Brunswick County Public Utilities

Brunswick County, NC Utilities 36+ mgd Low Pressure Reverse Osmosis Solution to Contaminants of Environmental Concern in the Cape Fear River

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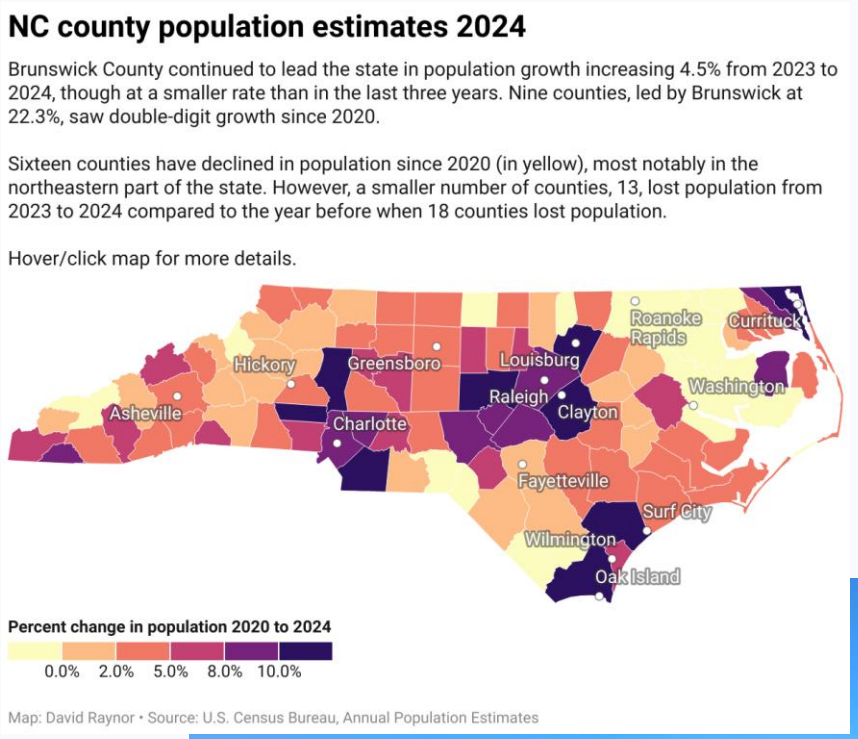
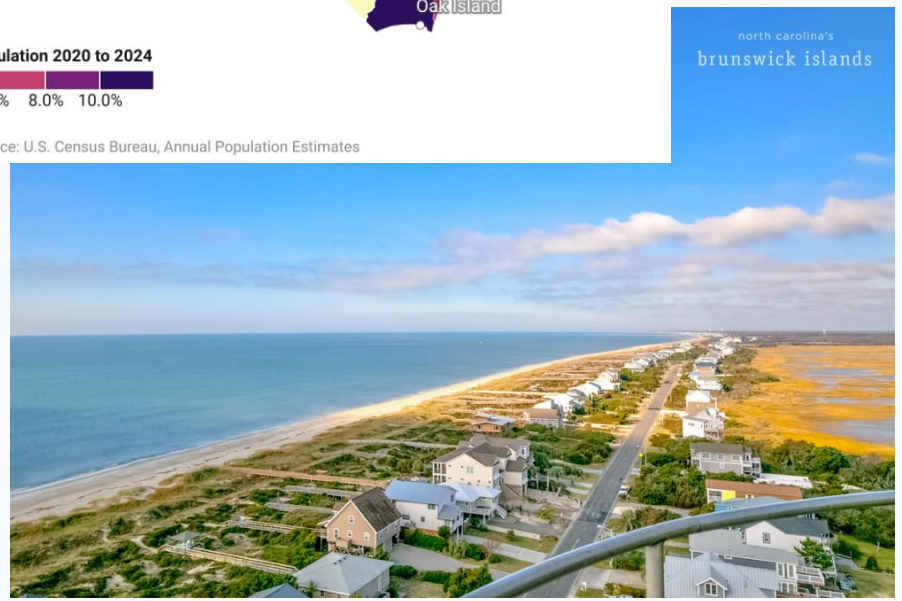
BRUNSWICK COUNTY

WHY MAKE BRUNSWICK HOME?

- Climate
- 45 Miles of Beaches on six Islands
- Lots of undeveloped property
- Multiple ferry systems and light houses
- Recreational Activities – Golf, Fishing, water sports
- Rural county with deep farming roots still evident
- Population 145,000 year-round, over 300,000 seasonally





BRUNSWICK COUNTY, NC & THE CAPE FEAR RIVER

- 20% of North Carolina in Cape Fear River Watershed (9200 sq miles)
- Upstream Industry
- Brunswick County Public Utilities
  - Last Water Supply Intake on River
  - Serves ~350,000 peak season population

THE NORTHWEST WTP HAS A PHASED APPROACH TO EXPANSIONS

PHASE I
2010

EXPANDED BULK CHEMICAL STORAGE, ADDITIONAL 5.25 MG FINISHED WATER CLEARWELL

PHASE II
2014

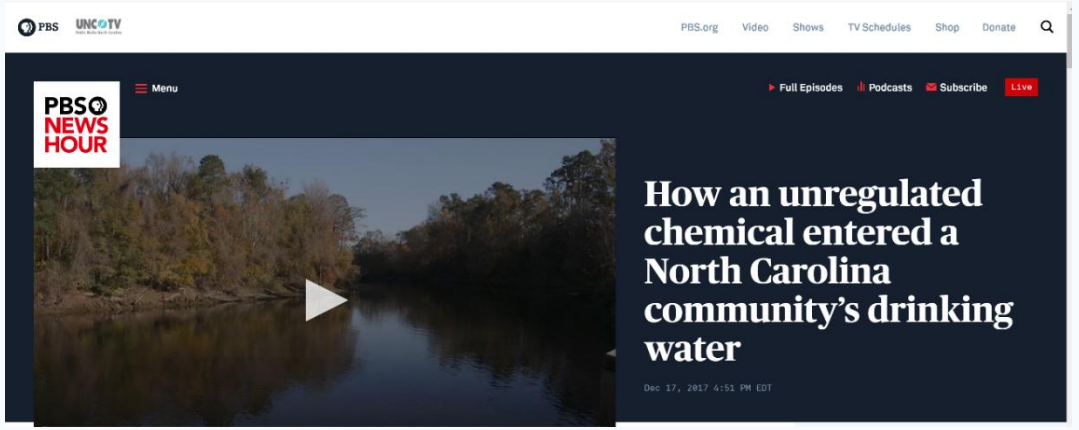
REHABILIATION OF EXISTING FILTERS, ADDITIONAL ADMINISTRATIVE SPACE AND NEW HS PUMPSTATION

