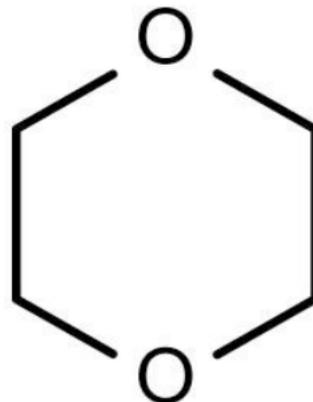
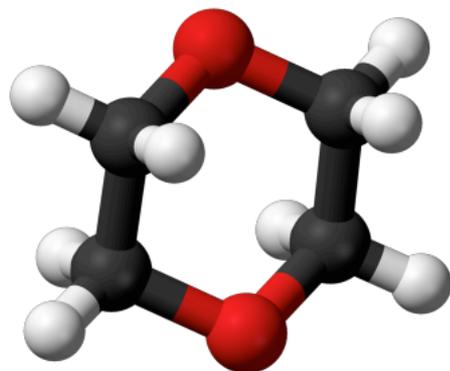


# 1,4-Dioxane Occurrence in the Haw River and in Pittsboro Drinking Water

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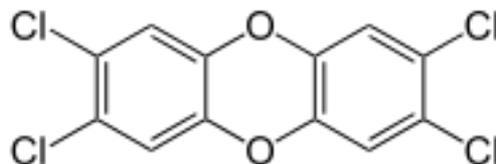
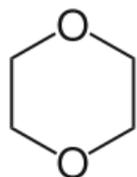
Pittsboro, NC, November 28, 2016

# Presentation Overview

- What is 1,4-dioxane?
- 1,4-dioxane occurrence in
  - Pittsboro source water (Haw River at Bynum)
  - Pittsboro drinking water
  - Fayetteville drinking water
- 1,4-dioxane sources
- Next steps

# What is 1,4-dioxane?

- 1,4-dioxane  $\neq$  dioxin



- Uses and potential sources of 1,4-dioxane
  - Solvent stabilizer (phased out)
  - Industrial solvent (textile, paper, specialty chemicals)
  - By-product of manufacturing processes involving ethylene oxide (polyester, PET, detergents, cosmetics)

# 1,4-Dioxane – Background Information

- Miscible in water
- Very difficult to remove from water
- Monitored nationwide in drinking water as part of EPA's 3<sup>rd</sup> Unregulated Contaminant Monitoring Rule (UCMR3)
  - Finished drinking water samples only
  - Public water systems serving >10,000 people

# 1,4-dioxane cancer risk

- Likely human carcinogen (EPA IRIS database)
- Lifetime consumption of drinking water containing
  - 0.35  $\mu\text{g}/\text{L}$  = 1:1,000,000 excess cancer risk
  - 3.5  $\mu\text{g}/\text{L}$  = 1:100,000 excess cancer risk
  - 35  $\mu\text{g}/\text{L}$  = 1:10,000 excess cancer risk
- Comparison with disinfection by-products
  - Bromodichloromethane: 0.6  $\mu\text{g}/\text{L}$  = 1:1,000,000 risk
  - Dibromochloromethane: 0.4  $\mu\text{g}/\text{L}$  = 1:1,000,000 risk

# Occurrence - EPA's Third Unregulated Contaminant Monitoring Rule (UCMR3)

		Samples*	Public Water Systems <sup>+</sup>
0.35 µg/L	US	3.0%	7.0%
	NC	6.0%	15.9%

\* n = 36,479 (US); 1,325 (NC) + n = 4,905 (US); 151 (NC)

- Drinking water samples  $\geq 0.35$  µg/L derived from surface water:
  - US: 23%
  - NC: 96%
- 7 of the 20 highest 1,4-dioxane concentrations occurred in NC (all derived from Cape Fear River water)



