HRSD's Vision for Managed Aquifer Recharge in Eastern Virginia

swift

Sustainable
Water Initiative
for Tomorrow

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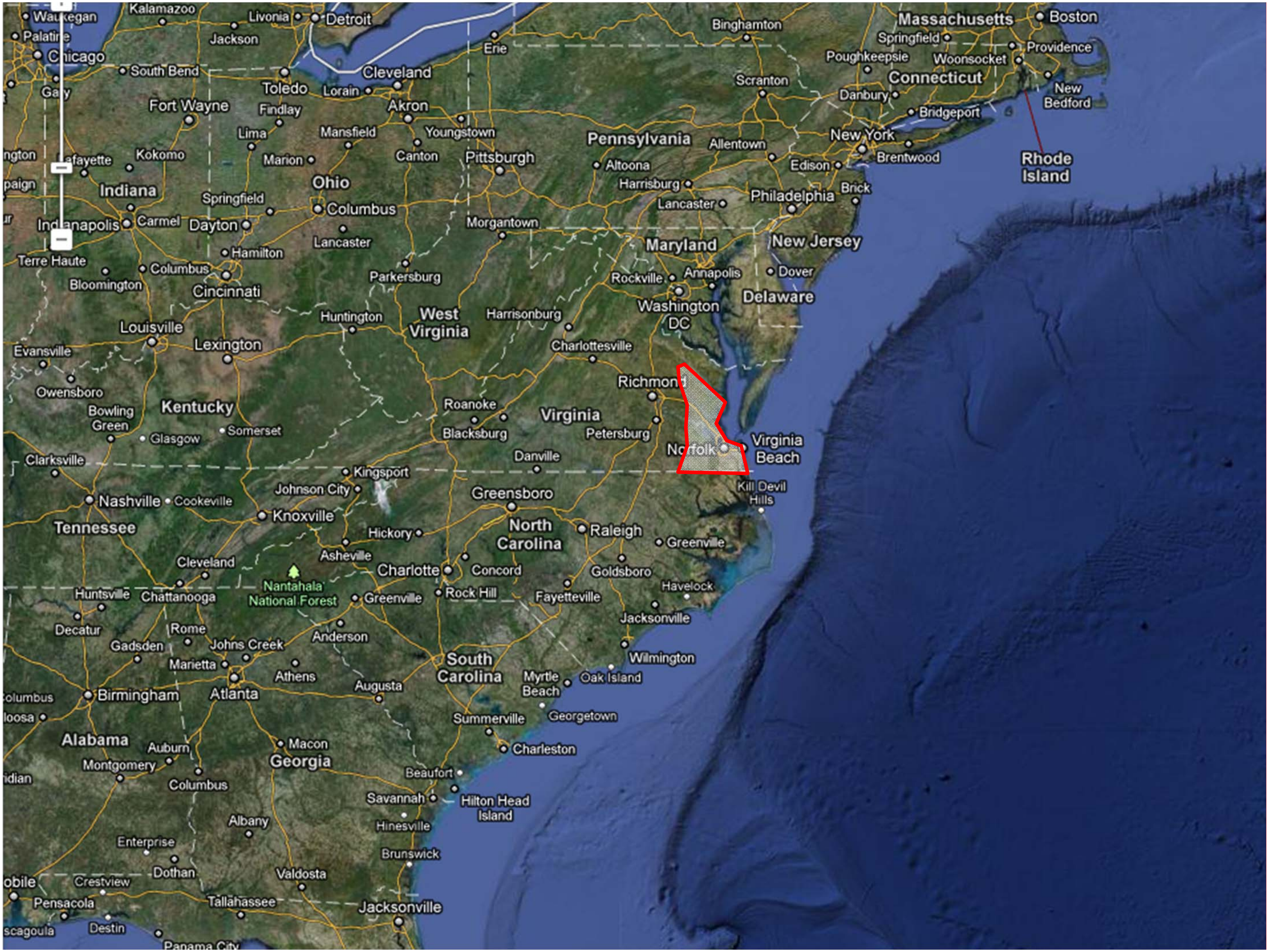
HRSD



Kalamazoo
Waukegan
Livonia
Detroit
Binghamton
Massachusetts
Boston
Palatine
Jackson
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South Bend
Cleveland
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Woonsocket
Toledo
Lorain
Scranton
Connecticut
Gary
Akron
Danbury
New Bedford
Fort Wayne
Findlay
Bridgeport
Lima
Mansfield
Youngstown
Pennsylvania
Allentown
New York
Kokomo
Marion
Canton
Pittsburgh
Brentwood
Rhode Island
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Kingsport
Kill Devil Hills
Johnson City
Greensboro
Nashville
Cookeville
Knoxville
North Carolina
Raleigh
Tennessee
Hickory
Greenville
Asheville
Cleveland
Charlotte
Concord
Goldsboro
Nantahala National Forest
Havelock
Huntsville
Chattanooga
Greenville
Rock Hill
Fayetteville
Jacksonville
Decatur
Rome
Anderson
Gadsden
Johns Creek
Wilmington
Marietta
South Carolina
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Myrtle Beach
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Augusta
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Georgetown
Alabama
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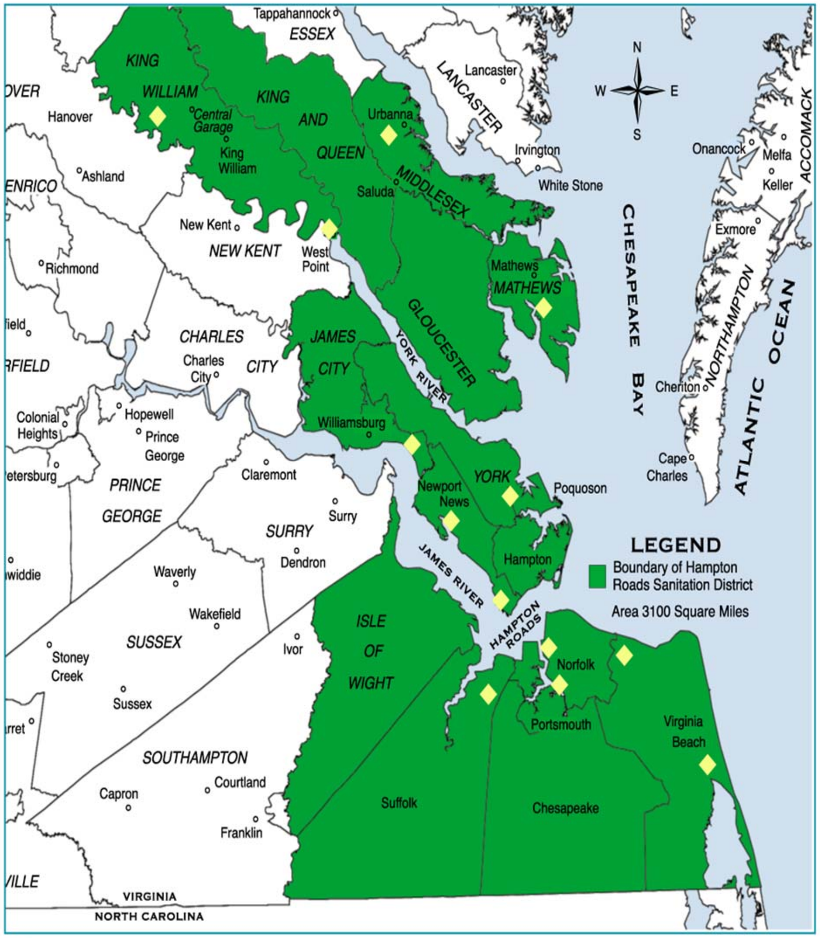
Charleston
Georgia
Montgomery
Beaufort
Columbus
Savannah
Hilton Head Island
Albany
Hinesville
Enterprise
Brunswick
Dothan
Valdosta
Crestview
Pensacola
Tallahassee
Jacksonville
Destin
Panama City

Who/What is HRSD?

HRSD Service Area Map



= treatment plant locations

- Provide wastewater treatment for 18 localities (250 mgd treatment capacity)
- Serve 1.7 million people (20% of all Virginians)
- Independent political subdivision with Governor appointed Commission

Sustainable Water Initiative for Tomorrow

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The Challenges/Opportunities for HRSD

- ~$750M in Nutrient Removal Upgrades by 2021
- ~$2B in Consent Decreed Mandated Upgrades to Reduce Sanitary Sewer Overflows
  - Aging infrastructure
- Very large managed aquifer recharge effort pending
  - Indirect potable reuse?
  - >100 MGD

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Water Issues Challenging Virginia and Hampton Roads

