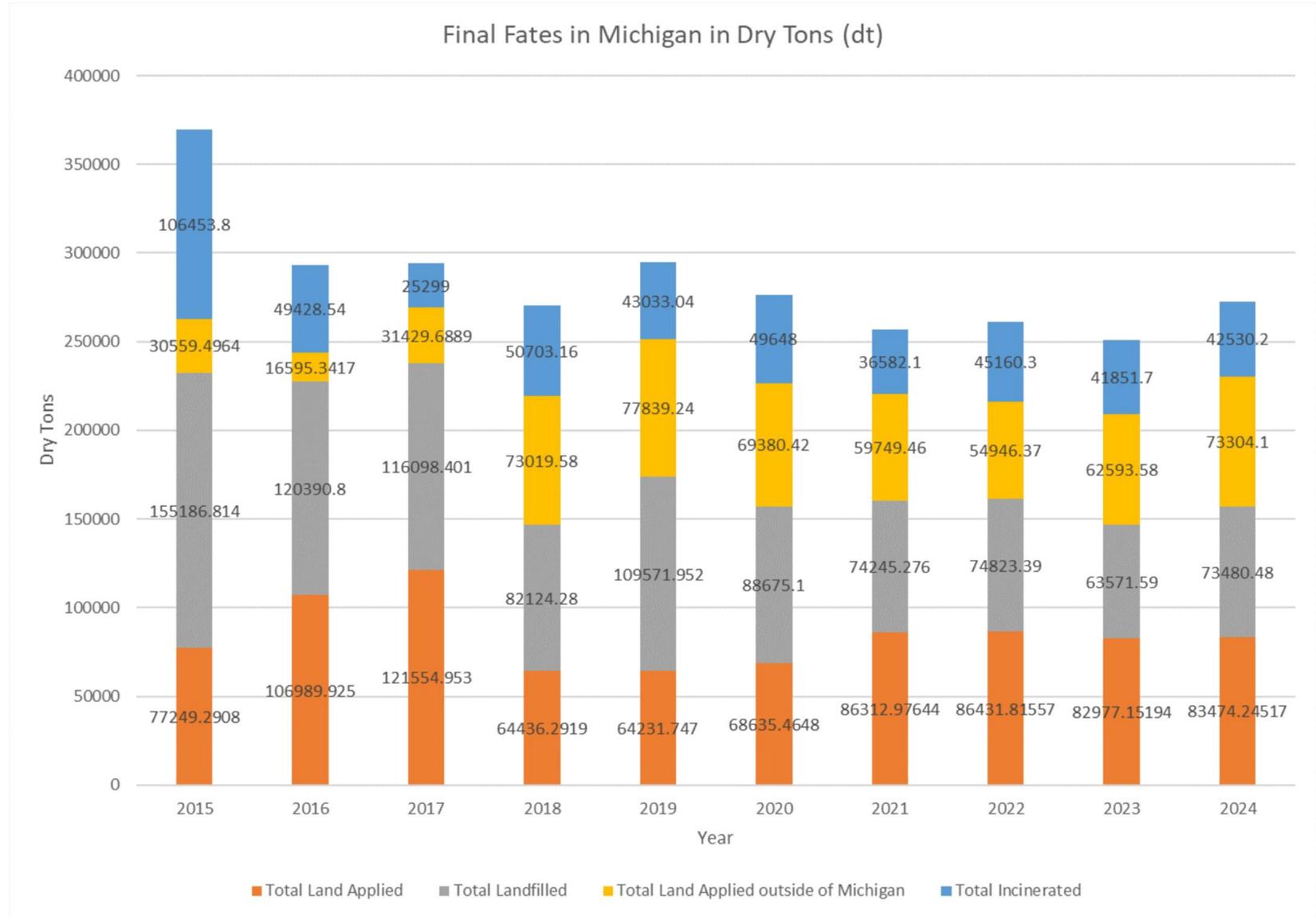
Reported End Use of Land Applied Sewage Sludge from 2024 Biosolids Annual Reports



(EPA, 2024)



Fate of Michigan Biosolids

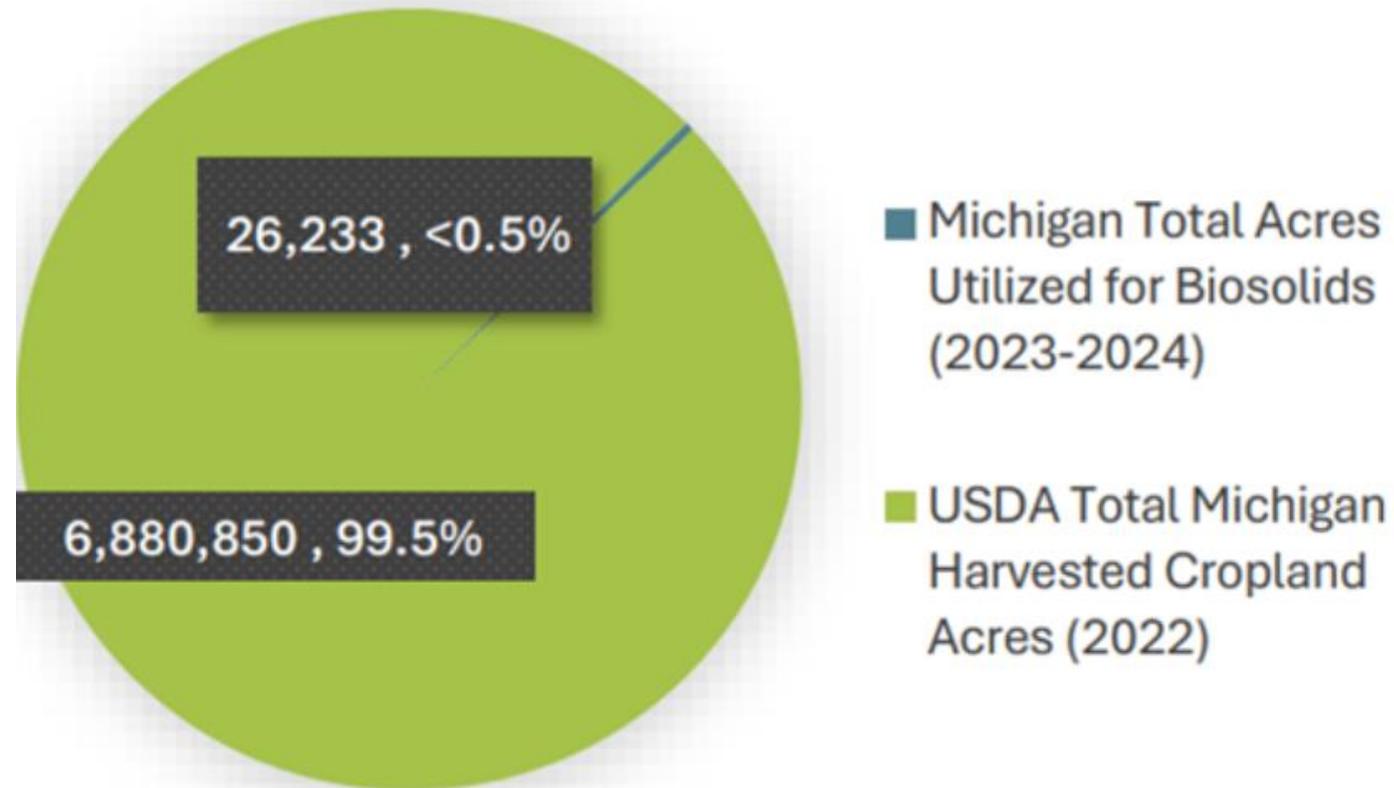


(EGLE, 2025)



Annual Biosolids Land Application in Michigan

Michigan Farmland Acreage Comparison





Benefits of Biosolids Land Application

- *Increase organic matter in soil*
- *They have important nutrients for plant growth and soil fertility*
 - *Nitrogen and phosphorous as well as essential micronutrients such like copper, iron, and zinc*
- *Inexpensive*
 - *Low/No cost to farmers*
 - *Allows for a reduction in the use of commercially produced fertilizers*



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Concerns with Biosolid Applications



