Interstate Commission on the Potomac River Basin

Water Research Foundation (WRF) Project #5082: Investigation of Alternative Management Strategies to Prevent PFAS from Entering Drinking Water Supplies and Wastewater

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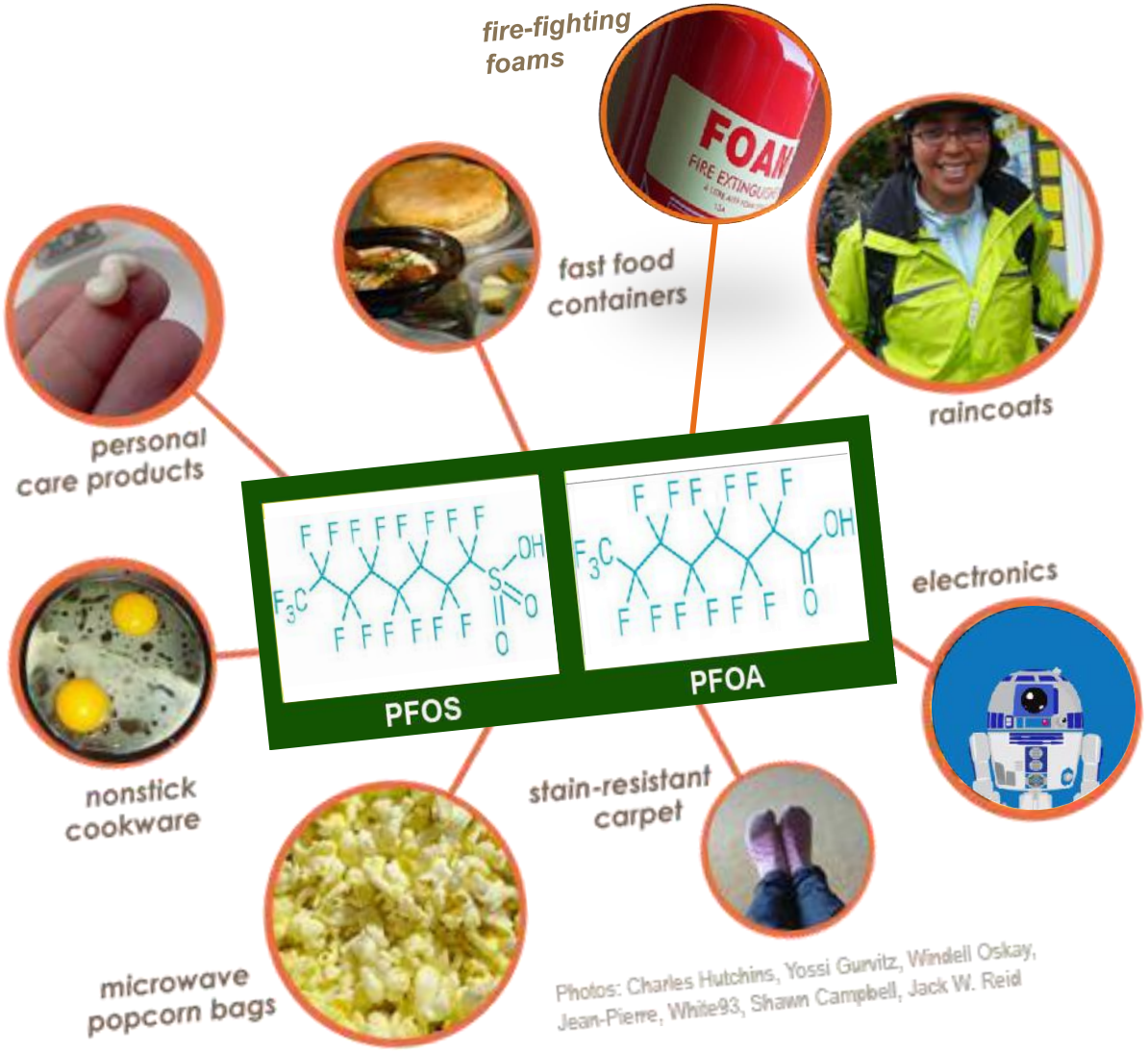
February 1, 2023

Per- and Polyfluoroalkyl Substances (PFAS) are fluorinated chemicals with many uses and unique properties.



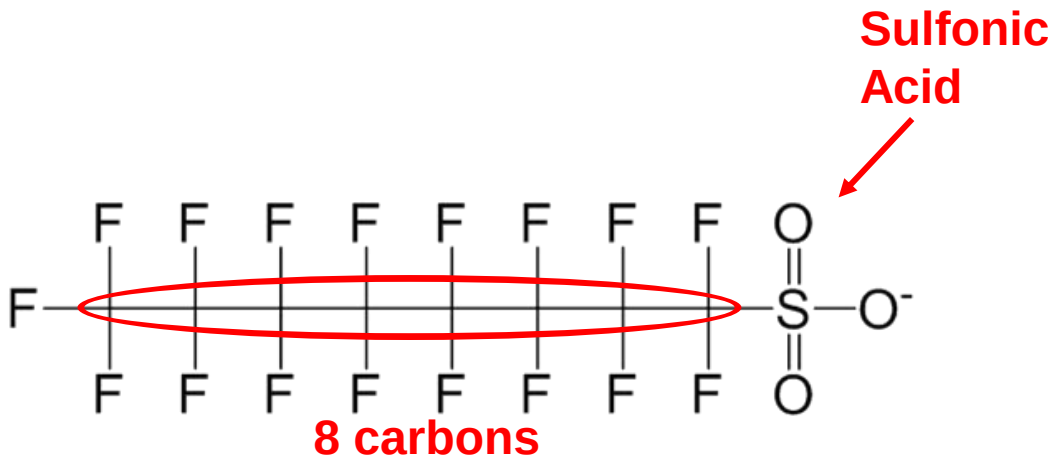
Unique Properties

- Stain repellant
- Flame resistant
- Non-stick
- Water resistant
- Good for coatings

PFOA and PFOS are of the most concern in the PFAS family.

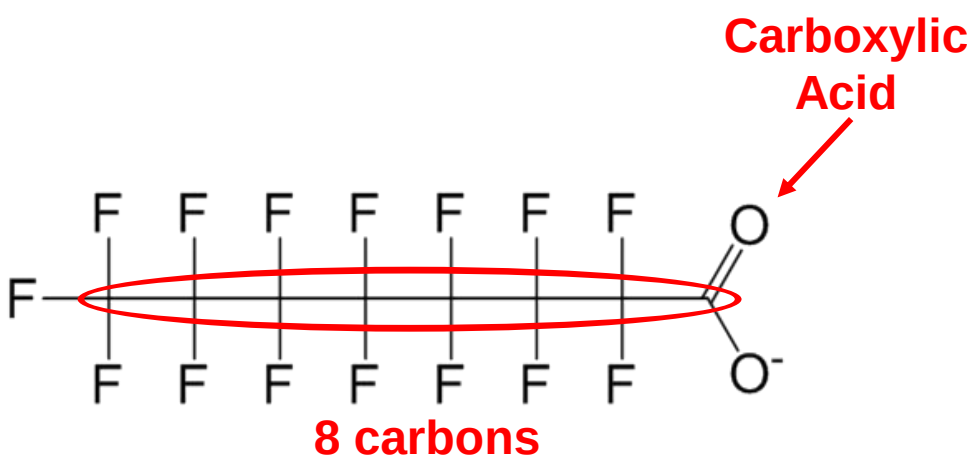
- Proposed MCLs expected next month.
- Extremely low new health advisory levels (HALs) indicate MCLs could be far below 70 ng/L.

HAL = 0.02 ng/L



Perfluorooctanoic sulfonic acid - **PFOS**

HAL = 0.004 ng/L



Perfluorooctanoic acid - **PFOA**

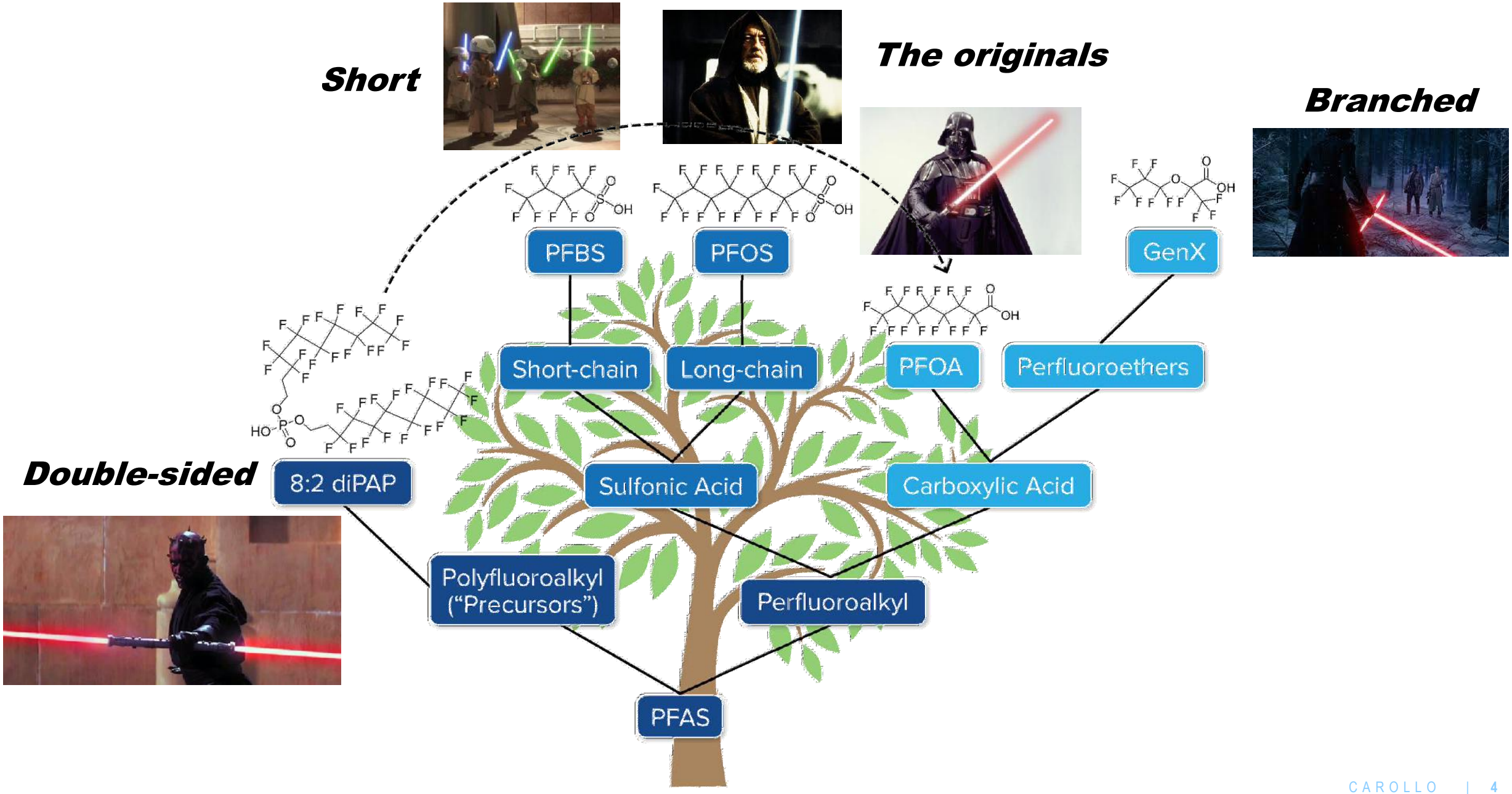
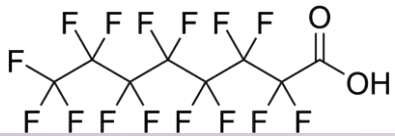
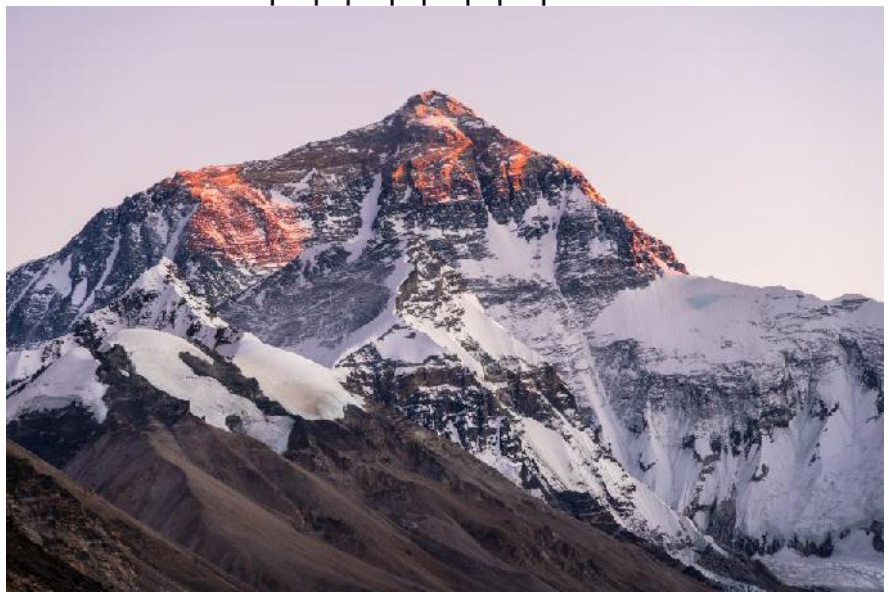


Image modified from: https://www.atsdr.cdc.gov/pfas/docs/PFAS_FamilyTree_EnvHealthPro-508.pdf

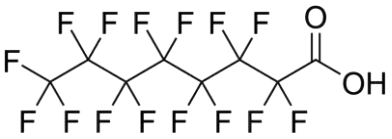
PFAS are everywhere.

PFAS have been detected even atop Mount Everest and at the North Pole.





