CLEMSON

Baruch Institute of Coastal Ecology and Forest Science

Colored Dissolved Organic Matter as a Precursor of Disinfection Byproducts in Drinking Water

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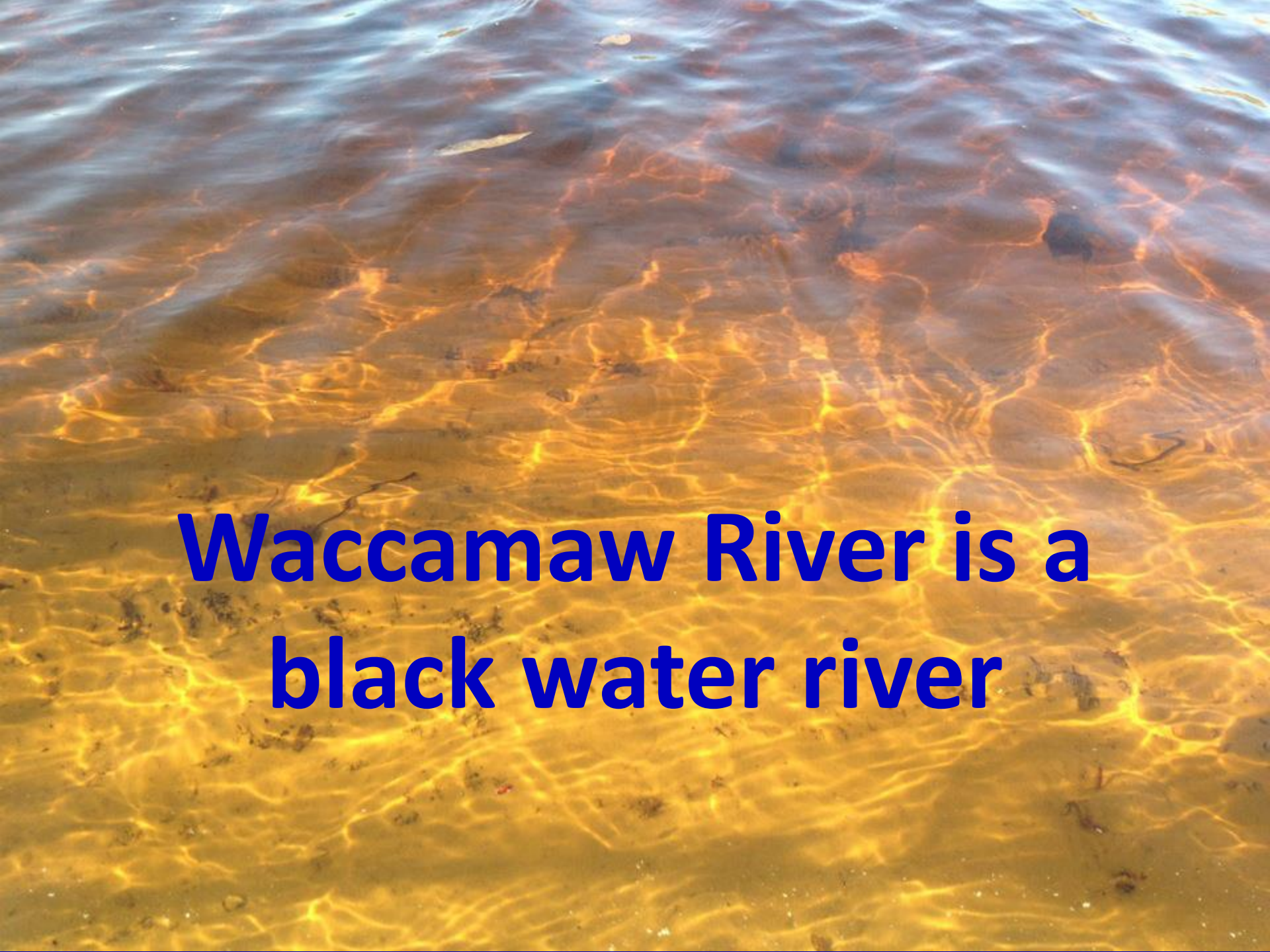
September 18, 2014

