

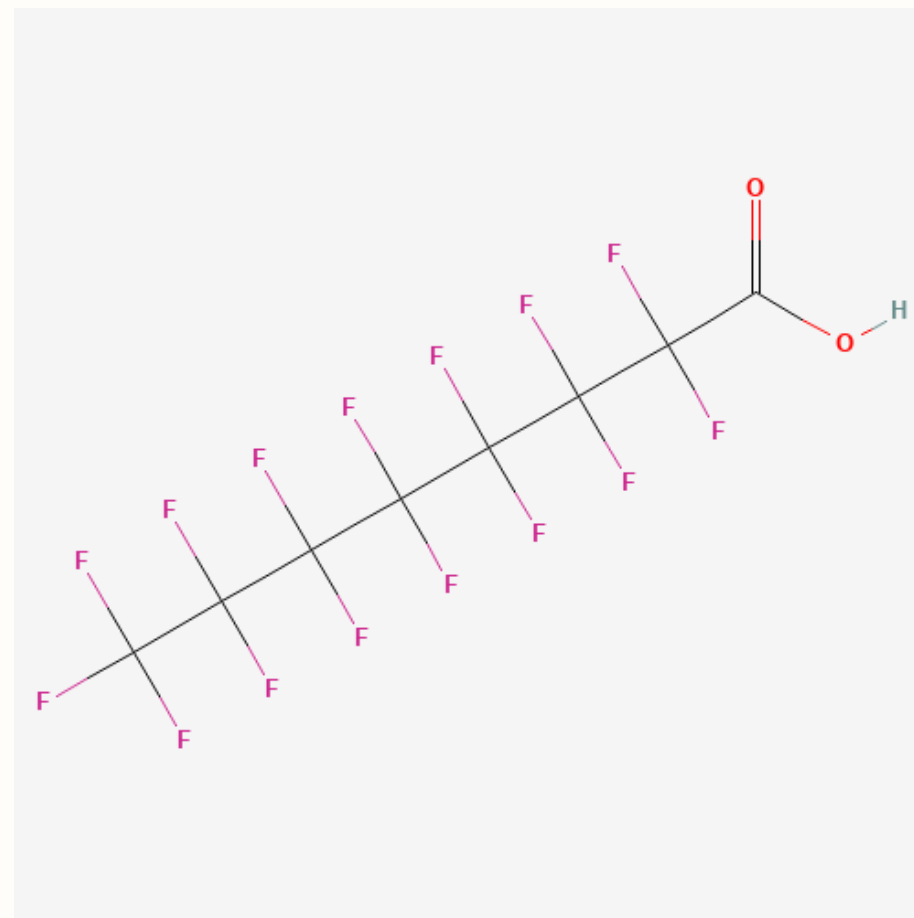


OCCURRENCE OF PER AND POLYFLUOROALKYL SUBSTANCES IN RURAL WASTEWATER TREATMENT PLANTS

Dr. Shannon Bartelt-Hunt

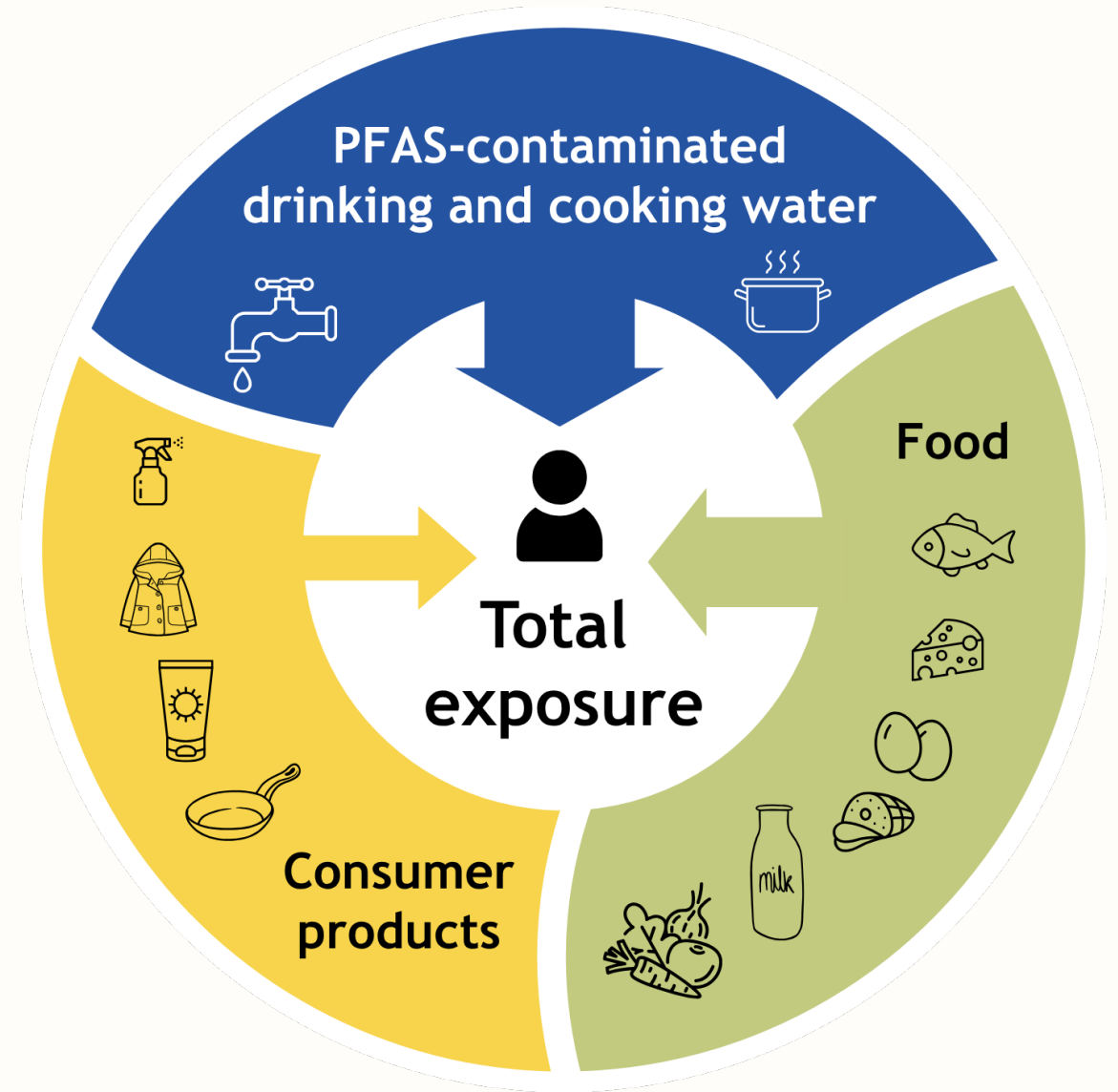
Per and Polyfluoroalkyl Substances

- PFAS ($C_n-F_{2n+1}-R$) defined by their C-F bonds
- Uses: Fire suppressants, cookware, food packaging, cosmetics, etc.