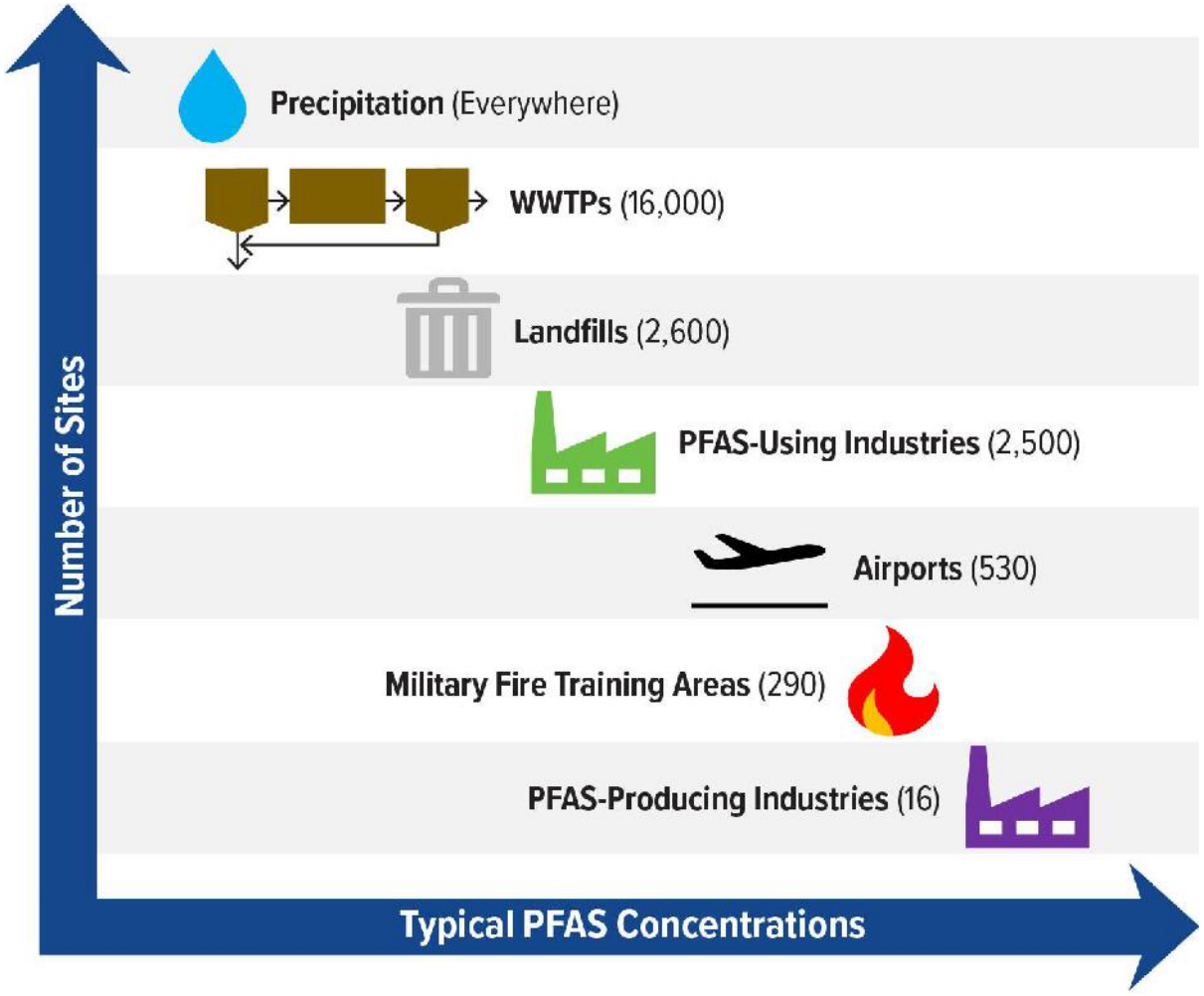
Miner et al. 2021. *Sci. Tot. Env.* 759, 144421.



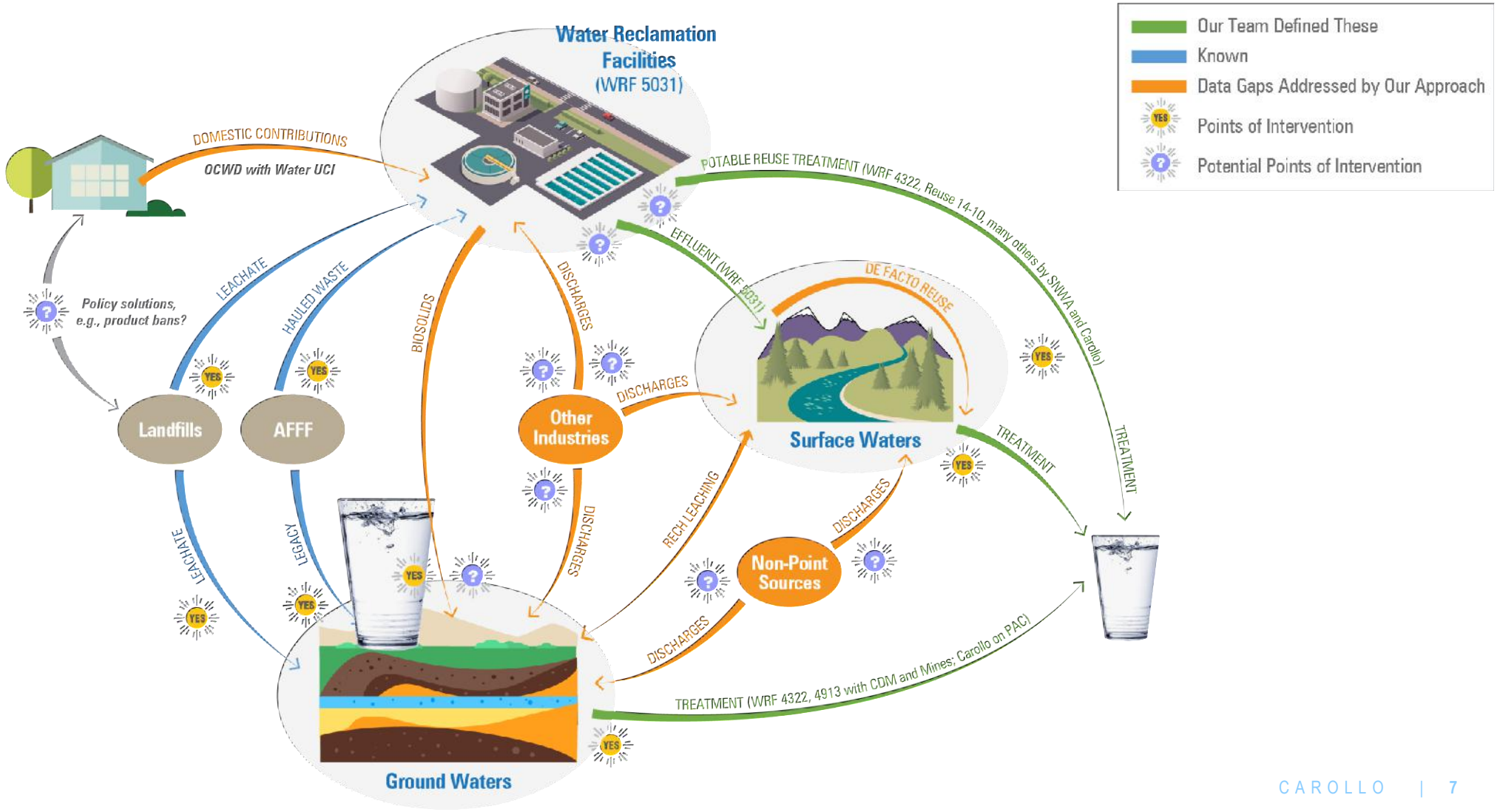
Young et al. 2007. *ES&T.* 41, 3455-3461.

Major PFAS sources include industrial sites, military fire training areas, and airports.

- Still challenging to link PFAS to a source due to site-specific differences.
- It's generally more **cost-effective** and **environmentally just** to remove PFAS at the source instead of at drinking water or wastewater facilities.
- Wastewater treatment plants (WWTPs) have small amounts of PFAS in their treated water.
  - WWTPs themselves are **not the source** of the PFAS detected in effluent



Gaps remain in understanding PFAS movement through the water cycle.

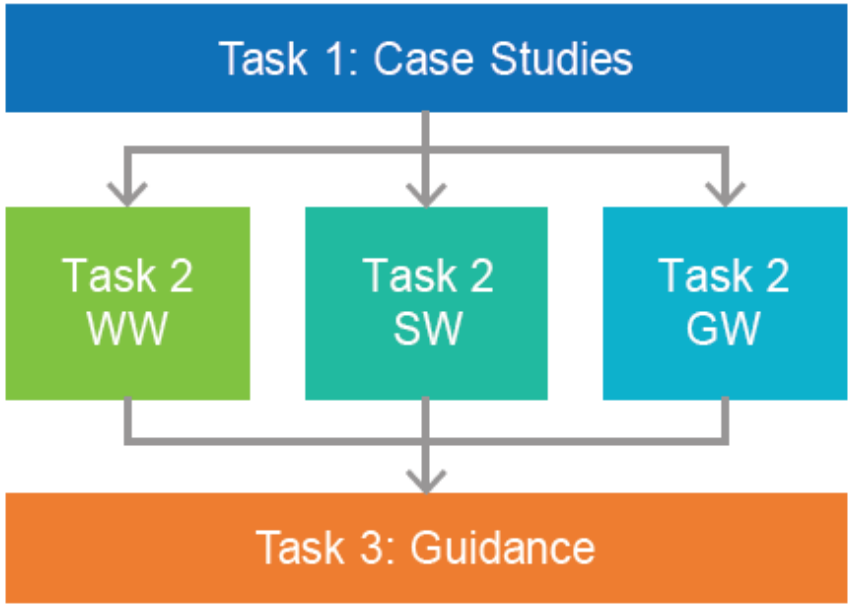


WRF #5082 Project Goals & Approach

Goal: Provide utilities with practical, implementable, and cost-effective guidance on PFAS source evaluation and mitigation strategies.

Approach:

1. Gather **utility data and experience**,
2. Strategically **fill data gaps**; and
3. Develop guidance with **practical, implementable** solutions.



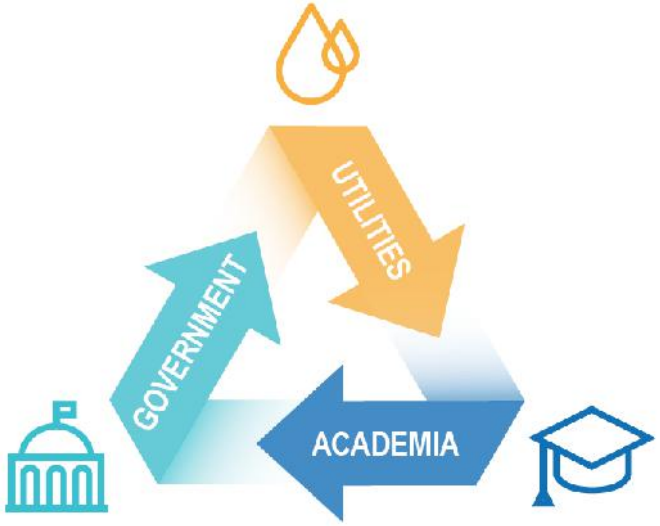
Case Study Results

Many wastewater utilities have sampled for PFAS but few have formally investigated sources.

Utility	Sewershed Sampling	Influent Sampling	Effluent Sampling	Point Source(s) Confirmed	Planning of Mitigation Strategies	Implementation of Mitigation Strategies	Outreach or Collaboration
WW1	●	●	●		●	●	●
WW2	●	●	●		●		●
WW3		●	●		●		●
WW4		●	●		●		●
WW5		●	●		●		●
WW6	●	●	●	●	●	●	●

Lessons Learned & Implications for Guidance

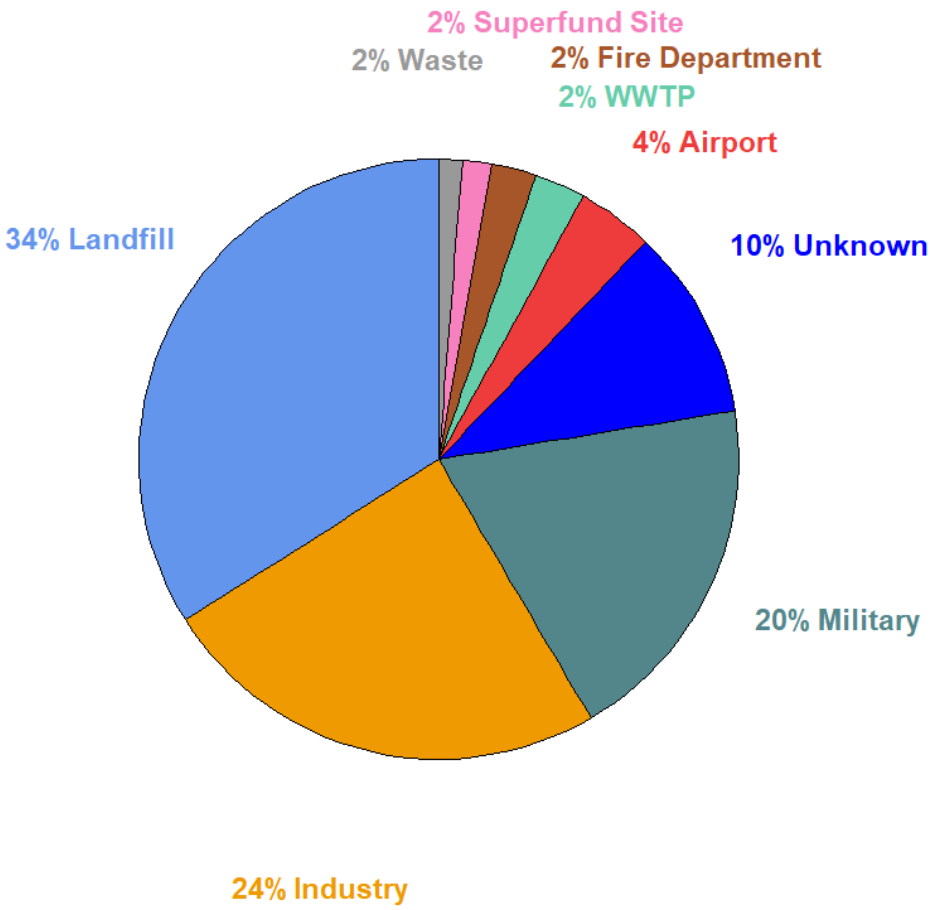
- Important to be proactive in a rapidly evolving regulatory environment.
- Benefits of collaboration:
  - State governments or regional entities may be able to gather samples farther afield.
  - Universities can offer cutting edge analyses.
  - Utilities can work together to exchange information and protect their shared watersheds.
  - Utility representatives can sit on state or federal panels guiding policy and regulations.