# Field Sample Collection



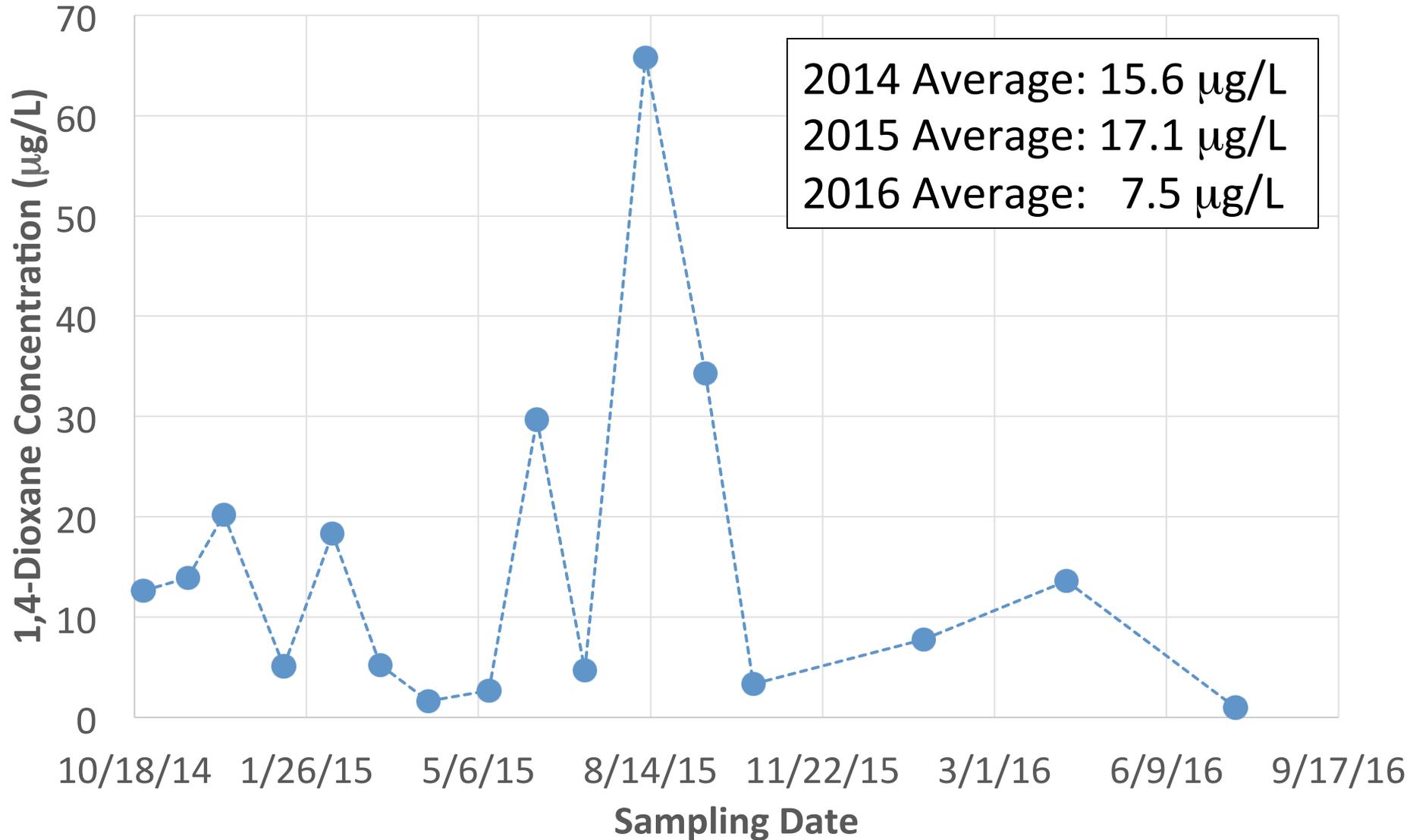
Brown glass bottles 500 mL with PTFE Caps



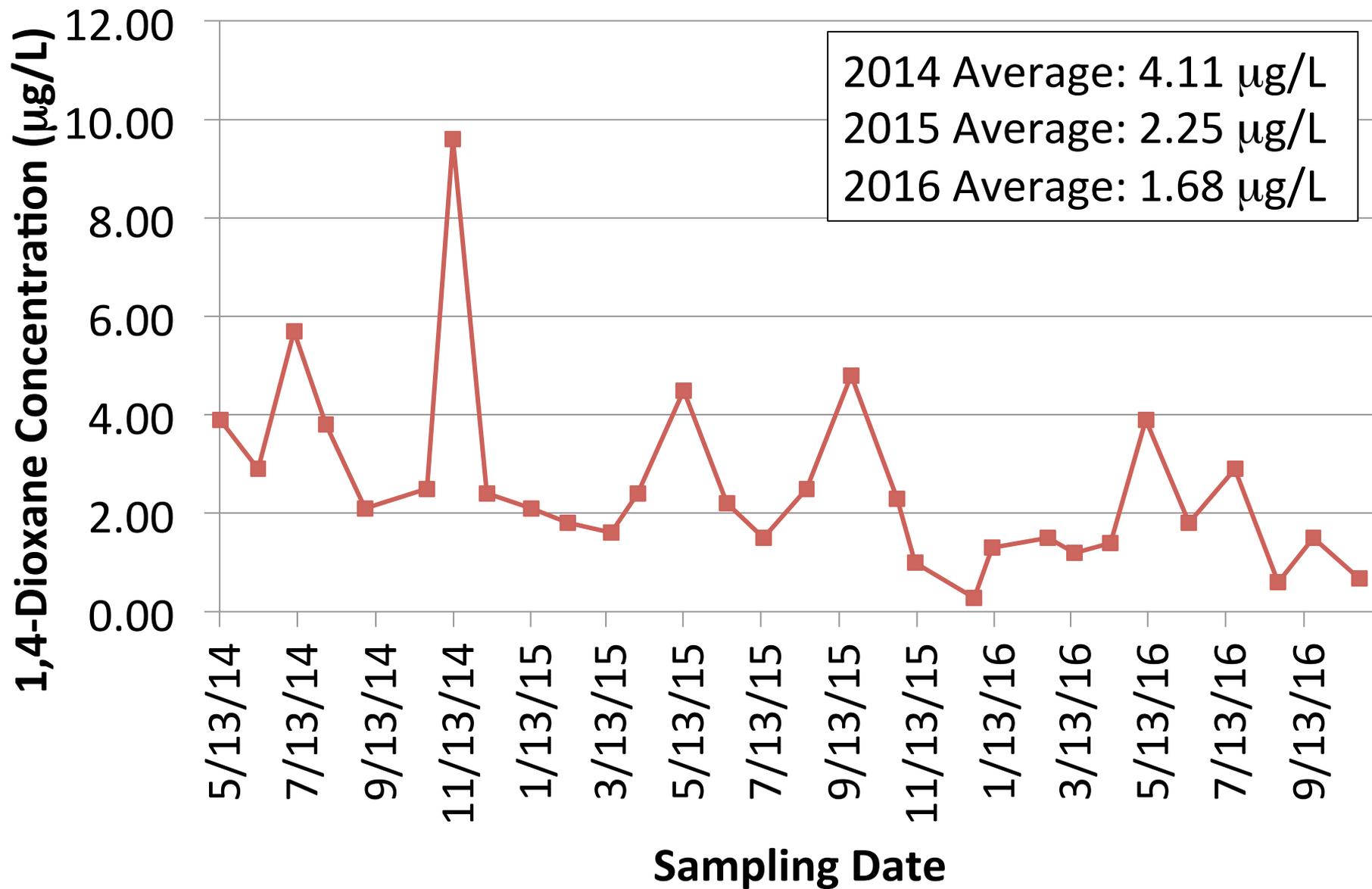
## Preservatives:

50 mg/L sodium sulfite  
1 g/L sodium bisulfate  
Added sequentially in the field

# 1,4-Dioxane Concentrations in Haw River at Bynum

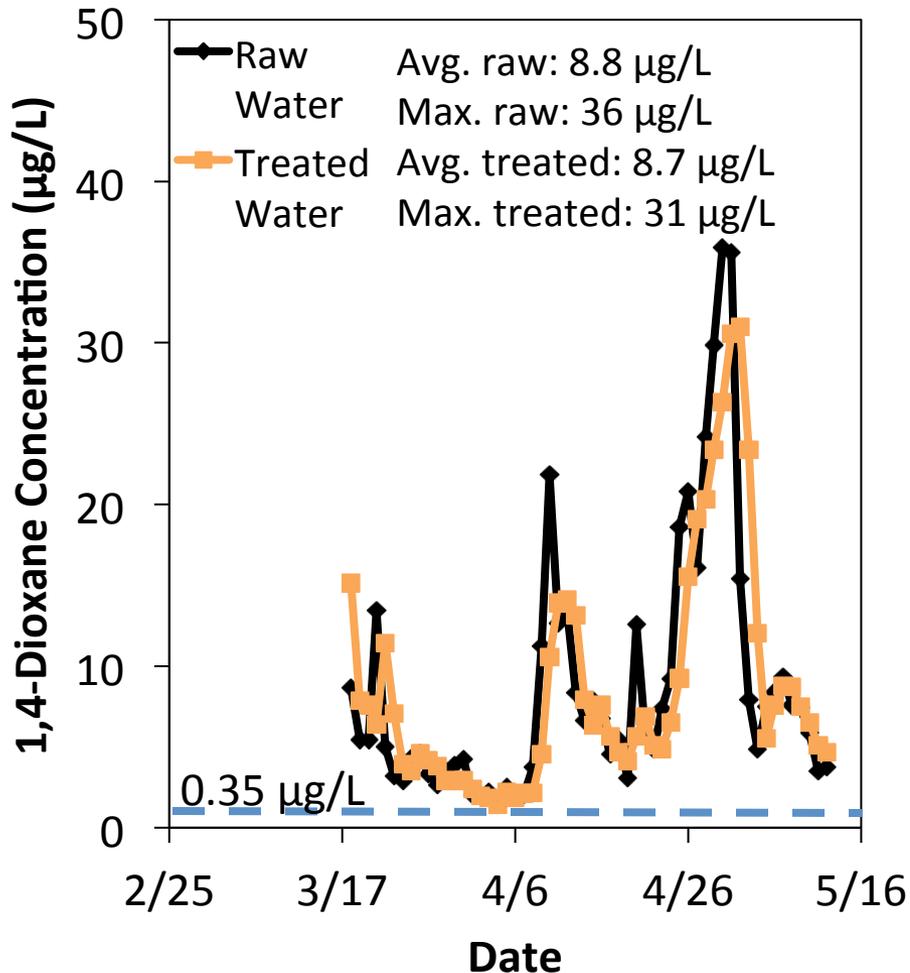


# Fayetteville Intake (P.O. Hoffer)

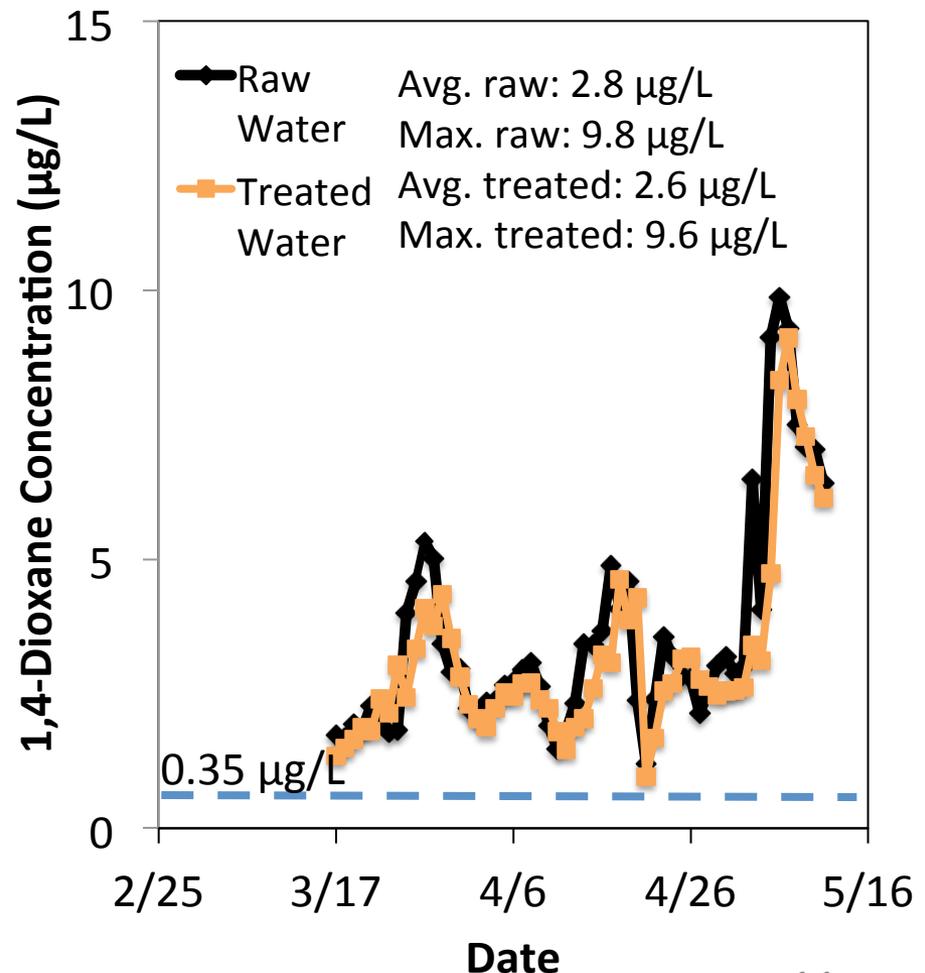


# 1,4-Dioxane is not Removed in Conventional Water Treatment Plants

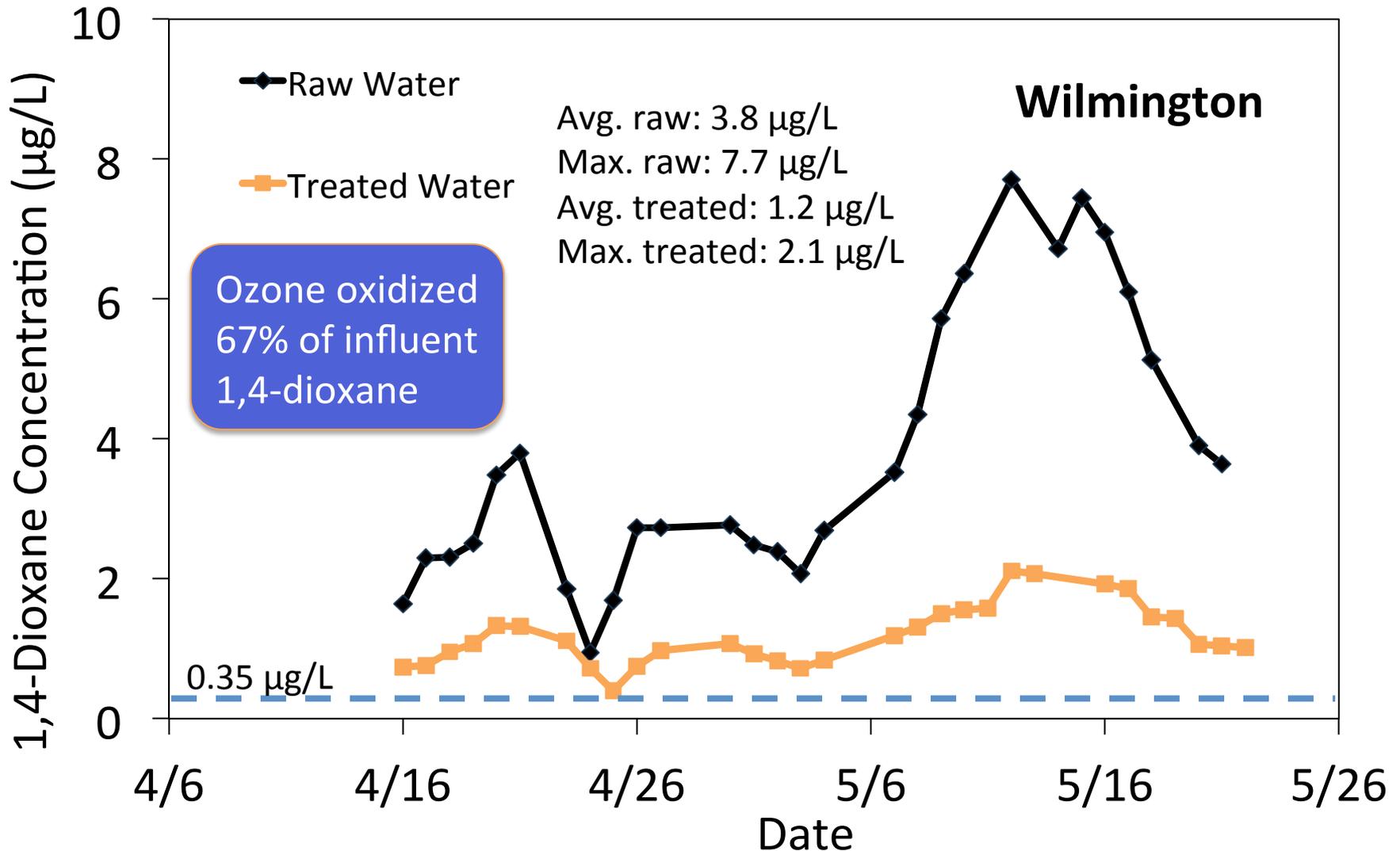
## Pittsboro



## Fayetteville

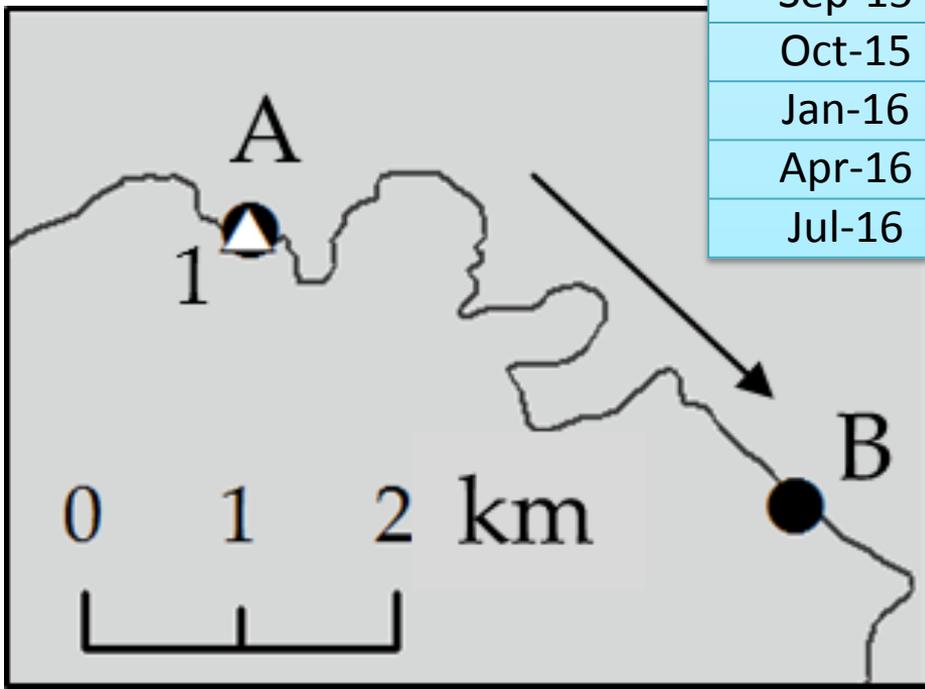


# 1,4-Dioxane is Partially Oxidized by Ozone



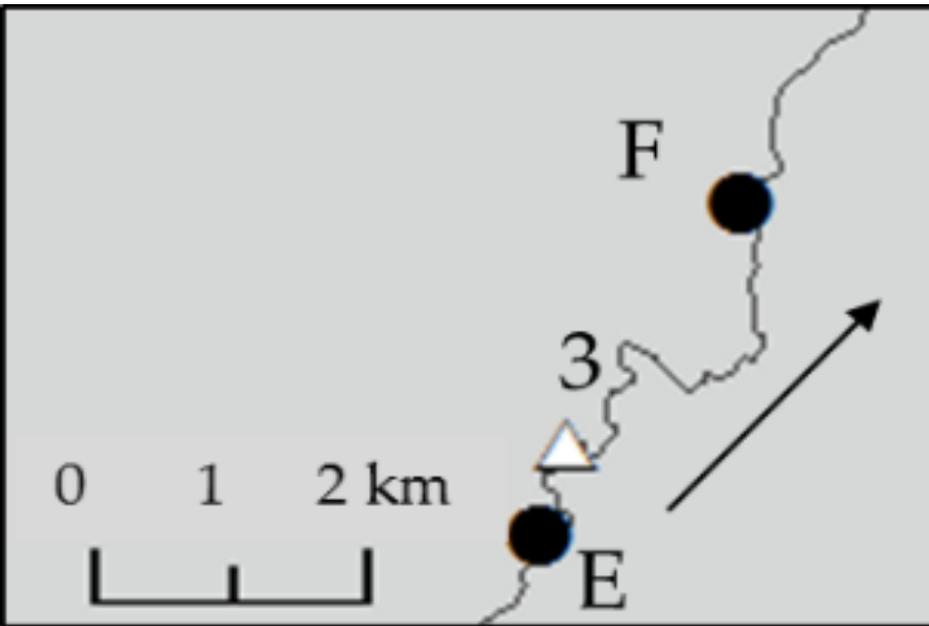
# Source Identification: Haw River

Date	Upstream Concentration ( $\mu\text{g/L}$ )	Downstream Concentration ( $\mu\text{g/L}$ )