- Depletion of groundwater resources
  - Including protection from saltwater contamination
- Water quality concerns
  - Chesapeake Bay restoration
  - Local water quality issues
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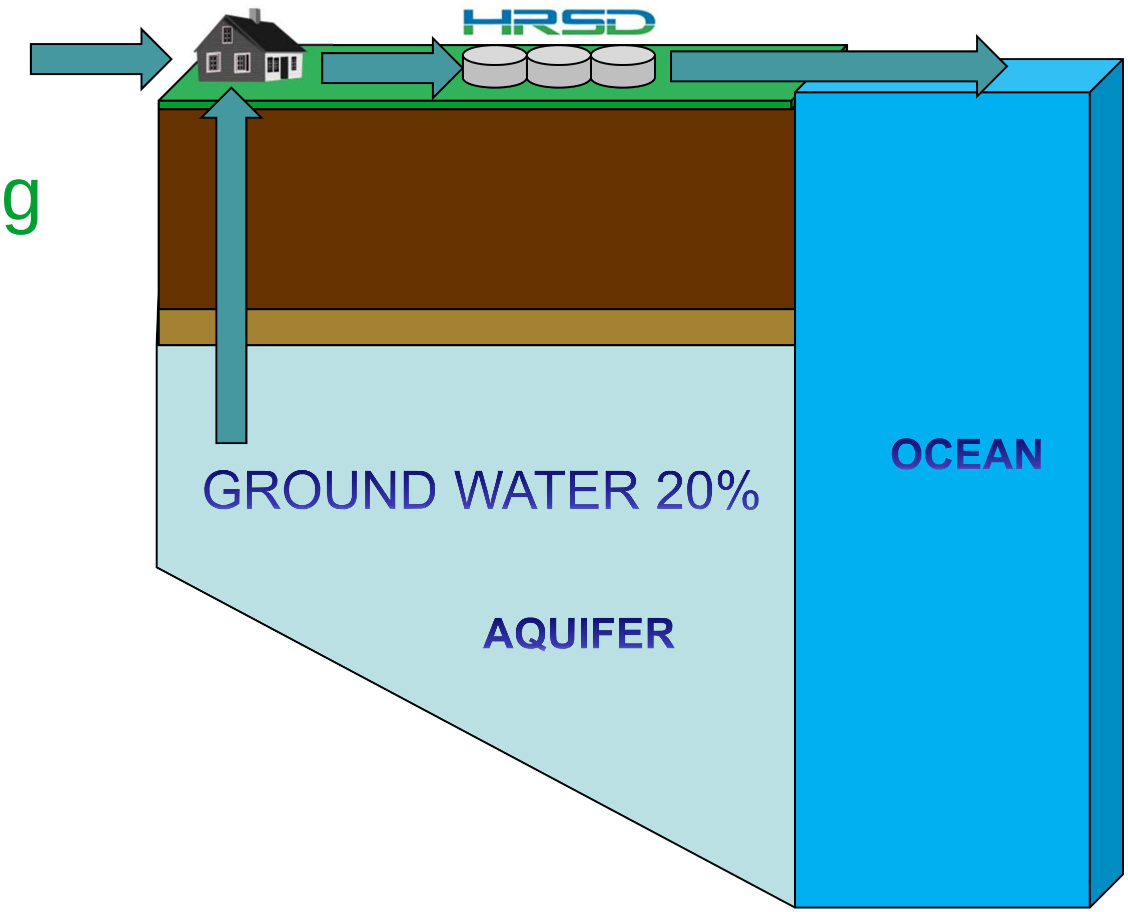
Current state of wastewater in Hampton Roads

SURFACE WATER 80%



HRSD costs are rising to treat water to higher standards.

Treated water currently discharged to area waterways – no beneficial use.

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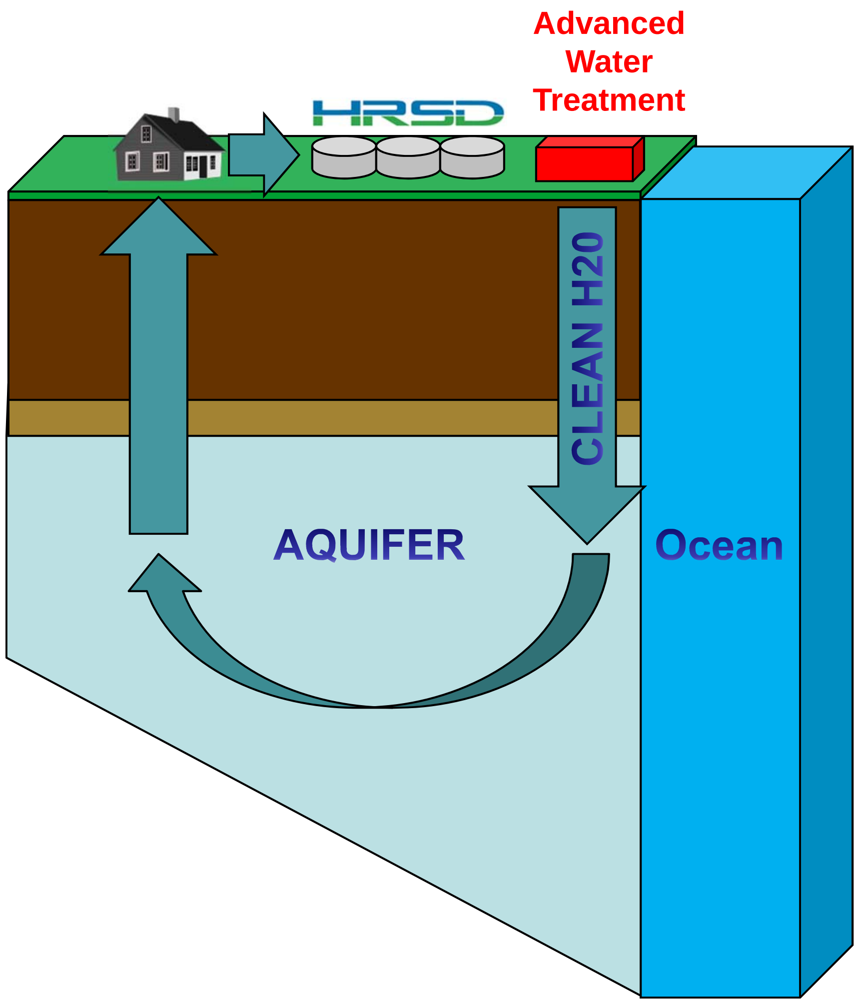
Regulatory uncertainty

- Wastewater permits have 5 year terms
- New regulations can require extensive investment in new treatment processes
- Always concerned about the next issue on the horizon
  - Viruses
  - Pharmaceutical products
  - Further nutrient reductions (e.g. TMDL Backstops)
- Challenging to manage appropriate risk factors

SWIFT – Sustainable Water Initiative for Tomorrow

- Treat water to meet drinking water standards and replenish the aquifer with clean water to:
  - Provide regulatory stability for wastewater treatment
  - Reduce nutrient discharges to the Bay
  - Reduce the rate of land subsidence
  - Provide a sustainable supply of groundwater
  - Protect the groundwater from saltwater contamination



Advanced water treatment – to drinking water standards

- Advanced treatment used throughout world, many locations in USA and even in Virginia to produce water that exceeds drinking water standards
  - Upper Occoquan Service Authority/Fairfax Water
  - Loudoun Water
  - Montebello Forebay, CA 1962
  - El Paso, TX 1985
  - Scottsdale, AZ 1999
  - Orange County, CA 2008
  - Arapahoe, CO 2009
  - ***San Diego, CA 2020***

Membrane based

Carbon based

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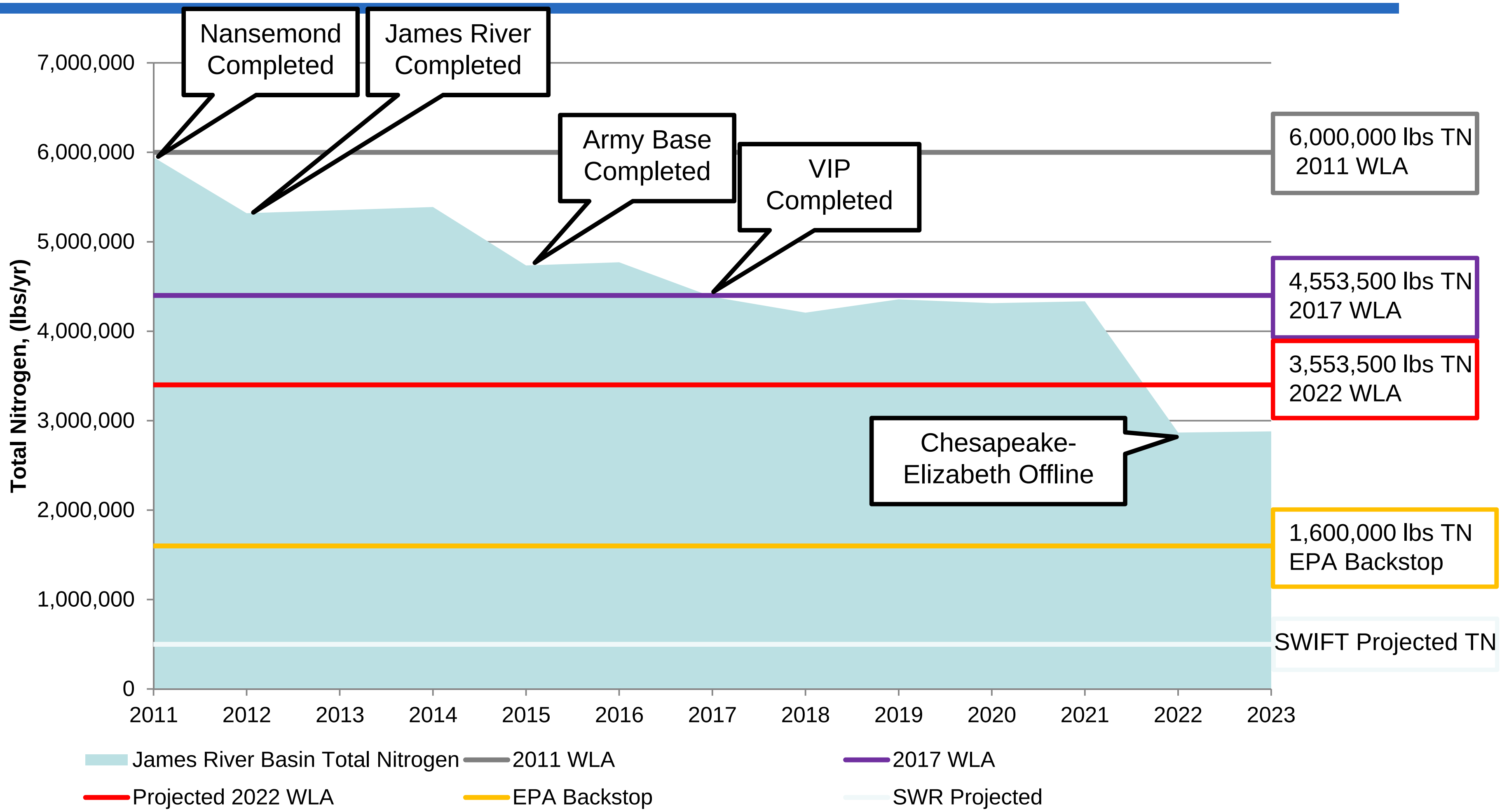
Impact on nutrient reductions



James River Basin – TN Similar results with TP and TSS and in other river basins.