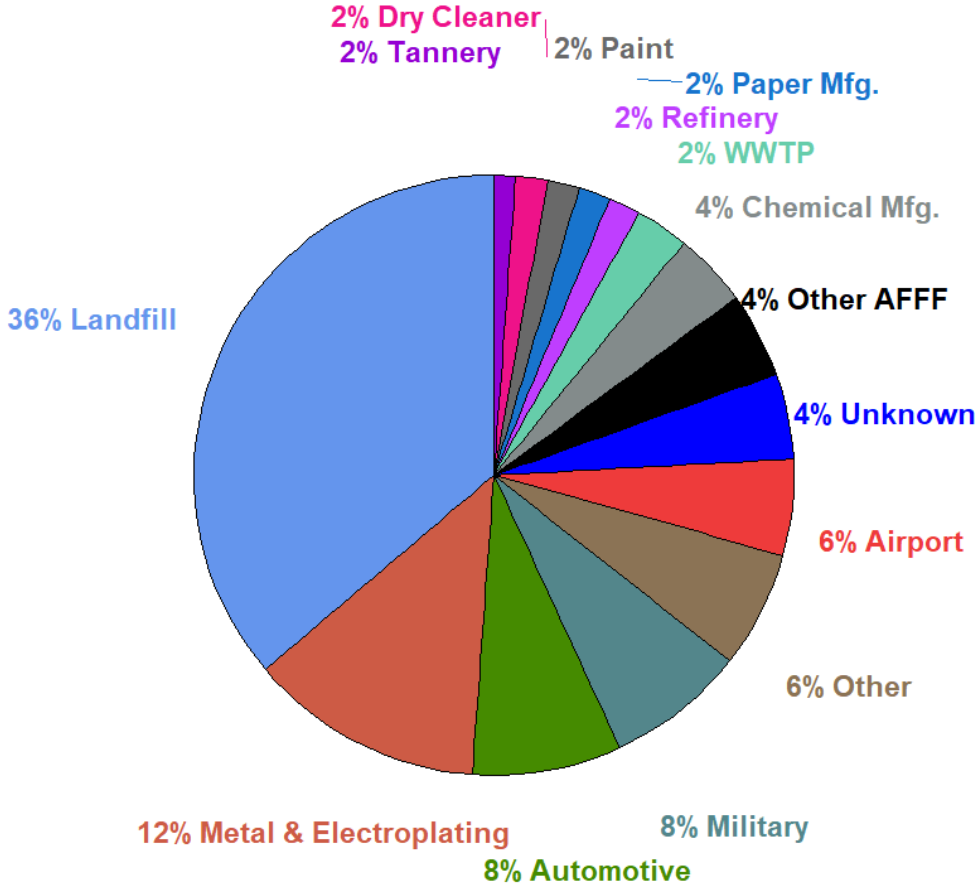
Groundwater Results

Landfills are frequent sources of PFAS to groundwater.

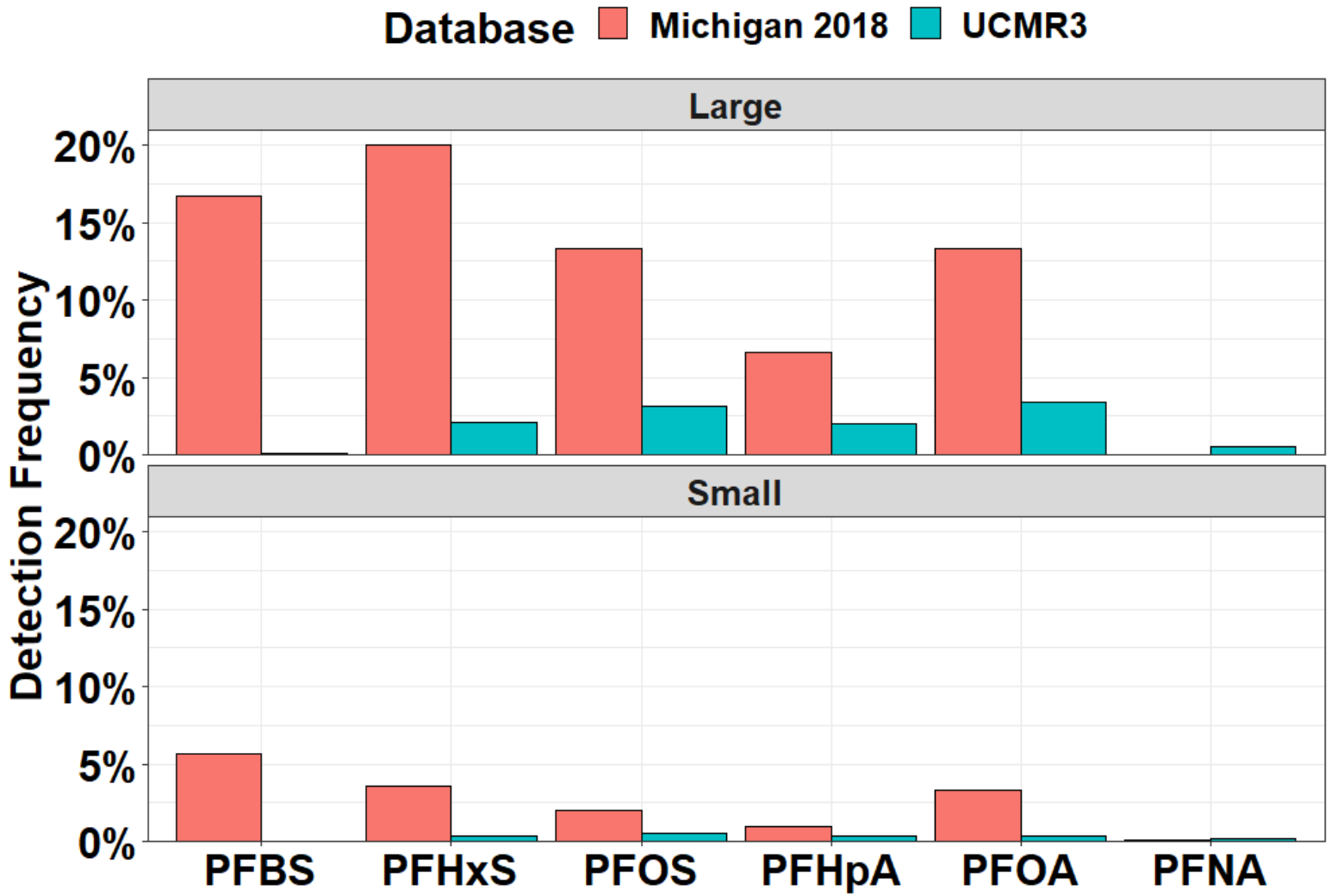
SSEHRI Database



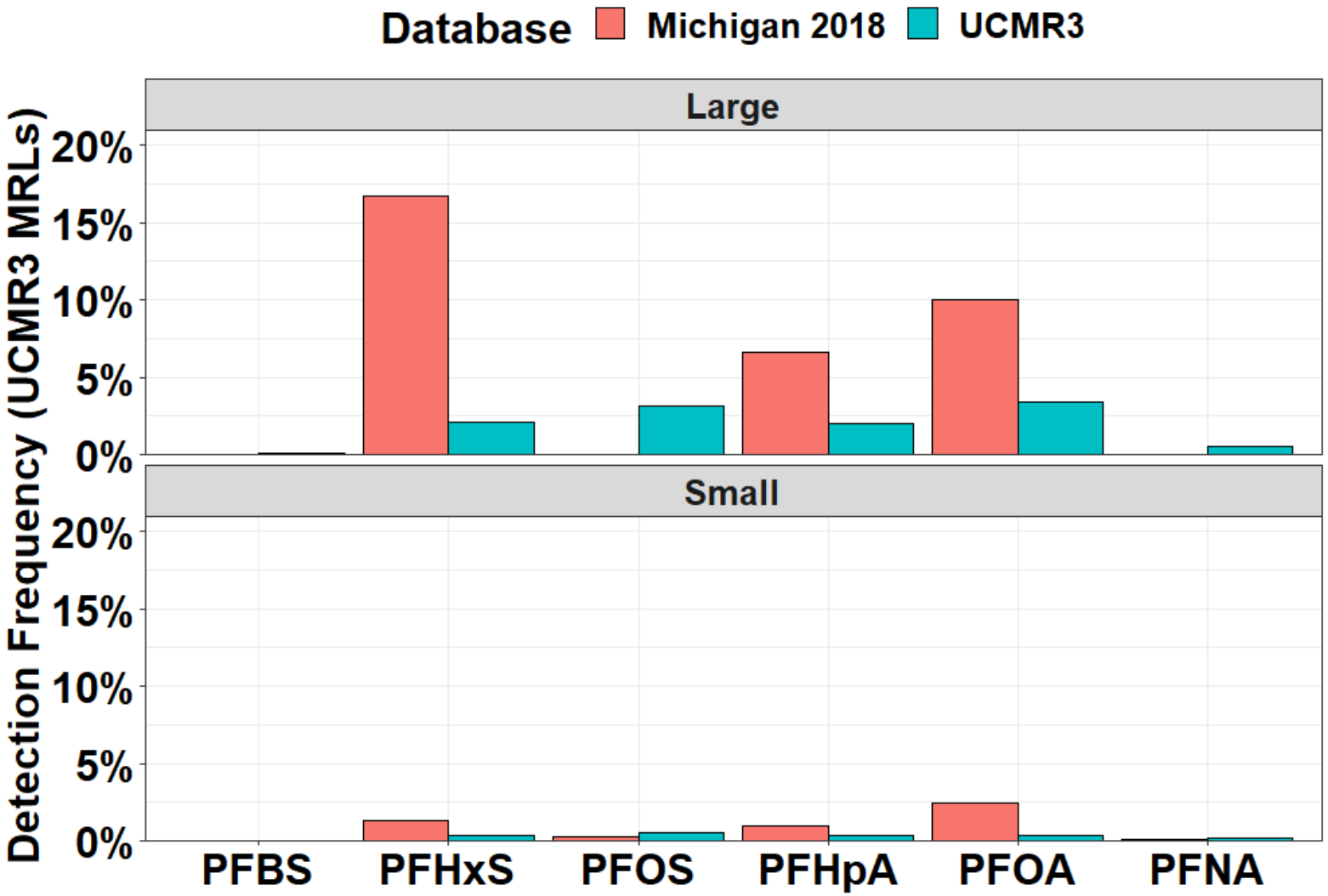
Michigan Database



PFAS detection frequencies were higher in the Michigan database than UCMR3.

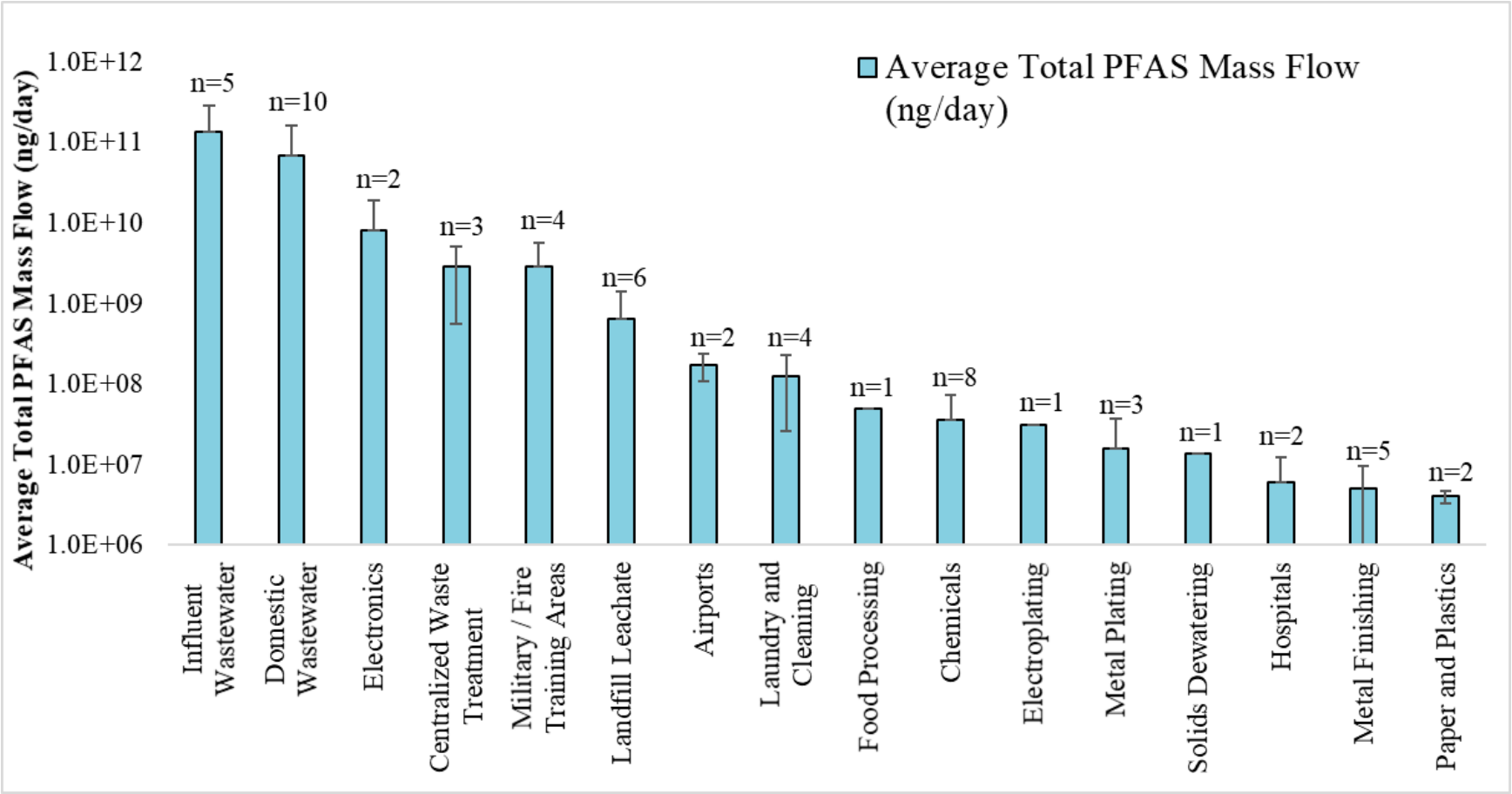


PFAS detection frequencies were higher in the Michigan database than UCMR3…even using the same MRLs.