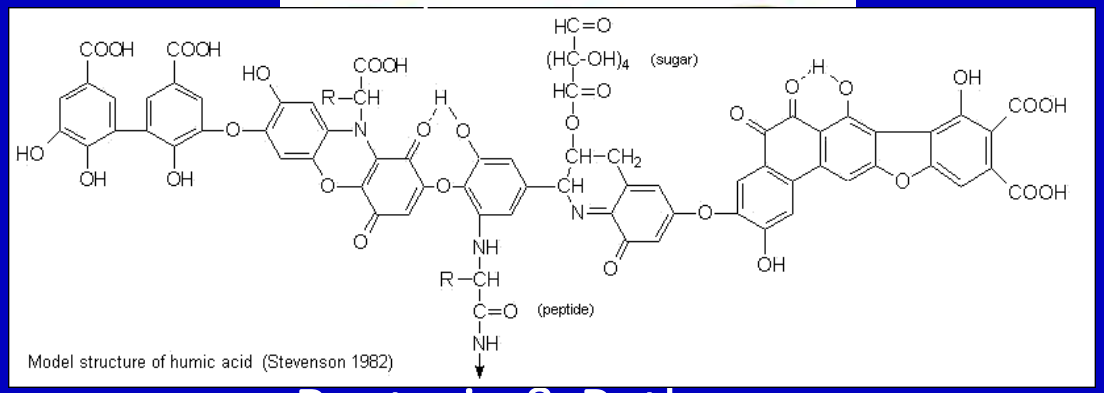

Waccamaw River is a
black water river

Tree litterfall and detritus laying on the forest floor can be a source of tea-color-like dissolved organic matter (DOM)

Why are we concerned about DOM in Waccamaw River?

Waccamaw River is a Drinking Water Source

Source Water



Dissolved Organic Matter

Bacteria & Pathogens

Chemical Reactions

Halogenated byproducts

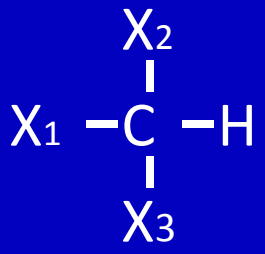
Disinfection Byproducts (DBPs)

Disinfectants

Chlorine

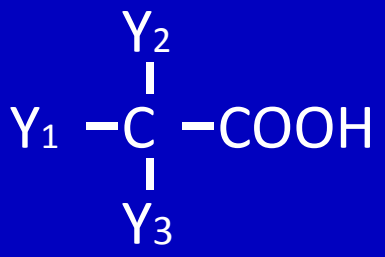
A Variety of DBPs in Treated Waters

- Trihalomethane (THMs)
  - $CHCl_3$ (chloroform)
  - $CHCl_2Br$ (bromodichloromethane)
  - $CHClBr_2$ (dibromochloromethane)
  - $CHBr_3$ (bromoform)



X_1, X_2, X_3 can be Cl and Br

- Haloacetic Acids (HAAs)