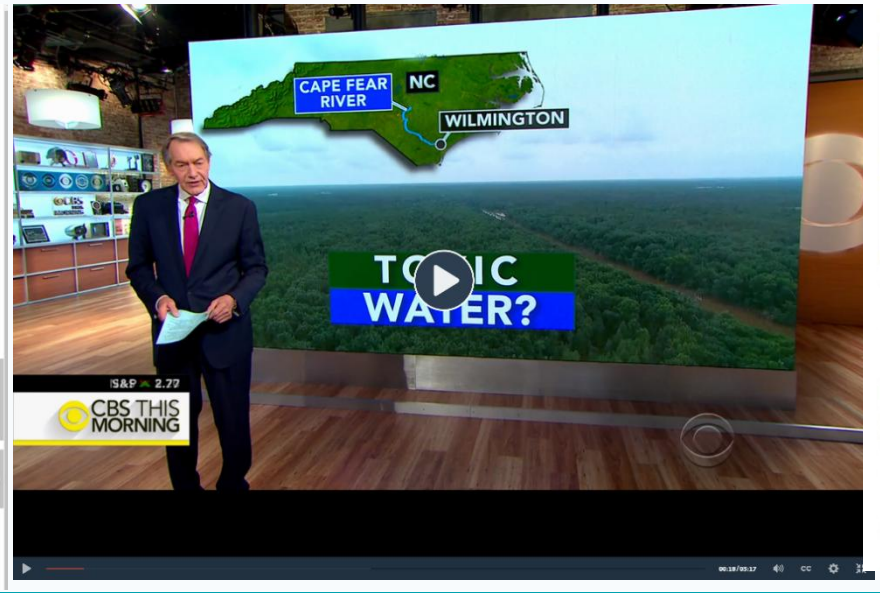
PHASE III
2018

CONVERTING TO SUPERPULSATOR TECHNOLOGY AND ADDING A NEW GREENLEAF FILTER, WHEN...

THE GENX STORY

- Research Study
- Media Involvement



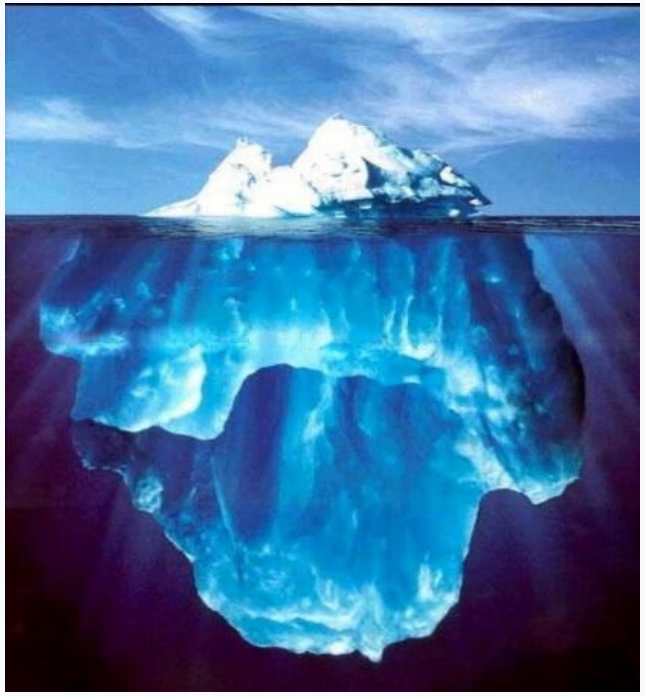


QUEST FOR THE SOLUTION - TARGET CONTAMINANTS

Primary Target Contaminants

Per- and Poly-fluoroalkyl Substances (PFAS)

- GenX and other PFAS
  - PFMOAA, PFMOPrA, PFMOBA, PFPrOPrA (GenX), PFO2HxA, etc.
- Nafion by-products
- Other identified PFAS compounds
- Additional PFAS compounds not yet identified

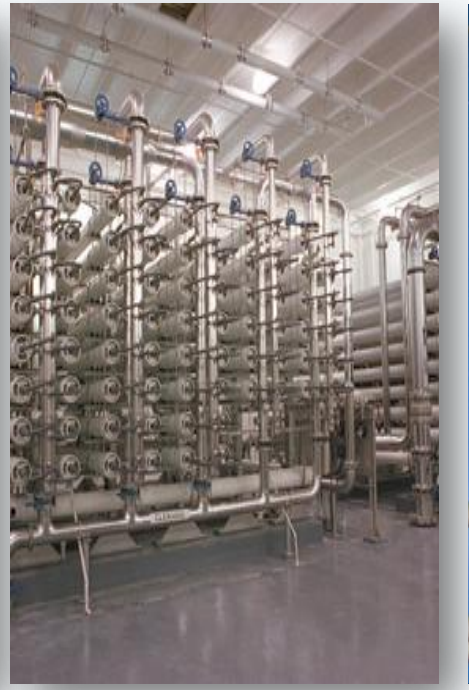


Secondary Target Contaminants

- 1,4-Dioxane
- Pharmaceuticals and Personal Care Products (PPCPs)
- Endocrine Disrupting Compounds (EDCs)
- Pesticides and Herbicides
- NDMA, Brominated DBPs
- Other identified compounds
- Additional compounds not yet identified

QUEST FOR THE SOLUTION – THE OPTIONS

Ion Exchange (IX)



Low Pressure Reverse Osmosis (LPRO)