Wastewater Results

Across 4 sewersheds, domestic wastewater was the largest source of PFAS mass.



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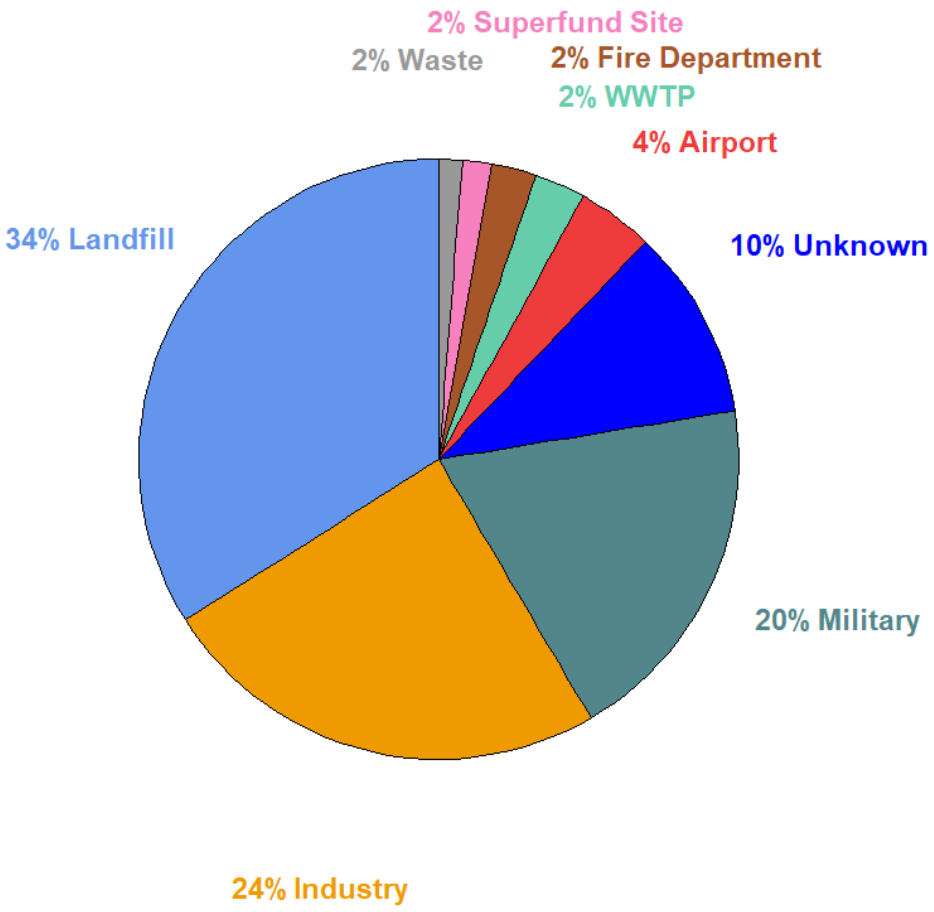

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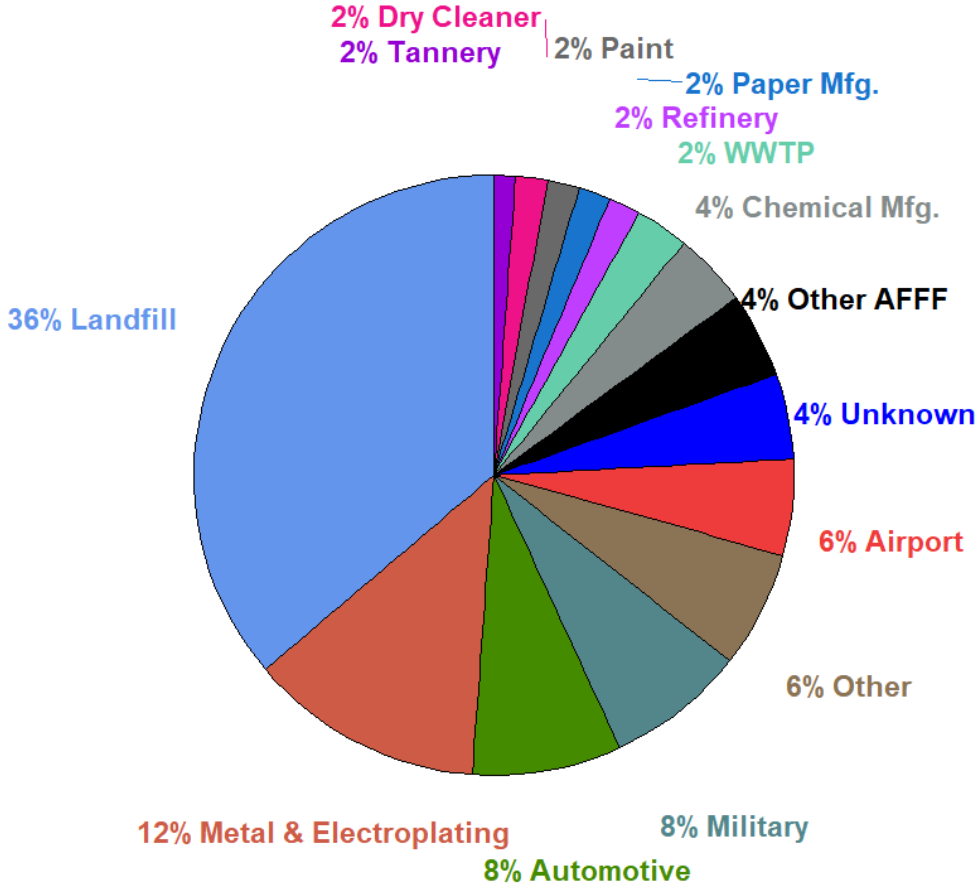

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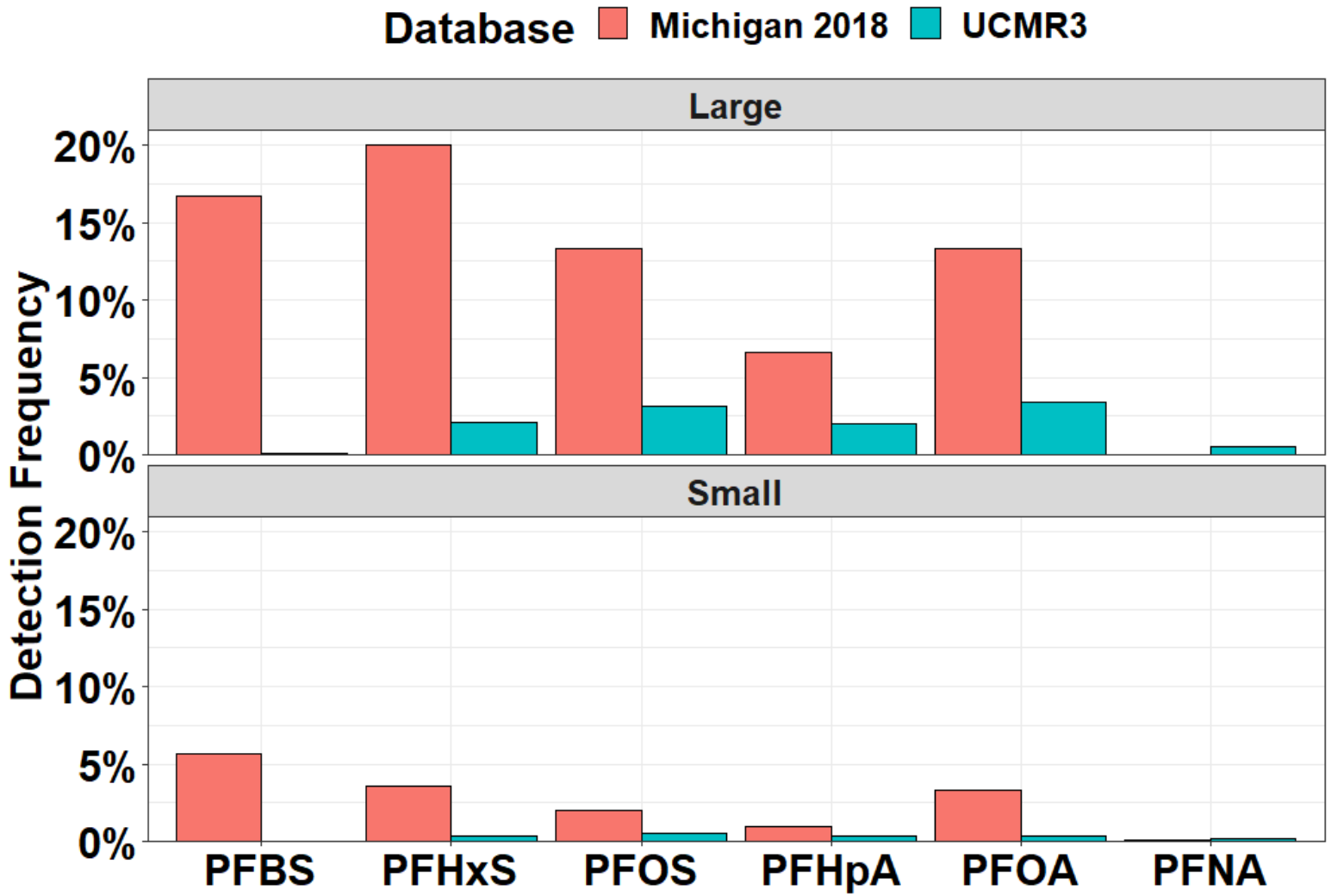