WLA – Nutrient Waste Load Allocation in lbs/yr

SWIFT Benefits: Chesapeake Bay Restoration Goals

	HRSD Bay TMDL Allocations	HRSD Post SWIFT Loads (2030)	Available for other needs	Stormwater Reduction Needs*
Nitrogen				
James	3,555,500	500,000	3,055,500	63,039
York	288,315	39,000	249,315	19,114
Phosphorus				
James	318,436	50,000	268,436	13,088
York	19,315	6,000	13,315	3,887
Sediment				
James	14,000,000	700,000	13,300,000	5,269,142
York	1,400,000	66,000	1,334,000	1,413,762

* DEQ Regulated Stormwater w/o federal lands

SWIFT Benefits: Trading Opportunities

- HRSD is working with Hampton Roads' localities to enter into trade agreements for TMDL required reductions
  - Hampton first locality to sign

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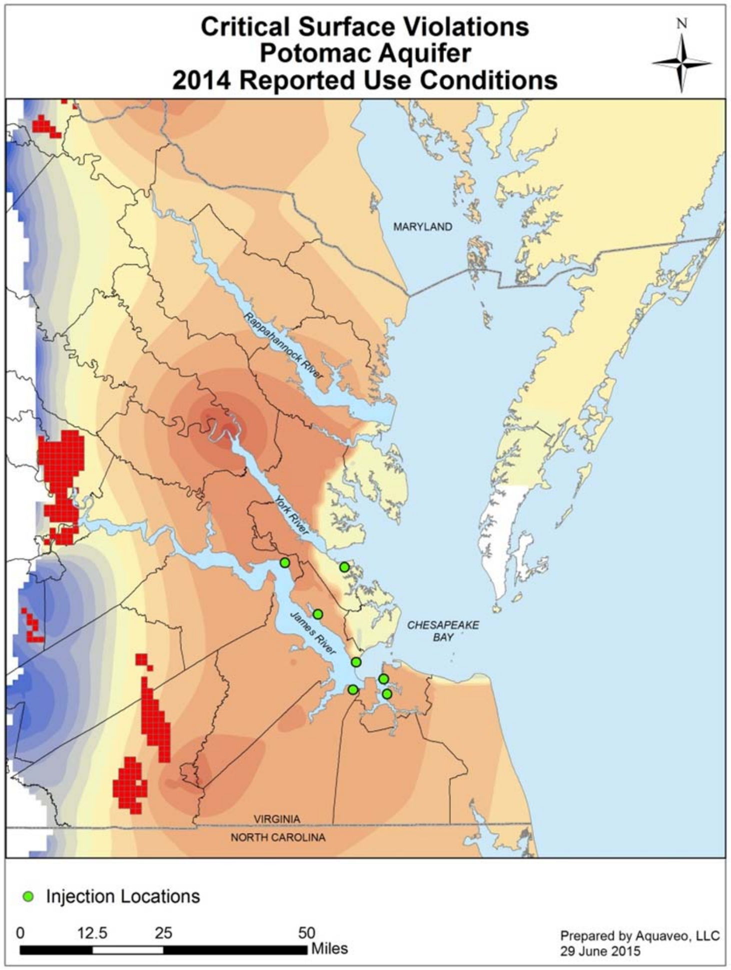
Unsustainable Aquifer Withdrawals

- Over-allocated permitted withdrawal
  - Water levels falling several feet/yr
- 177 permits = 147.3 MGD
  - Currently withdrawing approximately 115 mgd
- 200,000 unpermitted “domestic” wells
  - Estimated to be withdrawing approx. 40 mgd growing at 1 mgd per year



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Hydrogeologic Section: Coastal Plain of Virginia

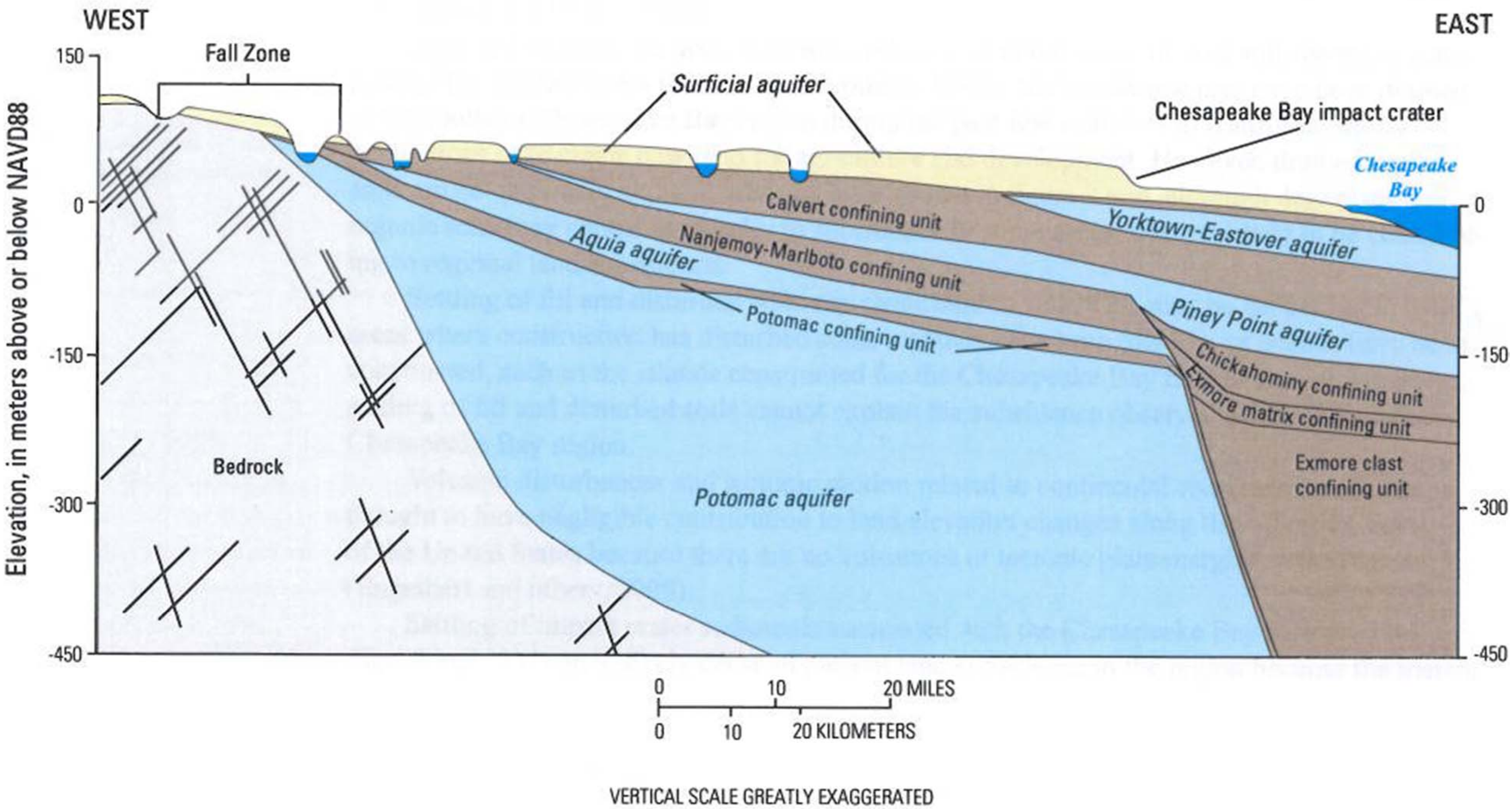
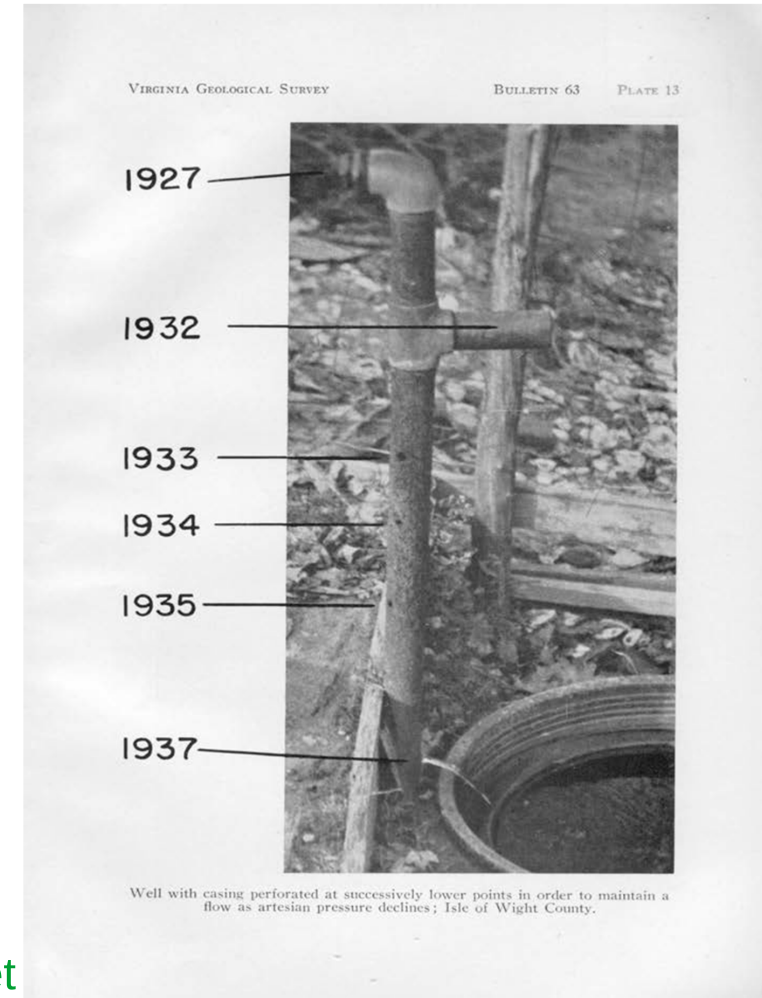


Figure 11. Section illustrating layering in the Virginia Coastal Plain aquifer system from west to east. Elevation relative to North American Vertical Datum of 1988 (NAVD88). Modified from McFarland and Bruce (2006).

Groundwater depletion has been rapid

A, Overflow from artesian well in Isle of Wight County is wasted.