Neighbor relations

- Odor
- Truck traffic



Nutrient runoff*



Contaminants

- PFAS
- Pharmaceuticals
- Artificial sweeteners



Contaminant runoff*



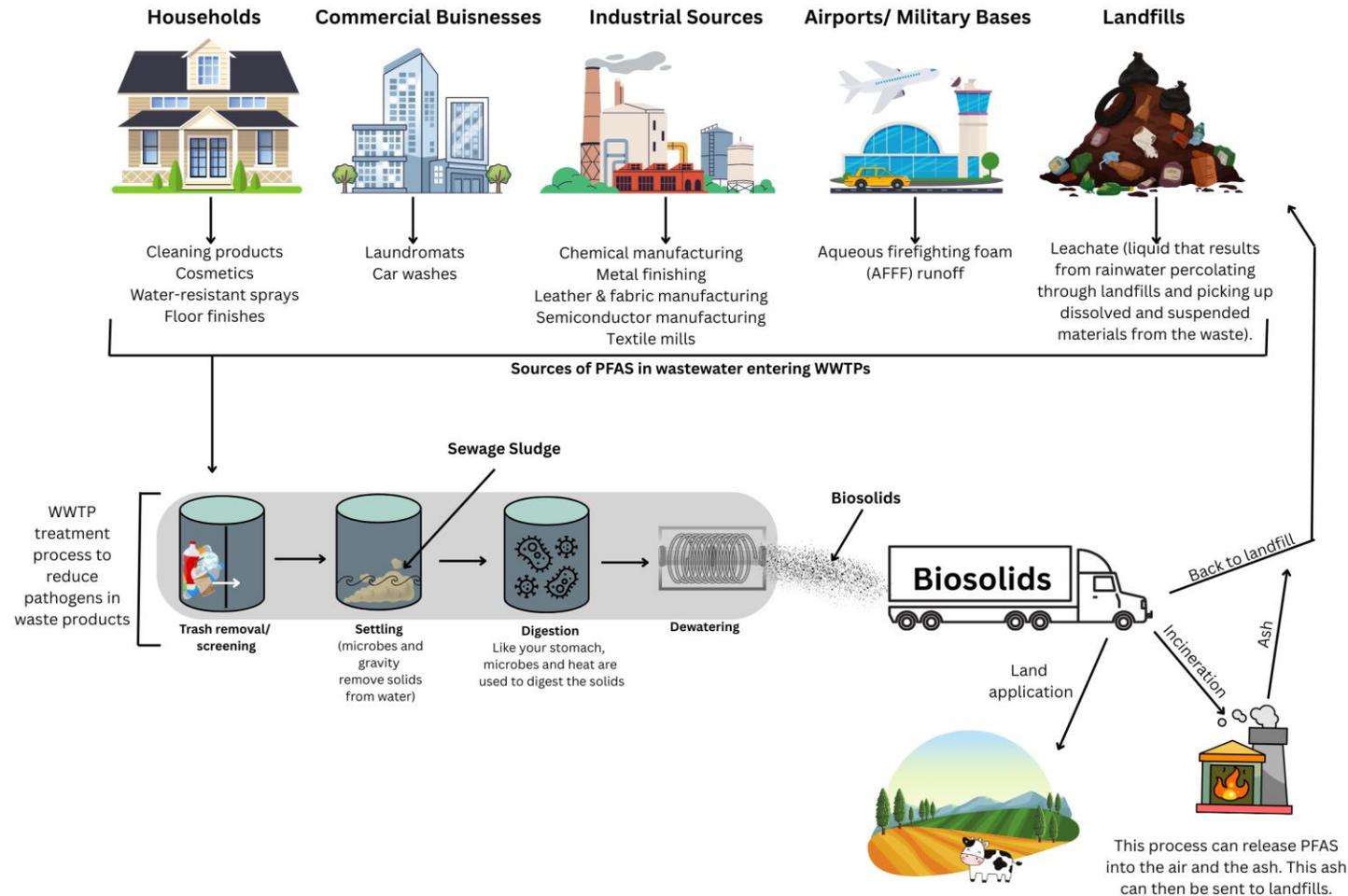
Regulatory Considerations Prior to Land Application

- *Distance of application from:*
 - *Surface water*
 - *Municipal wells*
 - *Domestic wells*
 - *Homes*
 - *Commercial buildings*
- *Crop harvest time restrictions*
- *Slope*
- *Soil fertility test results (phosphorous)*
- *Frozen/ saturated ground*
- *Groundwater depth*





How do PFAS get into biosolids?

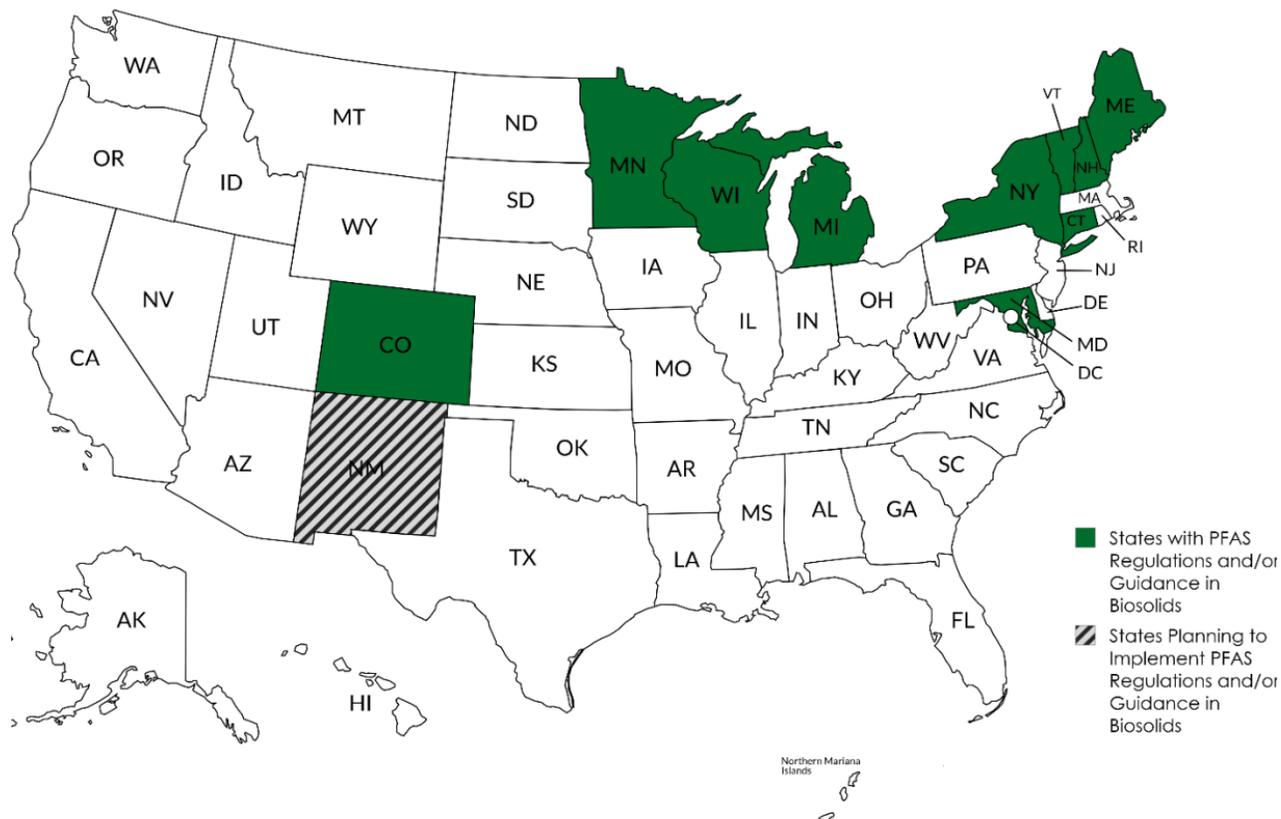




States with Guidelines for PFAS in Biosolids (as of April 2025)

Biosolids

States with PFAS Guidelines in Biosolids



- Maine was the first state to enact a ban of biosolid land applications
- Several states have new legislation regarding PFAS in biosolids
 - Virginia
 - Rhode Island
 - Washington

map shows the distribution of states with enacted or planned regulations and/or guidance for PFAS in biosolids