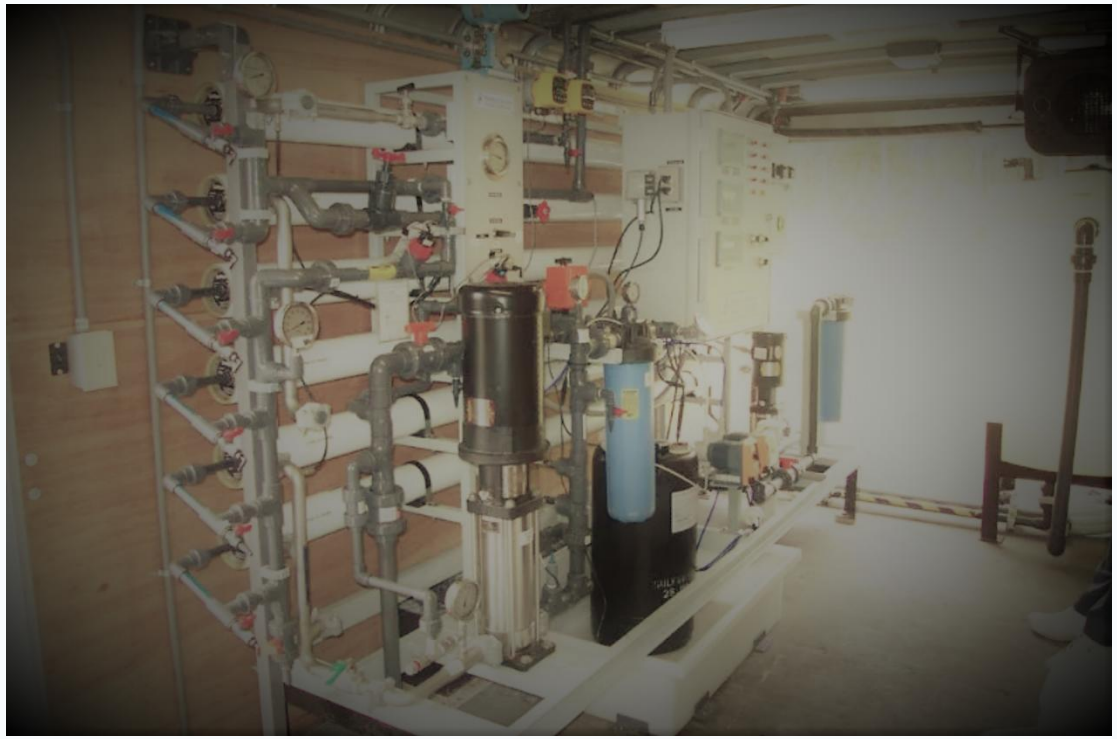
Granular Activated Carbon (GAC)

UV-Advanced Oxidation Process (UV-AOP)

Ozone-Biofiltration

QUEST FOR THE SOLUTION – PILOT STUDIES

Low Pressure Reverse Osmosis Membrane



Granular Activated Carbon & Ion Exchange

	Advanced Treatment Technology Description	1,4 Dioxane Removal	PFAS[2] Removal (GENX, Nafion, etc.)	PPCP[3] (Pharmaceuticals) /EDC Removal	Capital Cost (Construction + Engineering)	O&M Cost (25-years)	Total 25-Year Cost (Net Present Worth)	Resilience to Extended PFAS Spills	Resiliency for Future Contaminants
	Treatment Level A								
A1	O3-BAF/GAC [1]	60%	90%	Many	$99 M	$94 M	$193 M	Poor	Good
A2	GAC [1]/UV-AOP	90%	90%	Many	$90 M	$97 M	$187 M	Poor	Good
A3	IX/GAC/UV-AOP	90%	90%	Moderate	$84 M	$94 M	$178 M	Poor	Fair
A4	RO	90%	90% +	Most	$99 M	$59 M	$158 M	Best	Best
	Treatment Level B								
B1	O3-BAF/GAC [1]	60%	75%	Many	$109 M	$59 M	$168 M	Poor	Good
B2	GAC [1]/UV-AOP	75%	75%	Moderate	$89 M	$71 M	$160 M	Poor	Good
B3	IX/GAC/UV-AOP	75%	75%	Moderate	$83 M	$69 M	$154 M	Poor	Fair
B4	RO w/ Bypass	75%	75%	Moderate	$86 M	$53 M	$139 M	Good	Good

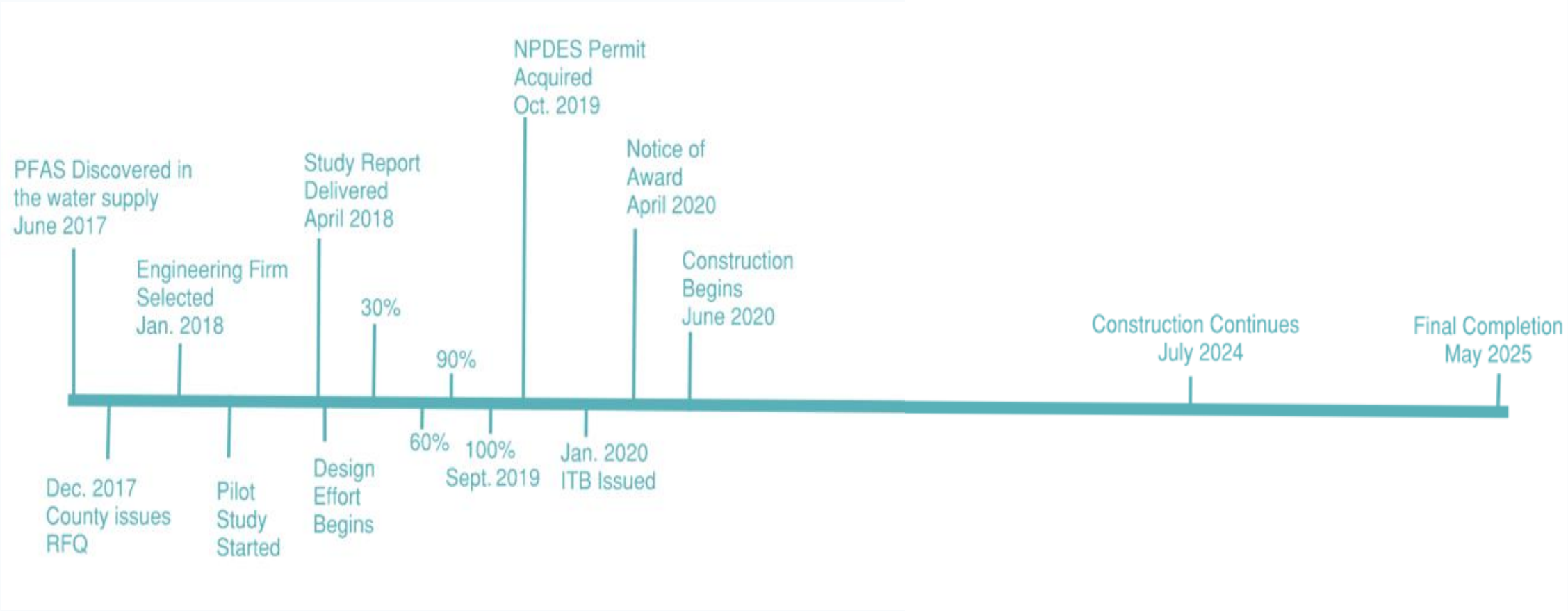
[1] Assumes 20-min Empty-Bed Contact Time (EBCT)
[2] PFAS – Per- and Poly- Fluoroalkyl Substances (Includes GenX, PFMOOA, Nafion By-Products, etc.
[3] PPCP/EDC - Pharmaceutical and Personal Care Products / Endocrine Disrupting Compounds