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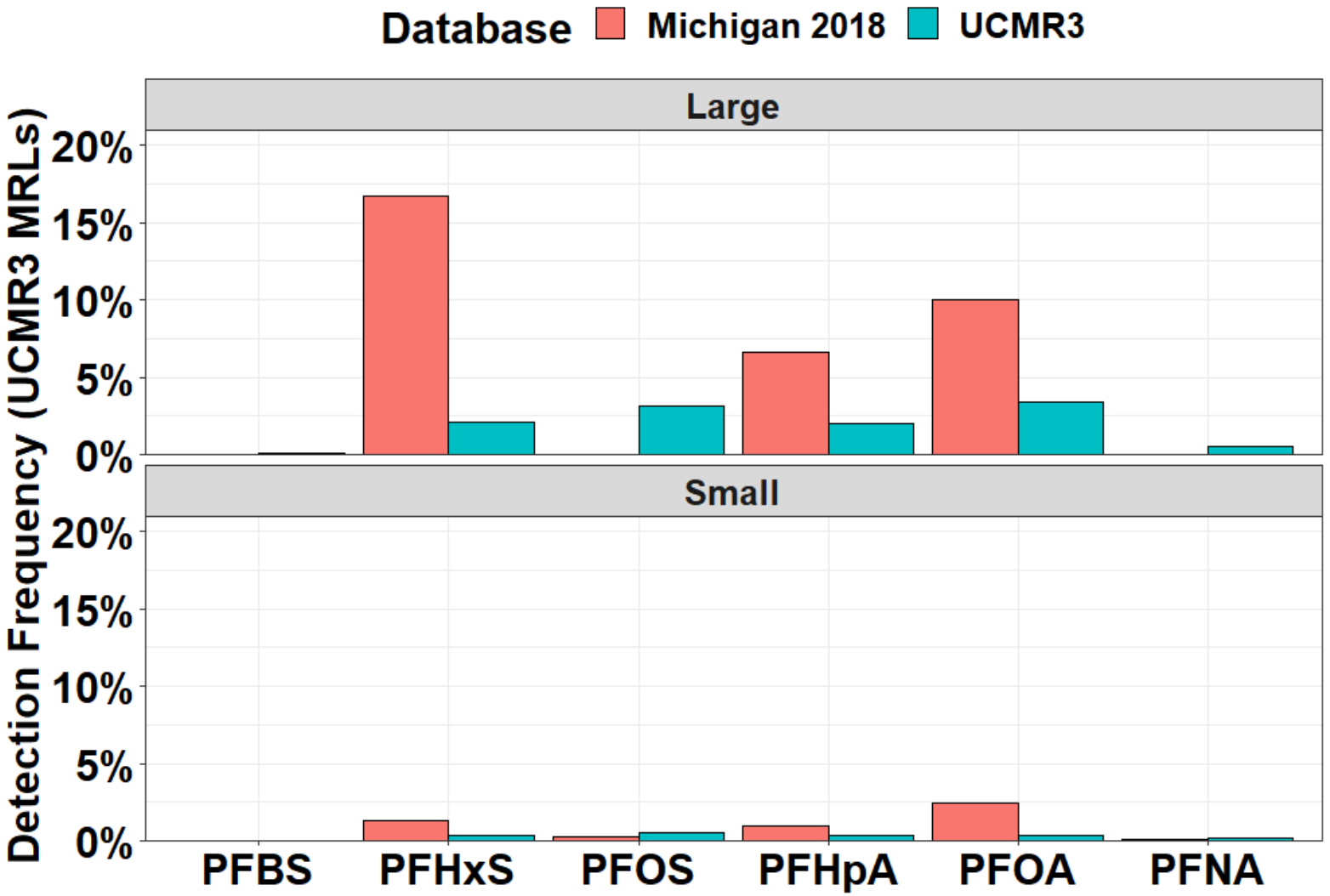
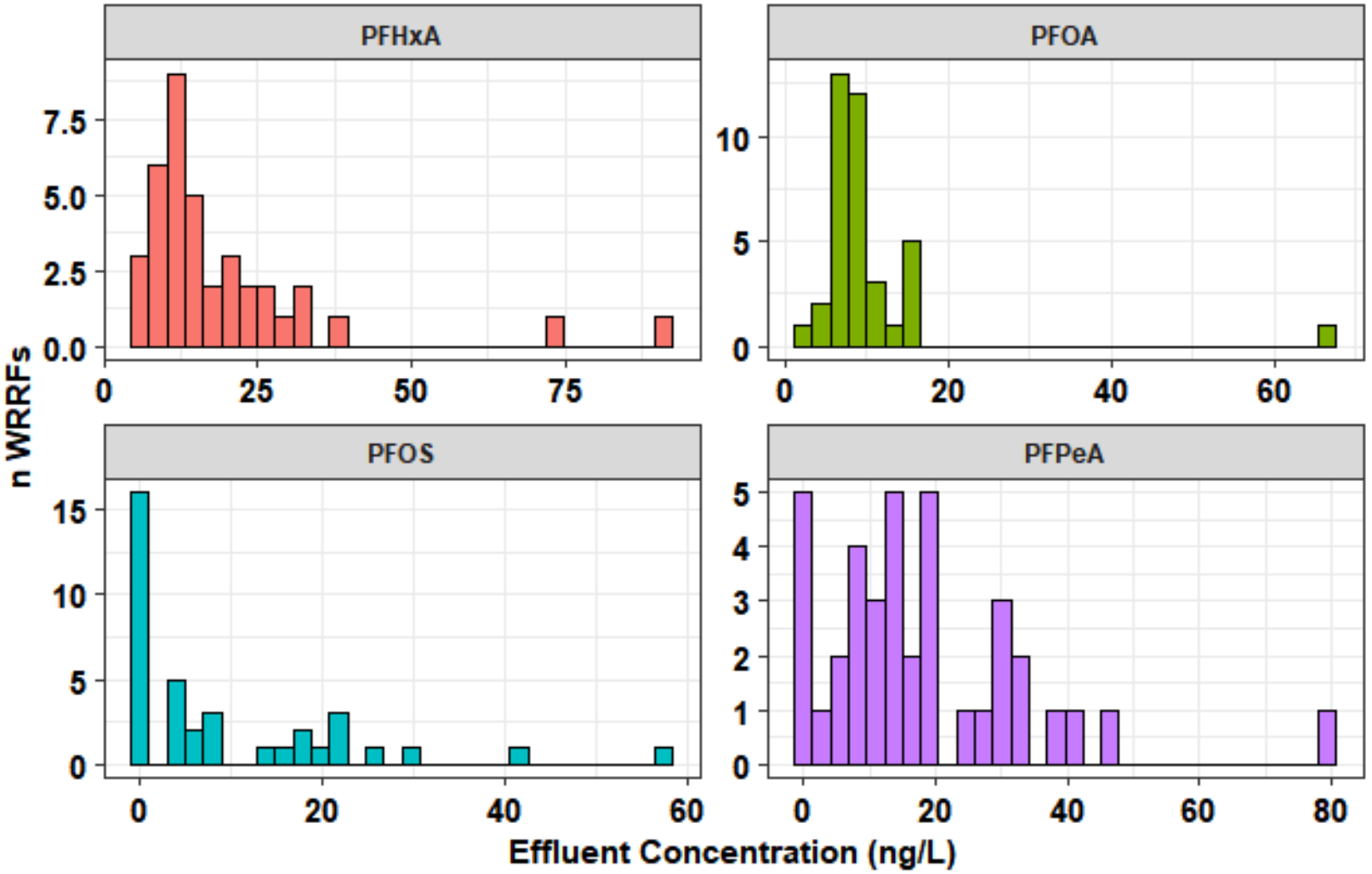


Wastewater Implications for Surface Water

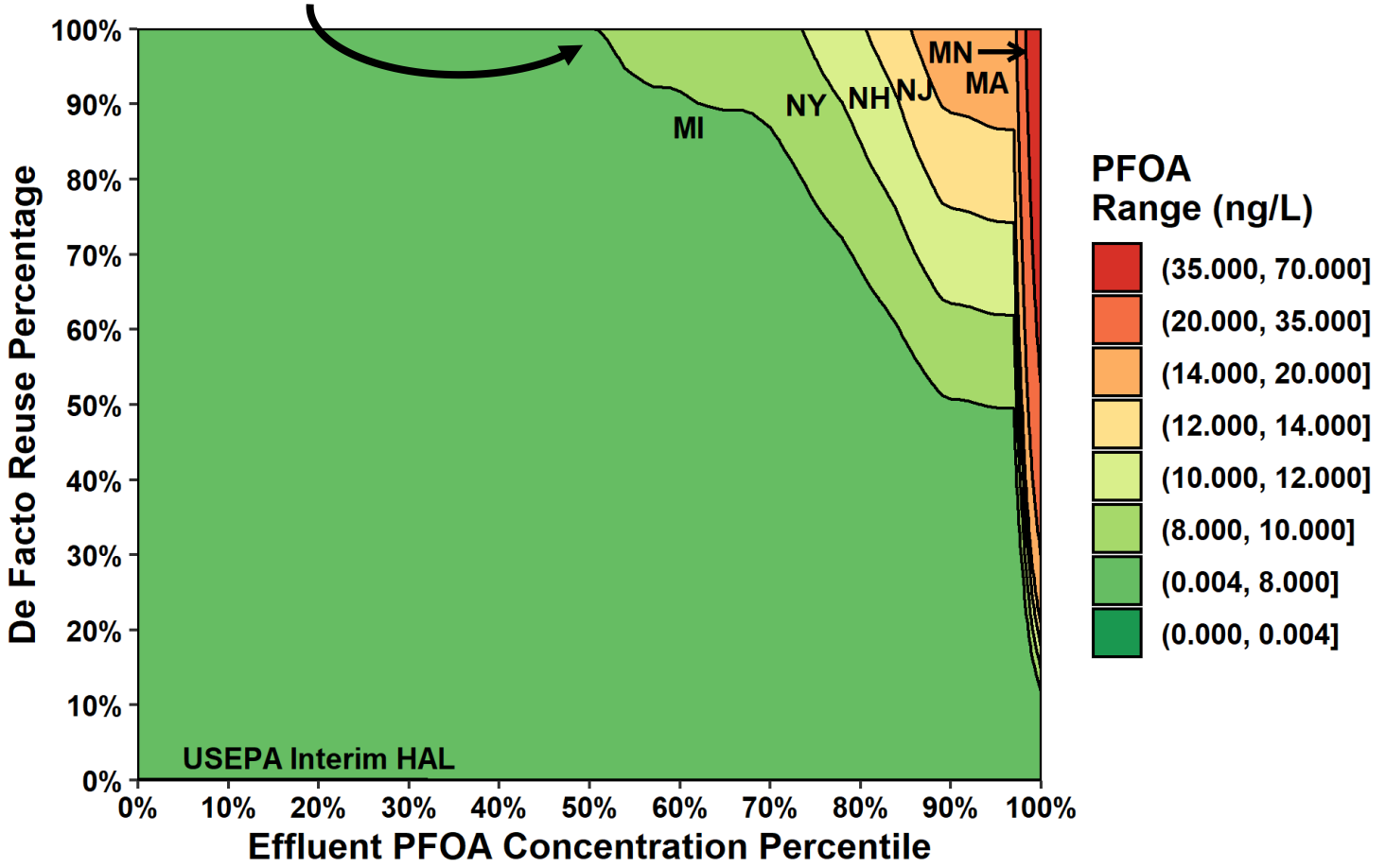
Median PFOA and PFOS are around 8 ng/L and 4 ng/L respectively in wastewater effluent.



Data from: Schaefer et al. 2022. *Occurrence of PFAS Compounds in U.S. Wastewater Treatment Plants (WRF 5031).*

Just 1:2000 of median effluent could exceed the PFOA 2022 interim HAL of 0.004 ng/L.

However, it would take >50% of above average effluent to exceed enforceable state standards.



Data from: Schaefer et al. 2022. *Occurrence of PFAS Compounds in U.S. Wastewater Treatment Plants (WRF 5031).*

Surface Water Investigation #1

Lake Mead is the drinking water source for approximately 40 million people and Southern Nevada's primary water source.

Lake Mead is near 25% of the total storage capacity.

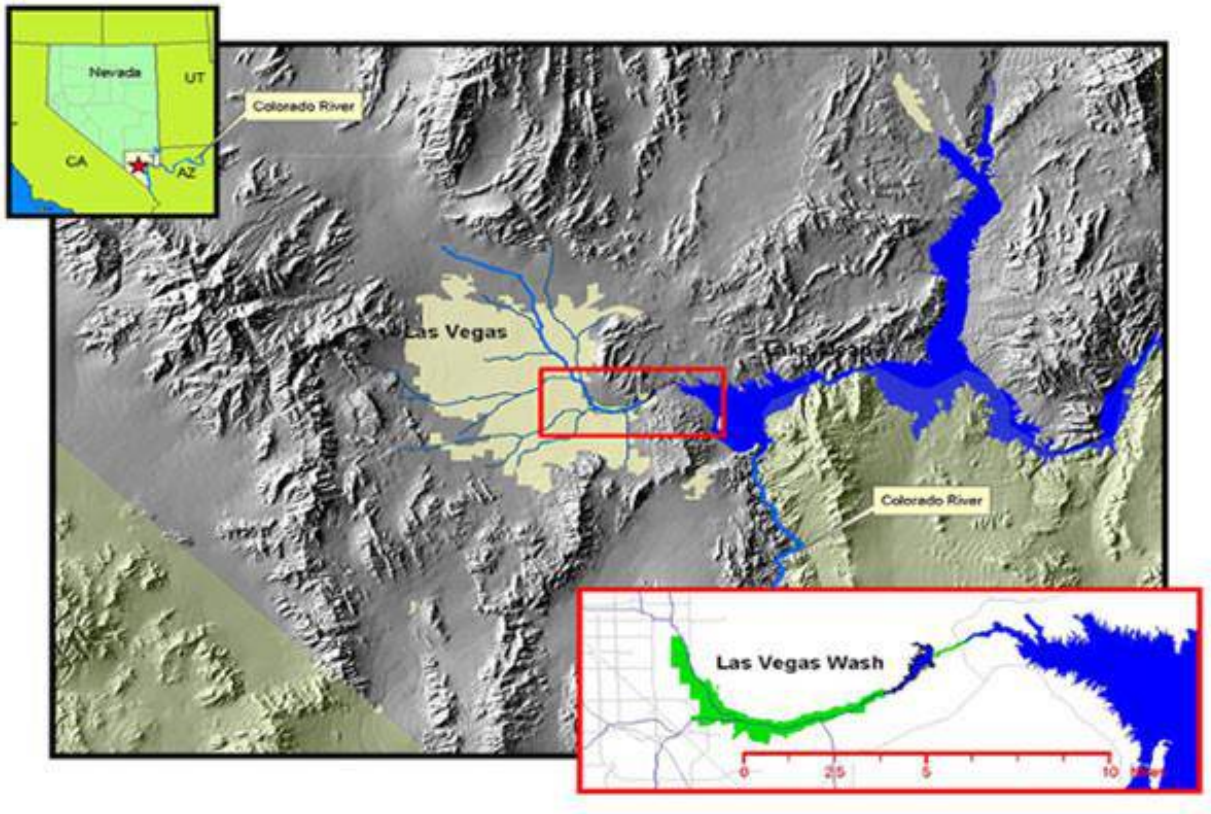
NATURE WORLD NEWS Natureworldnews.com

TRENDING US UNITED STATES CLIMATE CHANGE HEATWAVE FLOODING

Lake Mead Nearing Dead Pool Status, Water Level Dramatically Drops by 27% Due To Drought

By Paw Mozter Jul 30, 2022 03:31 PM EDT

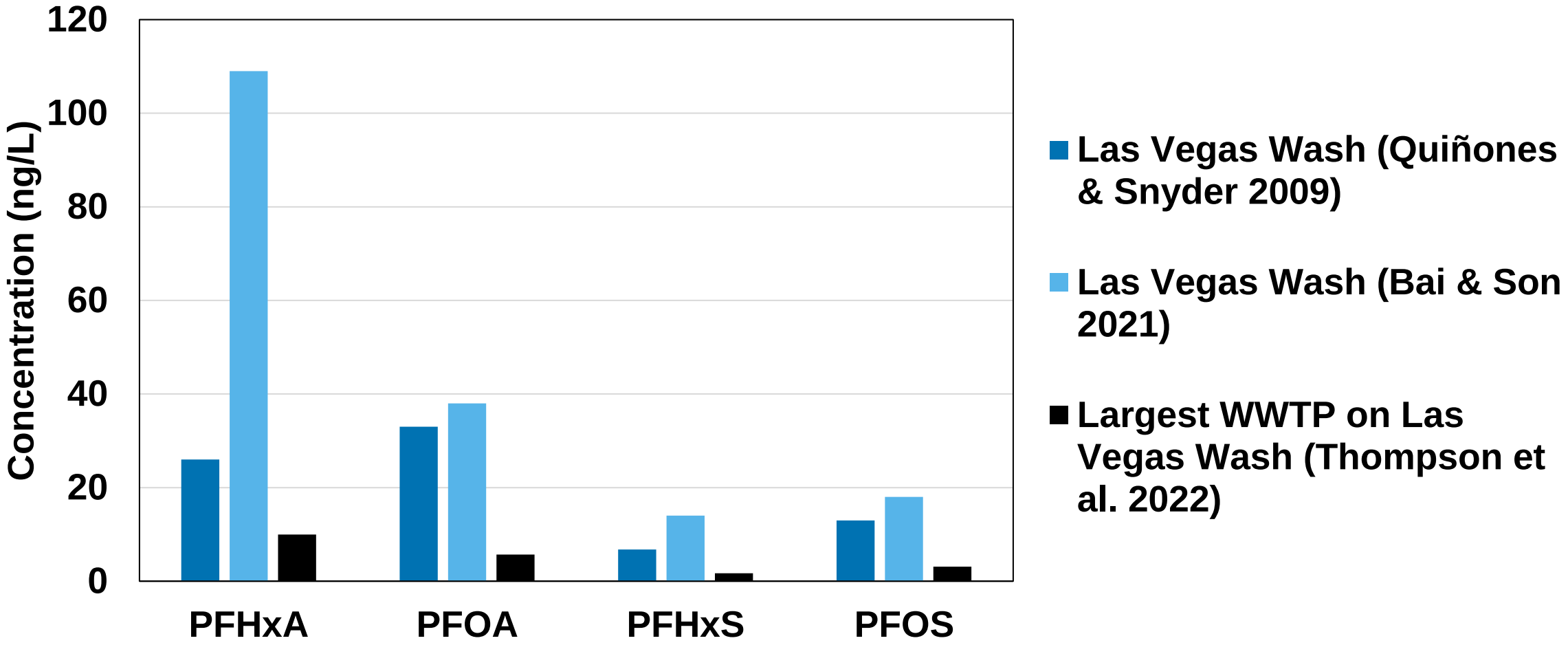
The Las Vegas Wash drains the Las Vegas metro area and flows into Lake Mead.