Michigan Industrial Pretreatment Program (IPP) PFAS Initiative

- *The discharge of pollutants from industrial wastewaters to WWTPS is regulated in Michigan through the IPP*
- *In 2017, EGLE identified a WWTP passing through PFOS received from a chrome plating facility exceeding Michigan's water quality standard for PFOS of 12 ng/L*
- *To respond, EGLE initiated the IPP PFAS Initiative in 2018 to reduce PFOA and PFOS entering WWTPs from industrial sources*
 - *Required all WWTPs with IPPs to evaluate if PFOA and/or PFOS may be passing through their treatment systems*

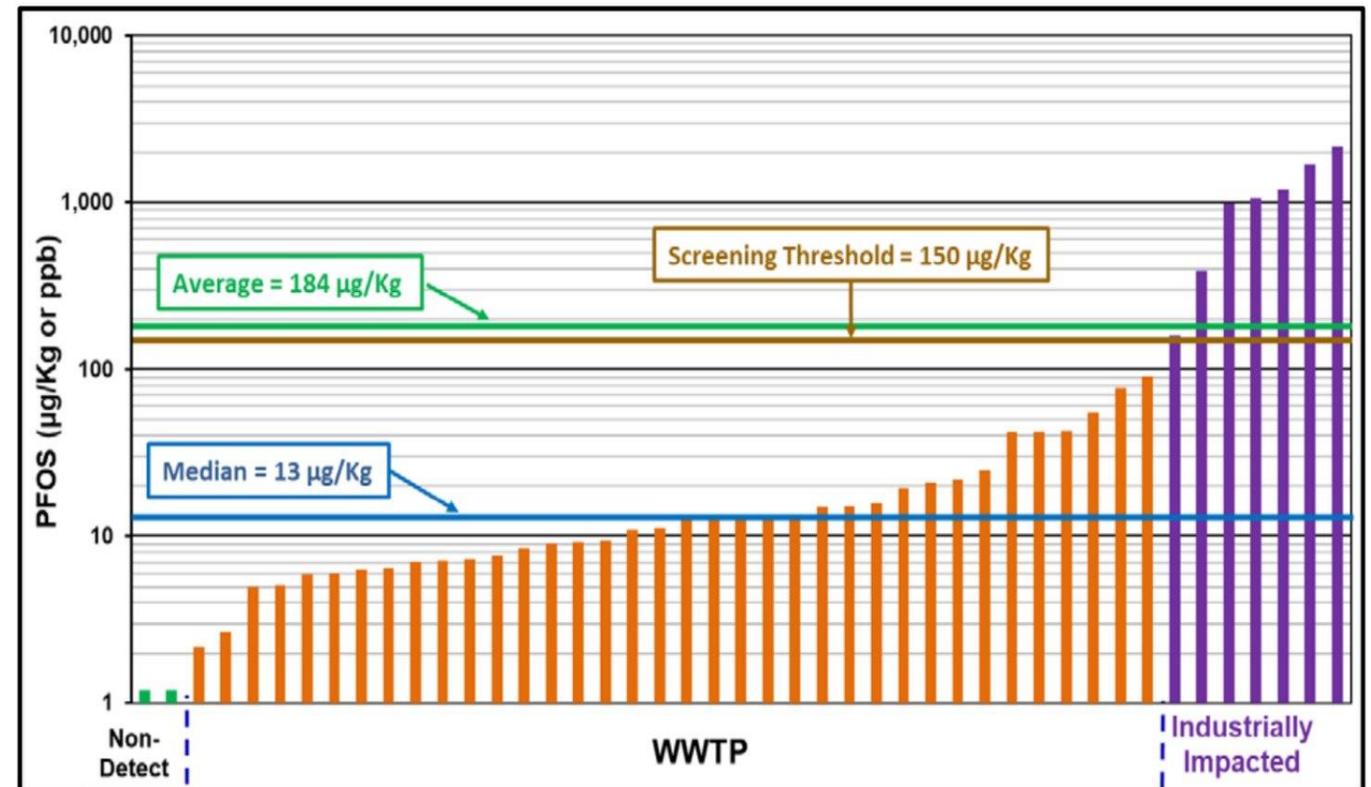




EGLE PFAS Initiative

- In the fall of 2018, EGLE launched a second statewide PFAS initiative
 - Assessed of 42 municipal WWTPs
 - Sampled influent, effluent and residuals
- PFOS was detected in 43 out of 45 final treated solids samples
- 6 WWTPs had solids above 150 ppb
- Short-chain PFAS were more frequently detected in the aqueous samples
- Long-chain PFAS were more frequently detected in solid samples

Figure 33. Final Treated Solids (Sludge and Biosolids) PFOS Concentrations for 42 WWTPs



(Bogdan, 2021)



Michigan Biosolids Interim Strategy

- *Implemented in 2021, with modifications in 2022 and 2024*
- *Regulate PFOS and PFOA in biosolids used for land application*
 - *Monitor 28 chemicals*
- *Class A & B biosolids must sample annually*
- *Class A EQ samples quarterly*
 - *Combined PFOA + PFOS less than 20 ppb*

PFOA and
PFOS < 20 ppb

May be land applied
with no additional
requirements

PFOS or PFOA
≥ 20 ppb

Reduced land
application rate of 1.5
dry tons per acre
(dt/acre)

Must implement a
source reduction plan

PFOA or
PFOS ≥ 100
ppb

Considered industrially
impacted and cannot
be land applied

Must find alternative
treatment or disposal
option

Must implement
source reduction plan



Current Biosolids Concentrations

Mean and Median Values of Biosolids/Sludge Concentrations Since 2018				
Year	PFOS		PFOA	
	Mean	Median	Mean	Median
2018*	184	13	25	7
2021	21	9	8	4
2022	16	10	7	3
2023	12	7	6	3
2024	8	5	5	2
2025	8	6	4	2
2026**	7	5	3	2



*Includes results from industrially impacted facilities as part of a statewide study

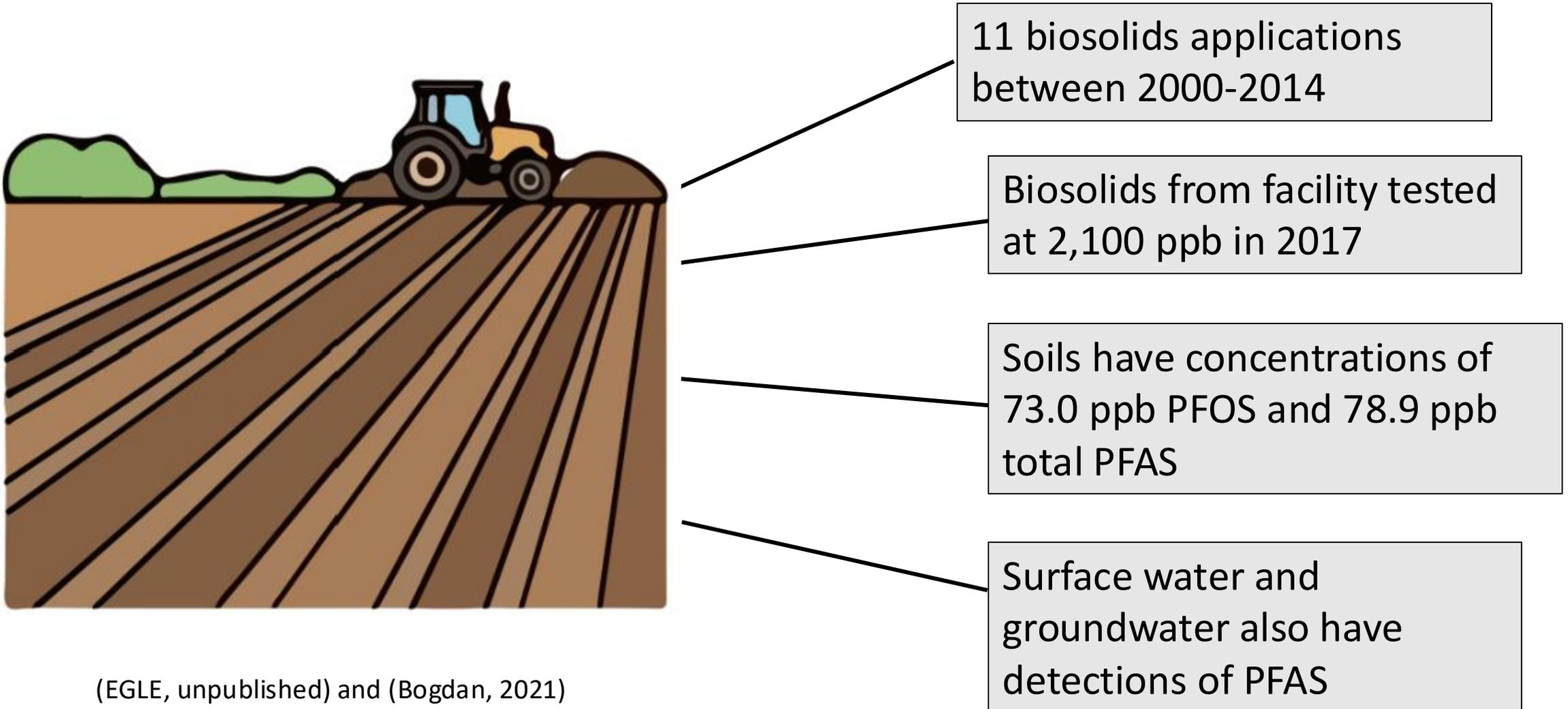
** 2026 values updated 3/05/2026 including results from 56 facilities