GAC – Granular Activated Carbon
IX – Ion Exchange
UV-AOP – Ultra-violet Advanced Oxidation Process
RO – Reverse Osmosis
O3-BAF – Ozone with Bio-filtration

CHALLENGES PRESENTED

- Limited Regulatory Guidance for Treatment Goals **(Still Pending)**
- Funding – Will state and federal agencies approve funding for unregulated contaminant? **(Still Pending)**
- Concentrate Waste Stream Disposal
  - Deep Well Injection not permitted in NC
  - Direct Discharges of Membrane Concentrate require additional regulatory approval **(2019 Received Permit)**
- Rate Increases **(40%)**

SCHEDULE


PFAS Discovered in the water supply June 2017
Dec. 2017 County issues RFQ
Engineering Firm Selected Jan. 2018
Pilot Study Started
Study Report Delivered April 2018
Design Effort Begins
30%
60%
90%
100% Sept. 2019
NPDES Permit Acquired Oct. 2019
Jan. 2020 ITB Issued
Notice of Award April 2020
Construction Begins June 2020
Construction Continues July 2024
Final Completion May 2025

CONSTRUCTION STATUS

- Notice to Proceed – June 5, 2020
- Plant Bid – $122.6 million
- Conc. Pipeline Bid – $6.595 million
- Total Project Cost – $167.3 million
- 24 MGD existing to 45 MGD Conventional
- LPRO 41 MGD
- 85% Complete
- Beneficial Use RO – Late Spring 2025

NEW RAPID MIX STRUCTURE

The existing rapid mix structure could not accommodate the additional flow needed for LPRO

SUPER PULSATOR CLARIFIER

The existing pulsator clarifiers were uprated with the addition of super pulsator technology.

ADDITIONAL DUAL MEDIA FILTERS

The expanded treatment capacity required eight (8) new filters.

0.5 MG BACKWASH EQUALIZATION TANK

The additional filters require a source of backwash water and the LPRO needs a tank to pull water from

LOW PRESSURE REVERSE OSMOSIS

Pumping System and Cartridge Filters:

- Eight 500hp 9 stage turbine pumps
- Two separate feed headers
- Powered by Square D - VFDs
- Eight filter vessels rated to 6.05 MGD
- 272 cartridge filters per vessel
- All monitored and controlled through the SCADA system

LOW PRESSURE REVERSE OSMOSIS

Skid Design Elements:

- Three Stage System Arranged in a 66:32:16 Array
- Eight elements per vessel = 912 per skid
- Each skid can produce 5.14 MGD of permeate

PERMEATE TREATMENT SYSTEMS

Lime slurry and carbon dioxide will be used to adjust pH, hardness, and alkalinity to closely match existing treatment goals

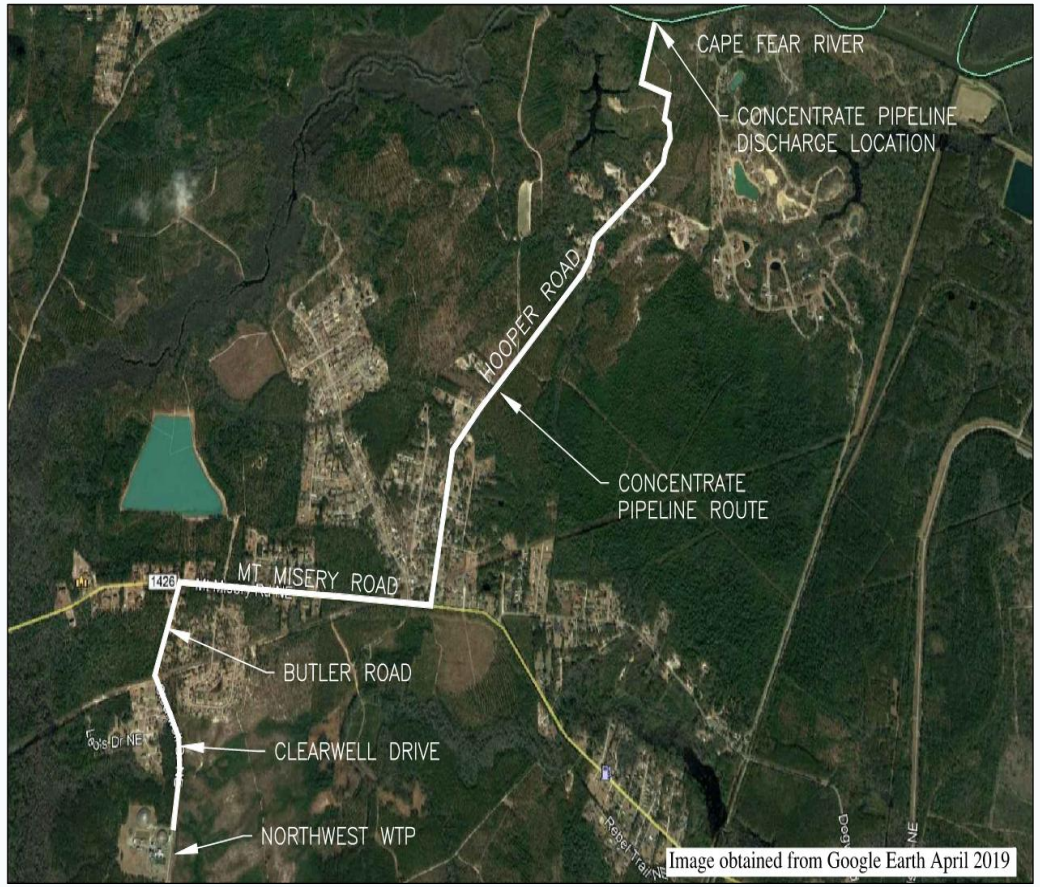
CHLORINE AND CHLORINE DIOXIDE SYSTEMS

New chlorine and ClO2 systems were designed to enhance disinfection and safety of the facility expansion