- Artesian wells in early 1900s – groundwater wells required valves not pumps!
- In about 100 years have gone from water levels at 31 feet above sea level to 200± feet below.



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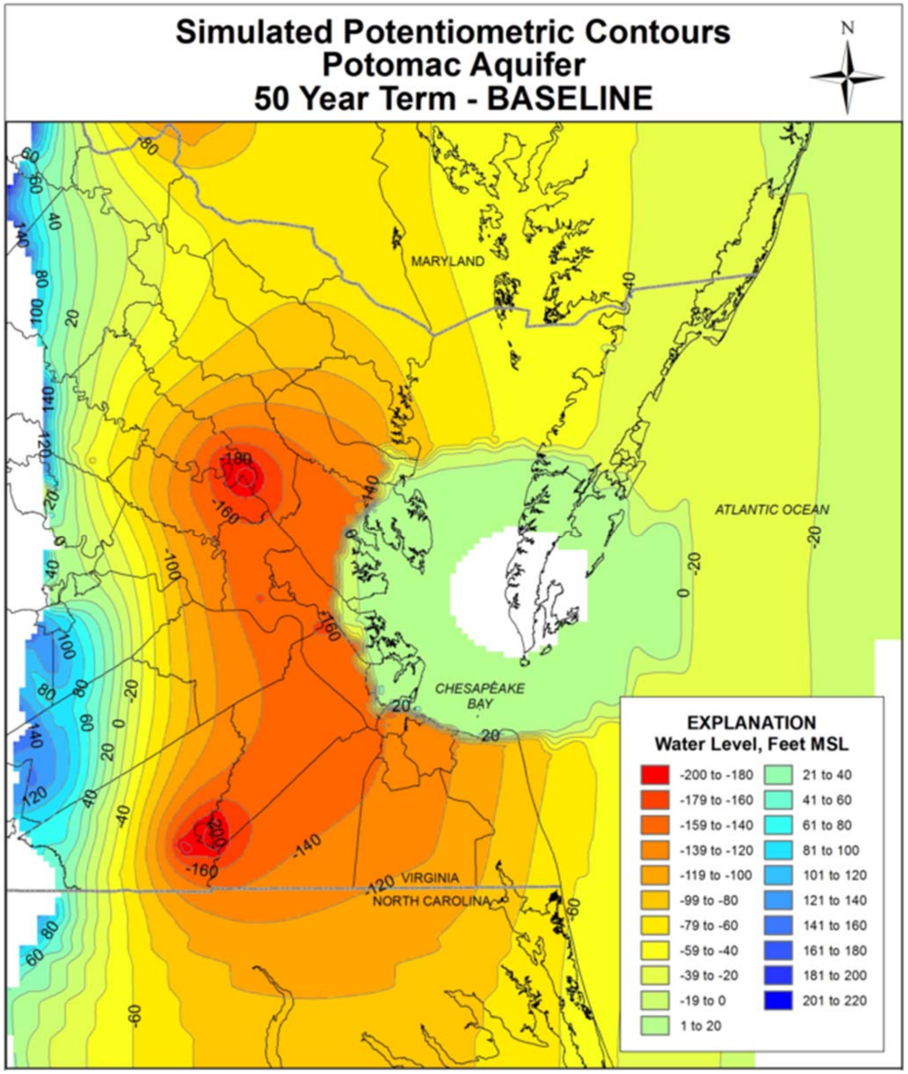
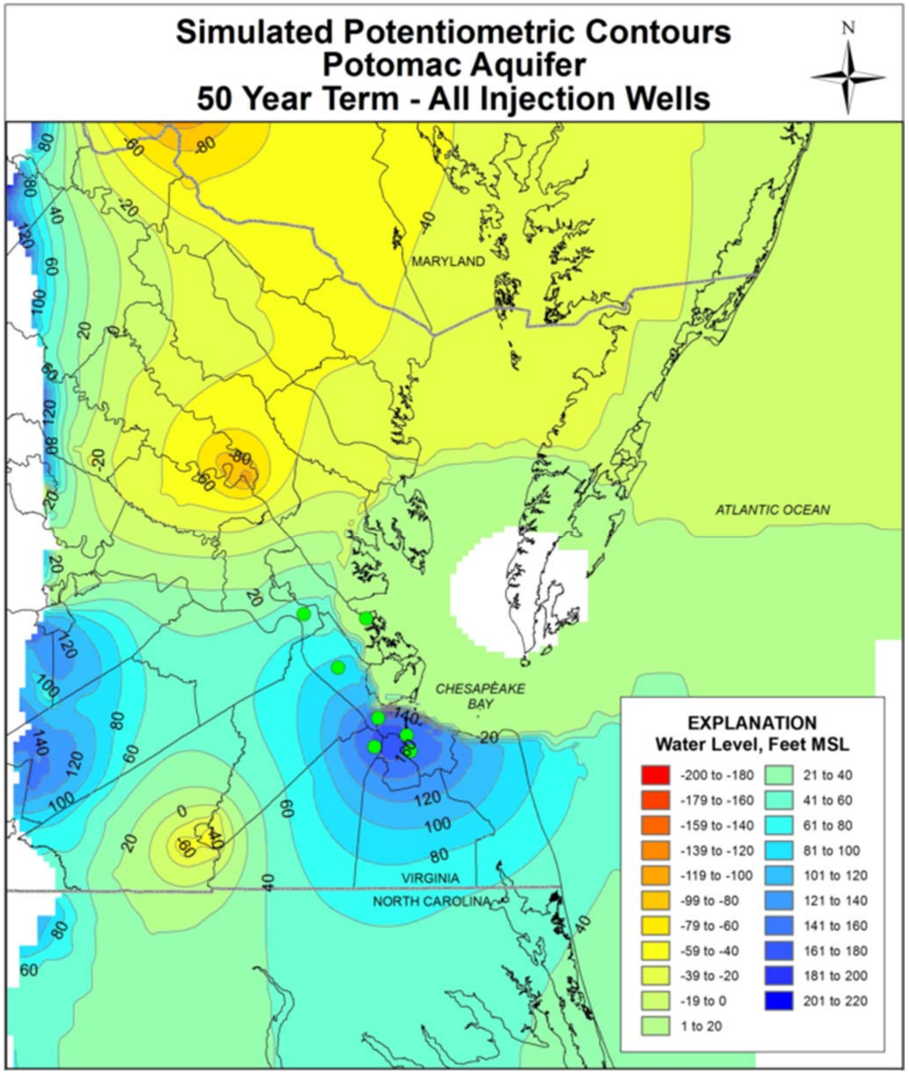
Modeled Potomac Aquifer water levels with and without SWIFT





What is the travel time of the injected water?

- Injectate migration modeling
  - –Could not run transient injection scenario
  - –MODPATH simulation using steady-state – approximately 3 ft/yr
  - –Glacial model simulation – approximately 27 ft/yr
  - –Calculated travel times from injection scenario – approximately 29 ft/yr

- Summary – ***"These results indicate that injected water travel times are relatively slow – with injected water taking approximately 180 years to travel one mile."***

Water Issues Challenging Virginia and Hampton Roads

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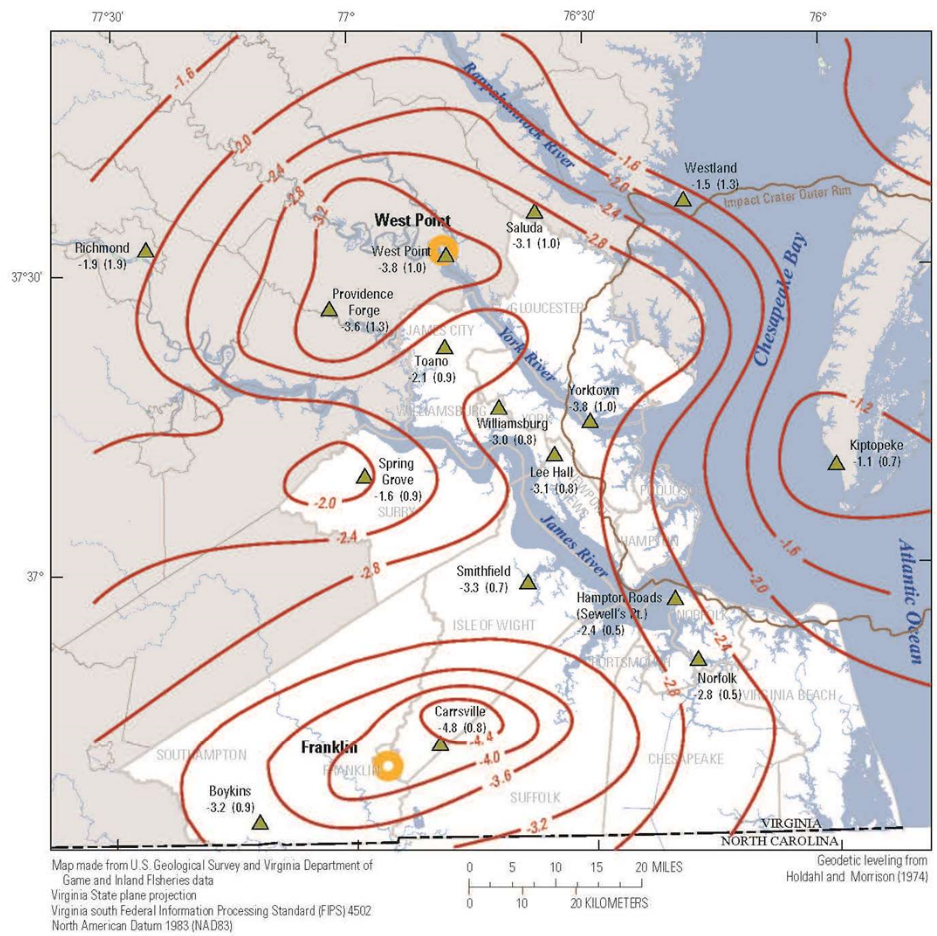
Land subsidence – *we are sinking*

- According to USGS
  - Up to 50% of relative sea-level rise may be due to land subsidence
  - **Up to 50% of land subsidence may be due to aquifer compaction**