All values reported in microgram per kilogram ($\mu\text{g}/\text{Kg}$, parts per billion [ppb])

(EGLE, unpublished)



Field with Prior Historical, Industrially Impacted Biosolid Applications





MSU Soil Results in Biosolid Land Application Fields

Field Type	Sample Size	# of Non-Detect Fields (ND)	Range of PFOA (ppb)	Range of PFOS (ppb)	Range of Total PFAS (ppb)	Max # of PFAS Compounds Detected
Baseline Study Field	17	4	ND-0.2	ND-0.51	ND-1.16	5
Biosolids Land Application Field	3	0	ND-0.16	0.25-0.58	0.58-0.89	5

Data is preliminary and unpublished, Cullens-Nobis and King



EPA DRAFT Sewage Sludge Risk Assessment for PFAS

January 2025



- *Focuses on risk to those living on or near IMPACTED sites or those that rely primarily on their products*
- *A lot of assumptions were used in the model:*
 - *Toxicity values*
 - *Health impacts*
 - *Plant uptake/bioaccumulation factors*
 - *Livestock/bioaccumulation uptake factors*
 - *Fish/bioaccumulation uptake factors*
 - *Consumption rates*
 - *Cooking and food prep loss*
 - *Soil ingestion rates*
 - *Climate conditions*
 - *Soil characteristics*
 - *Aquifer characteristics*
 - *Farming practices*



*Model exceeded the EPA's acceptable human health risk thresholds for some scenarios when the sludge has **1ppb** PFOA or PFOS*





EPA DRAFT Risk Assessment

- *Focused on a narrow population that consumes the majority of their diet from a single impacted farm*
 - *Not the general public*
 - *Not consuming foods from a variety of sources*
- *Did not consider occasionally consuming impacted products or drinking water*
- *Draft!*
- *Over 20,000 comments received*
- *Not regulation*
- *Could result in limits or BMP's*
 - *Implications?*

<https://www.epa.gov/system/files/documents/2025-01/draft-sewage-sludge-risk-assessment-pfoa-pfos.pdf>



What is Septage?



- Domestic Septage-
 - Liquid or solid material removed from a septic tank cesspool, portable toilet, type III marine sanitation device, or a similar system that receives only domestic septage (household, non-commercial, nonindustrial sewage).
- Generally, federal permits are not required for land application of domestic septage onto non-public contact sites (agricultural land, forests and reclamation sites)
 - State regulations for land application of septage must be followed

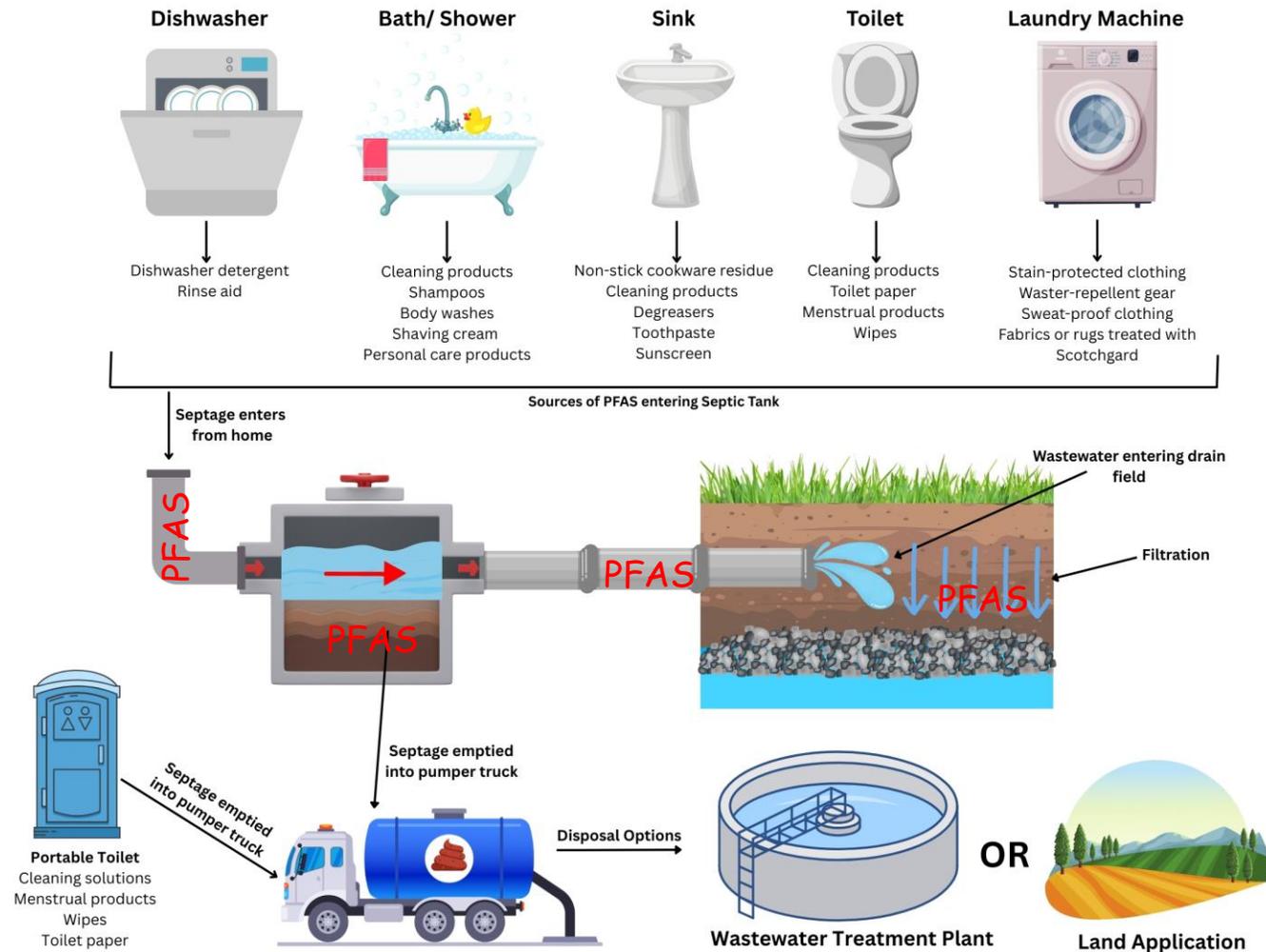


Land Application of Septage in Michigan

- *Details in MCL-451-1994-11-3 Part 117*
- *Disposal of domestic septage at authorized wastewater treatment plants (septage waste receiving facilities) **IF** the septage waste is pumped from a location within the established service area of a given facility*
- *If a septage waste receiving facility is not available, then **domestic** septage can be applied at approved permitted sites*
 - *Application rates*
 - *Slope*
 - *Groundwater depth*
 - *Isolation distances*