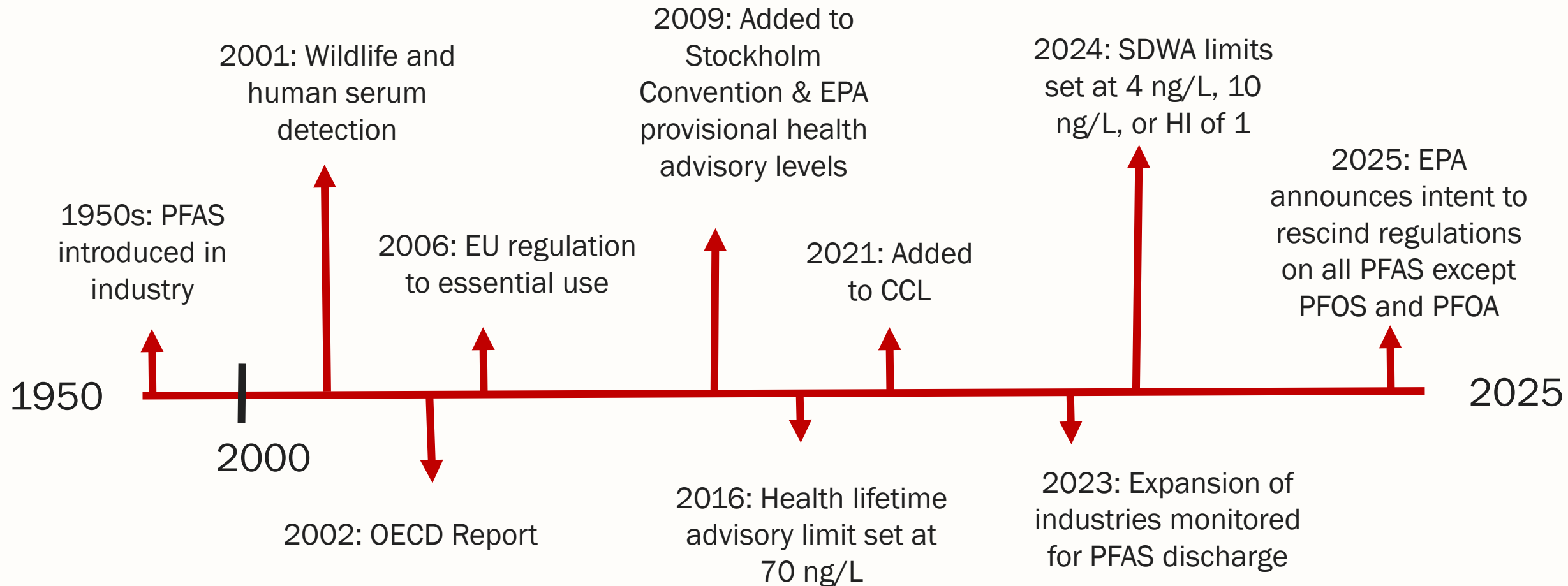
Health Impacts

- Reduced Vaccine Response
- Kidney and Testicular Cancer
- Hyperthyroidism
- Ulcerative Colitis
- Reduced Birth Weights
- Immunosuppression
- High Cholesterol





Regulatory Timeline



Environmental Sources

Point Sources

- Manufacturing Plants
- AFFF Initial Application
- Wastewater Treatment Plant Effluent

Nonpoint Sources

- Surface runoff
- Atmospheric transport
- Biosolids Application

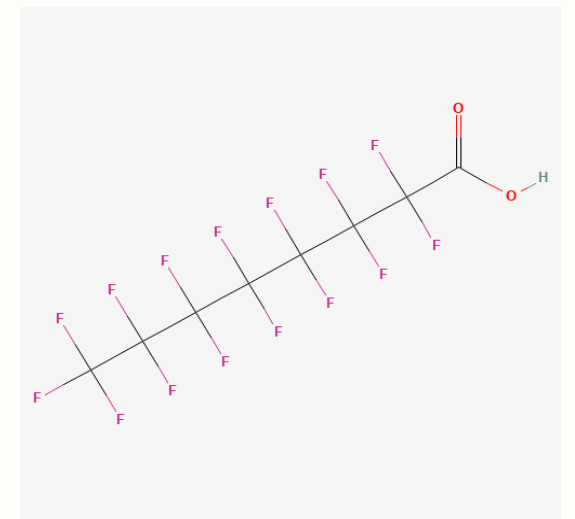
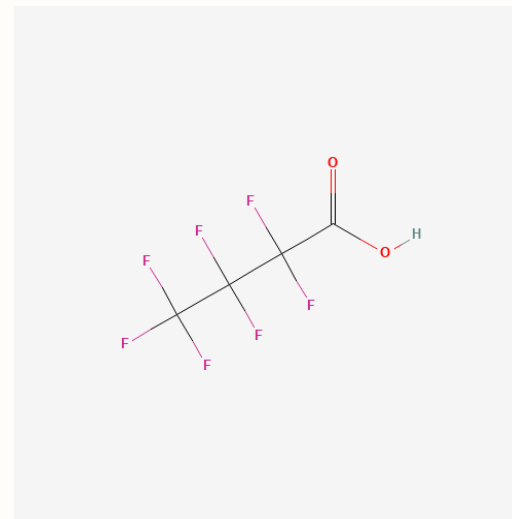
Classifications

Head Group

- Perfluoroalkyl acids (PFAA)
 - Carboxylic acid
 - Sulfonic acid
 - Phosphonic acid
 - Phosphinic acid
 - Ether compounds (carboxylic or sulfonic) (PFECA or PFESA)
- Fluorotelomer Based Substances
- Perfluoroalkane sulfonyl fluoride (PASF)-based substances