HAMPTON ROADS IS THE #2 LARGEST POPULATION CENTER AT RISK

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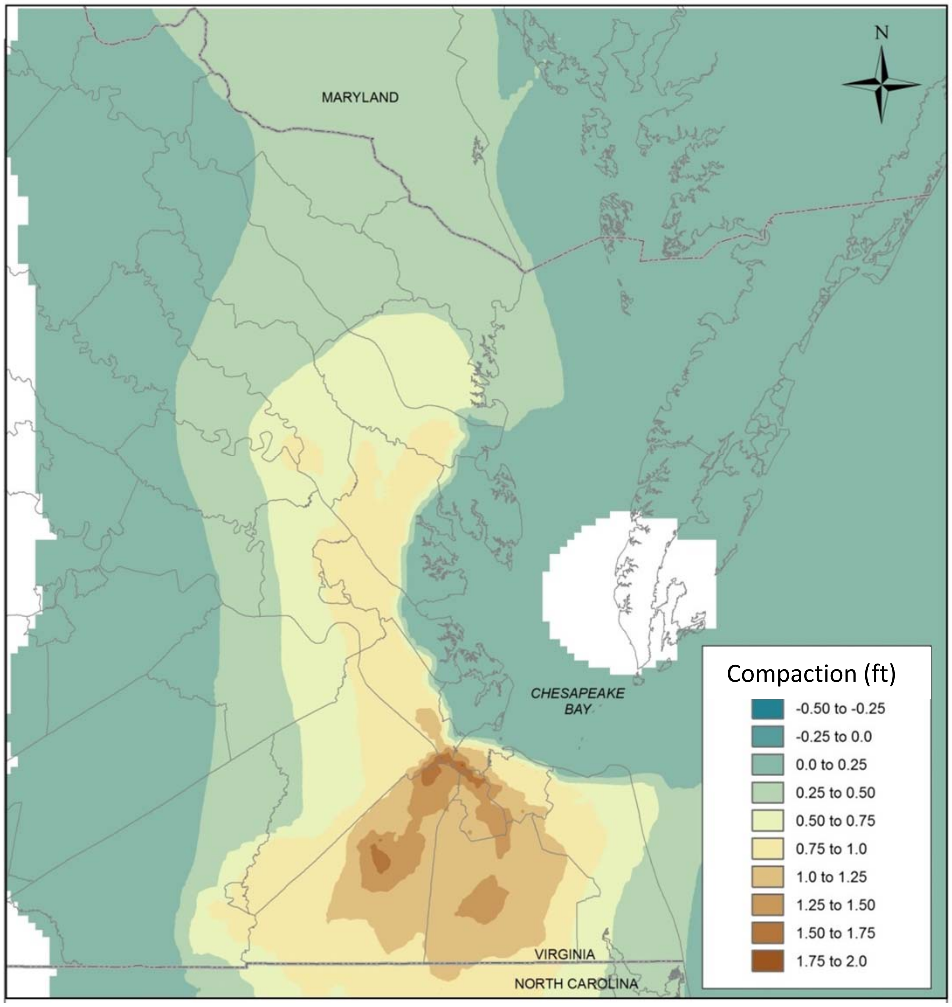
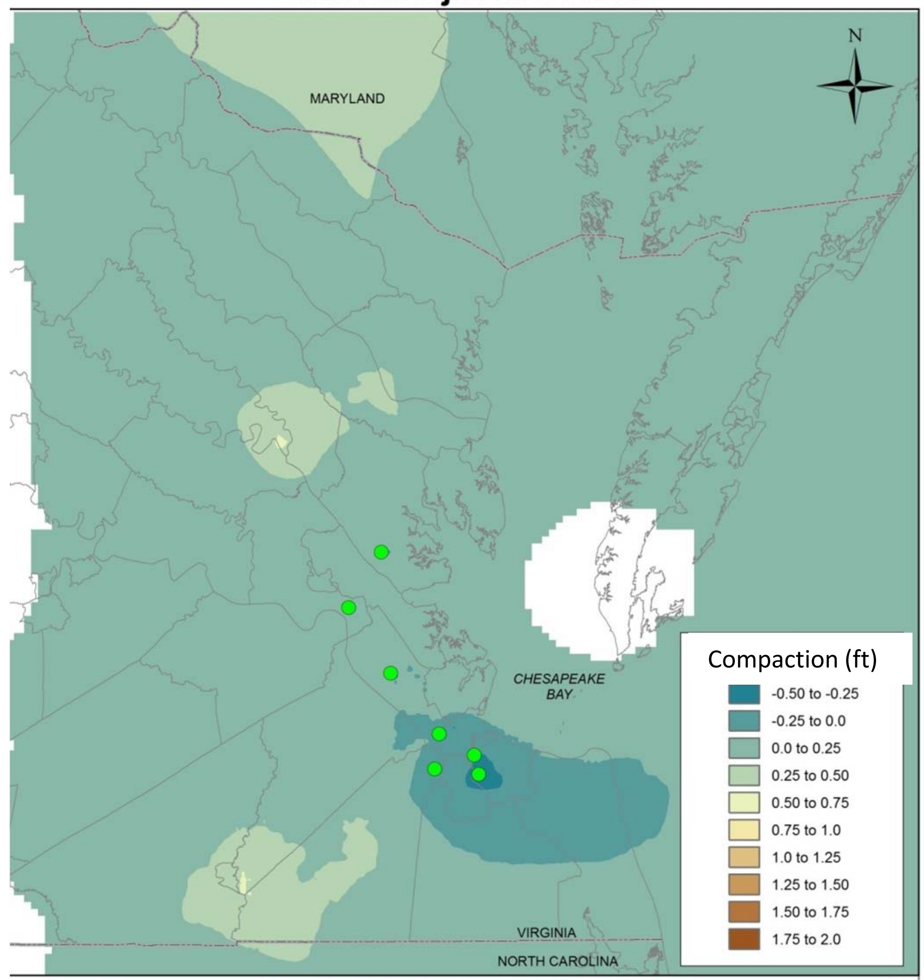
Extensometer – HRSD Nansemond Plant, Suffolk

Aquifer compaction without and with SWIFT

Simulated Total Aquifer System Compaction from 1890 to 2064 - Total Permitted



Simulated Total Aquifer System Compaction from 1890 to 2064 - Total Permitted with All Injection Wells



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Sewer Overflows

- No chronic locations
- No data to support episodic SSOs contribute to local water bacteria impairment
- Recent success with more focused efforts
  - Wet weather and dry weather monitoring
  - Source tracking “hot spots”
  - Coordinating field work with locality
- Overflows not eliminated with Regional Wet Weather Plan when weather event generates flows above designed service level

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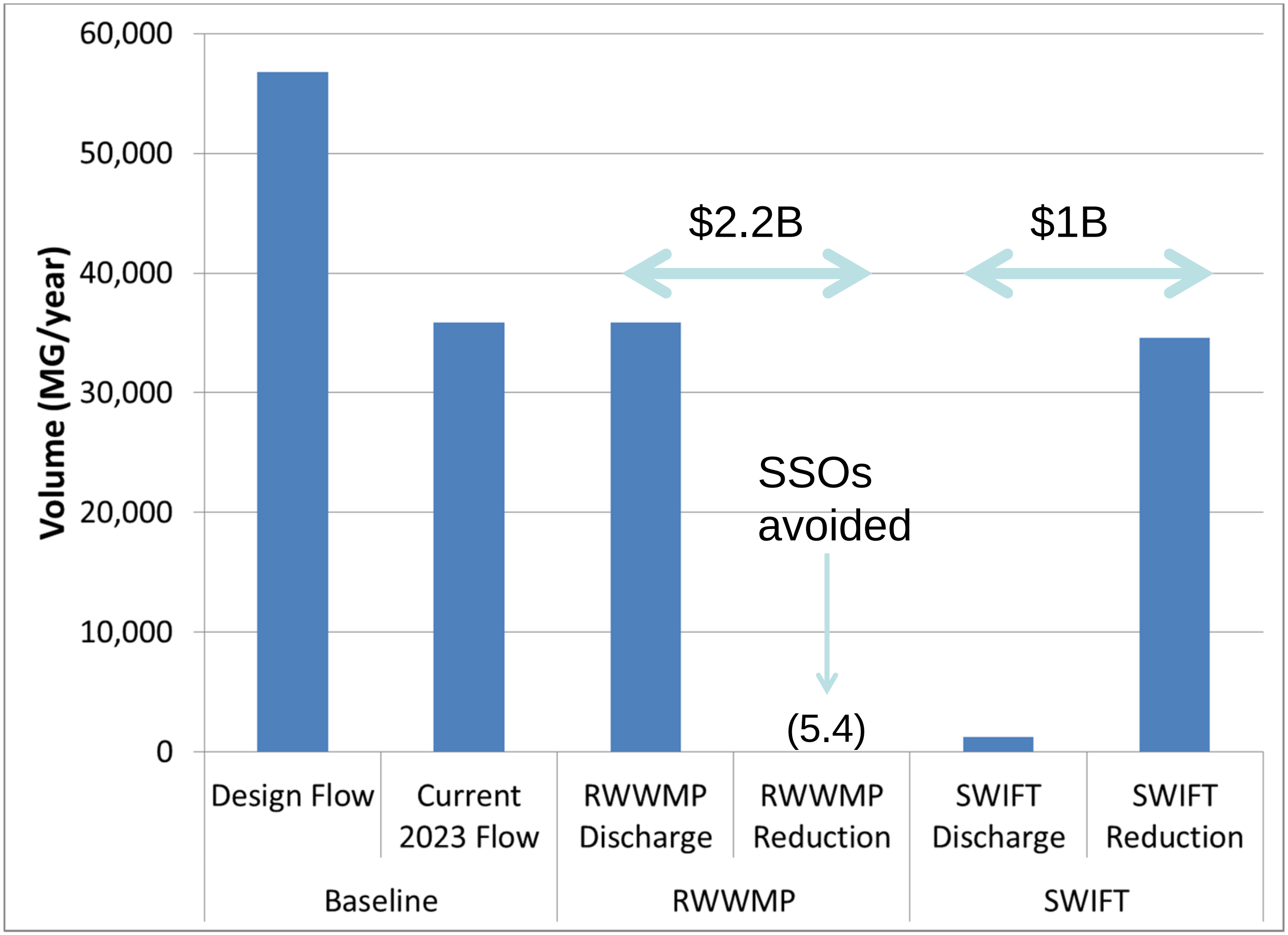
SSO Work Versus SWIFT – Volume Discharged