Oct-14	0.60	77
Dec-14	0.16	123
Jan-15	0.20	1.0
Feb-15	0.20	76
Mar-15	<0.15	3.8
Apr-15	0.15	27
May-15	0.20	26
Jun-15	<0.15	40
Jul-15	0.25	270
Aug-15	0.20	86
Sep-15	-	1030
Oct-15	-	46
Jan-16	-	3.8
Apr-16	-	6.6
Jul-16	-	<2



-  WWTP Discharge
-  Sampling Point

# Source Identification: S. Buffalo Creek



-  WWTP Discharge
-  Sampling Point

Date	Upstream Concentration (µg/L)	Downstream Concentration (µg/L)
Oct-14	0.2	4.8
Dec-14	2.0	38
Jan-15	0.9	226
Feb-15	3.7	11
Mar-15	1.8	436
Apr-15	1.9	30
May-15	3.8	20
Jun-15	3.6	62
Jul-15	0.43	22
Aug-15	0.45	14
Sep-15	-	38
Oct-15	-	6.7
Jan-16	-	86
Apr-16	-	15
Jul-16	-	41

# Regulatory Framework

- No federal drinking water standard
- No NC drinking water standard
- NC groundwater standard: 3  $\mu\text{g}/\text{L}$
- Surface water quality (in-stream) standard:
  - 0.35  $\mu\text{g}/\text{L}$  for streams classified as water supplies (WS-I through WS-IV)
  - 80  $\mu\text{g}/\text{L}$  for other stream classifications

15A NCAC 02B .0208

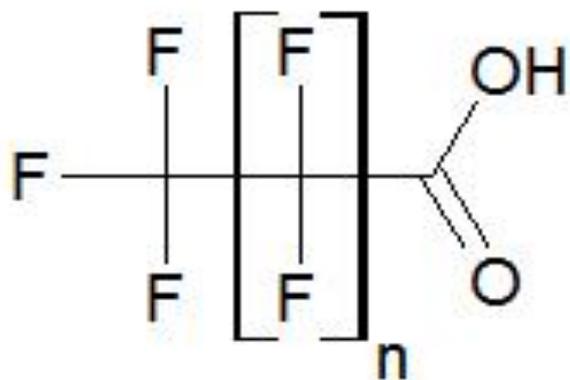
STANDARDS FOR TOXIC SUBSTANCES AND TEMPERATURE

For carcinogens, the concentrations of toxic substances shall not result in unacceptable health risks and shall be based on a Carcinogenic Potency Factor (CPF). An unacceptable health