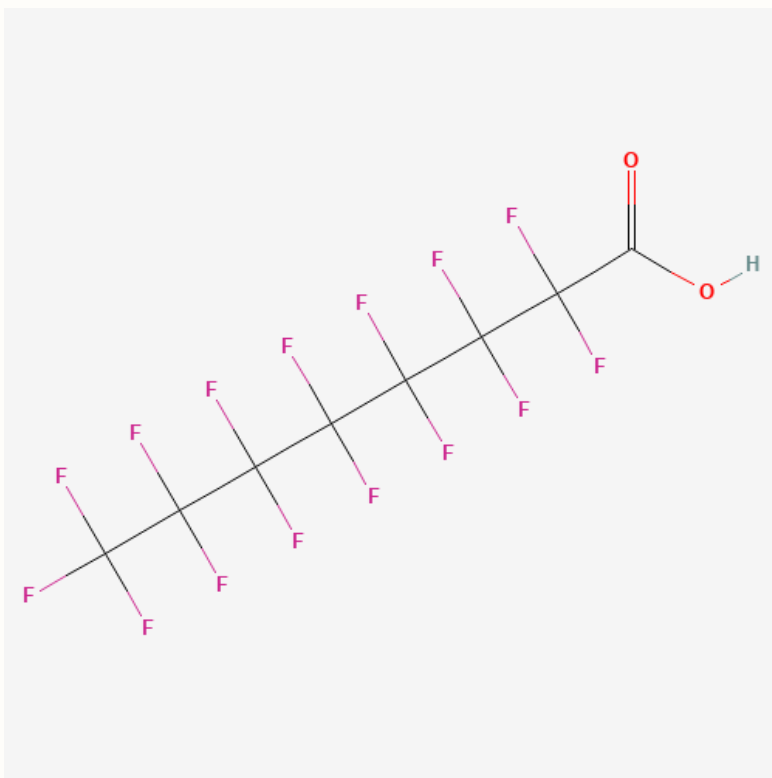
Long or Short Chain

- Long chain >7 carbons
- Exception for PFSA (>6 carbons)

