



Addressing Contaminants of Emerging Concern in the Cape Fear River Basin

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Introduction

- The Cape Fear River has historically been vulnerable to non-point and point discharges and CECs
 - PFAS
 - GenX
 - 1,4-dioxane
 - Bromide
 - Others
- Many of these contaminants are not federally regulated
- Conventional treatment has limited effectiveness for removing many CECs



Unregulated Contaminant Monitoring Rule (UCMR)

- Once every 5 years, EPA needs to issue a list of no more than 30 unregulated contaminants to be monitored by public water supply systems
- UCMR provides scientifically valid occurrence data used to
 - Assess exposure
 - Develop regulatory decisions
- Samples are collected at the point-of-entry to the distribution system and maximum residence time

EPA's Unregulated Contaminant Monitoring Rule 3

UCMR 3 Contaminant List

Assessment Monitoring (List 1 Contaminants)

1,2,3-trichloropropane	bromomethane (methyl bromide)	chloromethane (methyl chloride)	bromochloromethane (Halon 1011)
chlorodifluoromethane (HCFC- 22)	1,3-butadiene	1,1-dichloroethane	1,4-dioxane
vanadium	molybdenum	cobalt	strontium
chromium	chromium-6	chlorate	perfluorooctanesulfonic acid (PFOS)
perfluorooctanoic acid (PFOA)	perfluorobutanesulfonic acid (PFBS)	perfluorohexanesulfonic acid (PFHxS)	perfluoroheptanoic acid (PFHpA)
perfluorononanoic acid (PFNA)			

Screening Survey (List 2 Contaminants)

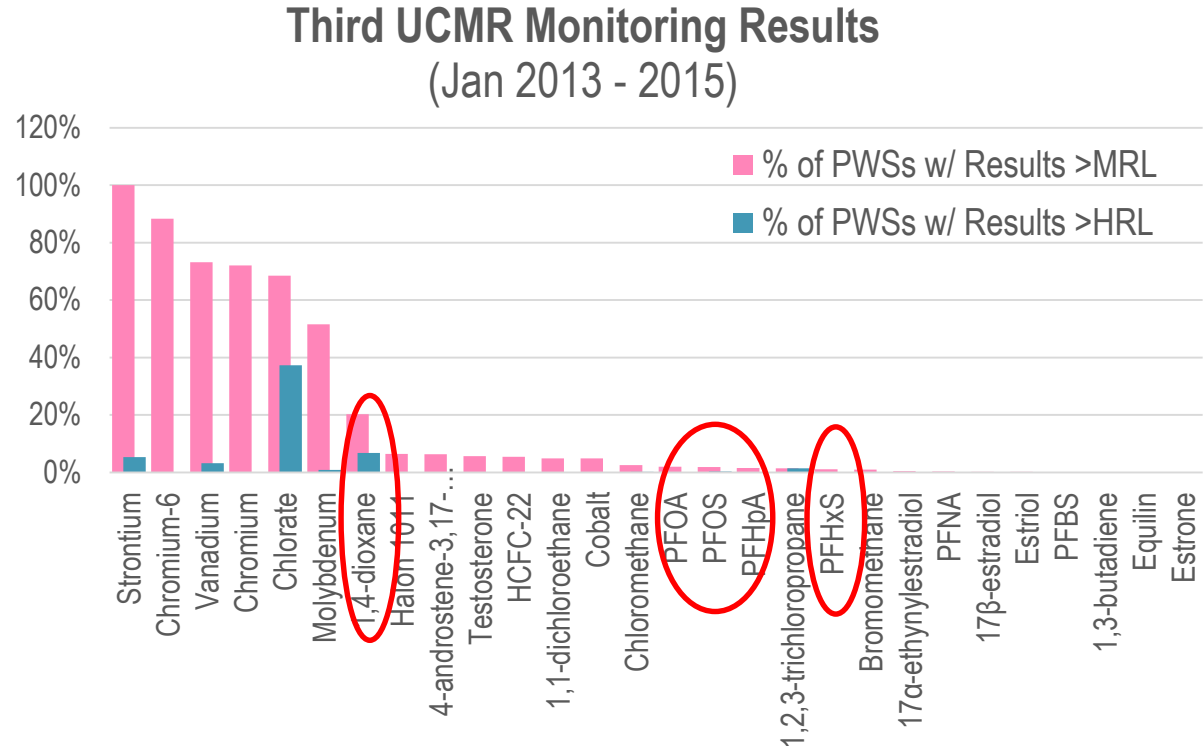
17-β-estradiol	estriol	estrone	4-androstene-3,17-dione
17-α-ethynylestradiol	equilin	testosterone	