SO WHERE DOES THE CONCENTRATE GO? - NPDES DISCHARGE

- **Discharge Composition**
  - No Salts (not a brine)
  - Treated water quality with some CECs
- **Pre-project PFAS distribution**
  - Consumer
  - Cape Fear, Waccamaw, Lockwood's Folly, Shallotte basins
  - Irrigation
  - 6 Wastewater Treatment Plants - Infiltration
- **No net increase in CEC's**
- **Background levels Achieved**
  - 10 ft. upstream, 10 ft. downstream, 30 ft. across the river
- **Treatment versus Environmental Remediation**
  - Effectiveness
  - Who Pays?

CONCENTRATE PIPELINE AND OUTFALL DETAILS

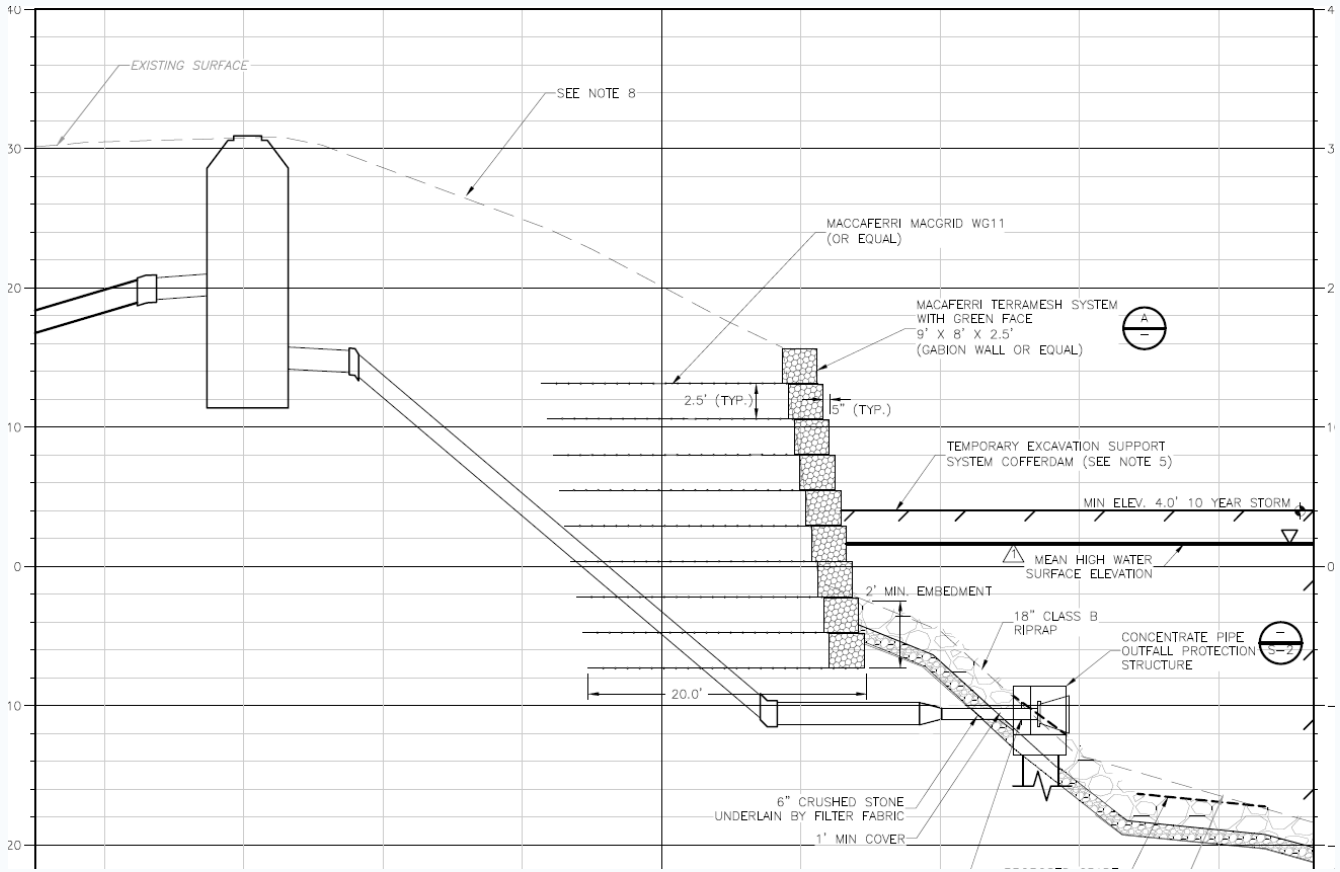


- NPDES permit was issued before construction began.
- 18-inch PVC pipeline runs 4.5 miles from the Northwest WTP to the Cape Fear River.
- Pressure from the LPRO skid feed pumps drive the concentrate flow to the outfall.
- The outfall discharges perpendicular to the riverbank.
- Extensive modeling was performed to ensure adequate mixing (CORMIX)
- Due to the nature of the Cape Fear River, required instream sampling will be difficult.