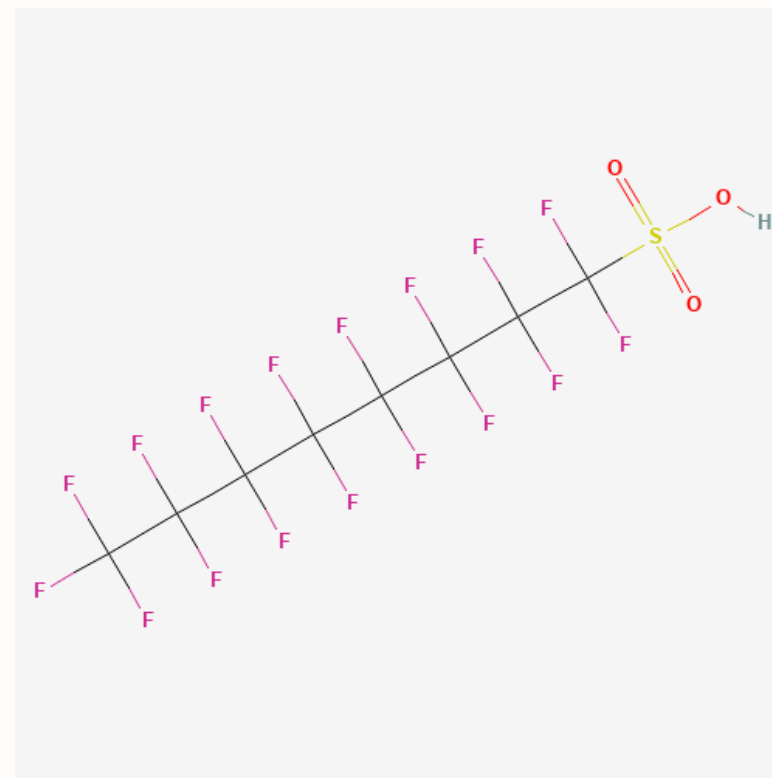


PFAAs

PFCAs

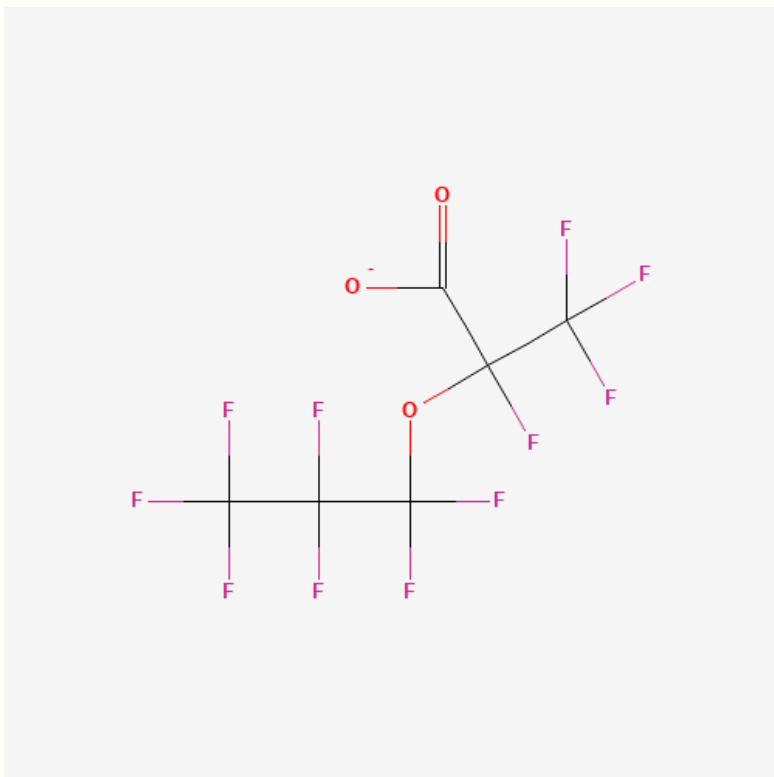


PFSAs

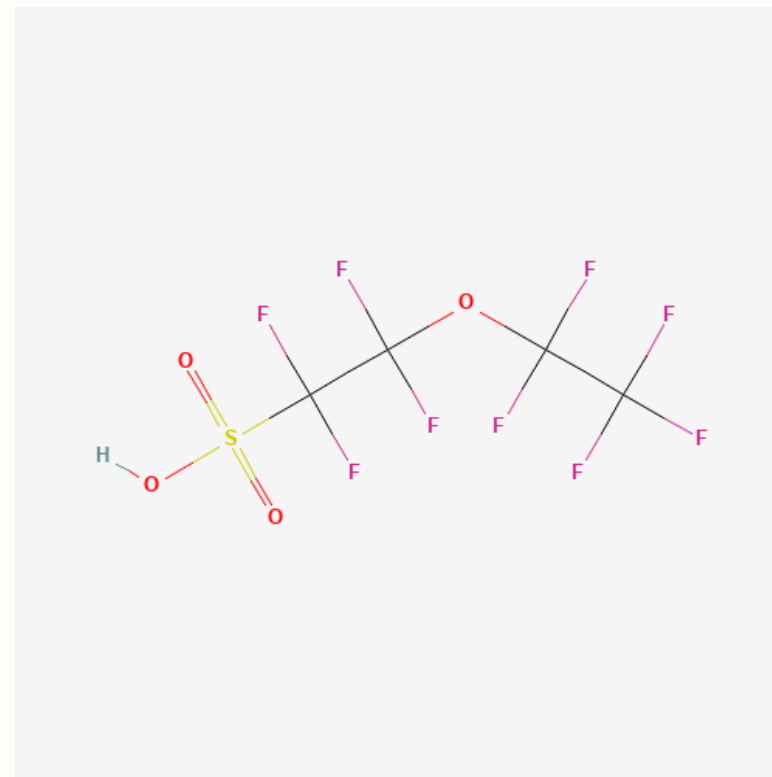


Ether Compounds

PFECAs

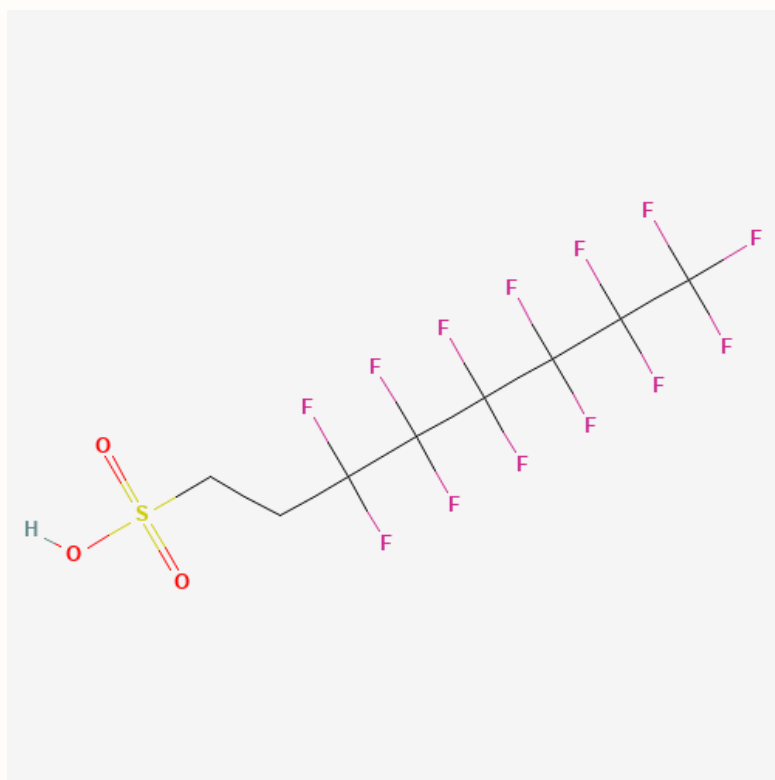


PFESAs

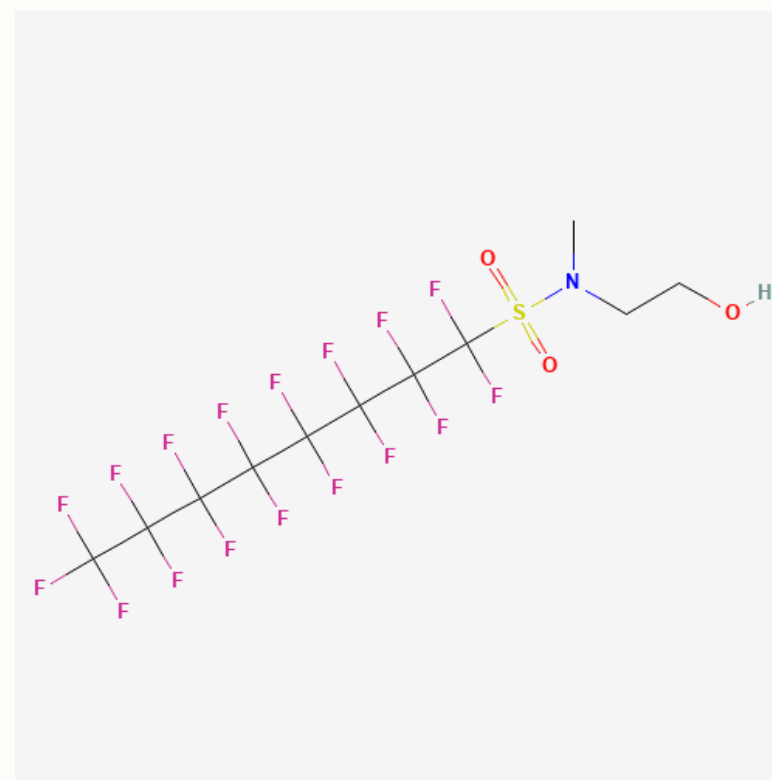


Precursor Compounds

Fluorotelomer Based Substances

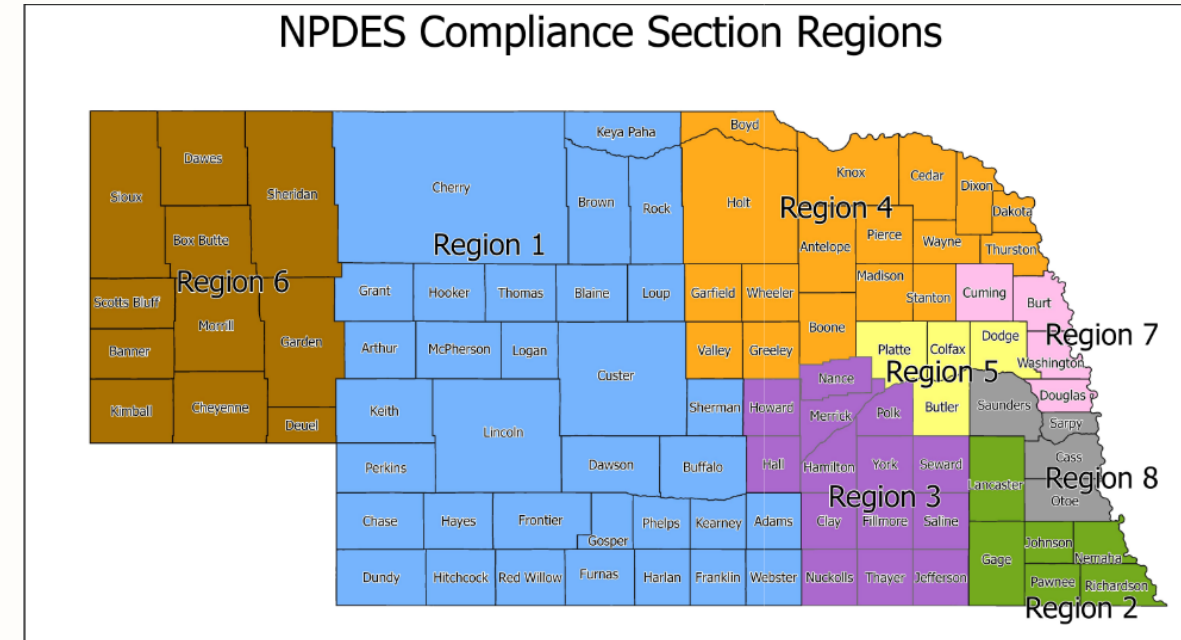


PASF Based Substances



Study Design

- Plants serving under 10,000 people
- Seventeen plants agreed to participate
- Samples taken from influent, effluent, early process solids, and finished biosolids
- Samples analyzed using a modified version of US EPA 1633 (40 PFAS)