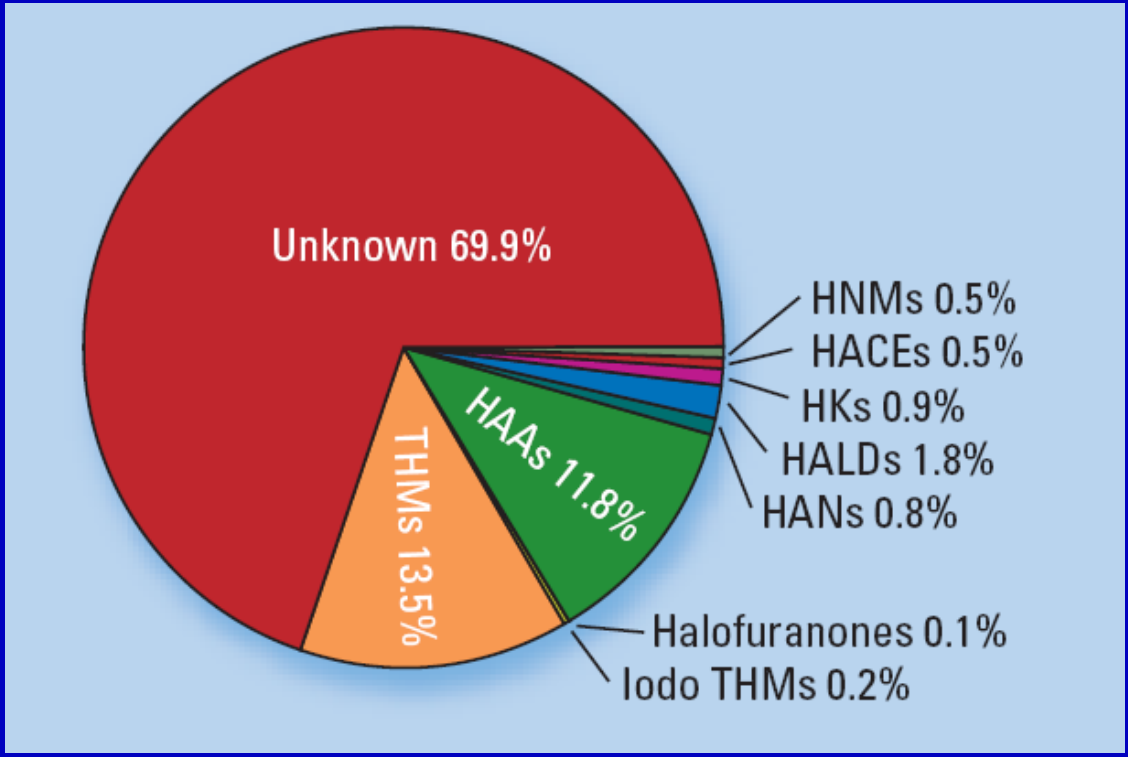


Y_1, Y_2, Y_3 can be H, Cl, and Br

$CH_2ClCOOH$	$CHBrClCOOH$	$CH_2BrCOOH$
$CHCl_2COOH$	$CBrCl_2COOH$	$CHBr_2COOH$
CCl_3COOH	$CBr_2ClCOOH$	CBr_3COOH

USEPA Stage 2 D/DBP rule: 80 ppb THMs and 60 ppb HAA5

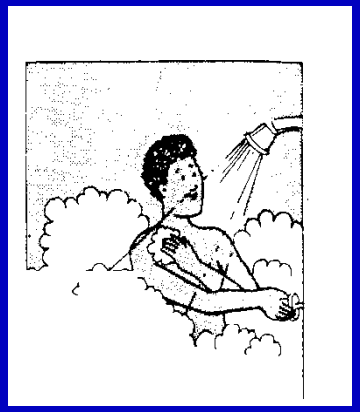
- Over 600 DBPs have been identified
- Identified DBPs account for about 30% of total organic halogens in treated waters



The diagram is from Environmental News, Environmental Science & Technology - Jan 15, 2007 - p.354

Health Concerns of DBP Exposure

- Most of identified DBPs are carcinogenic and mutagenic
- Brominated DBPs are much more toxic than other forms
- DBP exposure through dermis, ingestion, or inhalation



- Blood THM concentrations increase simply due to showering, bathing, and hand dishwashing

Strategies to Minimize DBP Formation in Treated Waters

- Alternative disinfectants

- Improve treatment processes

- Remove DBP precursors

- Control DBP precursors at its source

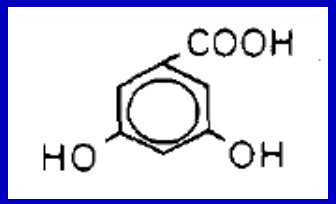
What is a DBP precursor?

- In general, the production of DBPs is proportional to the concentration of dissolved organic carbon (DOC) in source waters .

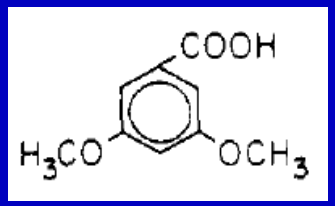
- The reactivity of DOC in forming trihalomethanes (THMs) ranges from 3 - 20 mmol-THM mol-C^{-1}.

1000 Carbon atoms ➔ 20 THMs

- Not all organic carbons are equally reactive in forming DBPs during chlorination.