risk for cancer shall be considered to be more than one case of cancer per one million people exposed ( $10^{-6}$  risk level).

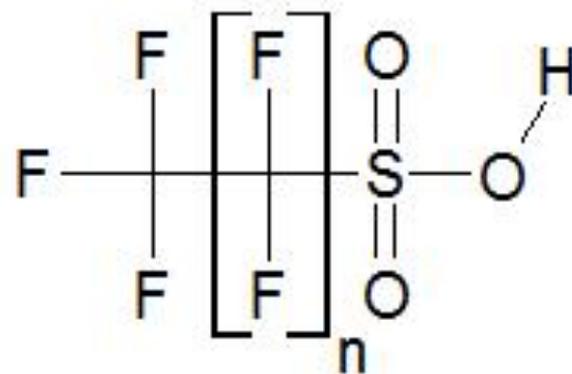
# CONCLUSIONS

- In the Cape Fear River watershed, multiple sources of 1,4-dioxane exist in the uppermost reaches of the watershed
- NC surface water quality standard of 0.35  $\mu\text{g}/\text{L}$  continuously exceeded at drinking water intakes in the watershed
- Pretreatment staff at municipalities have identified at least some 1,4-dioxane sources
- 1,4-dioxane concentrations in source water exhibit a decreasing trend, possibly as a result of source control efforts