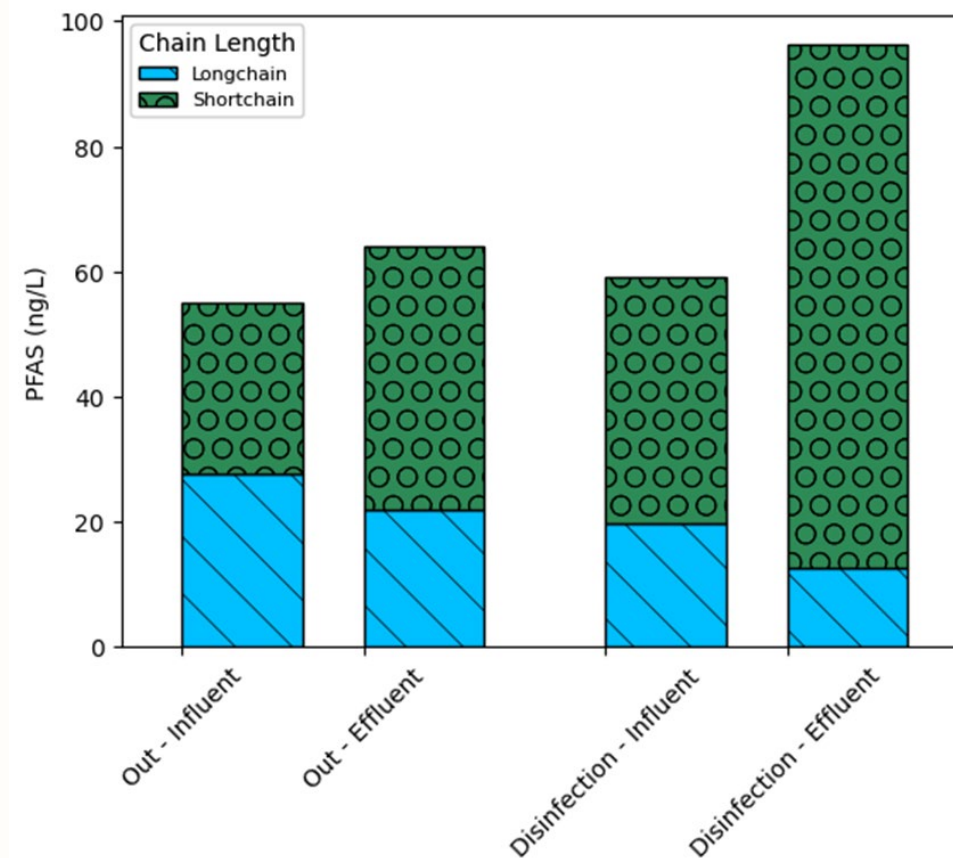
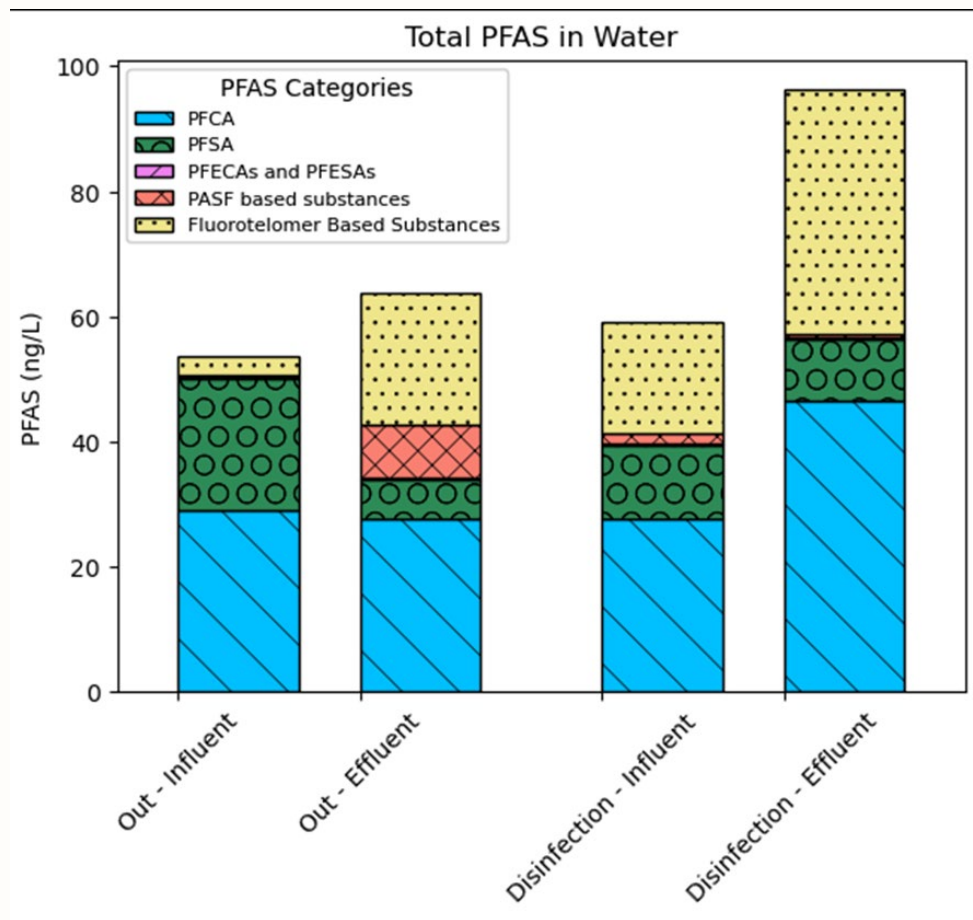