Pre-Screen Testing³ (List 3 Contaminants)

enteroviruses	noroviruses		
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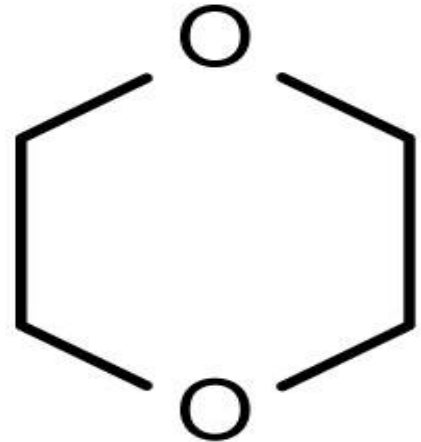
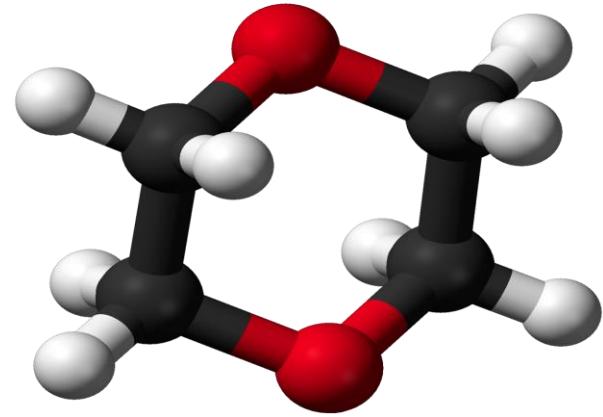
U.S. Unregulated Contaminant Monitoring

- Lots of low level detections for metals
- Few analytes appear at levels above health reference level



1,4-Dioxane

- Primarily used as solvent stabilizer and industrial solvent
- Probable human carcinogen. One in a million cancer risk associated with a 1,4-dioxane concentration of 0.35 mg/L (EPA IRIS database)
- Very stable (soluble and non-volatile)
- Difficult to treat



1,4-Dioxane (Graphic from eurofins | Eaton Analytical)

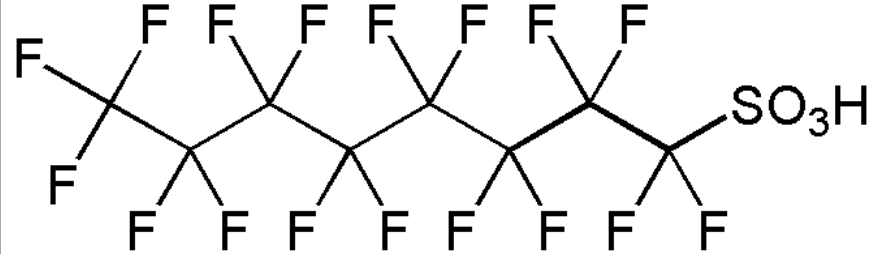


Detected in 12% of samples nationwide
~3% exceed the 0.35 ug/L HRL
~1% exceed a 10^{-5} risk level of 3.5 ug/L

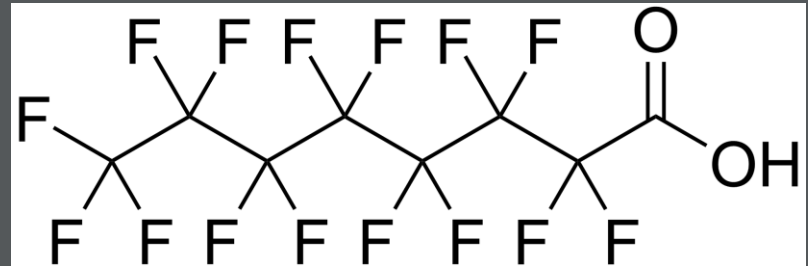
What are Perfluorinated Compounds (PFCs)?

- Organofluorine compounds
 - C-F bonds
 - C-C bonds
 - More stable than H-C bonds
- Stable, nonreactive, and effective at low concentrations
- Hydrophobic, hydrophilic, and lipophilic all in one – ideal surfactants
- Linked to Reproductive and Developmental Impacts, Cancer, Thyroid Function, Liver Damage