OUTFALL DESIGN

Design Elements:

- A dynamic environment with widely fluctuating river flow rates
- Variable flow orifice nozzle allows good mixing at a variety of discharge rates
- Submerged discharge avoids boat traffic and enhances mixing



OUTFALL CONSTRUCTION

Construction Elements:

- Seasonal access to the river due to spawning fish
- Encountered hard rock like material (Cocina rock)
- Coffer dam was instrumental to quick construction

OUTFALL FINAL

Physical Features:

- Gabion Baskets trap seeds and sediment
- Provides for enhanced blending with the surrounding environment
- Sheet piles provide a ridged frame and erosion protection

SECONDARY TARGET CONTAMINANT: 1,4-DIOXANE

- 1,4-Dioxane receiving attention due to its widespread detection within the waters of the State
- Currently, no Water Quality Standard exists (unregulated)
- Can be associated with heath impacts at certain concentrations
- Difficult and expensive to design treatment technology due to its hydrophilic and miscible nature

TYPICAL USES OF CHEMICALS CONTAINING 1,4-DIOXANE

- Chlorinated solvent stabilizer:
  →degreasing, electronics manufacturing, metal finishing
- Reaction medium solvent in organic chemical manufacturing
- Solvent in:
  →paint, lacquer, and varnish remover resins, oils, sealants, adhesives, waxes and cements
- Byproduct of manufacturing PET plastic and polyester
- Wetting and dispersion agent in textile processes
- Deodorants, shampoos and cosmetics

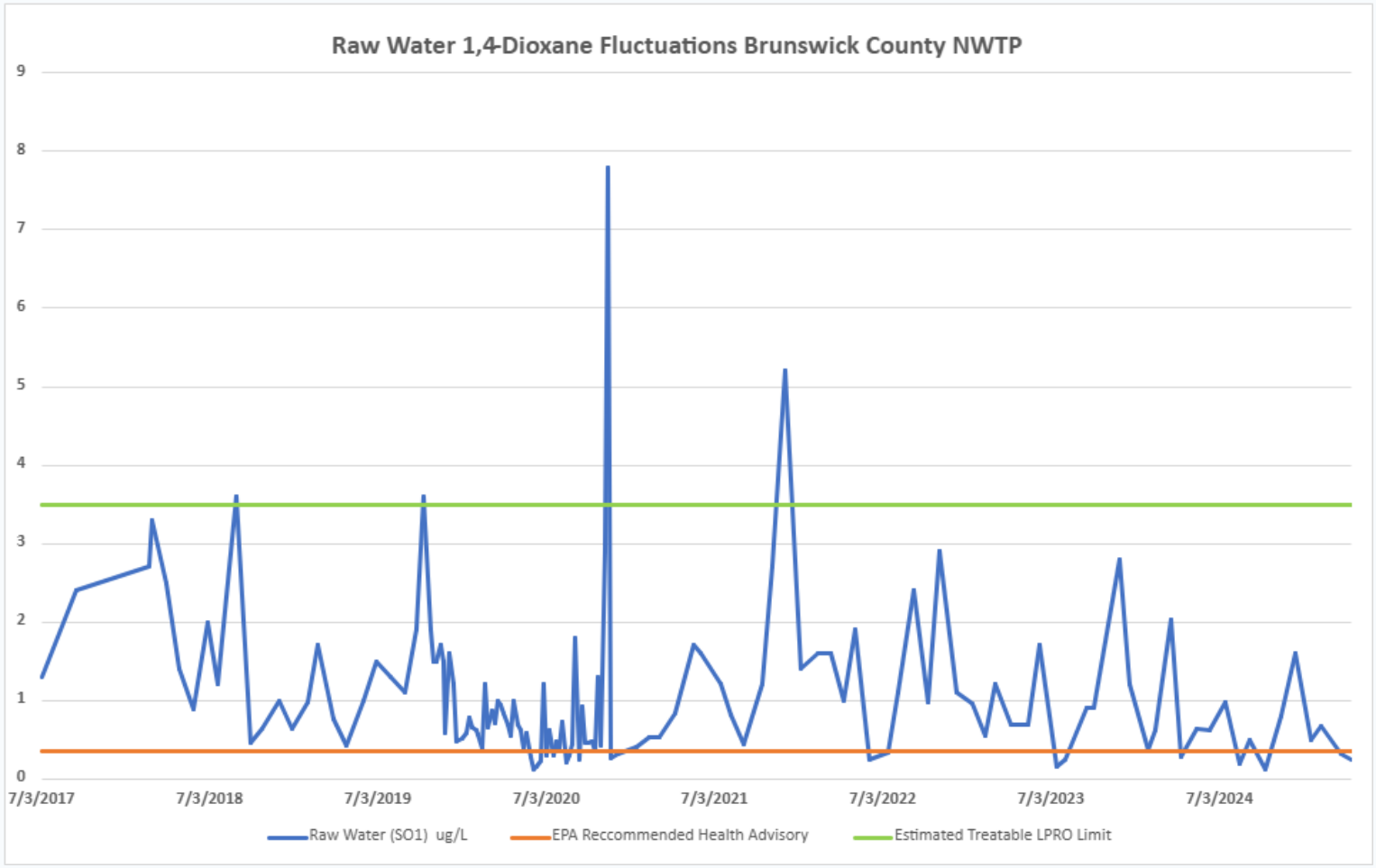
1,4-DIOXANE EXISTING HEALTH BASED LIMITS FOR WATER CONSUMPTION

- EPA Recommended health Advisory (0.35ug/l)
- NC Groundwater Standard- Well Water (3.0 ug/l)
- However, no other regulatory drinking water standard currently exists

1,4-DIOXANE LPRO REMOVAL PROJECTIONS

- Based on existing monitoring data from the NWTP Raw Water Sampling
- Intake Concentration (0.12 - 7.8 ppb)
- RO removal rate estimated approximately 90%
- Finished Water estimated concentration - below 0.35 ppb

1,4-DIOXANE CONCENTRATION FLUCTUATIONS - APPROX. 8-YEAR PERIOD



REGULATORY ISSUES FOR 1,4-DIOXANE

- UCF River Basin Stakeholder's minimization strategy has shown recent in-stream reductions, but is voluntary
- S324 = S384: Bill requires Commission for Public Health to establish MCL by 10/15/25. (Referred to Committee On Rules & Operation of Senate on 3/19/25)
- H881: Bill requires "discharger" and "industrial user" to eliminate 1,4-Dioxane and PFAS from wastewater discharge. (Referred to Committee On Rules & Operation of House on 4/10/25)
- Draft Rules are before the NC EMC for 1,4-Dioxane Monitoring and Minimization (very similar Draft Rule for PFAS as well)

POTENTIAL REGULATORY ISSUE CHALLENGING THE PUBLIC WATER SYSTEMS OF THE STATE

PROTECTING THE “PASSIVE RECEIVER”

WHAT IS A PASSIVE RECEIVER?