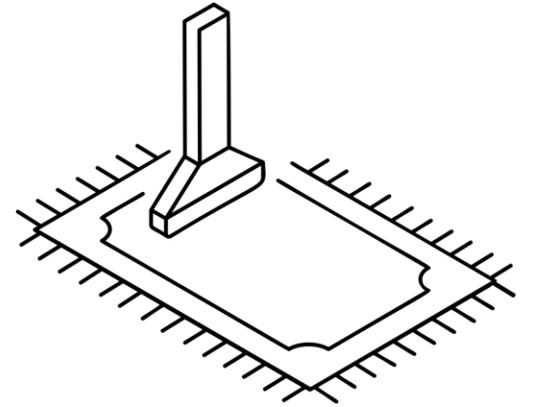
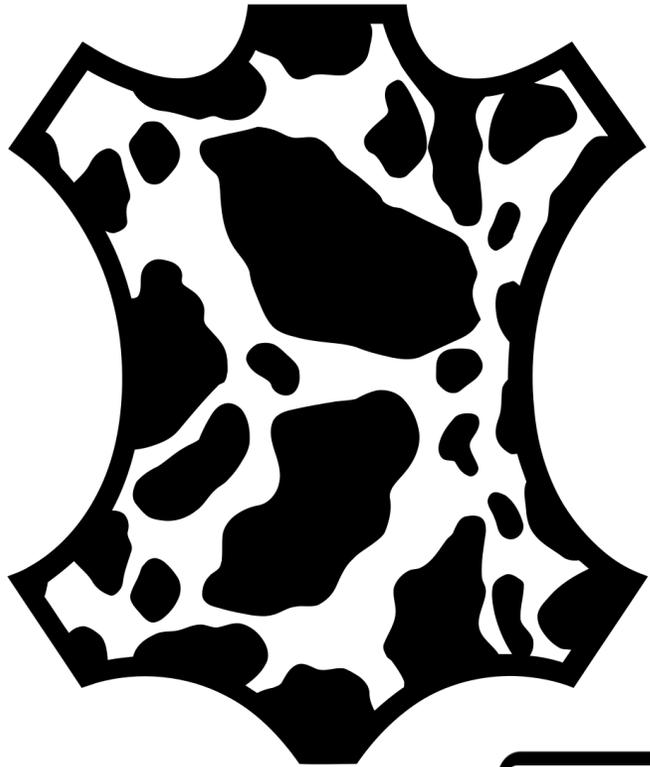


How do PFAS get into domestic septage?





PFAS Contributors to Non-Domestic "Septage"





PFAS in Michigan Septage

- *No testing requirements for PFAS*
- *They do require permits to ensure public safety, ground and surface water protection*
- *Small number of samples voluntarily tested/ sent to EGLE*
- *Mostly domestic septage*
 - *Some haulers also haul industrial waste or non-domestic septage*
 - *Potential for this waste to contain more PFAS*
 - *Data labeled accordingly*





PFAS in Michigan Septage (n=5), 2021-2023

State	Sample #	Number of PFAS Compounds Tested	PFOS+PFOA (ppt)	Total PFAS (ppt)	Notes
Michigan	1	31	23.0	105.9	Domestic septage
	2	28	32.0	878.1	This hauler also hauls industrial waste. The sample should primarily contain domestic waste but may include some industrial waste.
	3	28	105.8	690.3	This sample should be primarily domestic waste but could possibly contain some industrial waste.
	4	28	25.0	25.0	Domestic septage
	5	28	33.5	214.1	Domestic septage

Data is limited, so this may not reflect average concentrations of PFAS in Michigan septage. More samples are needed to fully understand the scope of PFAS contamination in septage. Note data is reported in ppt



Soil PFAS at Septage Land Application Site- Michigan (n=1)

- *Field with no septage application*
 - *Total PFAS = 0.13 ppb (100% PFOS)*
- *Field with septage applications in 2025*
 - *Total PFAS = 0.10 ppb (100% PFOS)*
- *Field with septage applications in 2024 & 2025*
 - *Total PFAS = 0.10 ppb (100% PFOS)*

The PFAS concentrations in these fields are not different than agricultural fields that we sampled with low risk factors!