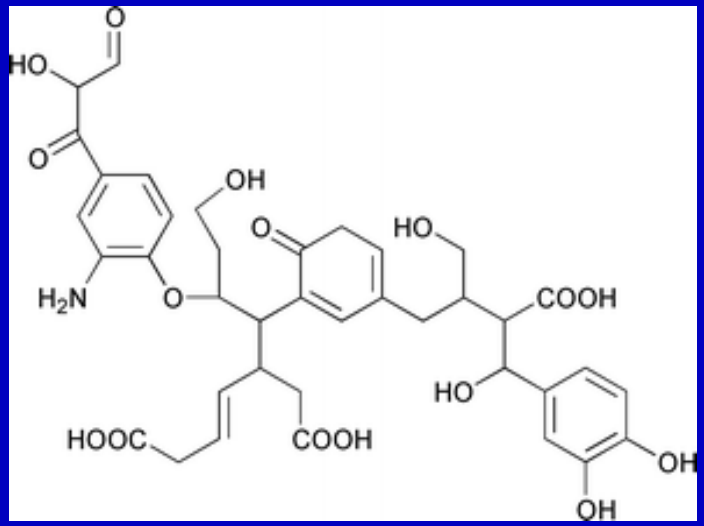
0.45 mole $CHCl_3$ /mol



0.01 mole $CHCl_3$ /mol

What is a DBP precursor?

- Reactive sites of complex organic molecules are responsible for THM formation, rather than discrete molecules



The Steelink model of the humic acid monomer.

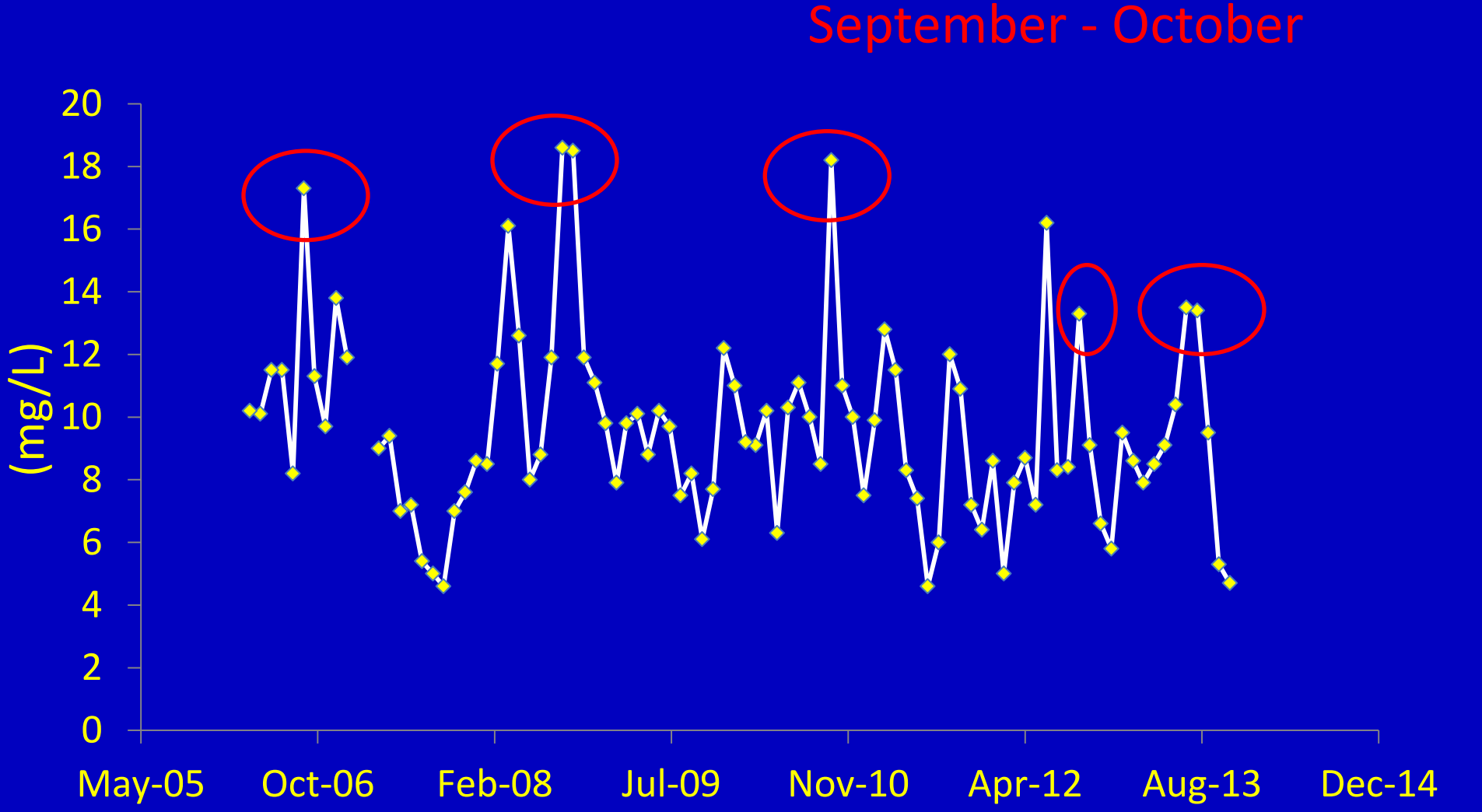
- A DBP precursor is a complex organic molecule that has a high density of reactive sites.