- Entities who did not manufacture or intentionally use regulated contaminants or contaminants of environmental concern but receive them unintentionally as incidental components of products or resources they routinely use.

- Public Water Systems using contaminated water resources as source water to produce drinking water are Passive Receivers.

NPDES PASSIVE RECEIVER PROTECTIONS

Why needed?

- Ensures polluter pays
- Public water providers can focus on most effective DRINKING WATER treatment solutions instead of selecting based on residual management
- Avoid Utilities being Unintended target of pollution reduction regulations
- Allows time for new regs to reduce upstream contaminant loading so that Utility may avoid costly upgrades to treat contaminants in source water
- Keeps ratepayer from paying both drinking water treatment cost and residual treatment cost

PASSIVE RECEIVER LANGUAGE

Allow the direct discharge of contaminants to surface waters of the State where:

- Part of a process producing public drinking water
- Mass Balance of contaminants

  →i.e.: Intake raw water contaminants => NPDES discharge of contaminants downstream

THANK YOU!
ANY QUESTIONS?

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LPRO PILOT – EXAMPLE (SECONDARY) TEST RESULTS

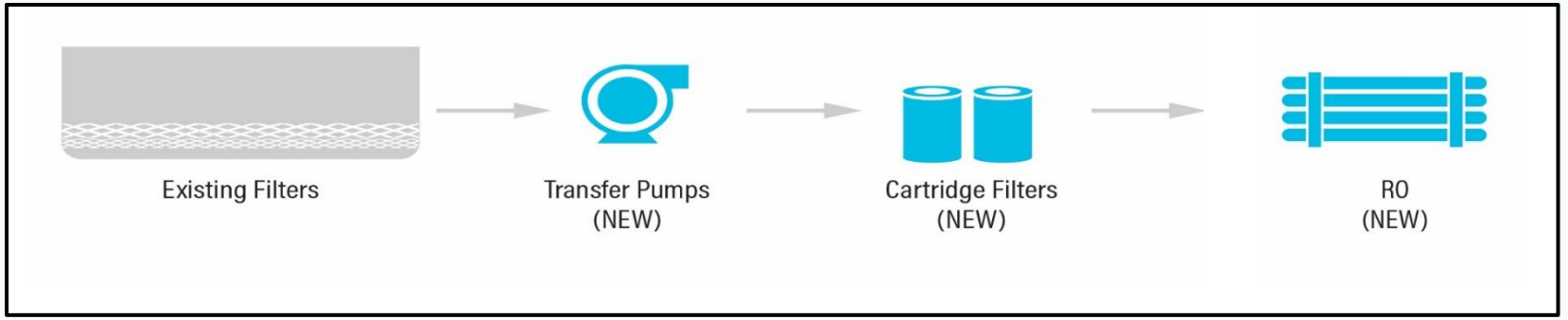
Parameter	Filtered Water Concentration	RO Treated Water	Calculated Removal %
1,4-Dioxane (industrial chemical)	3.2 µg/L	0.2 µg/L	94%
Carbamazepine (seizure medicine)	13 ng/L	ND	--
Atrazine (herbicide)	58 ng/L	ND	--
Cotinine (metabolite of nicotine)	15 ng/L	ND	--
DEET (insect repellant)	44 ng/L	ND	--
Simazine (herbicide)	57 ng/L	ND	--
Tris (1,3 dichloro-2-propyl)phosphate (pesticide, flame retardant)	120 ng/L	ND	--

LPRO PILOT – EXAMPLE (PRIMARY) TEST RESULTS

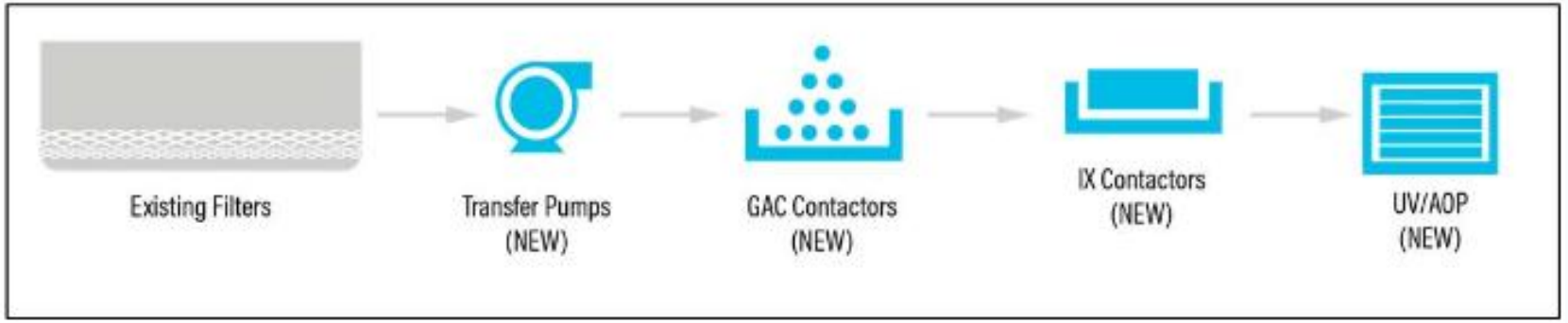
Parameter	Filtered Water Concentration	RO Treated Water	Calculated Removal %
Gen X	7 – 12 ng/L	ND	--
Nafion Byproduct 1 & 2	ND	ND	--
PFMOAA	320 – 750 ng/L	ND – 11 ng/L	98%+
PFO2HxA	12 – 26 ng/L	ND	--
PFHxA	19 – 20 ng/L	ND	--
PFPeA	16 - 17 ng/L	ND	
PFOS + PFOA	26 ng/L	ND	--
Sum (45) of PFAS Tested	423 – 892 ng/L	ND – 11 ng/L	--