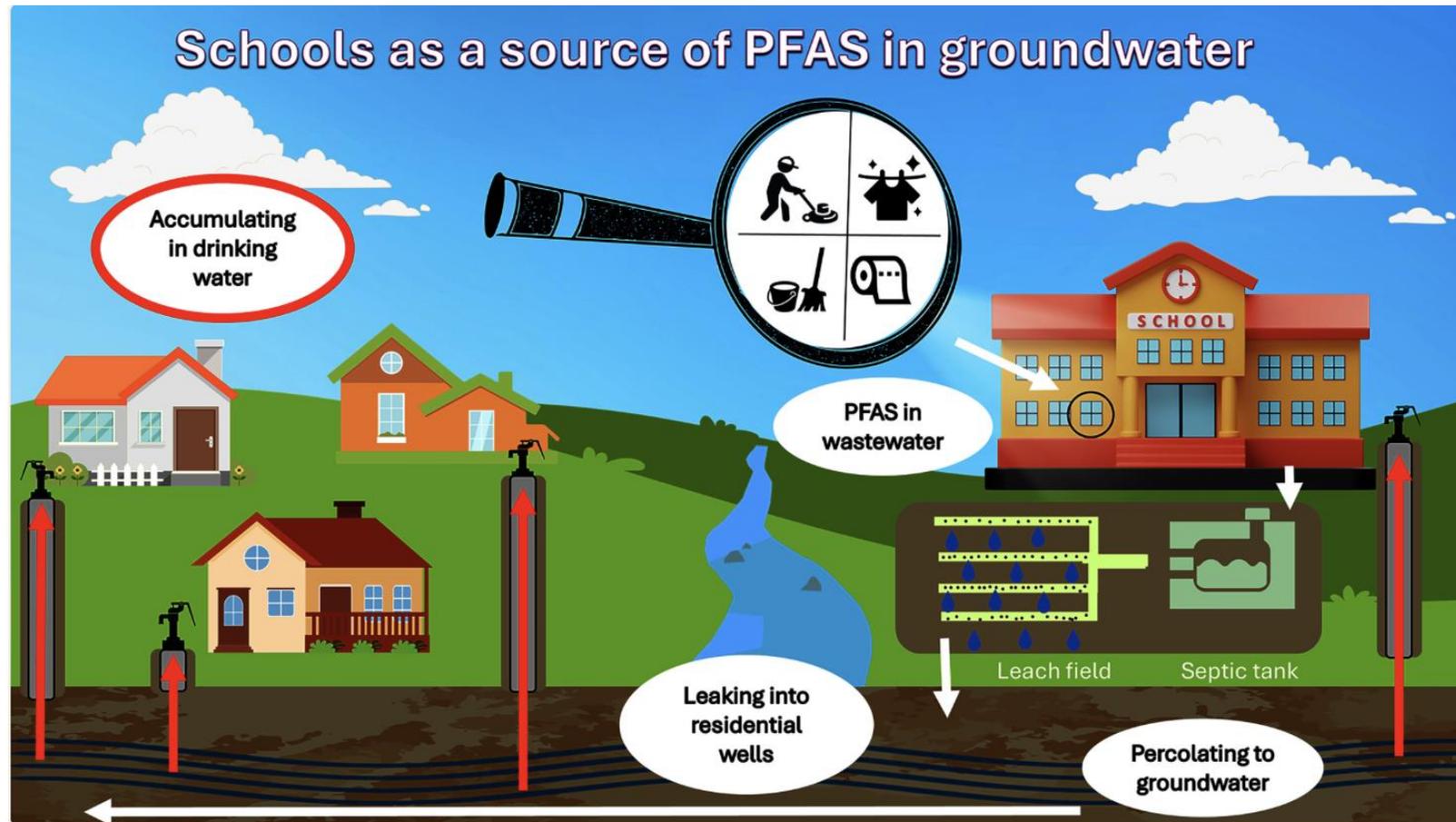


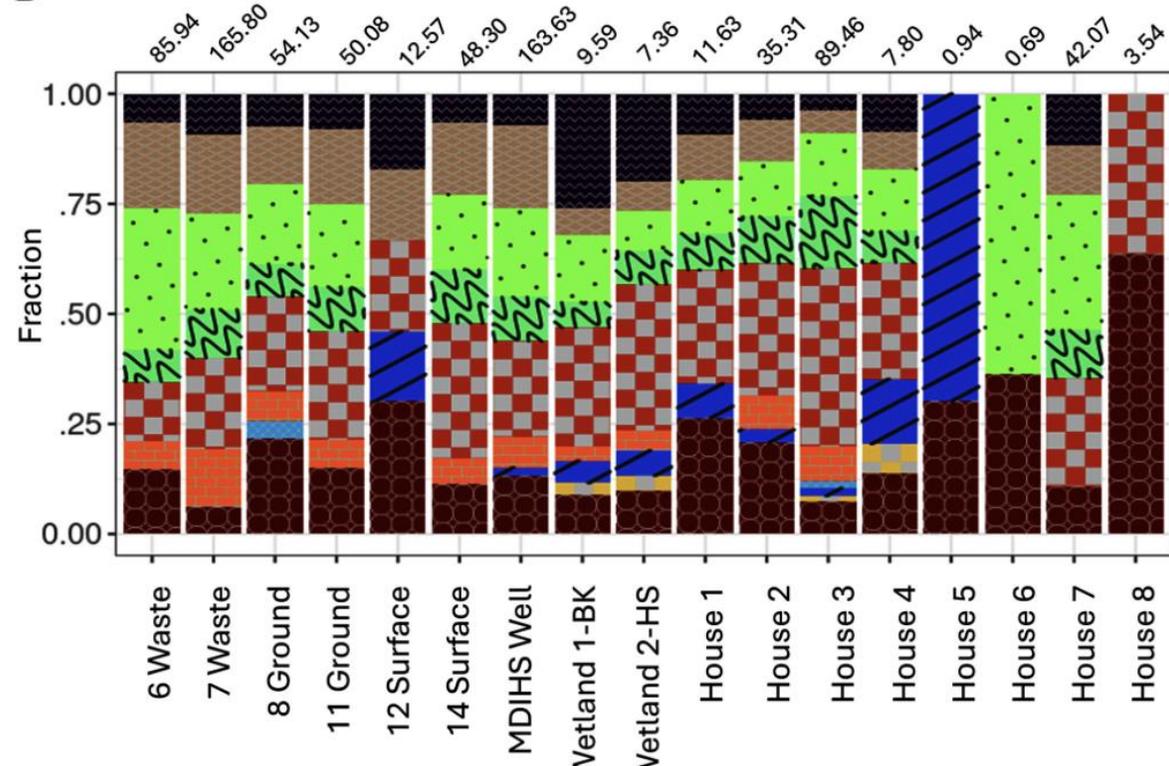
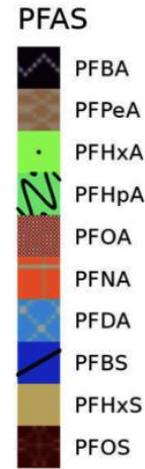
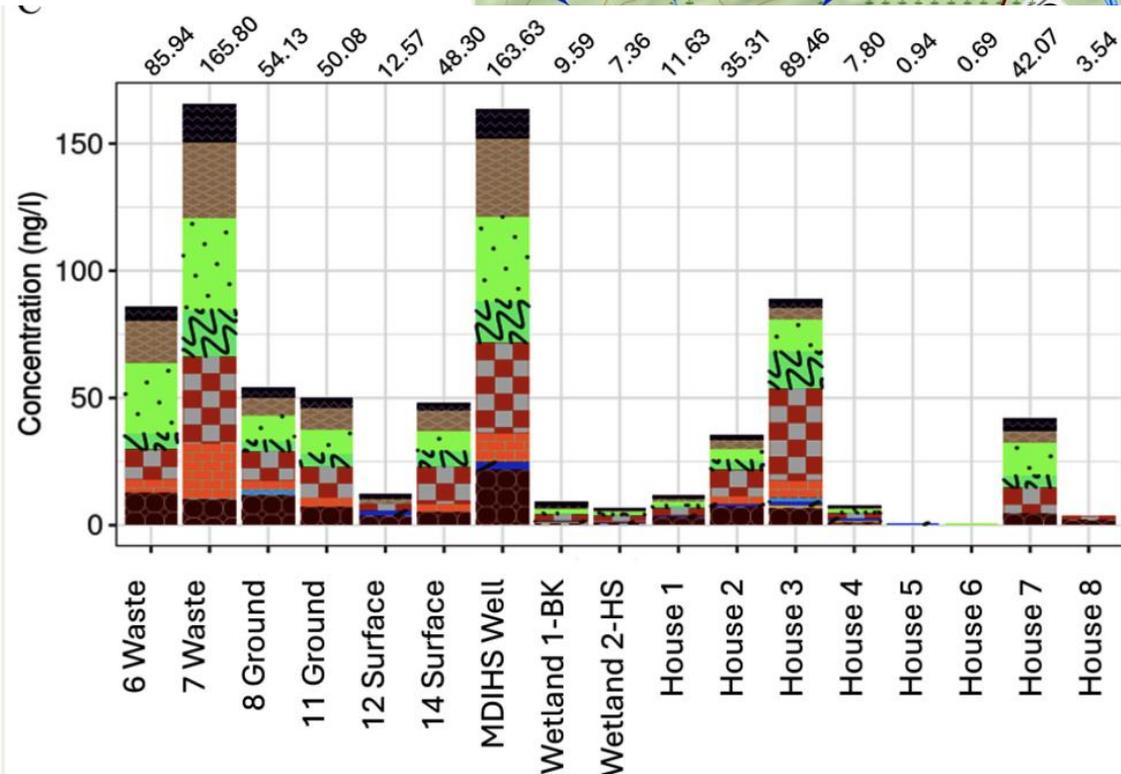
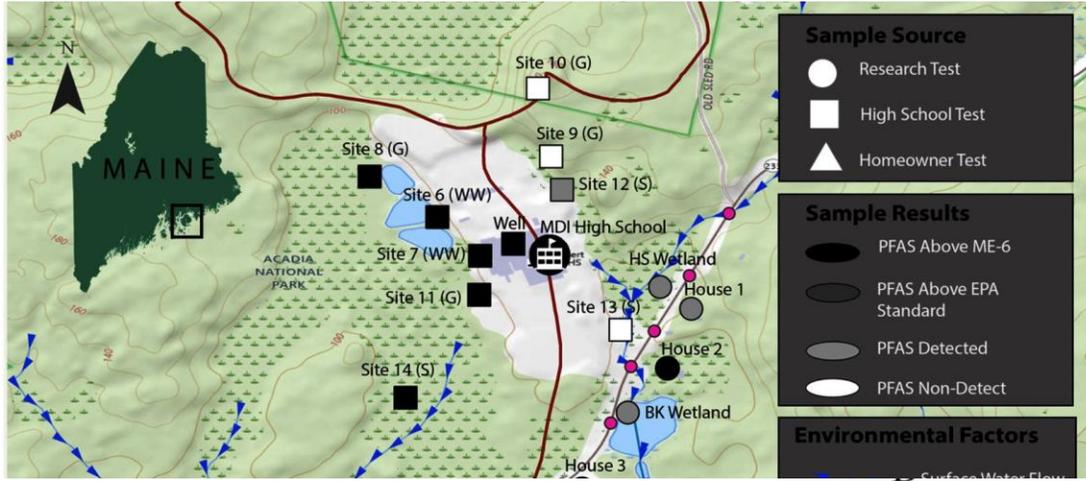


Impacts to Groundwater

Examining Potential PFAS Contamination of Private Wells from a High School in Rural Maine

[Ludwin Moran Sosa](#)^{1,2}, [Ashley Taylor](#)², [Alexis C Garretson](#)², [Ann Backus](#)³, [Katie Richards](#)⁴, [Joel H Graber](#)², [Richard F Hilliard](#)², [Jane E Disney](#)^{2,✉}







**REPORT ON THE OCCURRENCE OF PER- AND
POLYFLUOROALKYL SUBSTANCES (PFAS) IN FLOOR
STRIPPING AND REFINISHING WASTEWATER AT FOUR
SCHOOLS IN NEW HAMPSHIRE**

Prepared by

Groundwater Discharge Program
Drinking Water and Groundwater Bureau
Water Division