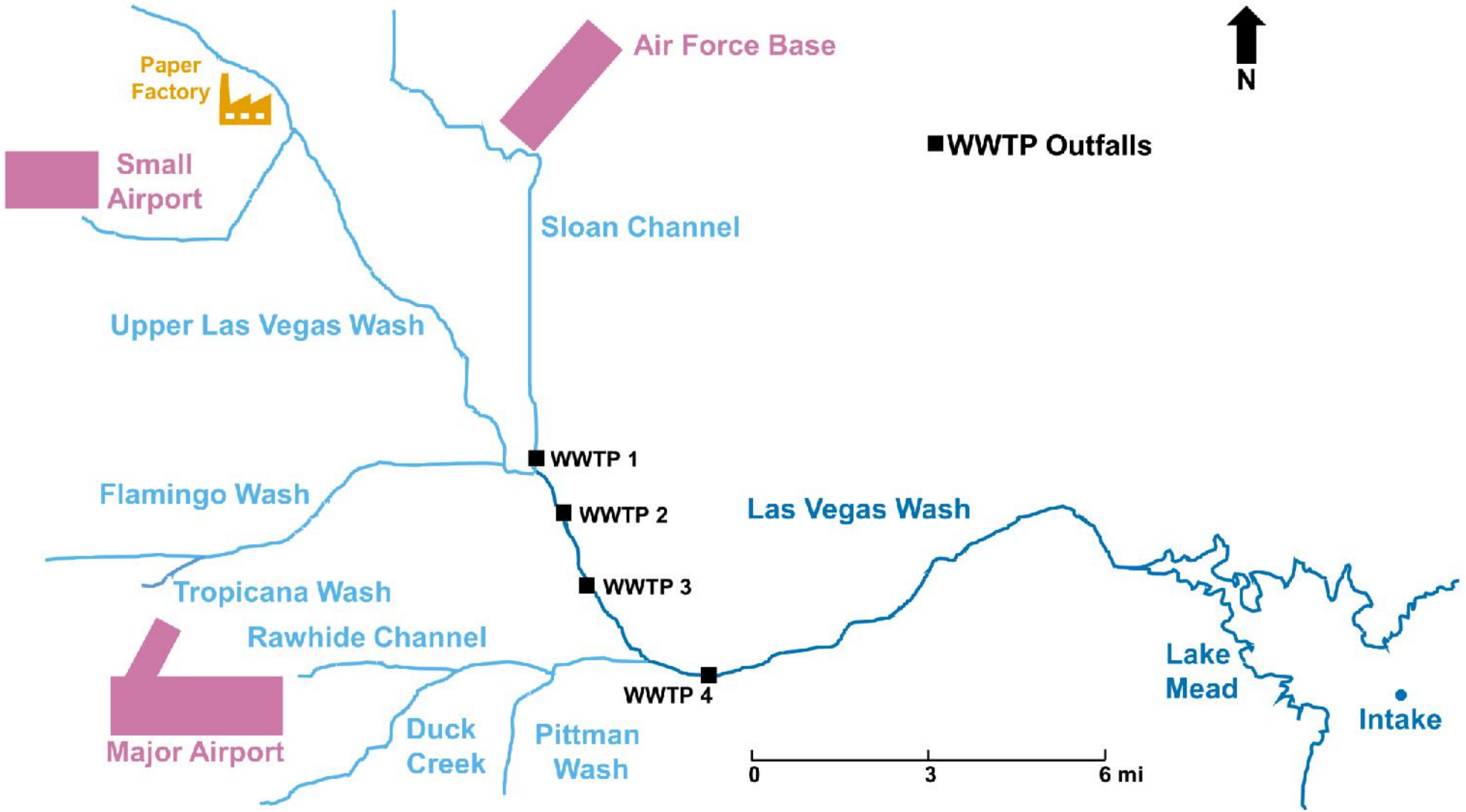
- 2-3% of the inflow comes from the Las Vegas Wash.
- Treated Wastewater: 89-91%; Other sources: groundwater and urban runoff.

Higher PFAS have been measured in the Las Vegas Wash than in the largest of the 4 WWTPs discharging to it.

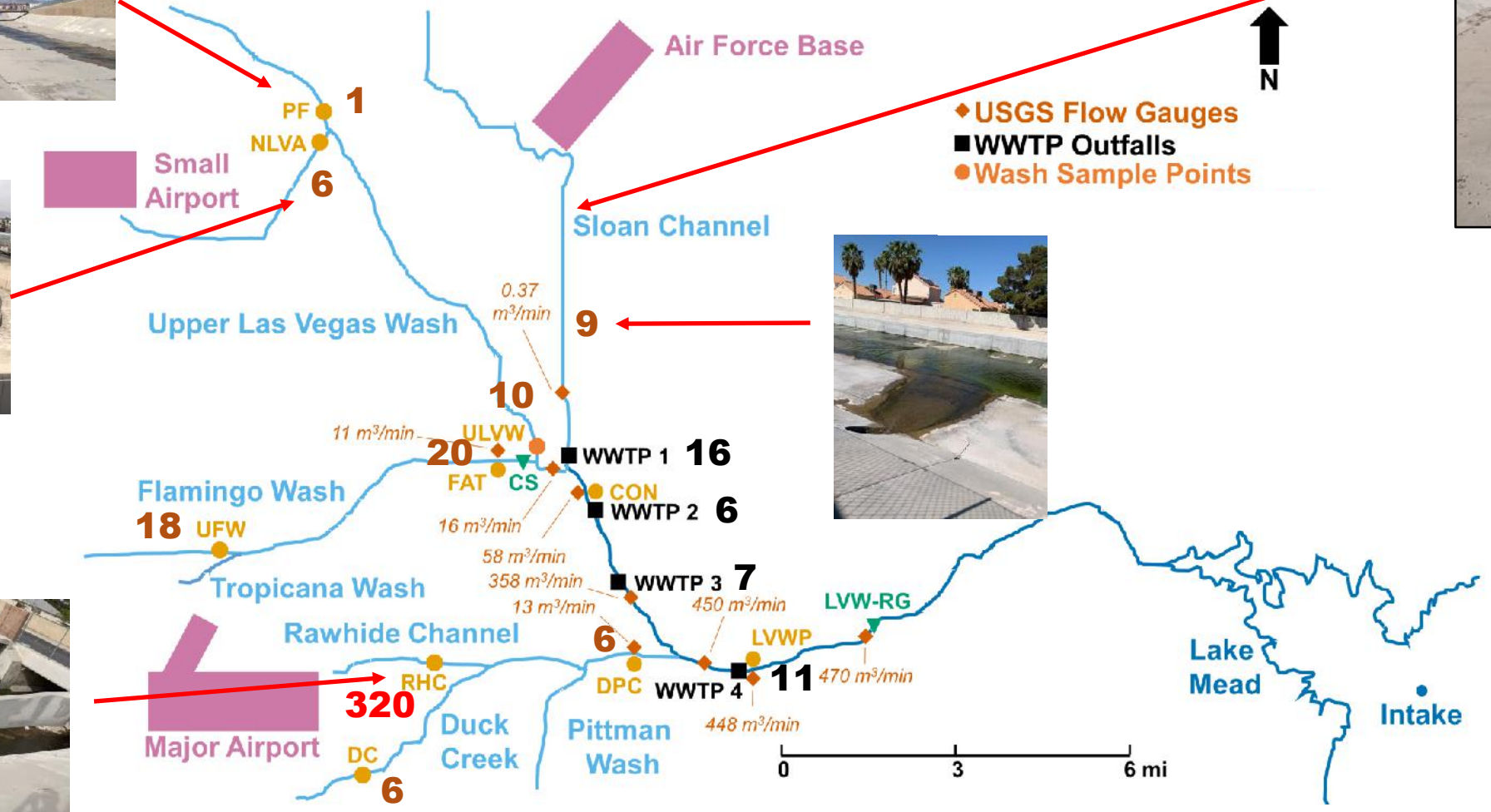
Are there other sources?



Hypothesized sources included four WWTPs, an Air Force Base, two airports, and a paper factory.



PFOA (ng/L) collected over campaigns #1, #2 and #3.



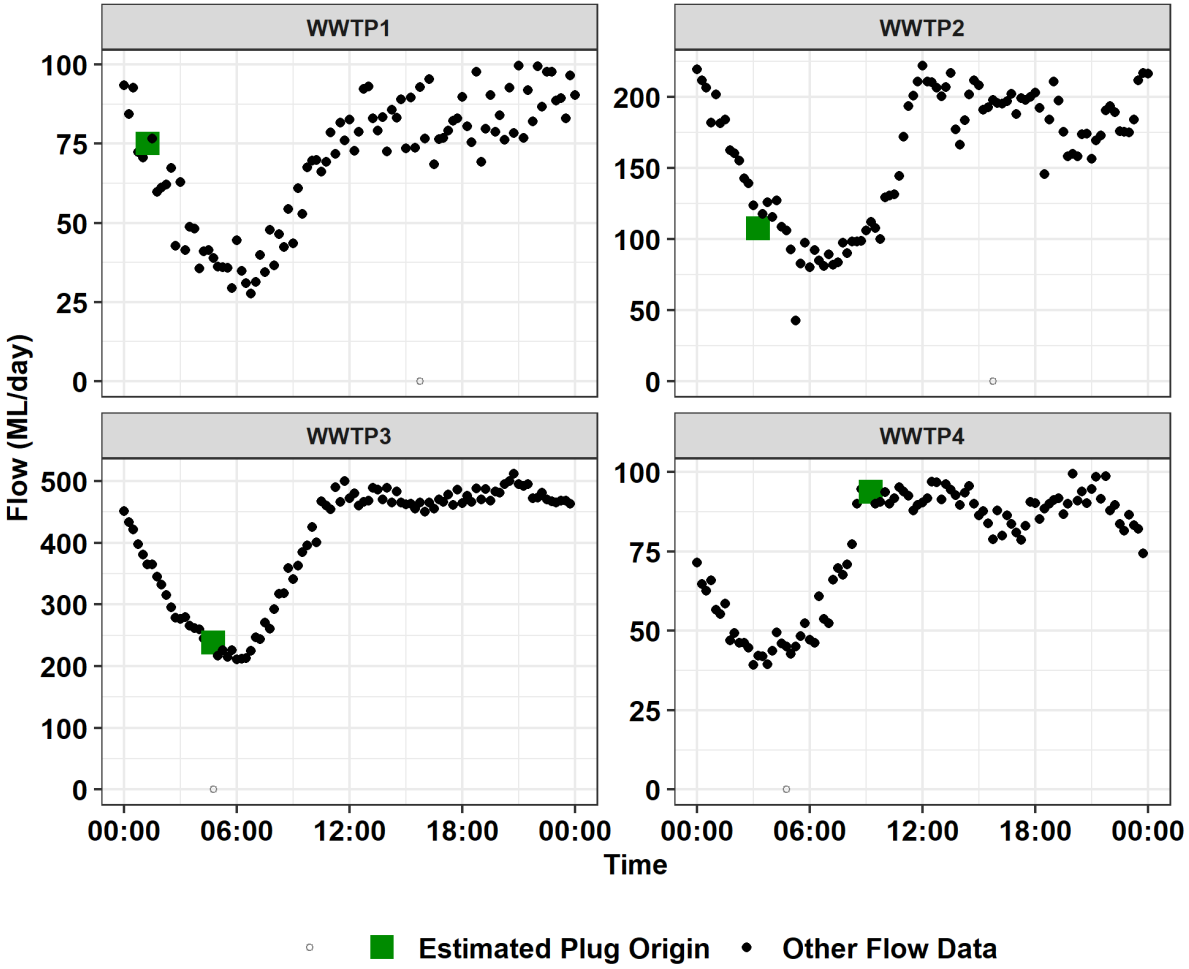
A mass balance was calculated using samples with known flow.