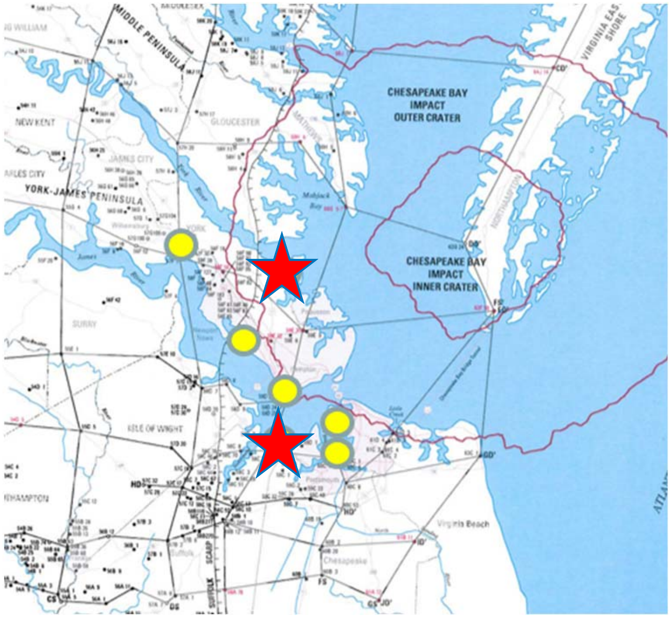
RWWMP values: based on avoidance of 271 MG loss over 50 years associated with capacity-related overflows (5 yr LOS).

SWIFT Approach

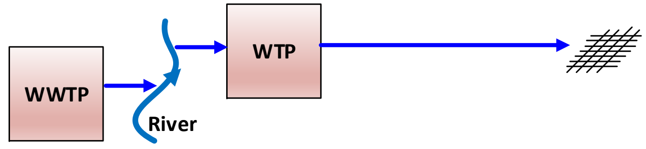
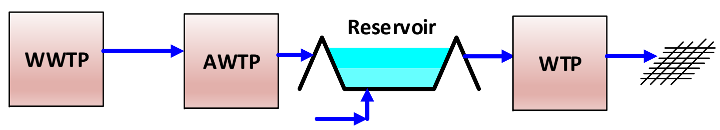
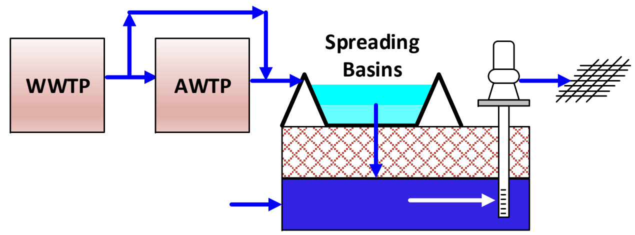
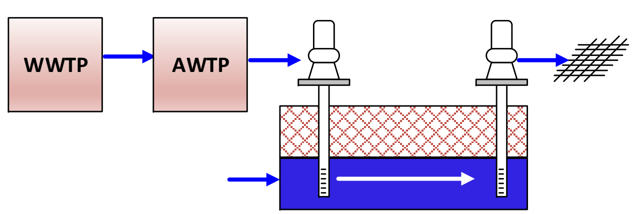
- Initial feasibility study – desktop and modeling
- Work with regulators, policy makers and public to identify challenges and build support
- Define water quality targets
- Drill test wells at injection sites
- Pilot treatment at HRSD facility
- 1 MGD demonstration facility – treatment and aquifer injection
- Obtain UIC permits for full scale

Test Wells

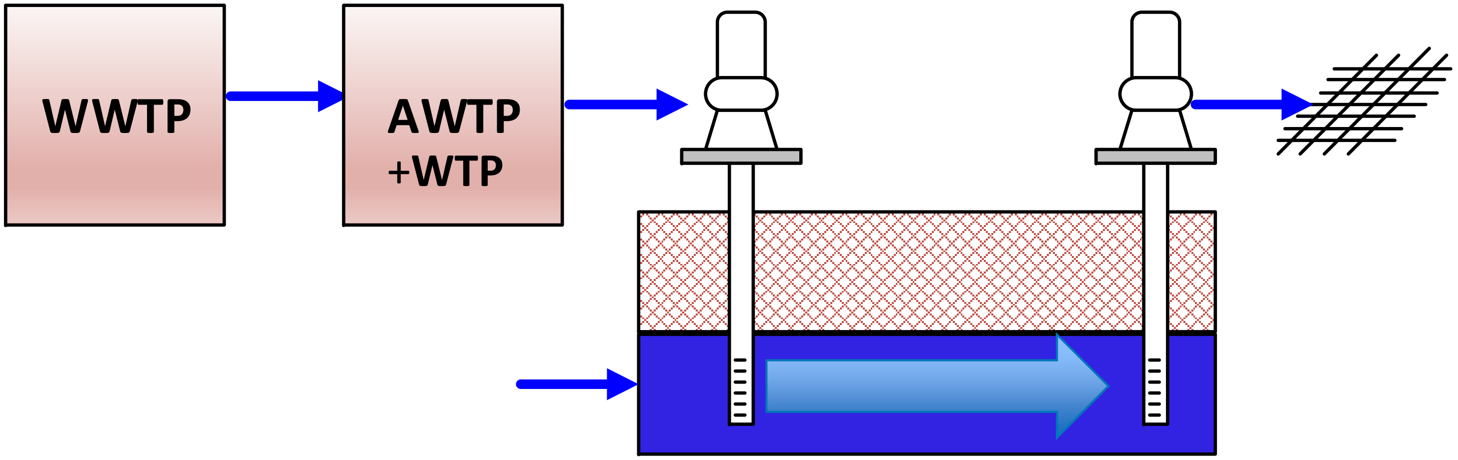
- Nansemond Plant 1,500 ft deep
  - –12” Diameter
  - –400 ft screened (27%)
- York River Plant 2,000 ft deep
  - –8” Diameter
  - –645 ft screened (32%)
- More coarse sand than predicted



Water Supply Augmentation Approaches

Indirect Potable Reuse Approaches	Examples
De Facto 	Common throughout the world (e.g., Mississippi River, Colorado River, etc…)
Surface Water Augmentation 	Upper Occoquan Service Authority (Northern Virginia); Gwinnett County (Georgia); Singapore NEWater
GW Recharge via Spreading Basins 	Montebello Forebay (Los Angeles, CA); El Paso (Texas); Chino Basin (Chico, CA)
GW Recharge via Direct Injection 	GWRS (Orange County, CA); West Basin (CA); Los Alamitos (Long Beach, CA); Scottsdale Water Campus (AZ)

Managed Aquifer Recharge



- Travel time – >100 years?
- Soil aquifer treatment, blending with existing groundwater
- Human health criteria still apply due to drinking water designation of aquifer
- Geochemical compatibility is required!

Typical Approach to Developing Finished Water Goals for Groundwater Recharge

- Meet all primary Maximum Contaminant Levels (MCLs) regulated by the USEPA in the SDWA
- Provide multiple barriers to pathogens and organics (including chemicals)
- Aquifer compatibility

- Hazard Analysis – Critical Control Points
  - Alarm values
  - Shut down values

Example Water Quality Goals

Parameter	Pertinent Regulatory Requirements					
	UOSA (VA); Surface Water Augmentation	El Paso (TX) – Direct Injection	FL – Direct Injection	EPA Guidelines – Direct Injection	CA – Direct Injection	TX – Direct Potable Reuse (min reqmts)
MCLs		Comply with all primary drinking water MCLs				
Nitrogen	TKN < 1 mg/L	NOx – N < 10 mg/L	TN < 10 mg/L	None	TN < 10 mg/L	NO3-N < 10 mg/L; NO2-N < 1 mg/L
Solids	TSS < 1 mg/L; Turb < 0.5 NTU	Turb < 1 NTU	Turb < 2 to 2.5 NTU	Turb < 2 NTU	Turb < 2 NTU	-
Organics (TOC/COD)	COD = 10 mg/L (~ 3.8 mg/L TOC)	None	3 mg/L; TOX < 0.2 mg/L	2 mg/L (of WW origin)	0.5 mg/L	-
Enteric Viruses	Multiple barriers required (total coliform < 2 / 100 mL)	None, but multiple barriers required	Multiple barriers required (Total Coliform < 4 / 100 mL)	Multiple barriers required (Total Coliform BDL)	12-log LRV	8-log LRV
Crypto					10-log LRV	5.5-log LRV
Giardia					10-log LRV	6-log LRV
Misc	TP < 0.1 mg/L					

Not all parameters are listed; for example other requirements such as travel time, disinfection residual, etc… are required in some states and locations