Known Trends in Large Treatment Facilities

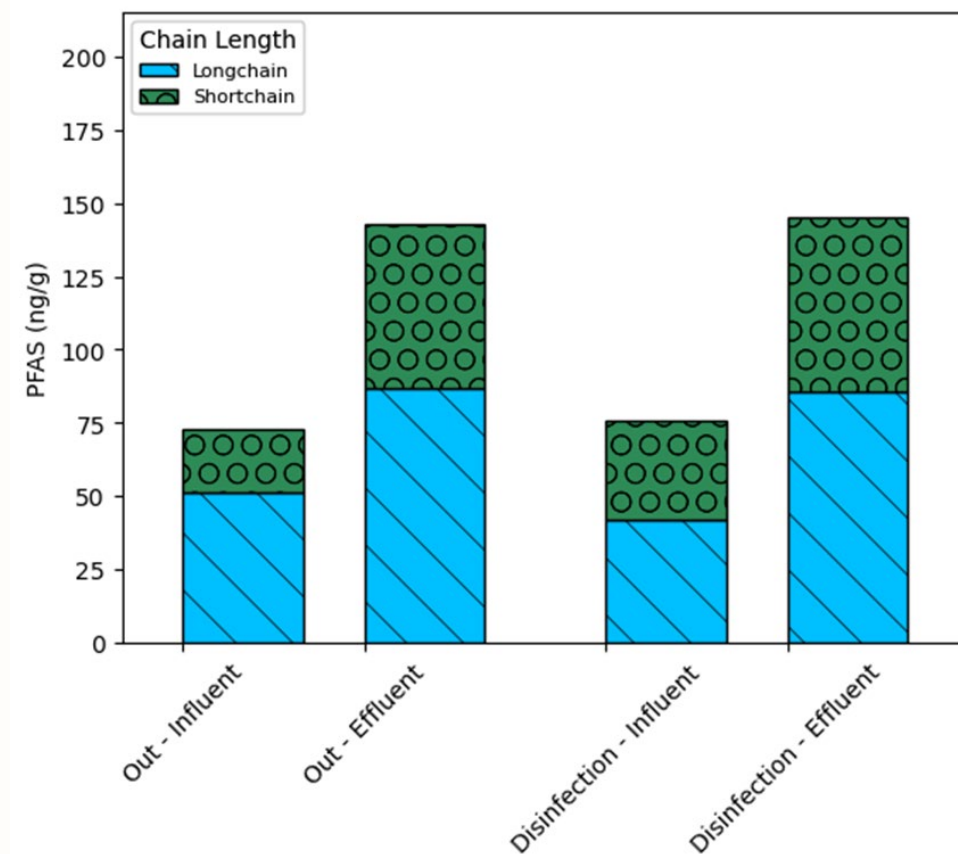
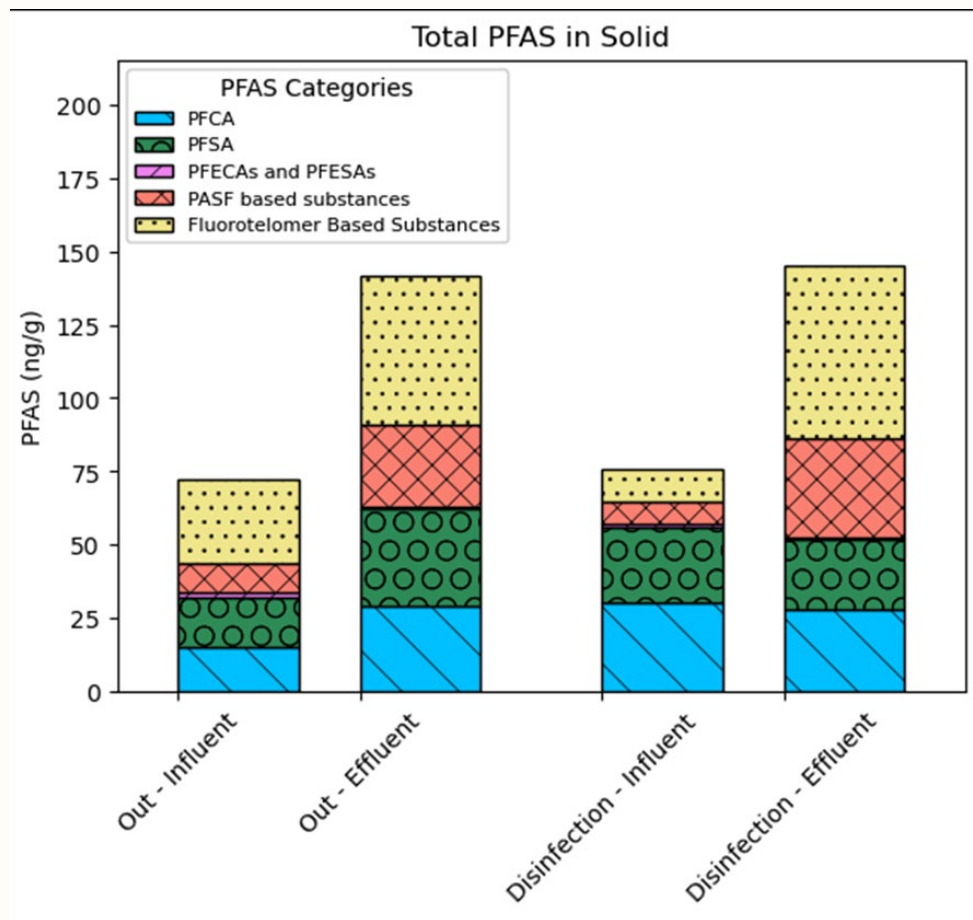
- Increase from influent to effluent of total PFAS
 - Typically PFCAs and PFSAAs
- Partitioning of long chain compounds into biosolids

	Influent (ng/L)		Effluent (ng/L)		Early Process Solids (ng/g)		Finished Solids (ng/g)
City	In Disinfection	Out of Disinfection	In Disinfection	Out of Disinfection	In Disinfection	Out of Disinfection	
Burwell	23.55	391.13	10.21	36.41	2.345	26.03	19.59
Central City	14.75	30.23	119.12	126.92	310.37	110.76	163.35
Chadron	36.89	33.62	75.23	37.29	54.14	200.75	111.86
Cozad	227.02	65.25	96.38	98.91	216.45	53.73	150.31
Fairbury	9.34	23.97	24.53	16.40	25.33	12.08	59.73
Falls City	28.82	16.43	77.67	34.53	45.72	66.12	72.82
McCook	142.89	41.00	81.61	241.82	21.25	27.83	146.90*
Ogallala	16.43	57.53	26.98	53.24	130.72	138.05	71.16
O'Neill	14.89	23.52	19.25	74.81	19.17	75.27	971.07
Sidney	16.06	22.87	53.49	48.99	35.90	71.49	61.57
Superior	3.46	26.43	580.43	24.27	9.68	9.40	5.43
Valentine	36.62	11.14	57.77	59.36	34.33	150.74	412.17
Wahoo	153.90	65.72	108	78.10	0.039	79.15	9.68
Waverly	74.50	31.79	124.79	84.87	94.49	65.76	92.11
Wayne	19.00	7.25	27.60	10.25	117.39	33.78	96.37
West Point	112.18	62.63	87.91	28.67	132.46	38.81	117.46
York	74.047	12.07	64.06	29.17	43.07	75.48	0.66