OPTION IMPLEMENTATION DIAGRAM

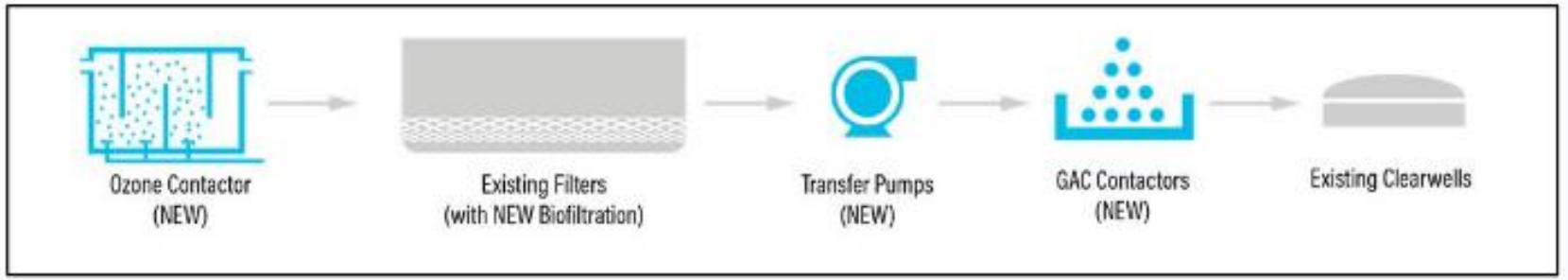
Low Pressure Reverse Osmosis



GAC> IX> UV/AOP



Ozone/biofiltration > GAC



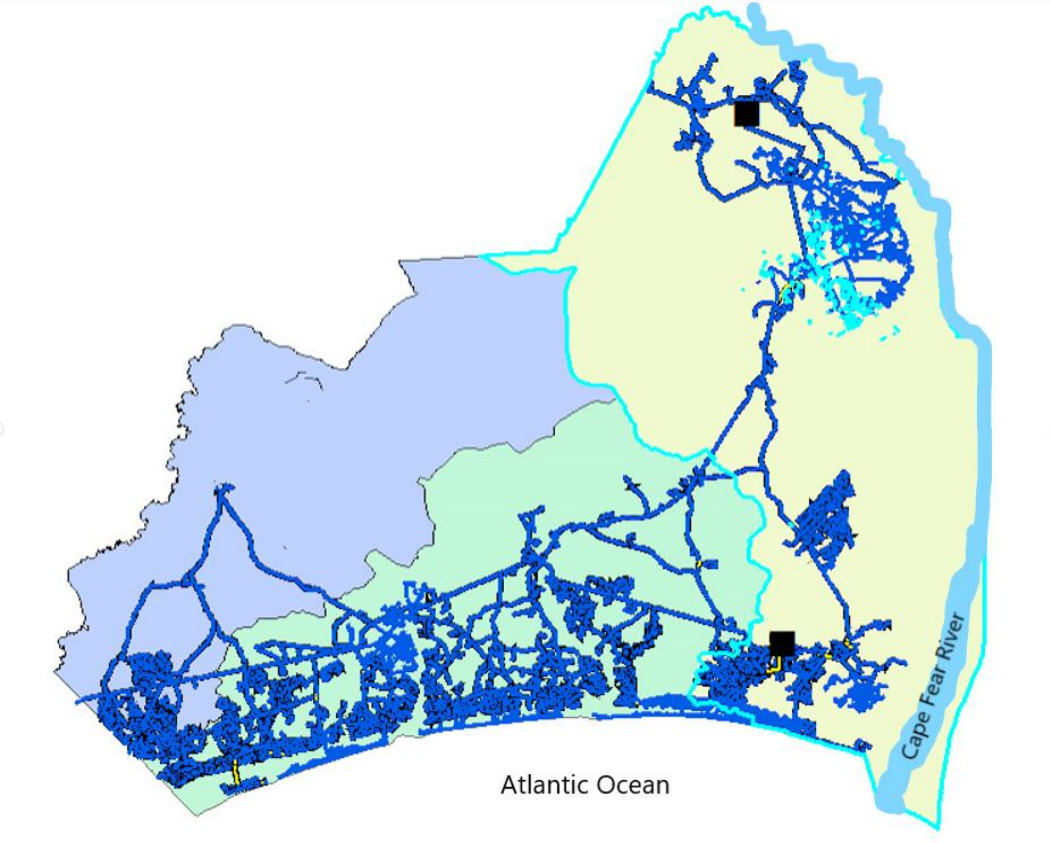
WHERE DOES THE PFAS GO?

- **Ubiquitous** (Merriam-Webster definition) - *existing or being everywhere at the same time; constantly encountered*
- Removal and then…
  - →Conversion (Incineration??)
  - →Relocation
  - →Sequester (Deep well injection, landfill)
  - →Destruction??
- Treatment versus Environmental Remediation
  - →Effectiveness
  - →Who Pays?

WHO PAYS?

- **Who Should Pay?**
  - Ratepayer
  - Industry/Polluter
  - Everyone
- **Who pays now?**
  - Drinking Water Improvements
  - Disposal of Captured PFAS (Concentrate, Spent GAC, Resin)
  - Sludge

CUSTOMER OUTREACH AND RATE IMPACTS



- **Water and wastewater service to residents of the County**
  - 64,262+ residential connections
  - 4 wholesale customers
    - 35,000+ customers
  - Serves 19 municipalities
  - Estimated 350,000 people during peak season
- **Outreach**
  - NC Division of Health and Human Services
  - NC Division of Environmental Quality
  - Neighboring Utilities
  - Customer Communication
- **Rate Impacts**
  - Average Retail User (4,500 gallons per month): $34.68
    - → FY 21 bill: $24.83 /month
    - → FY 22 bill: $34.68 /month
    - → Difference: $9.85
    - → % Difference: 40%

LOW PRESSURE REVERSE OSMOSIS

System Design Elements:

- Eight 500hp 9 stage turbine pumps
- Two separate feed headers
- Powered by Square D - VFDs
- Eight filter vessels rated to 6.05 MGD
- 272 cartridge filters per vessel
- All monitored and controlled through the SCADA system

THE MEMBRANE SOLUTION – LOW PRESSURE REVERSE OSMOSIS

- Best removal of PFAS (GENX) and other Target Contaminants (Most non-detect)
- Most Cost-Effective advanced treatment technology for removing 90% or more of the Target Contaminants for Brunswick
- Most Resilient Technology - Best protection against unidentified contaminants and spills/spikes in the Cape Fear River
- Lowest lifecycle cost

WHEN TO CONSIDER A MEMBRANE SEPARATION SOLUTION

- Very high removal rate required
- Life cycle cost comparisons
- Multiple contaminants of concerns
- Resiliency (Contaminant Spikes)
- Concentrate Disposal Options