NOTE: LRV= Log Removal Value

Finished Water Quality Preliminary Targets

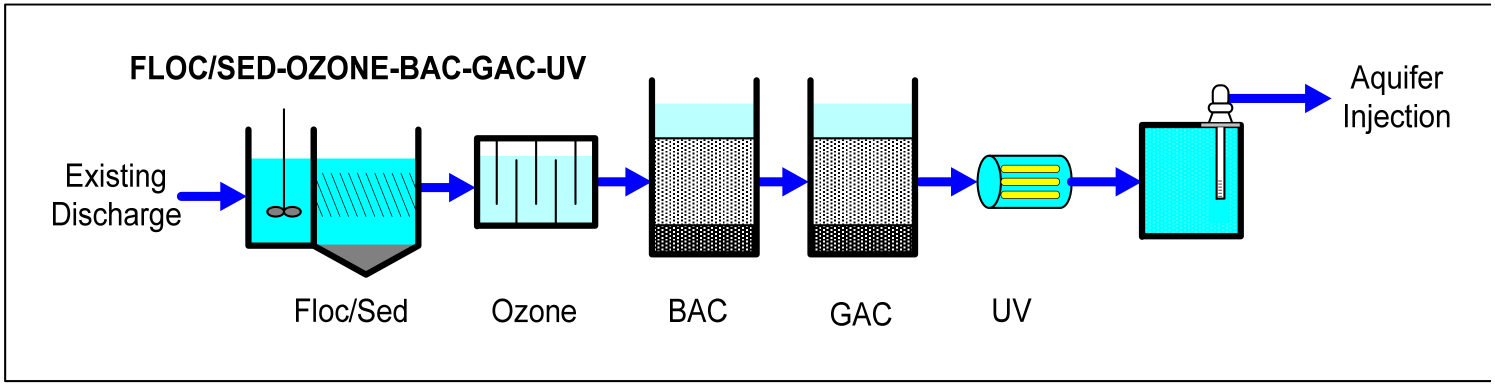
Parameter	Proposed Regulatory Limit	Water Quality Goal (non-regulatory)
MCLs	Meet all primary MCLs	N/A
Nitrate (NO3-N)	5 mg/L monthly average; 8 mg/L max daily	Secondary Effluent CCP Action Limit for TIN = 8 mg/L
Turbidity	IFE <0.15 NTU 95% & never > 0.3 NTU in two consecutive measurements	CCP Action Limit at 0.10 NTU
TOC	4 mg/L monthly average (TBD)	CCP Action Limit at ? mg/L (TBD)
Total coliform	< 2 CFU / 100 mL; 95th perc.	CCPs to achieve 12 LRV for viruses and 10 LRV for Crypto & Giardia
E. Coli	Non-detect	
Unregulated Chemicals	None	Monitor suite of chemicals and address as necessary
Total Dissolved Solids	None	None

Aquifer Compatibility – TDS and pH/alkalinity

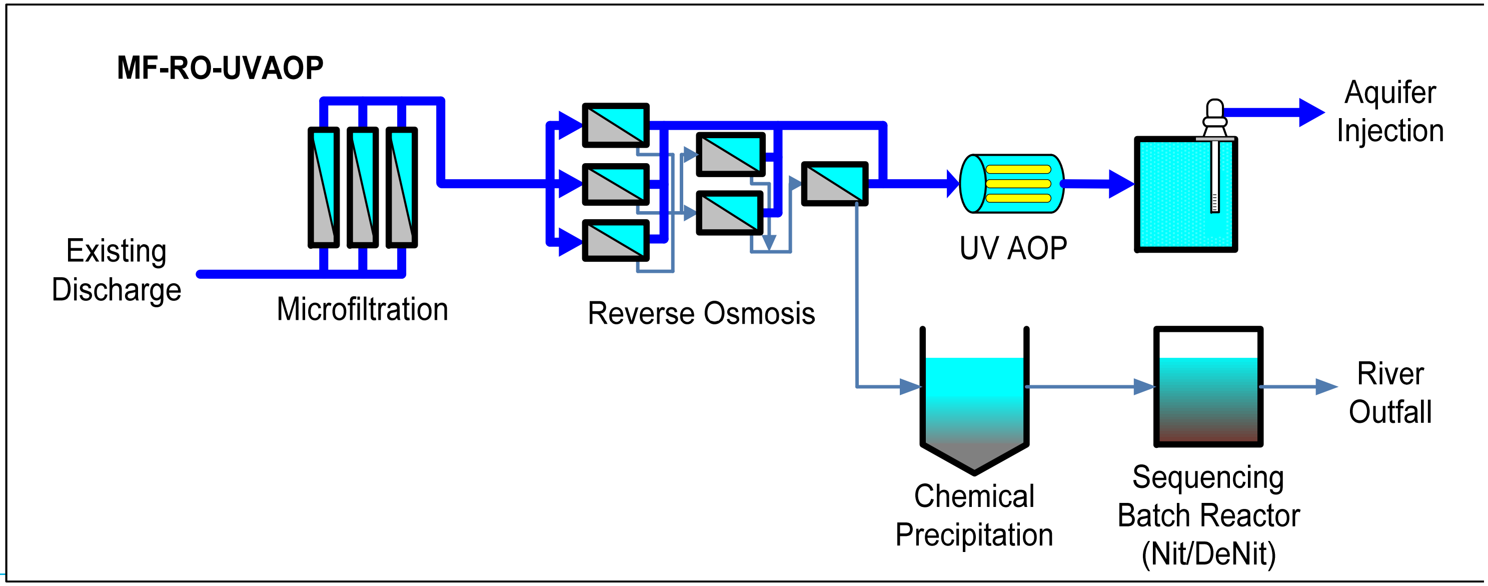
- Important to inject similar water quality to that present in the aquifer
  - Ionic strength should be within ½-order of magnitude of aquifer (TDS ~ 1,400 – 4,800 mg/L) to prevent swelling, repulsion, and migration of clay mineral fragments
  - Proportion of major ions should match to prevent damaging ion exchange
    - Calcium (~30 mg/L) and sodium (~1,000 mg/L)
- EPA secondary MCL for TDS = 500 mg/L
- Pilot values for Carbon-based Train:
  - 50th Percentile: 550 mg/L
  - 99th Percentile : 690 mg/L
- Recommendation:
  - Given high ionic strength of aquifer, aquifer compatibility should take precedence over finished water TDS limit
  - No specific TDS limit; targets will be created for compatibility

Advanced water treatment alternatives

Carbon Based



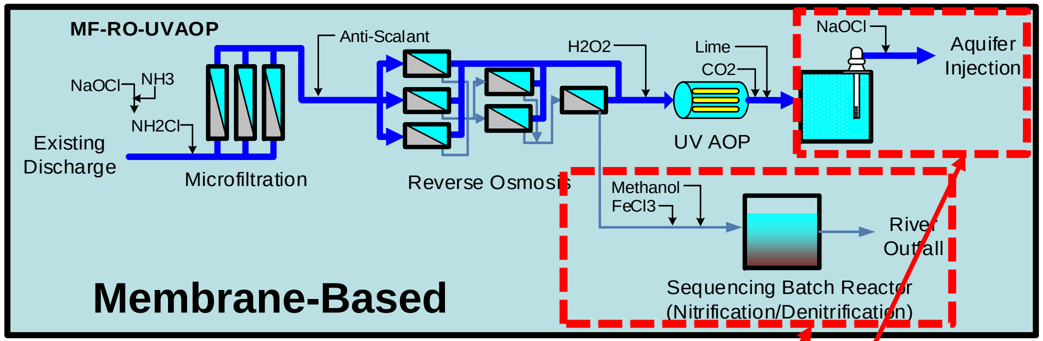
Membrane Based



The SWIFT Pilot

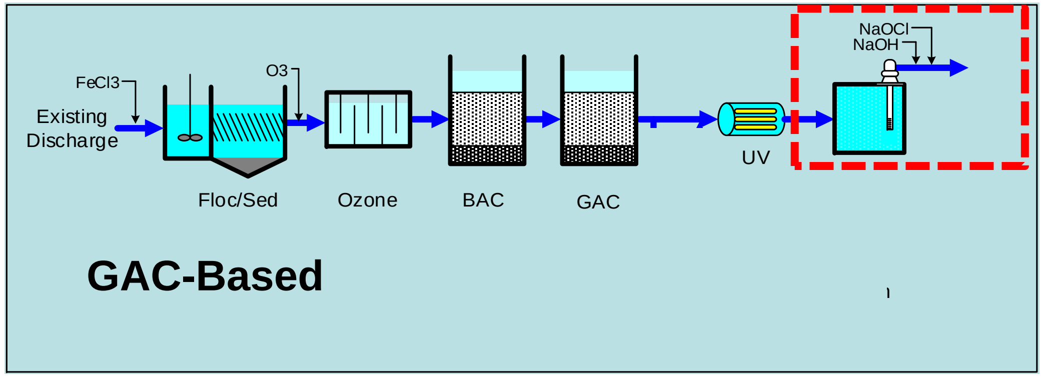
Pilot Plants

- Membrane-Based Train
  - Ultrafiltration
  - Reverse Osmosis
  - UV Advanced Oxidation



- Carbon-Based Train
  - Coagulation/Flocculation/Sedimentation
  - Ozone oxidation
  - Biologically Active Granular Activated Carbon (BAC)
  - Granular Activated Carbon (GAC)
  - UV Disinfection