PFOs

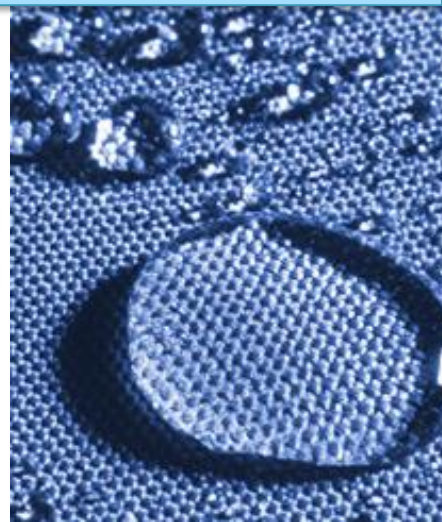


PFOA



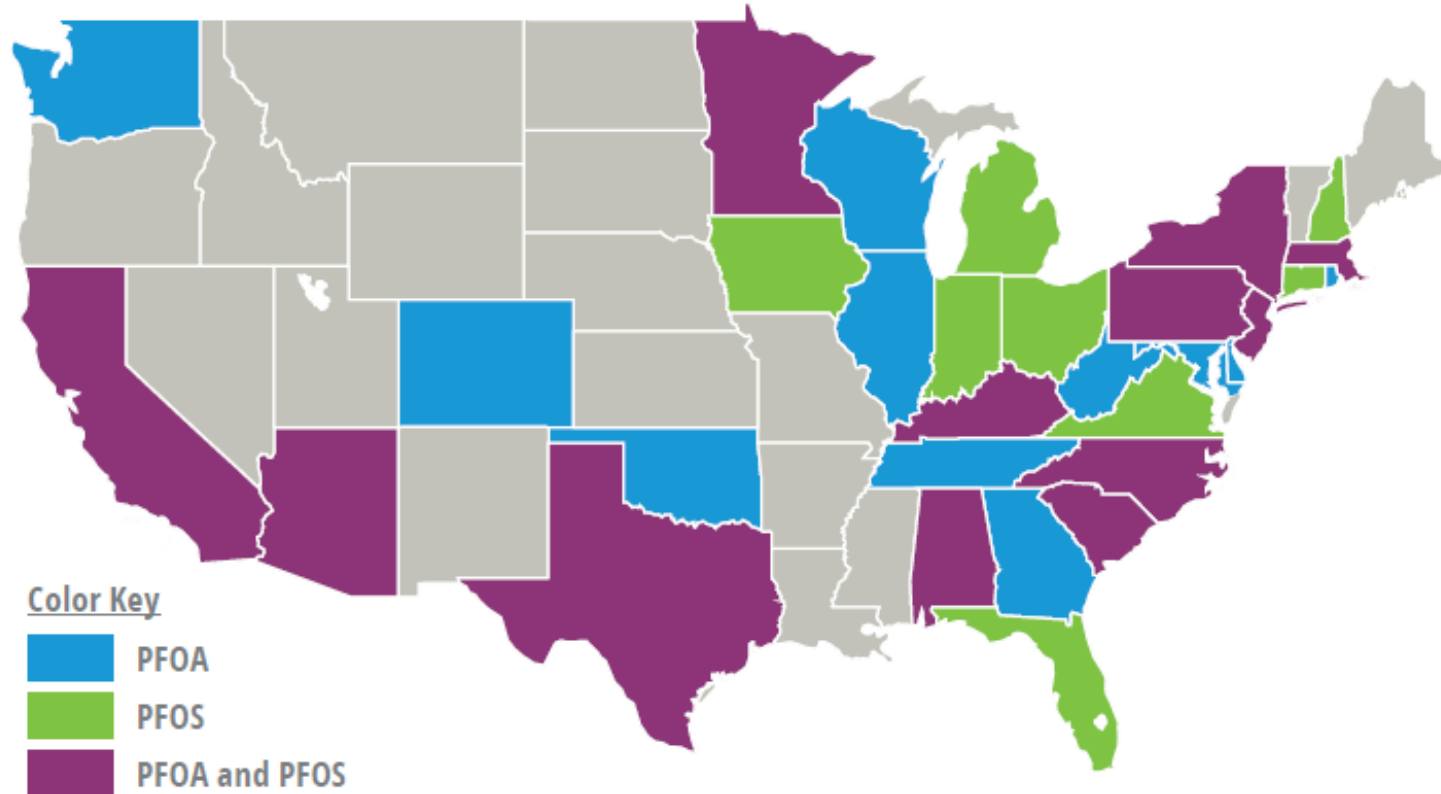


Where are PFCs found?