Baldcypress

Longleaf Pine

Water Tupelo

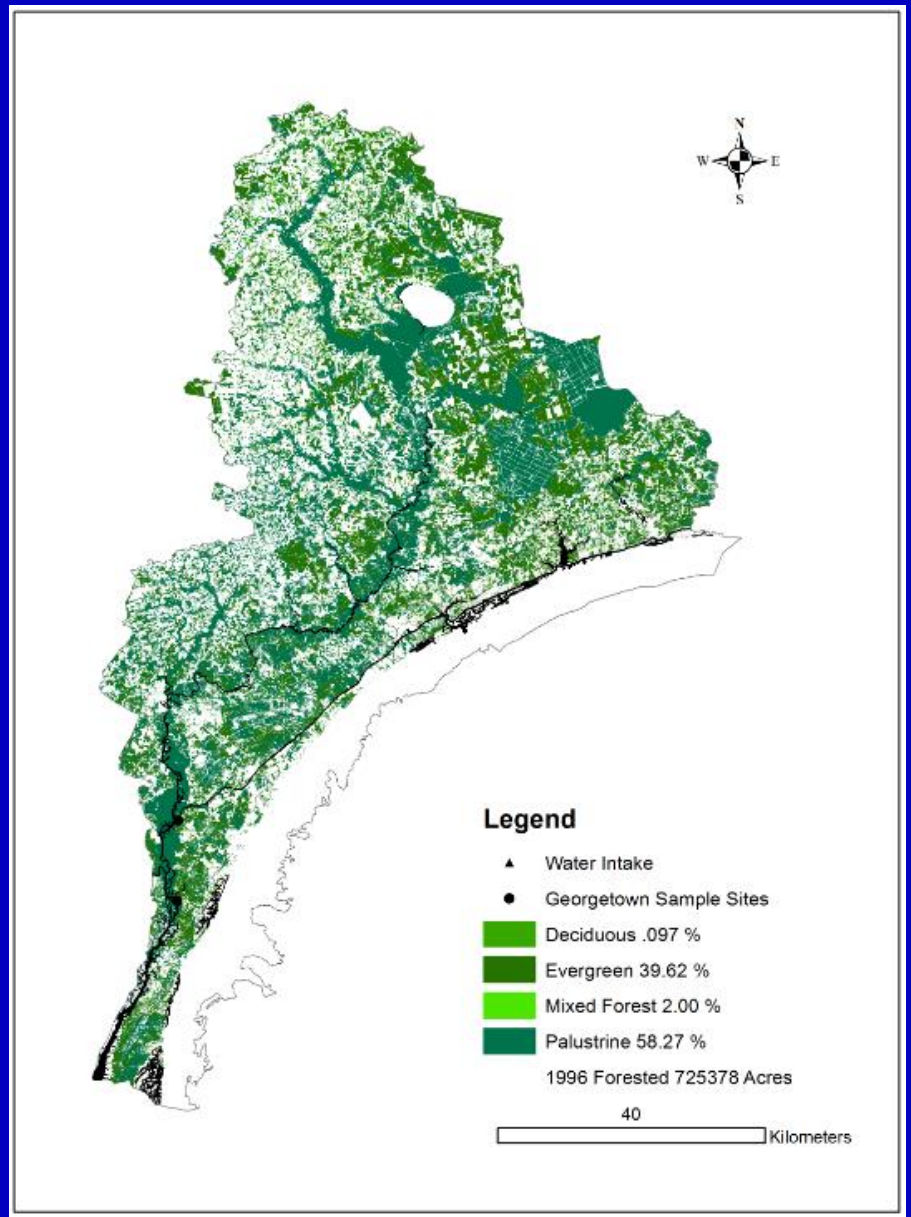
Total Organic Carbon

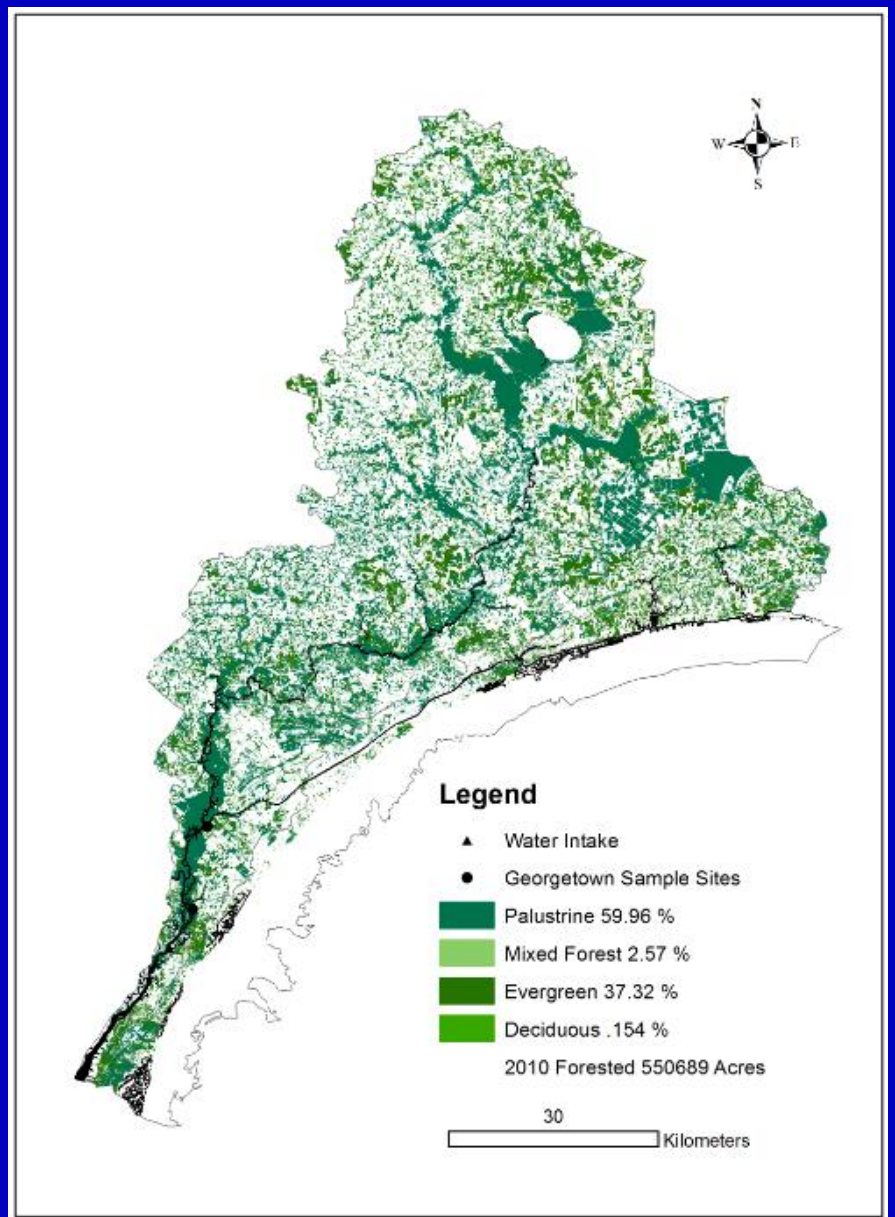


1996 Forest - 725378 Acres

24% Loss

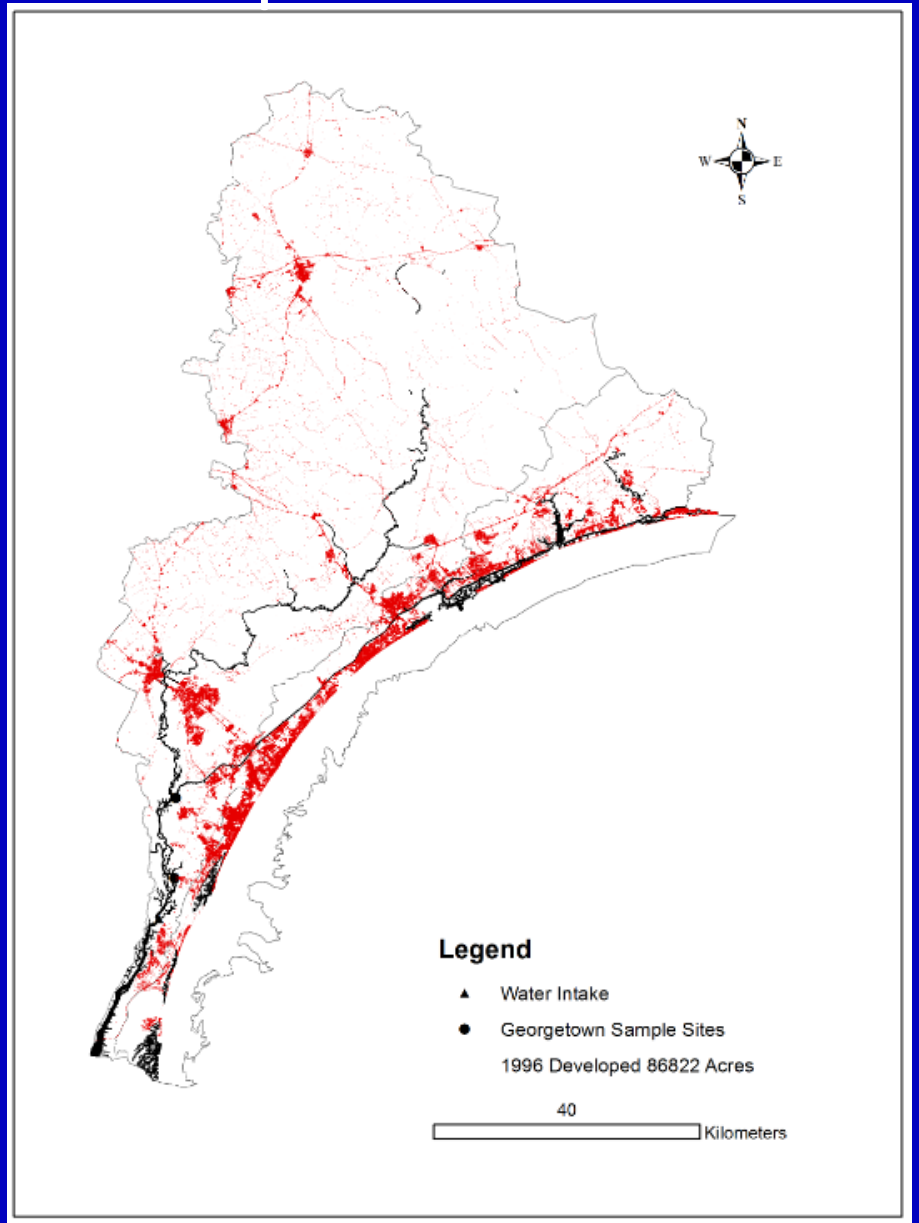