Robert R. Scott, Commissioner
Adam J. Crepeau, Assistant Commissioner

February 2024



Floor Stripping

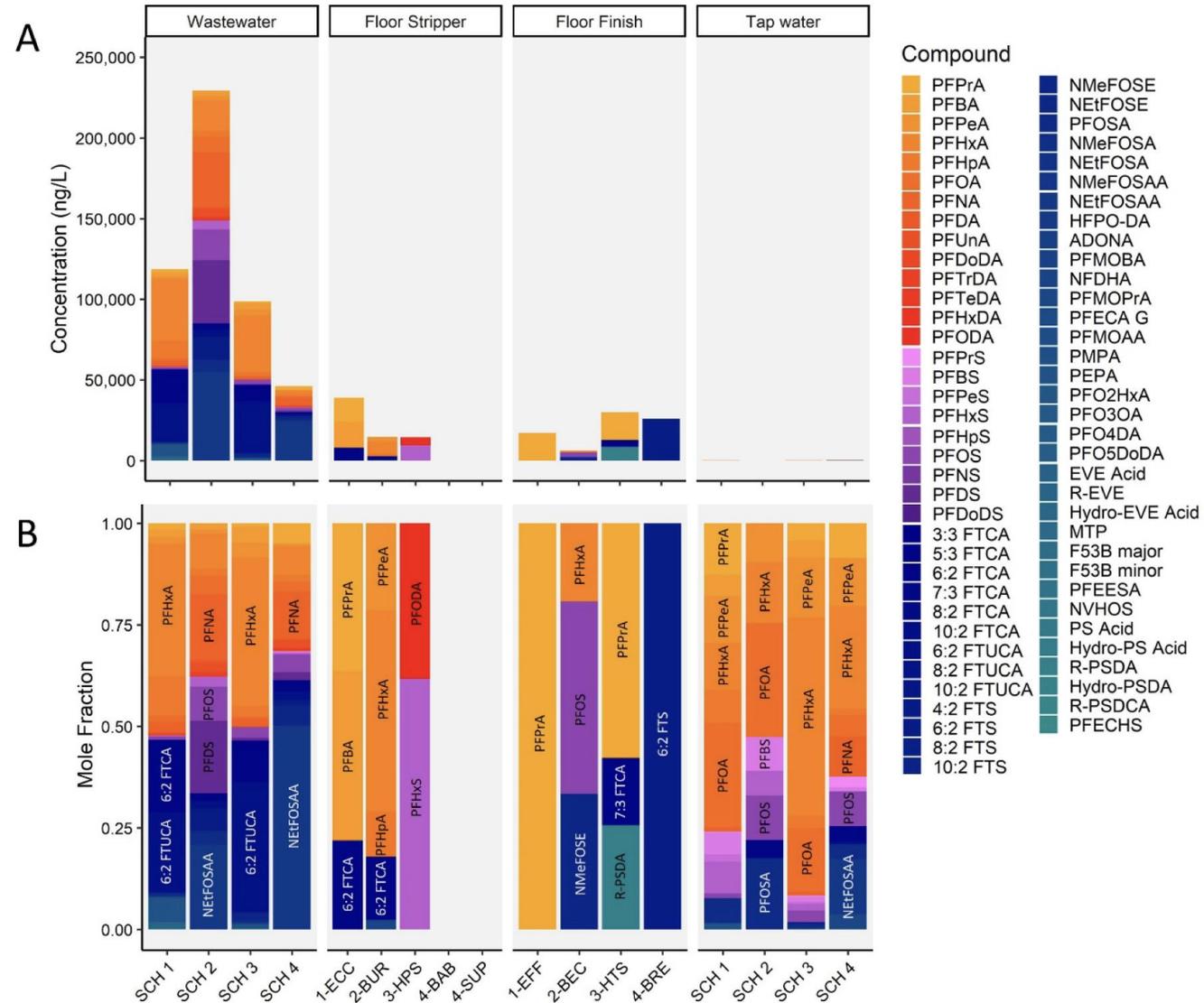


Figure 3. PFAS concentrations (ng L^{-1}) (A) and mole fraction (B) in floor stripping wastewater, floor strippers, floor finish, and untreated tap water.



Routine Floor Cleaning

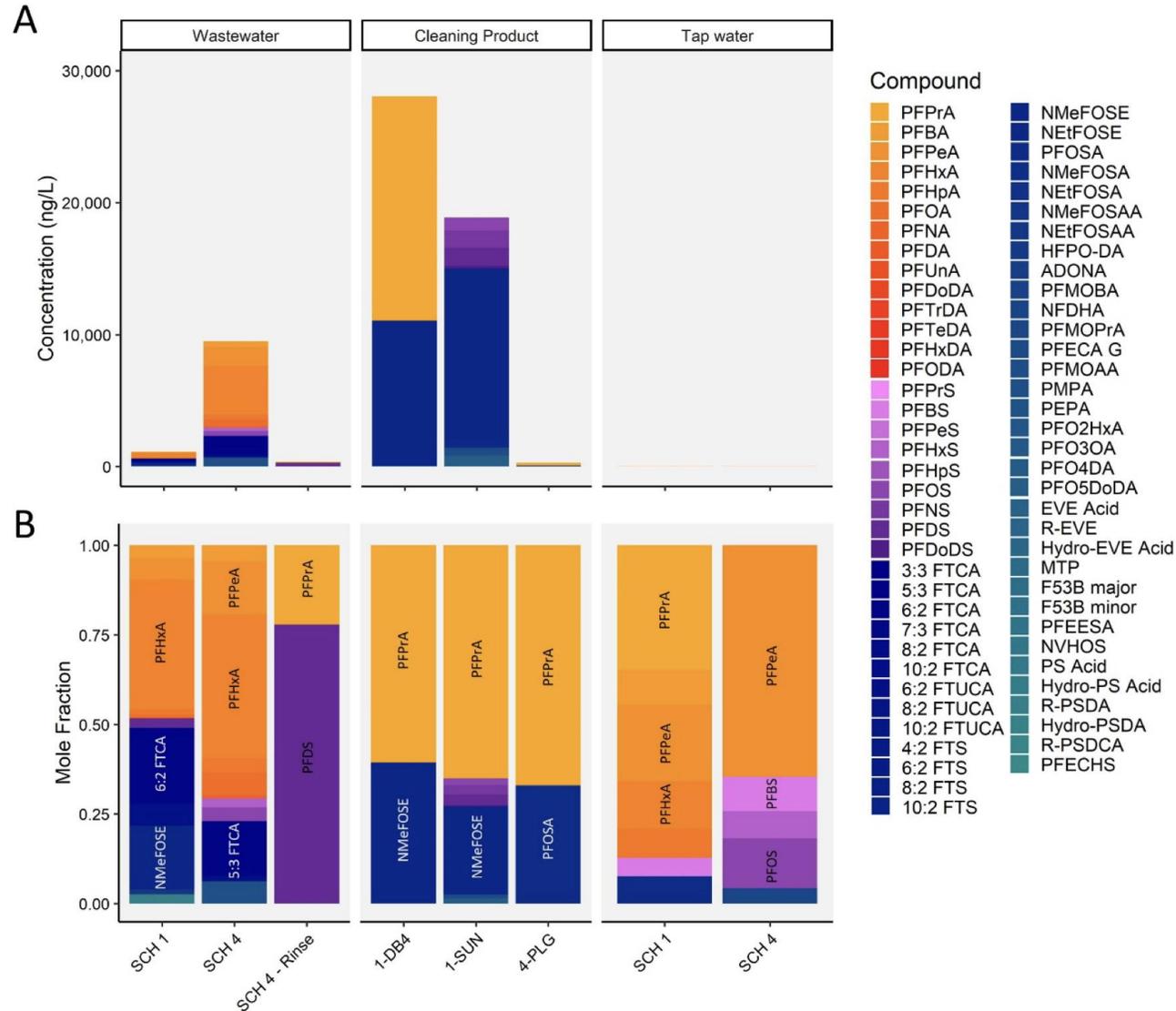
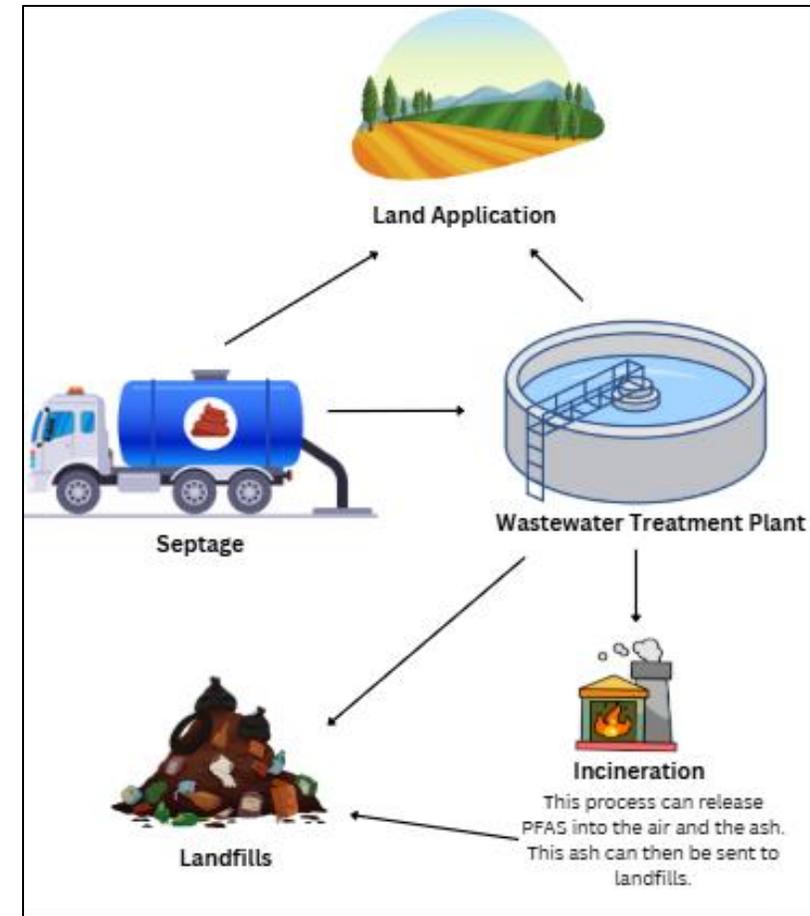