- Q = Flow (L/day)
- C = Concentration (ng/day)

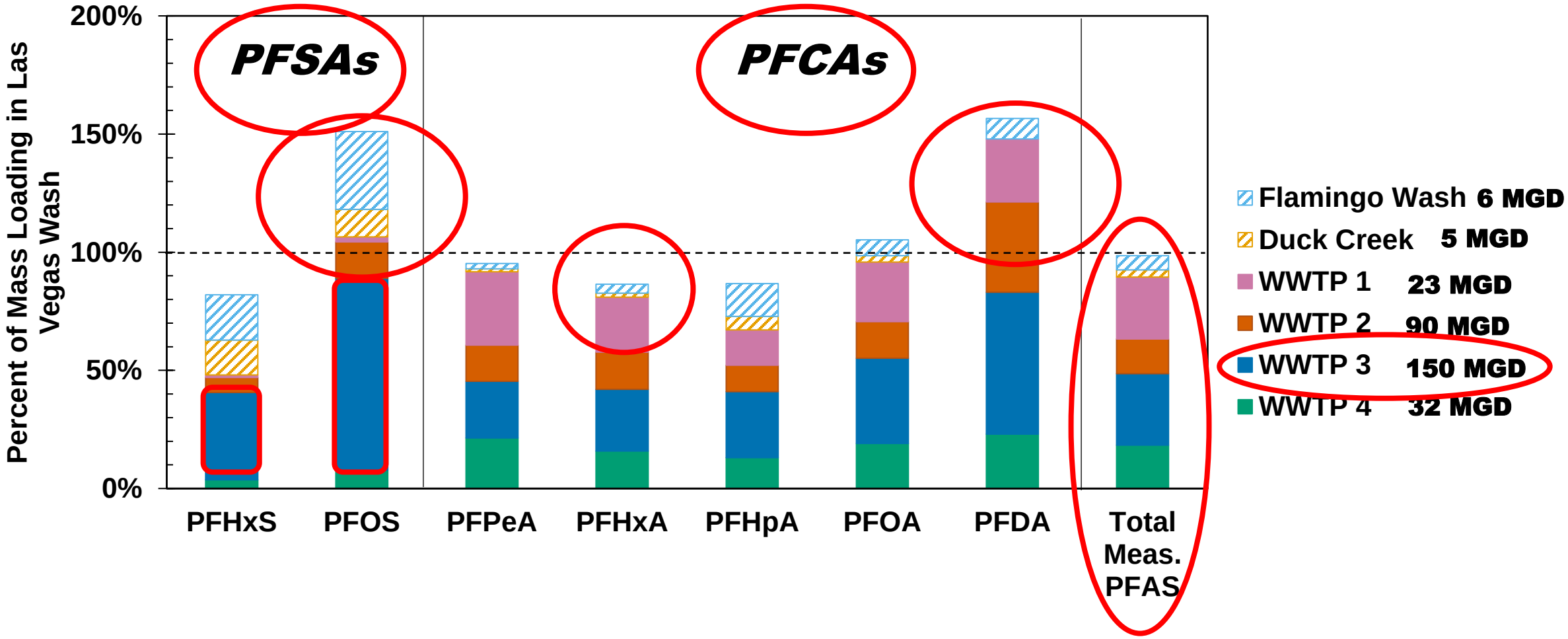
$$100 \times \frac{Q_{upstream} \times C_{upstream}}{Q_{Las\ Vegas\ Wash} \times C_{Las\ Vegas\ Wash}} = percent\ loading$$

Flow data was selected after adjusting for travel time in the Las Vegas Wash.

- Surface water flows from USGS
- Wastewater effluent flows from the wastewater utilities
- Las Vegas Wash travel times known thanks to a USGS dye tracer study

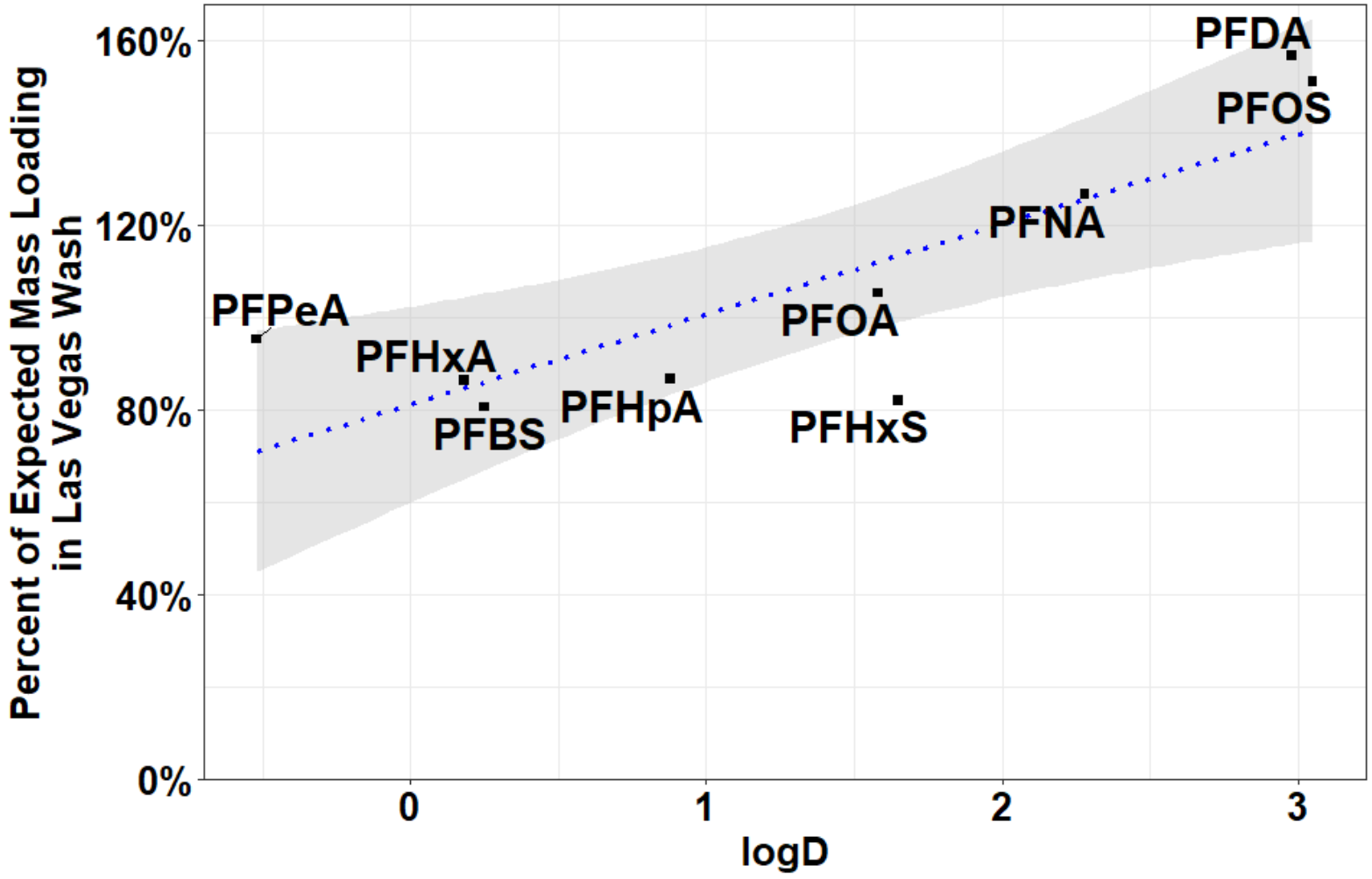


Wastewater effluent accounted for 90% of the total measured PFAS.

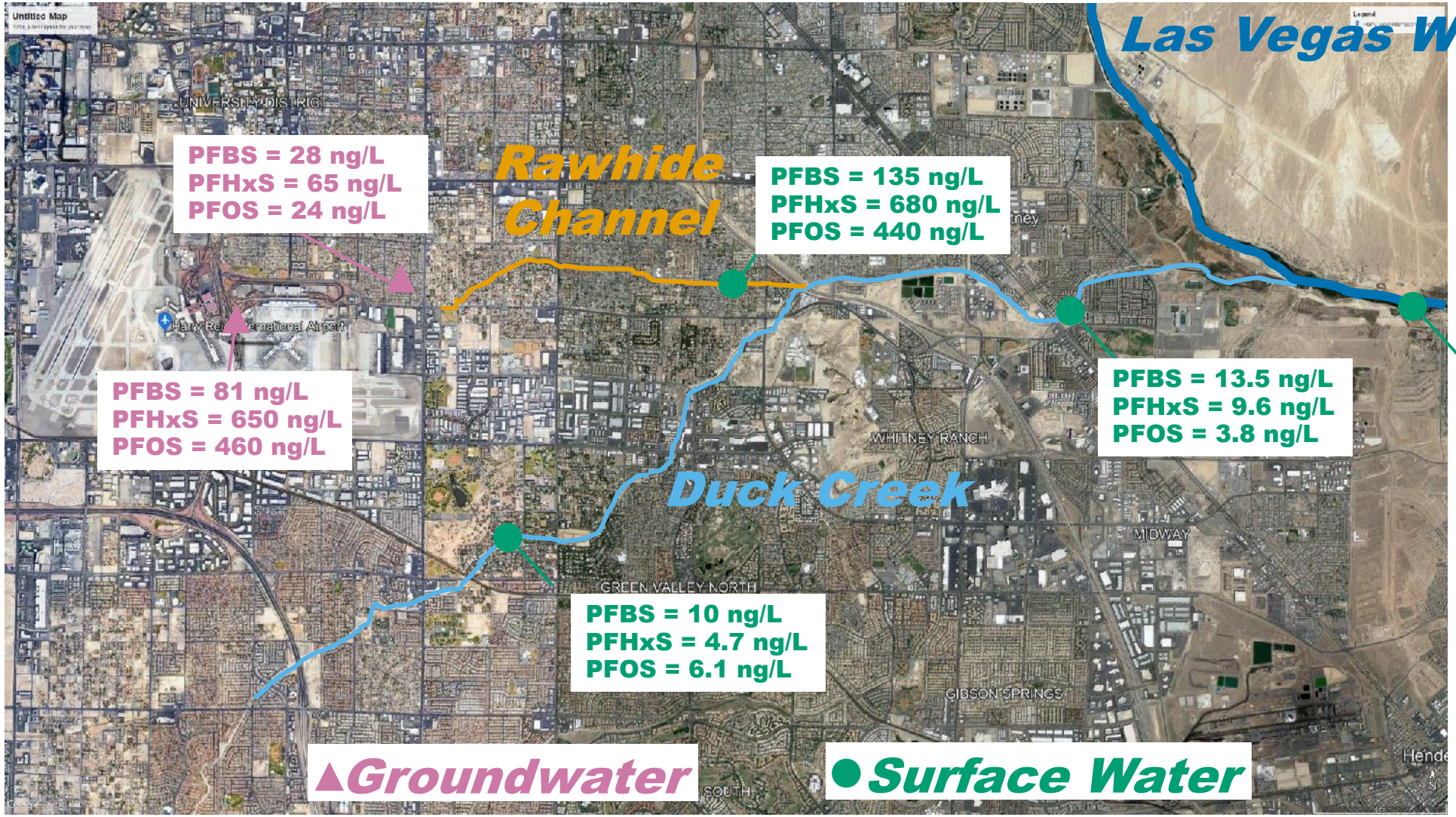


How much the upstream PFAS load exceeded the downstream PFAS load correlated with logD.

- LogD is a measure of the hydrophobicity of chemicals
- Long-chain PFAS with higher logD likely sorbed to sediment

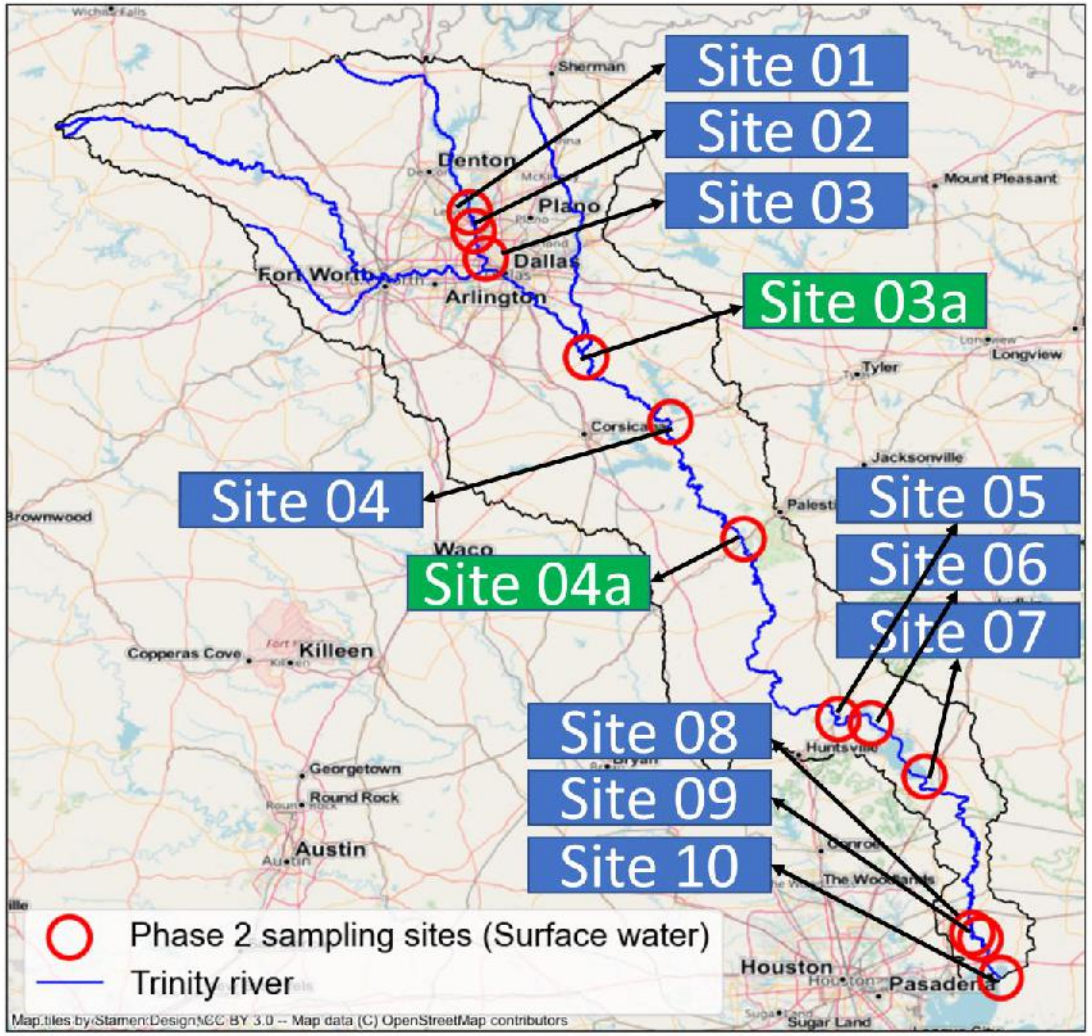


Sulfonic acids entered the Rawhide Channel but were sorbed to sediment or highly diluted before reaching the Las Vegas Wash.