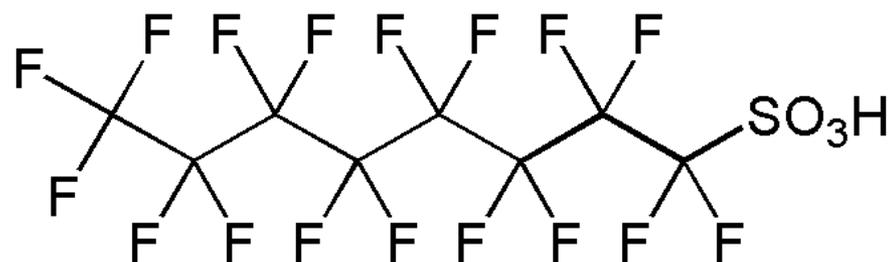
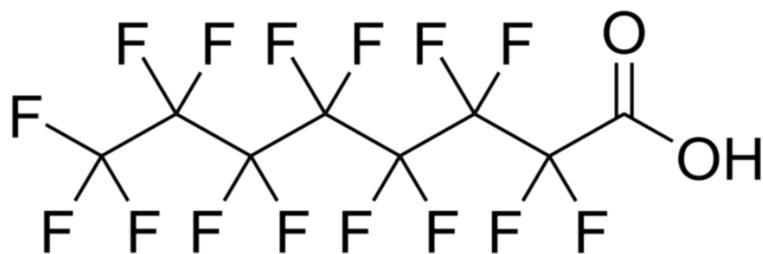
**Perfluoroalkyl substances (PFASs) are organic compounds in which all C-H bonds are replaced with C-F bonds.**



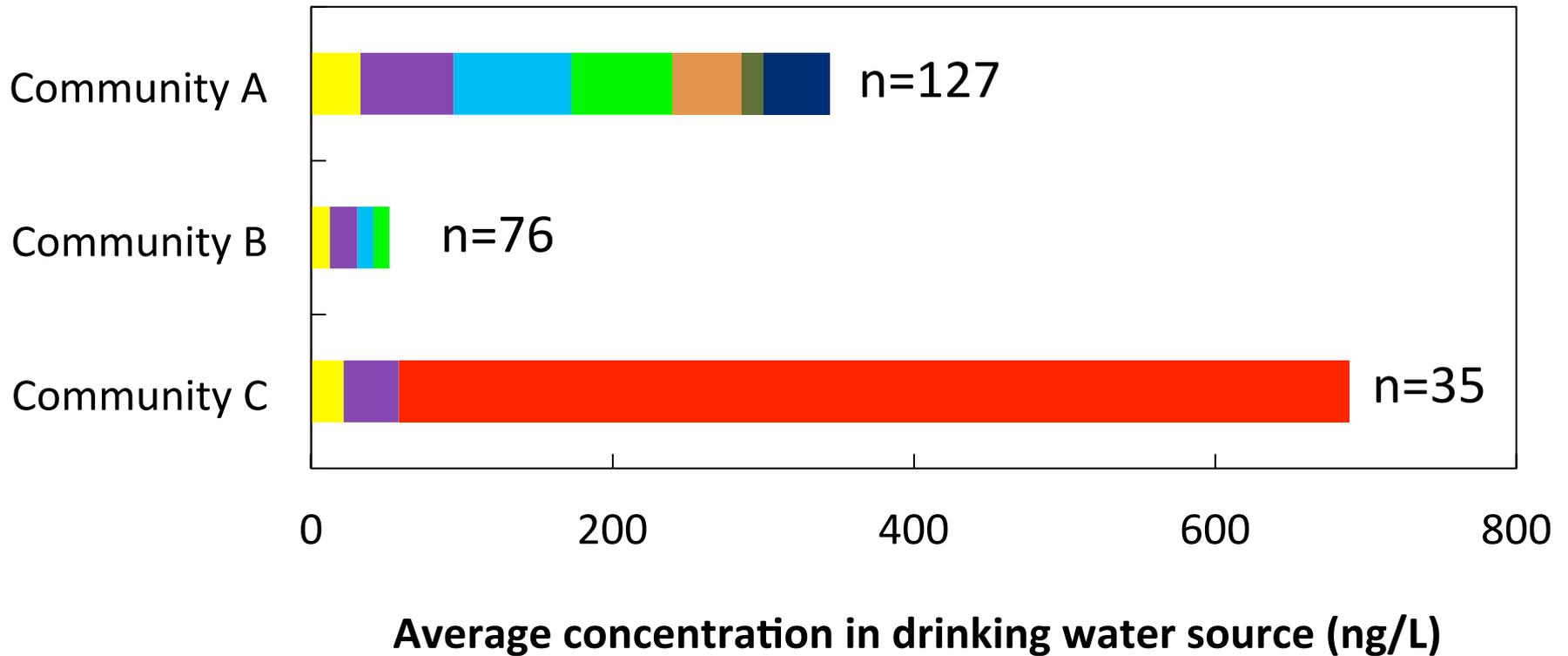
Perfluorocarboxylic acids  
(e.g. perfluorooctanoic acid,  
PFOA or C8)



Perfluorosulfonic acids  
(e.g. perfluorooctane  
sulfonate, PFOS)