Figure 4. PFAS concentrations (ng L⁻¹) (A) and mole fraction (B) in routine floor cleaning wastewater, cleaning products, and treated tap water.



Is the solution to haul all septage to WWTPs?

- *Not enough capacity at WWTPs*
- *Distance*
- *Costs will go up*
 - *Less frequent pump outs*
 - *More system failures?*
 - *Some pumpers go out of business?*
 - *More illegal dumping?*
- *Fate is still the same –Biosolids are land applied or landfilled (another capacity issue)*
 - *Some WWTPs are removing PFAS*





Reducing PFAS in wastewater is critical for protecting groundwater and soils

- *Reduce home use of PFAS containing products*
- *Proper disposal of:*
 - *Medications*
 - *Paint*
 - *Motor Oils*
 - *Pesticides*
 - *Paper towels*
 - *Feminine Hygiene Products*
 - *'Flushable Wipes'*





CONTAMINANTS IN AQUATIC AND TERRESTRIAL ENVIRONMENTS | March 1, 2023

Per- and Polyfluoroalkyl Substances in Toilet Paper and the Impact on Wastewater Systems

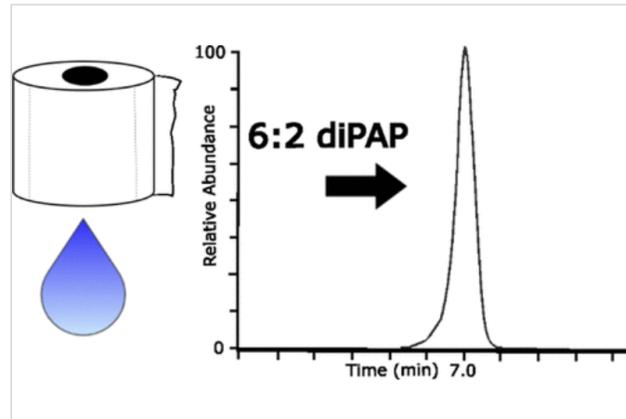
Jake T. Thompson, Boting Chen, John A. Bowden, and Timothy G. Townsend*

Open PDF

Supporting Information (1)

Abstract

Here, we evaluate a perhaps unexpected contributor of per- and polyfluoroalkyl substances (PFAS) to our wastewater, an input anticipated at every wastewater treatment facility—toilet paper. In this study, both toilet paper and wastewater sludge were characterized to explore the magnitude of the potential PFAS loading into wastewater systems from toilet paper. In both toilet paper and wastewater sludge, 6:2 fluorotelomer phosphate diester (6:2 diPAP) was the most prevalent PFAS detected, and toilet paper usage was estimated to contribute from 6.4 to 80 $\mu\text{g}/\text{person-year}$ of 6:2 diPAP to wastewater-water systems. **Our results suggest that toilet paper should be considered as a potentially major source of PFAS entering wastewater treatment systems.**



\$27.24

- ✓ FSC Certified
- ✓ Plastic-Free
- ✓ Chemical-Free
- ✓ Septic Safe

Bamboo Toilet Paper

Add: 48 Rolls

48 Rolls

\$109.98

Add to cart Buy with shop

More payment options

- ✓ Free of BPA, PFAS, chlorine, dyes, & fragrances
- ✓ Luxuriously layered 3-ply, 300 sheets per roll
- ✓ Naturally antibacterial, anti-fungal, & hypo-allergenic
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MSU and MPART are working to develop a strategy for working with farms

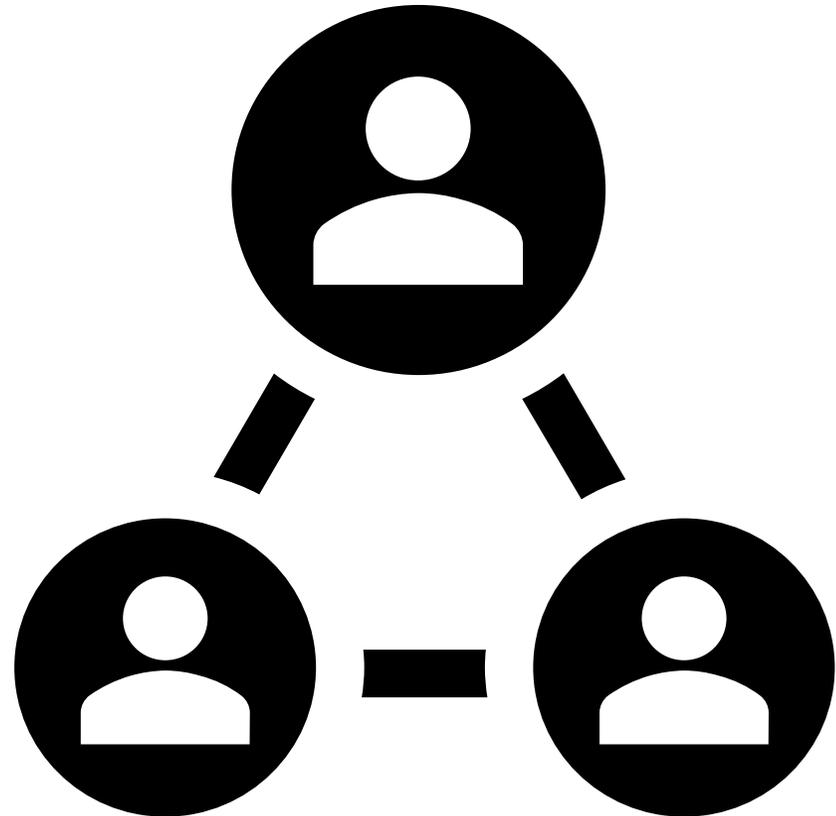
- *Education*
- *Risk assessment*
- *Sampling*
 - *Soil*
 - *Water*
- *Follow up discussions*
- *Mitigation strategies*
 - *Funding for infrastructure changes*





Resources

- *ITRC Biosolids Webinar*
 - *Interstate Technology & Regulatory Council (ITRC)*
 - https://www.clu-in.org/conf/itrc/PFAS-landapp_022626/
- *EGLE's PFAS Biosolids Webpage*
 - <https://www.michigan.gov/egle/about/Organization/Water-Resources/biosolids/pfas-related>





Contact Information for Regulatory Questions

Biosolids

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Septage

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CEU Tracking Number: MI 56999 **Approved CEUs:**

NM	SW	PM	CM	PD
0.0	1.0	0.0	0.0	0.0

Meeting Title: Introduction to PFAS in Agriculture-PFAS in Biosolids and Septage

Location: Online

Meeting Date: 03/26/2026 10:00 AM to 11:00 AM

SIGN-IN SHEET FOR CCA, CPAg, CPSS and CPSC ONLY.

Please scan code through the CCA App on your mobile device to receive CEUs immediately.

**No need to sign
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Evaluation Survey – Please!!



• <https://bit.ly/4sFvDiY>



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<https://www.canr.msu.edu/pfas/>



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mail:
U.S. Department of Agriculture
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410; or

fax:
(833) 256-1665 or (202) 690-7442;

email:
program.intake@usda.gov.

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