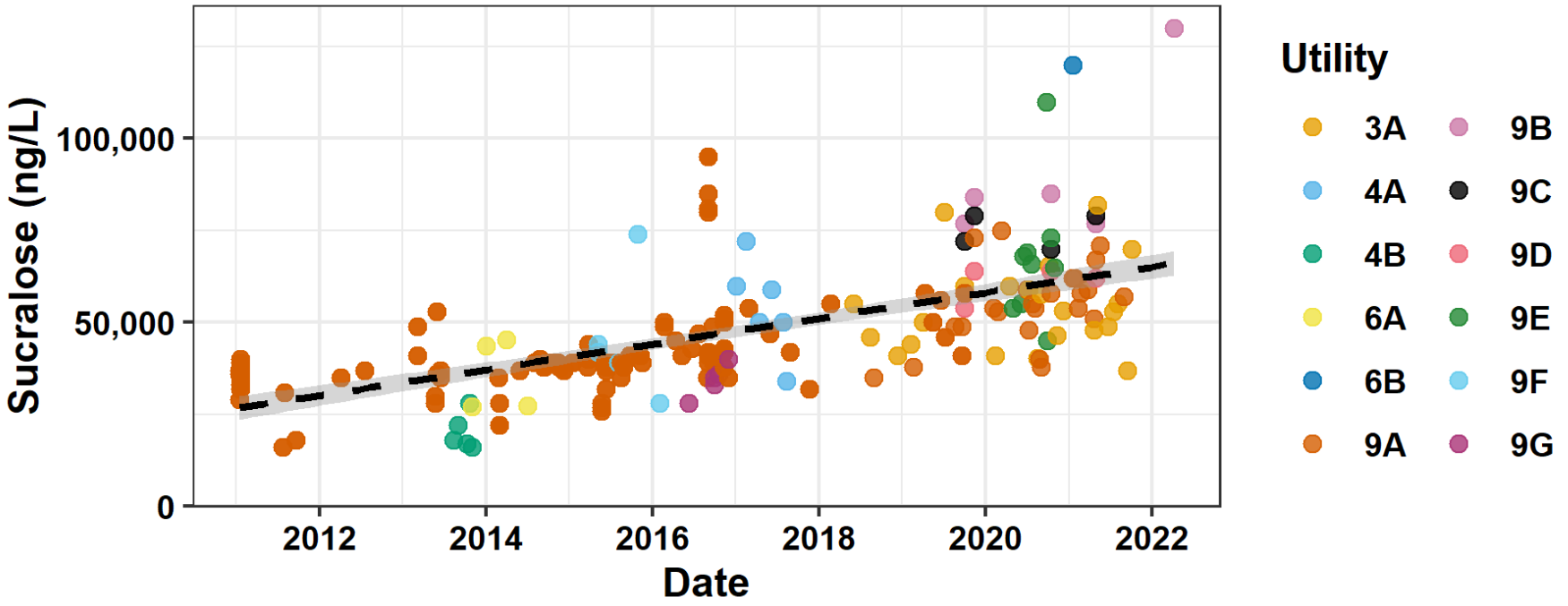
Surface Water Investigation #2

We sampled twelve surface water sites on the Trinity River (TX) for PFAS and sucralose.

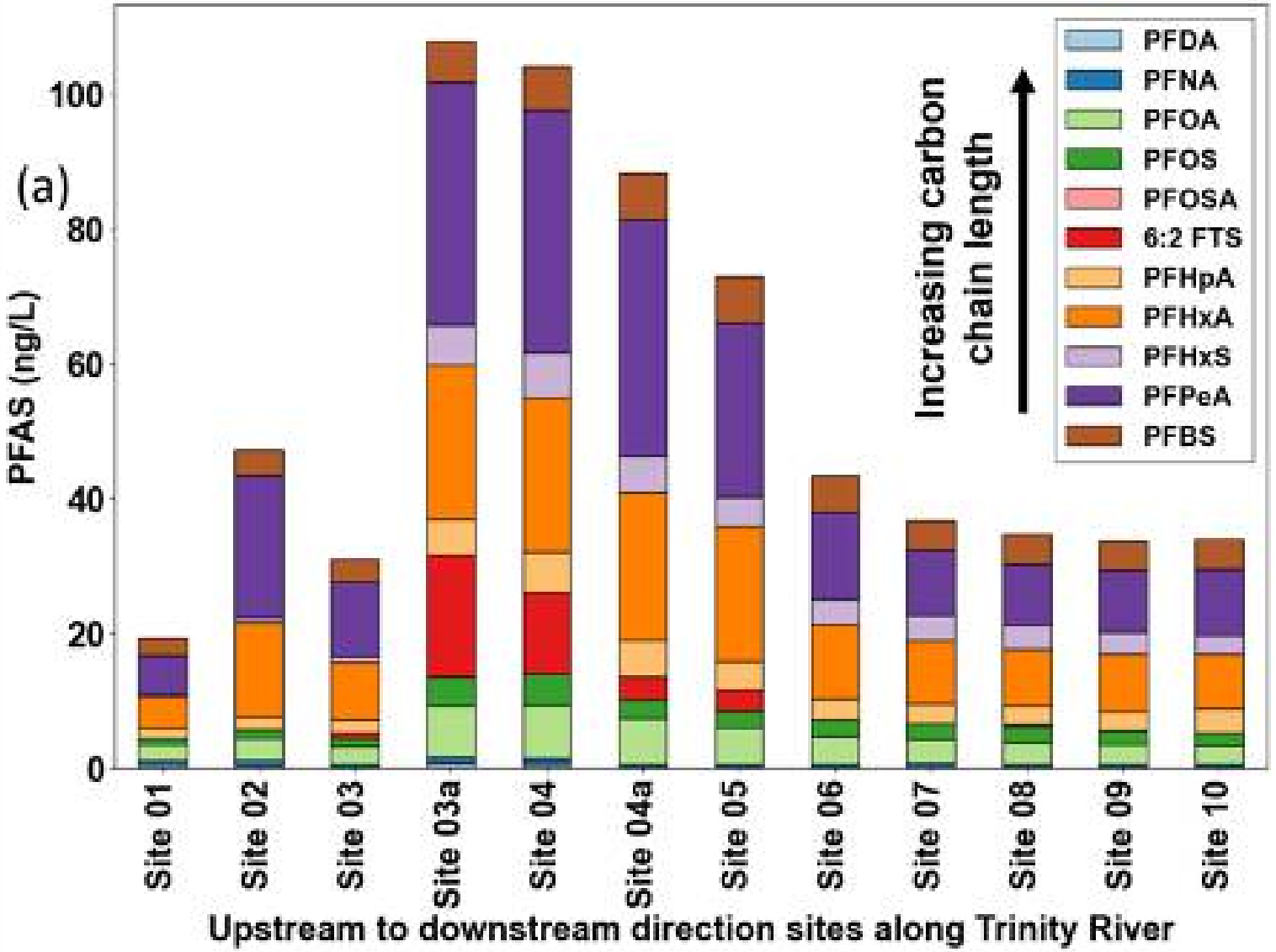


Sucralose is a wastewater effluent tracer.

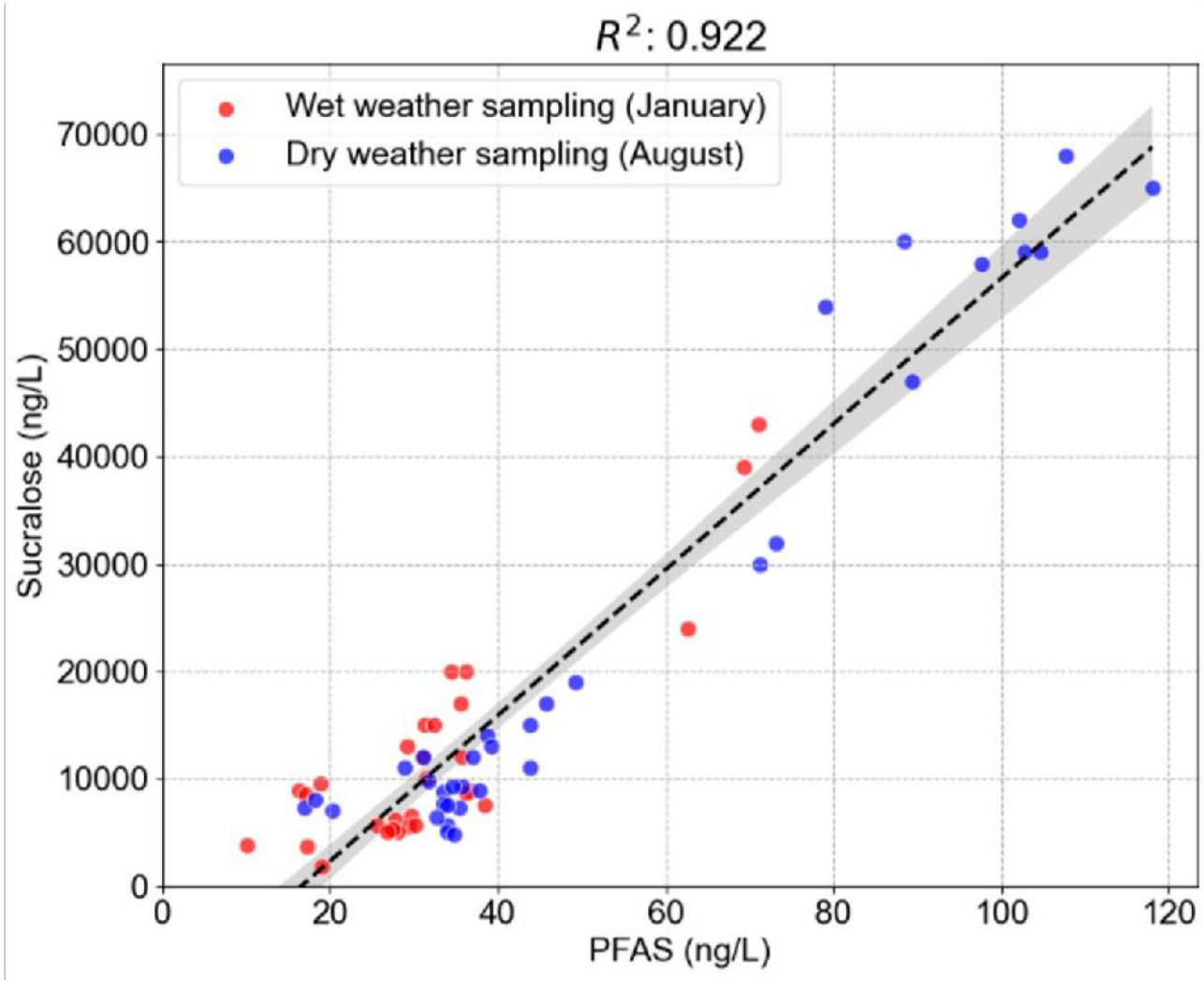
- Non-toxic
- Highly persistent in wastewater treatment and the environment
- High concentrations in wastewater effluent (≥50,000 ng/L)
- Consistent concentration among WWTPs



PFAS concentrations peaked in the middle reaches, downstream of an urban area before decreasing from dilution.



The sum of measured PFAS correlated strongly with sucralose in the river.



Guidance

The Guidebook lays out a step-by-step process to find and mitigate PFAS sources.

Guidebook for Preventing PFAS from Entering Drinking Water Supplies and Wastewater

The Guidebook discusses benefits and limitations of analytical methods.

Method	**Cost** $/sample	**Sensitivity (MRL)** How low of concentrations can it measure?	**Selectivity** Can it tell apart specific PFAS?	**Inclusivity** Can it measure a wide range of PFAS?
LC/MS	Low	High	High	Low
GC/MS	Low	High	High	Low
NTA	High	High	Medium-High	Medium-High
TOP Assay	Medium	Medium-High	Medium	Medium
AOF-PIGE	**To Be Determined**	Medium	Low	High
AOF-CIC	Low	Low	Low	High

We developed screening tools for levels of PFAS in wastewater effluent or biosolids indicating industrial sources.

PFAS	Literature Data Outliers Removed			WRF 5031 New Data Outliers Removed		
	n	Median	Max	*n*	Median	Max
PFBA	*40*	8.2	21			
PFPeA	*48*	22	44	*37*	15	47
PFHxA	*61*	21	54	*35*	13	33
PFHpA	*60*	4.8	15			
PFOA	*70*	8.5	15	*30*	7.6	11
PFNA	*62*	4.2	10			
PFDA	*56*	1.3	5.3			
PFBS	*53*	2.9	13			
PFHxS	*69*	4.7	10			
PFOS	*109*	7.1	31	*36*	3.5	30
6:2 FTS	*41*	4.4	24			
EtFOSAA	*30*	1.3	11			

Acknowledgments

- **Funding: The Water Research Foundation (Project #5082)**
- **Team**
  - **Carollo: Kyle Thompson, Giridhar Upadhyaya, Eva Steinle-Darling**
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  - **Arizona State University: Minhazul Islam, Paul Westerhoff**
  - **HRSD: Dana Gonzalez**
  - **Purdue: Linda Lee**
  - **CDM Smith: Jen Hooper, Charles Schaefer, Ibrahim Abusallout**
  - **Orange County Water District: Megan Plumlee**

Extra Slides

Some sites were relatively enriched with sulfonic acids.