UCMR 3 Results

Map created from data collected by Eurofins and Eaton Analytical



Brunswick County UCMR 3 Sampling Results

Constituent	Health Risk Level (HRL) or Health Advisory, mg/L	EPA MCL mg/L	Range Detected (mg/L)	SDWA Violation
Perfluoroheptanoic acid, PFHpA	**	**	0.013-0.022	No
Perfluorohexanesulfonic acid, PFHxS	**	**	0.01	No
Perfluorononanoic acid, PFNA	**	**	0.0068	No
Perfluorooctanesulfonic acid, PFOS	0.07	**	0.0235	No
Perfluorooctanoic acid, PFOA	0.07	**	0.0088-0.0162	No
Chromium, Hexavalent	10	**	0.062-0.33	No
Chromium	100	100	0.121-0.30	No
Molybdenum	40/80	**	0.361-0.903	No
Strontium	4,200	**	38.2-249	No
Vanadium	21	**	0.23-0.53	No
Chlorate	210	**	121-147	No
1,4-Dioxane	0.35	**	3.2	No

Emerging Fluorinated Alternatives - GenX

- Major manufacturers stopped production of PFOA in 2009/2015
- Perfluoroether carboxylic acid (PFECA) and perfluoroether sulfonic acid (PFESA) used as alternatives
 - PFOA replacement - GenX
- Little is known about their persistence, toxicology and treatability of Gen-X and other PFECA/PFESAs

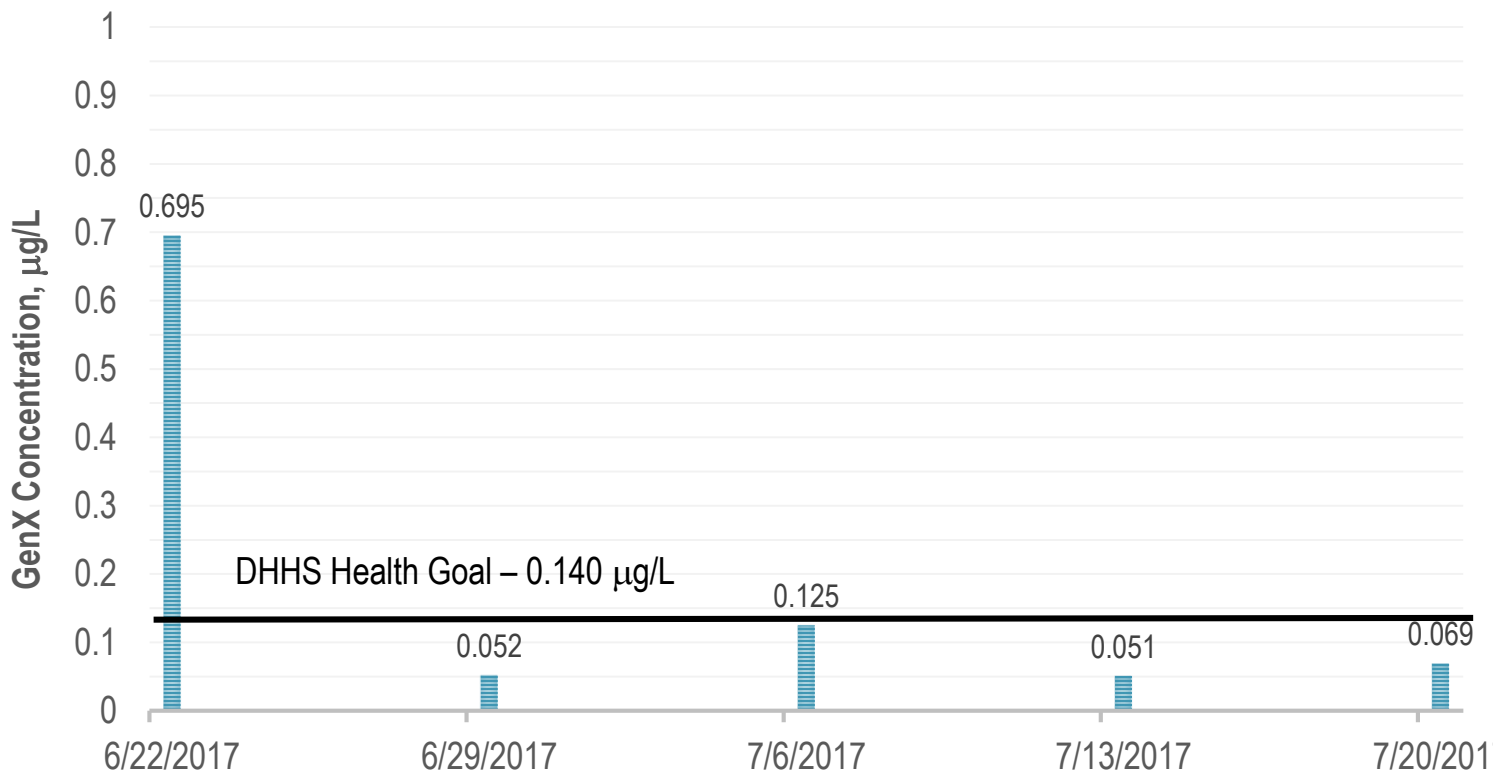
Property	
Nicknames	<u>GenX</u>
Chemical Names	<u>Ammonium perfluoro (2-methyl-3-oxahexanoate)</u>
	<u>Ammonium 2,3,3,3-tetrafluoro-2-(heptafluoropropoxy) Propionate</u>
	<u>Ammonium 2-(heptafluoropropoxy)tetrafluoropropionate</u>
Primary Use	<u>Fluoropolymer resin</u>
CAS Number	62037-80-3
Chemical Formula	C ₆ H ₄ F ₁₁ NO ₃
Molecular Weight	347.08 g/mol
Chemical Structure	