PFAS in Wastewater



PFAS in Biosolids

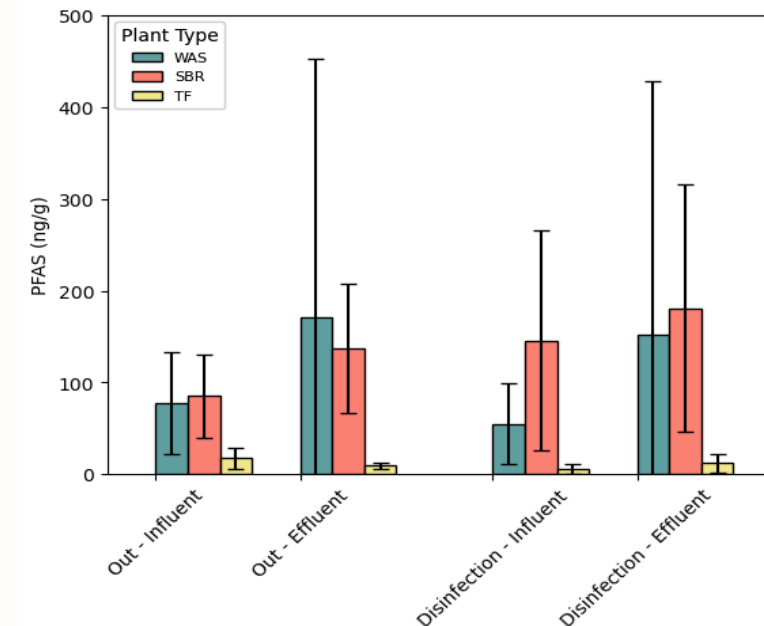
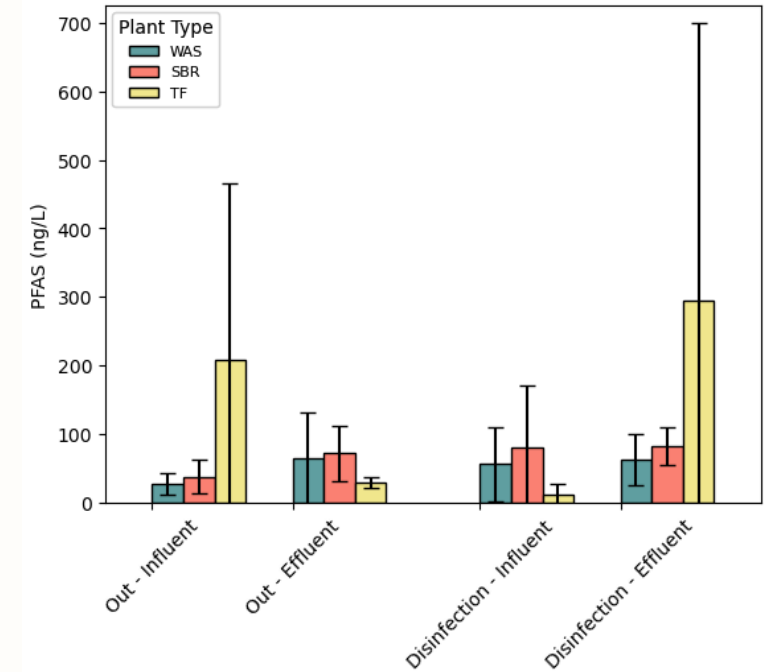


Field Data

- Field Data Collected
 - Chemical Oxygen Demand (COD)
 - Temperature
 - PH
 - Conductivity
 - Flow
- No relationship detected between total PFAS and any of these measures

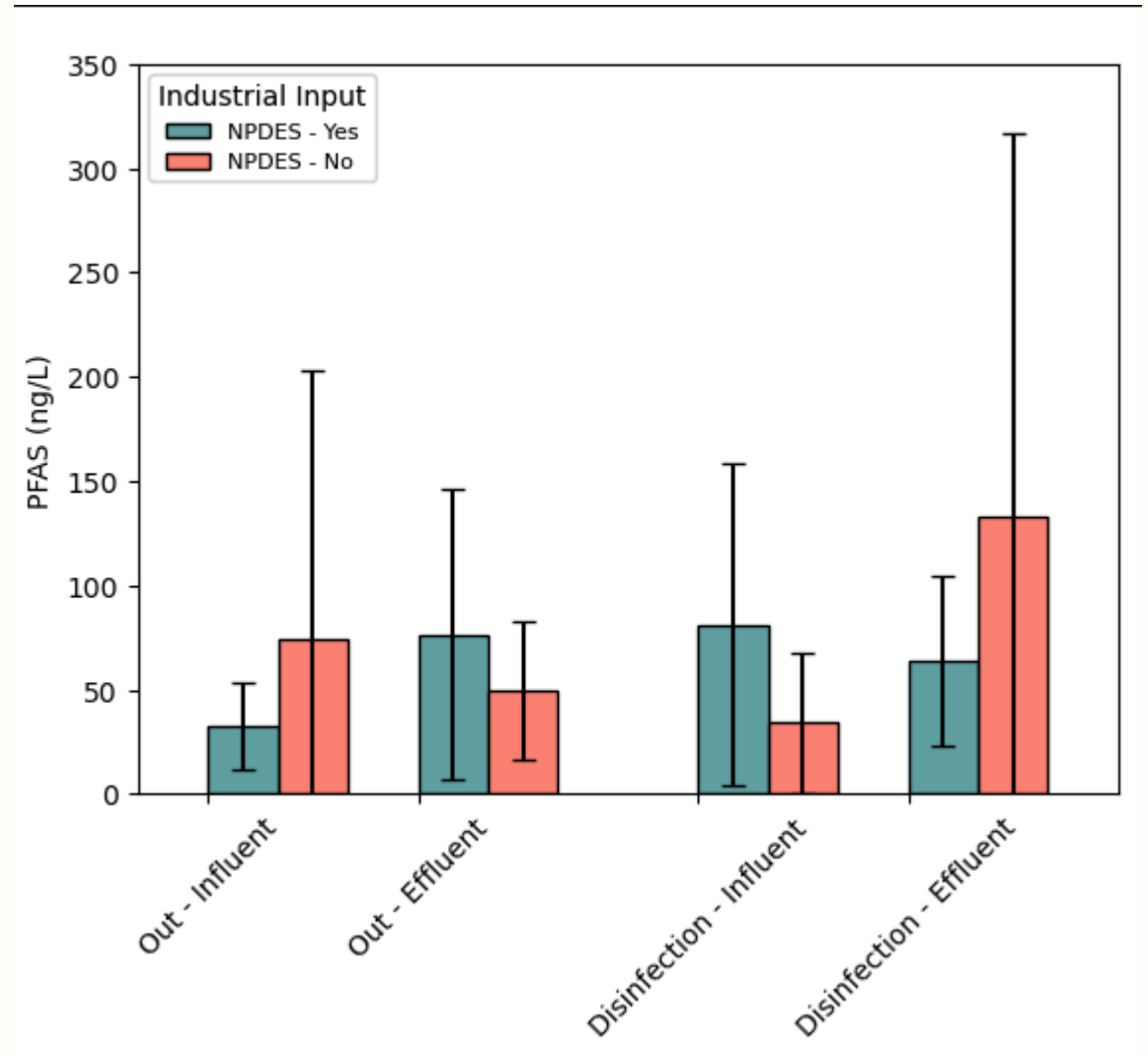
Type of Treatment Plant

- Three way ANOVA comparison between total PFAS in trickling filter, sequencing batch reactor, and waste activated sludge plants
- No difference found in influent or effluent
- May be some differences in solid concentrations between SBR and WAS