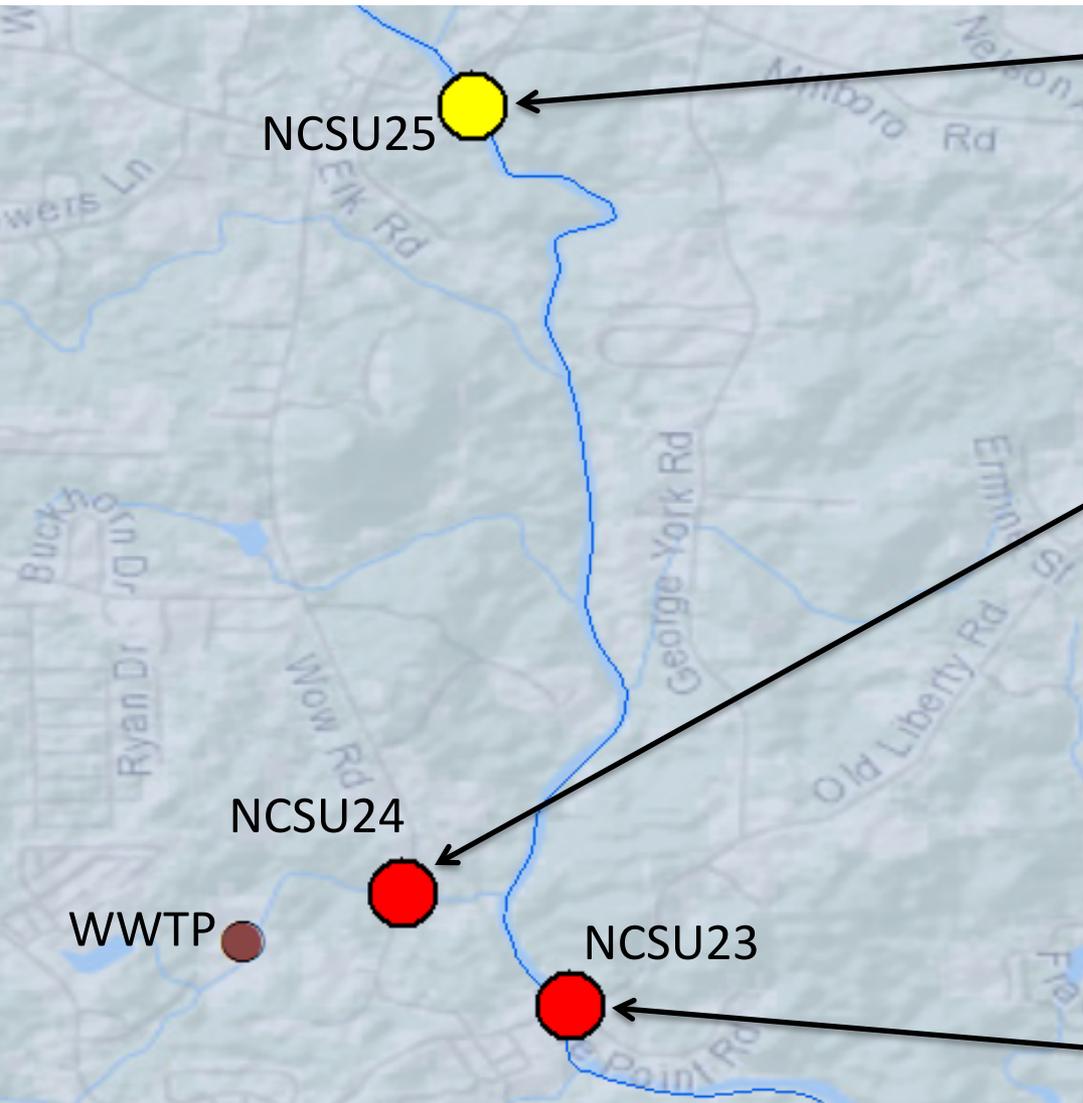
# PFAS Occurrence in CFR Watershed



# Acknowledgments

- Students in the Knappe research group: Zachary Hopkins, Harold Hounwanou, Joshua Kearns, Amie McElroy, Jonathan Moreno Barbosa
- Funding agencies
  - North Carolina Urban Water Consortium
  - NSF RAPID;GOALIE (#1449768)
- Utility participants: Fayetteville Public Works Commission, Cape Fear Public Utilities Commission, Town of Pittsboro
- North Carolina Department of Environmental Quality: Carrie Ruhlman, Tammy Hill

# Source Identification: Deep River



## NCSU25 - Upstream WWTP

Date	Concentration ( $\mu\text{g/L}$ )
Oct-14	1.5
Dec-14	2.0
Jan-15	0.7
Feb-15	1.7
Mar-15	2.5
Apr-15	4.5

## NCSU24-Downstream WWTP

Date	Concentration ( $\mu\text{g/L}$ )
Oct-14	254
Dec-14	1405
Jan-15	177
Feb-15	152
Mar-15	495
Apr-15	844

## NCSU23-Downstream WWTP

Date	Concentration ( $\mu\text{g/L}$ )
Oct-14	29
Dec-14	69
Jan-15	47
Feb-15	78
Mar-15	41
Apr-15	8.6