PFECAs and PFESAs Toxicological Information

	PFECAs and PFESAs
Persistence	Resistant to photolysis, hydroxyl (OH)-radical-mediated reactions, hydrolysis, and biodegradation, however more research is needed.
Bioaccumulation potential	Uncertain due to lack of information. They might be as bioaccumulative as their predecessors due to similar physicochemical properties, although some research indicates GenX is not as bioaccumulative as PFOA.
(Eco)toxicity	Three PFECAs have been shown to cause liver damage in rats; one PFECA has been suggested by its manufacturer to be classified as “T” under the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)* regulation. However, GenX appears to be less toxic than PFOA, particularly with respect to reproductive systems.
Long-range transport potential	Suspected to be mobile like their predecessors based on similar physicochemical properties

(Wang et al. 2015; Beekman et al. 2016)

Raw Water GenX Concentrations for the NWWTP



Contaminant Treatment Effectiveness

Constituent	Treatability (% Removal Range)							
	Conventional Treatment	Granular Activated Carbon	Powdered Activated Carbon	Ozone	Biofiltration	UV/AOP	Reverse Osmosis	Ion Exchange
Perfluoroheptanoic acid, PFHpA	NE	50 to 90%	0 to >90%	NE	UN	~5%	81 to >98%	38 to >54%
perfluoro-2-propoxypropanoic acid (GenX)	NE	UN	0 to 40%	NE	UN	UN	UN (Likely > 90%)	UN
Perfluorohexanesulfonic acid, PFHxS	NE	50 to >90%	0 to >90%	NE	UN	NE	94 to >96%	97 to >98%
Perfluorononanoic acid, PFNA	NE	>90%	0 to >90%	NE	UN	NE	87 to >98%	>67%
Perfluorooctanesulfonic acid, PFOS	NE	>90%	0 to 50%	NE	UN	~10%	96 to >99%	0 to >94%
Perfluorooctanoic acid, PFOA	NE	>90%	0 to 90%	NE	UN	~10%	47 to >98%	~5 to 76%
1,4-Dioxane	NE	NE	NE	2 to 11%	NE	>90%	~50%	>90%

NE = not effective: UN = Unknown, additional research needed

Advanced Technology Conceptual Cost Opinions

Conceptual Capital and Operating Cost Opinions			
Technology	Capital Cost (\$M)/MGD	Cost (36 mgd*)	Annual Cost/1,000 gallons
Granular Activated Carbon	\$0.5	\$18M	\$0.15 to \$0.70
Powdered Activated Carbon	\$0.05	\$1.8M	\$0.20 to \$0.50
UV/Advanced Oxidation	\$0.38	\$13.7M	\$0.10 to \$0.30
Reverse Osmosis	\$3.0	\$108M	\$0.5 to \$1.20

* Potential future Phase 3 capacity of the Northwest WTP

Conclusions and Recommendations

▪ **Conclusions:**

- The Cape Fear River and Brunswick County's intake has historically been vulnerable to point and non-point discharges of contaminants and will continue to be so in the future given its location in the watershed
- Brunswick County's WTPs provide conventional treatment that is not effective at the removal of many CECs including PFAS, GenX and 1,4-dioxane

▪ **Brunswick County Recommendations:**

- Continue to monitor for PFAS and 1,4-dioxane in the Cape Fear River and confirm that 1,4-dioxane is not a contaminant in the 211 WTP wellfield
- Continue to work at the local, State and Federal levels to eliminate CEC discharges into the Cape Fear River
- In the near term, evaluate performance and cost of providing granular activated carbon (GAC) for removal of PFAS by conducting bench scale studies at the Northwest WTP
- Depending on occurrence data and bench scale test results, conduct a more detailed pilot study to evaluate GAC performance for these compounds
- Evaluate the need for additional treatment as part of the next NW WTP expansion