2010 Forest - 550689 Acres



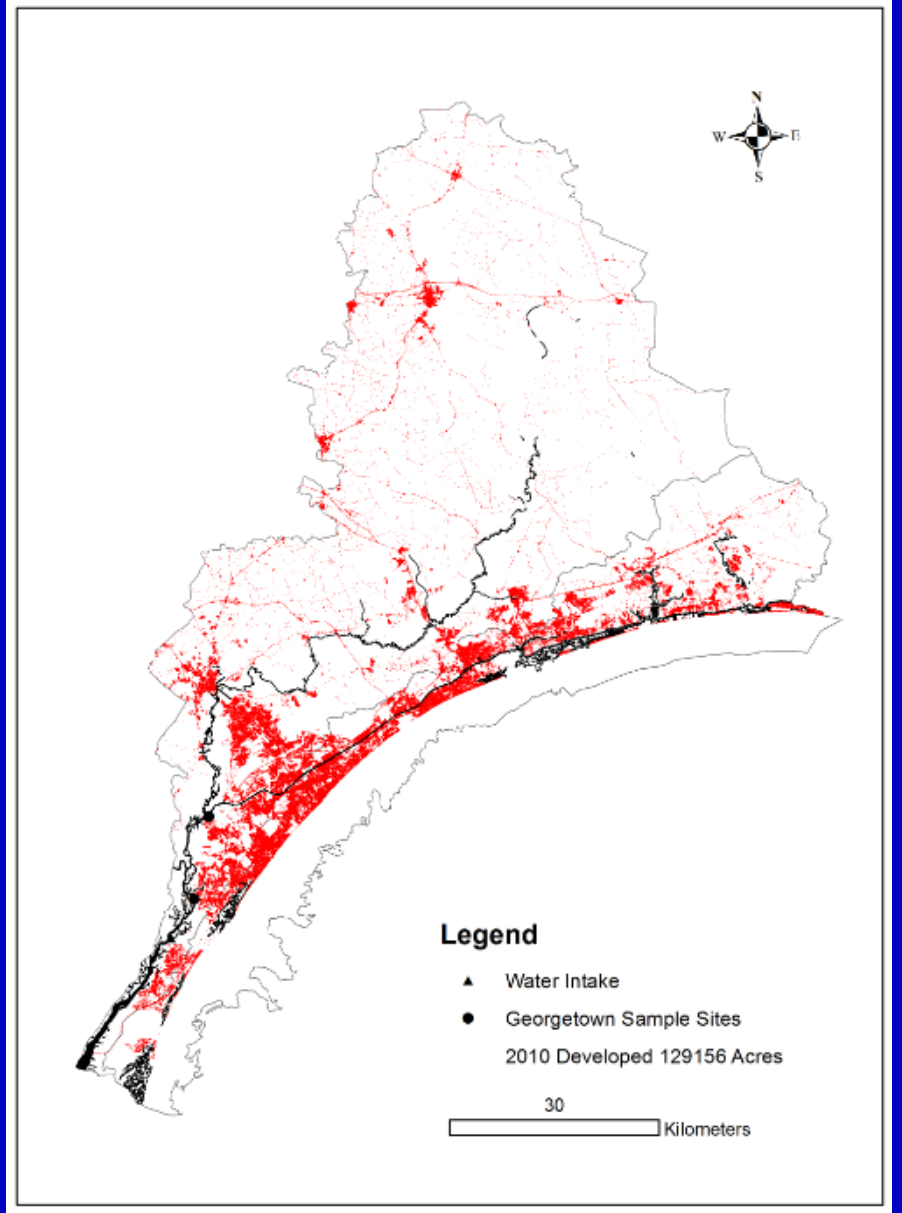


1996 49% Increase 2010

Developed - 86822 Acres



Developed - 129156 Acres



Take Home Messages

- DOM in a precursor of carcinogenic disinfection byproducts in our source water
- Changes in land use and climate alter the inputs and characteristics of DOM and DBP precursors in source waters

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at Clemson's **Belle W. Baruch Institute of Coastal Ecology & Forest Science**

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Tuesday, Sept. 23

3:00 – 6:30 p.m

177 Hobcaw Road, Georgetown

Parking is available on-site

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Thank You!