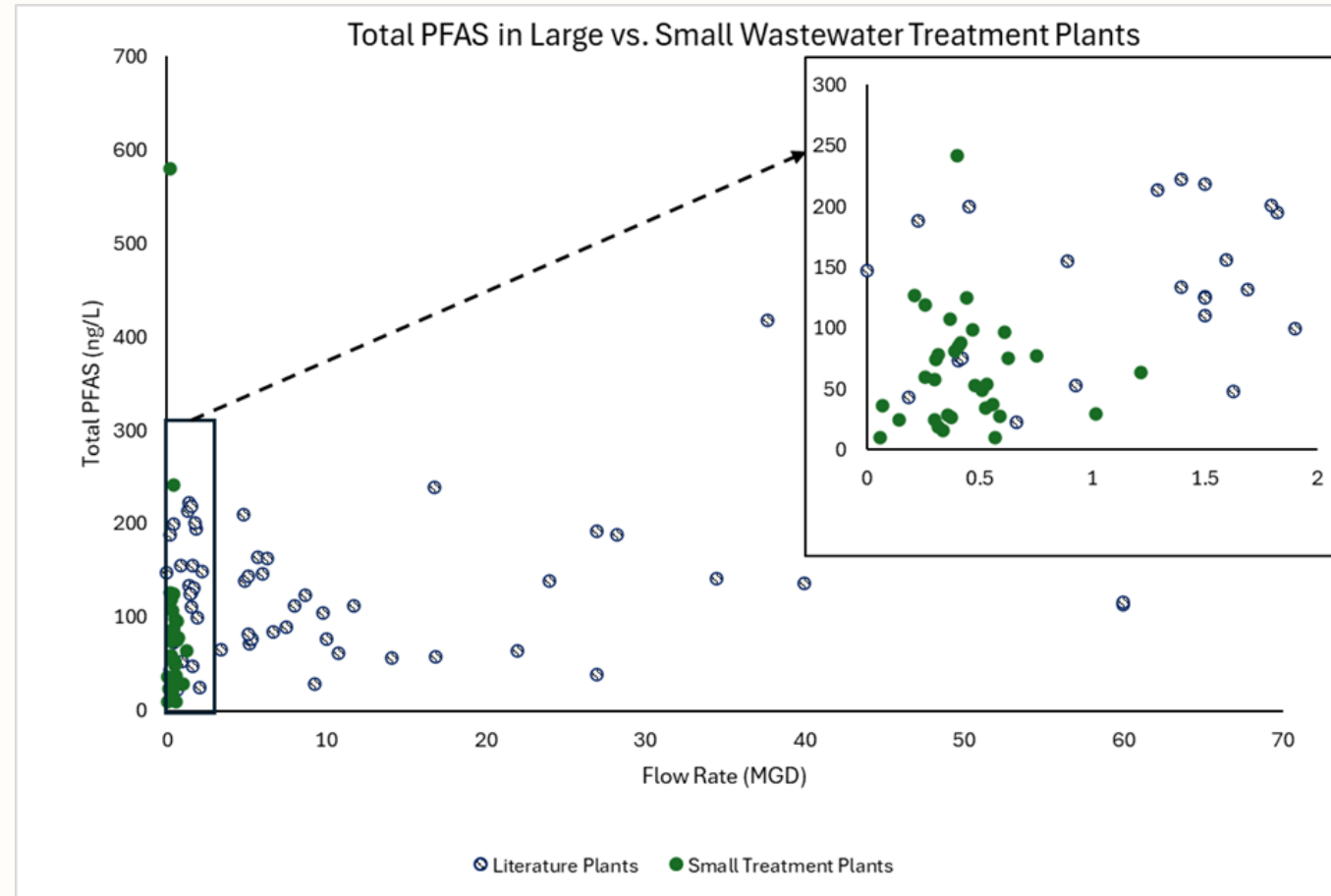
Industrial Input

- NPDES permit applications reviewed, divided into industrial input and no industrial input
- No differences in total PFAS
- Some change in influent composition, eg. more PFASs in nonindustrial plants



City	Type	NPDES	Industry Listed
Burwell	TF	No	N/A
Central City	SBR	No	N/A
Chadron	WAS	No	N/A
Cozad	SBR	Yes	Dry cleaners, animal byproduct processing
Fairbury	WAS	Yes	Meat Processing
Falls City	WAS	No	N/A
McCook	WAS	Yes	Parts Manufacturing
Ogallala	WAS	Yes	Metal Finishing*
O'Neill	WAS	Yes	Welding and Metal Finishing
Sidney	SBR	No	N/A
Superior	TF	No	N/A
Valentine	SBR	No	N/A
Wahoo	WAS	Yes	Meat Processing, Plastic Molding, and Paper Envelope Manufacturing

Comparison to Larger Treatment Plants



Conclusion

- PFAS are present in all samples (influent, effluent, early process solids, biosolids)
- No difference between types of inputs (industrial versus nonindustrial) implying most PFAS originating in municipal wastewater in these plants
- Variation in seasonality (disinfection, out of disinfection) seen in small treatment plants
- **Per capita addition of PFAS to municipal wastewater is the same across all treatment systems (comparison with literature for large**

Current Work

- Evaluating Grab Versus Composite Sampling Approaches for Quantifying PFAS
 - 4 SBR plants
 - 4 WAS plants

Sampling Site	Plant Type	1 st Trip	2 nd Trip	3 rd Trip
Cozad	SBR	12/16/2025	05/04/2026	
Central City	SBR	2/11/2026	05/04/2026	
Waverly/Wahoo	WAS	10/28/2025	3/19/2026	05/06/2026
York	WAS	4/23/2026	05/06/2026	
West Point	SBR	4/9/2026	05/11/2026	
Wayne	WAS	4/30/2026	05/11/2026	
Holdrege	SBR	4/23/2026	05/14/2026	

Acknowledgements

- Dr. Daniel Snow, UNL Water Sciences Laboratory
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Questions?