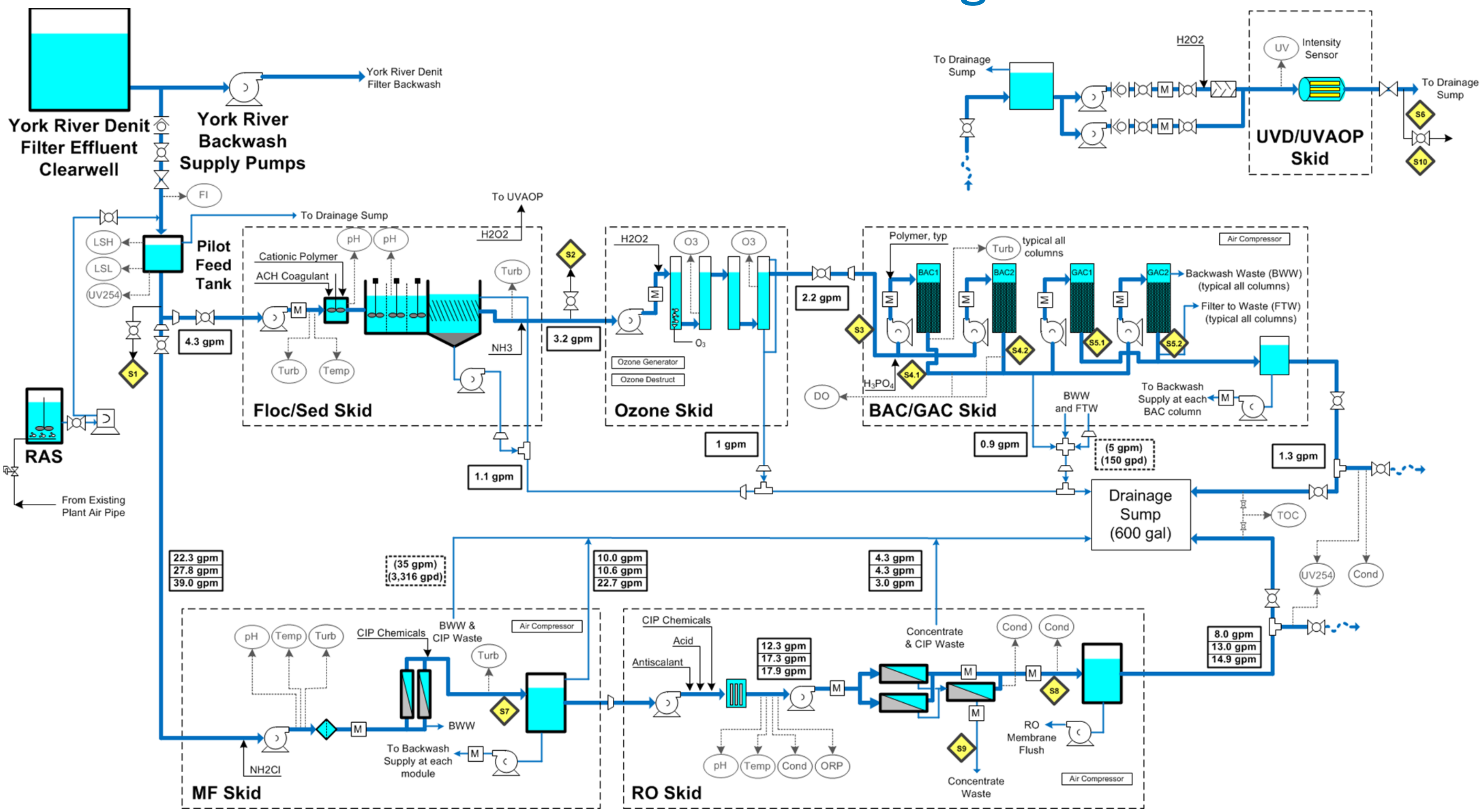
Not tested during piloting



Membrane-Based Pilot

Carbon-Based Pilot

SWIFT Pilot Process Flow Diagram



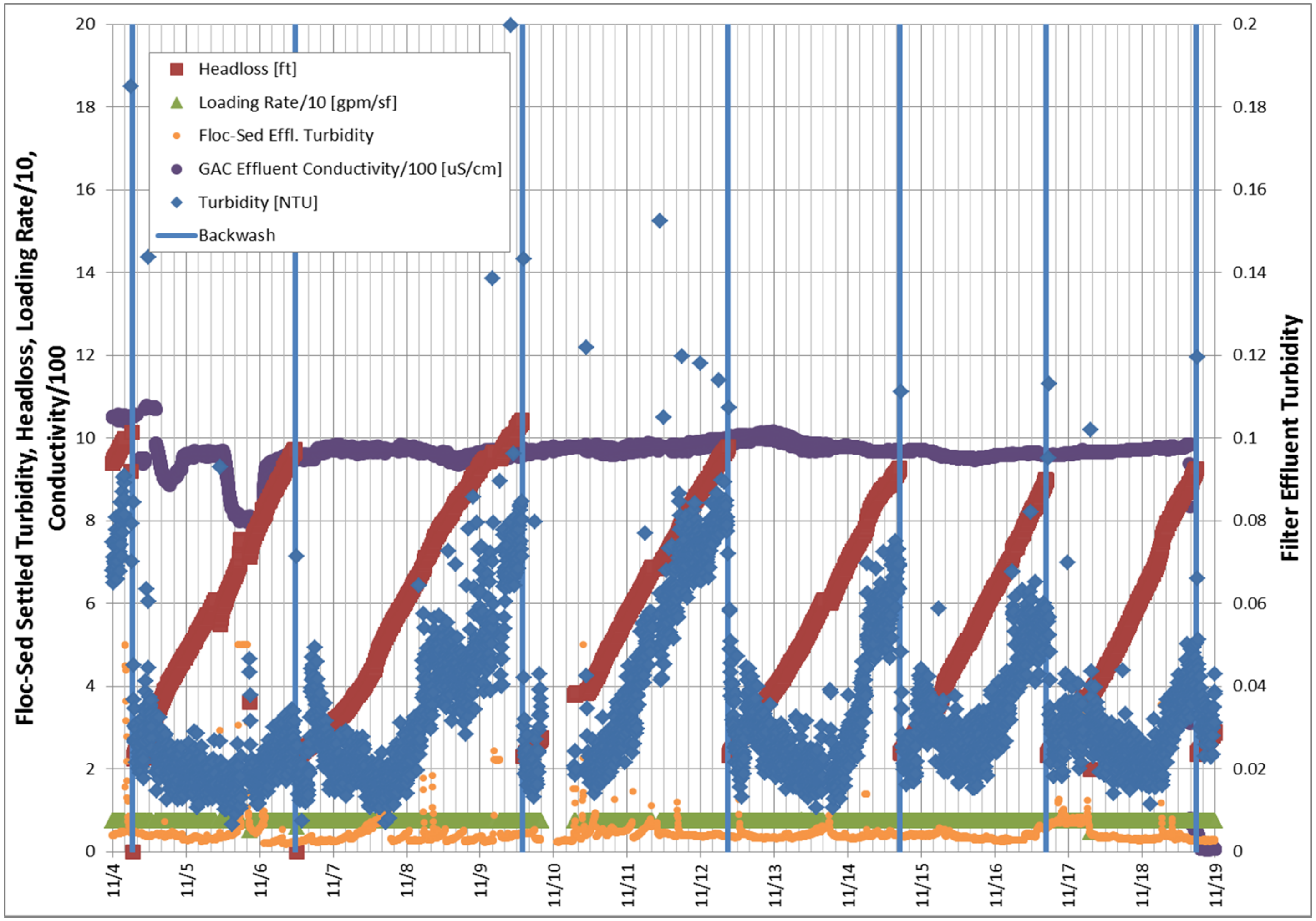
Preliminary Pilot Testing Results

- Both trains meet drinking water quality standards
- All primary MCLs (regulated) are being met
  - Bromate has been the only challenge (expected)
- All secondary MCLs (aesthetics) are being met, except in the Carbon-based AWT system:
  - TDS (salt) is slightly above 500 mg/L (50%/95% = 523/550 mg/L)
  - Sulfate and chloride are consistently less than 250 mg/L

BAC and GAC

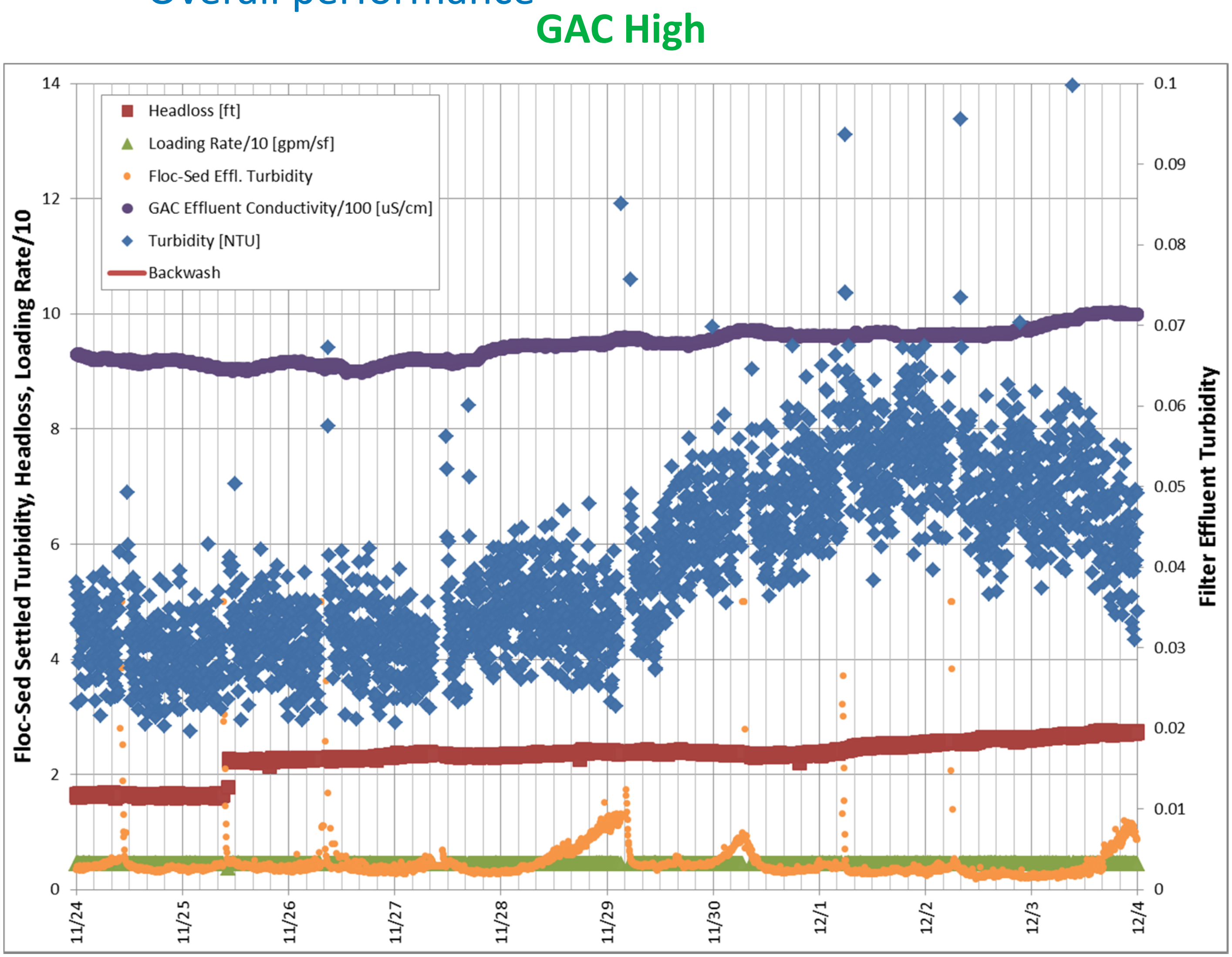
Overall performance

BAC High

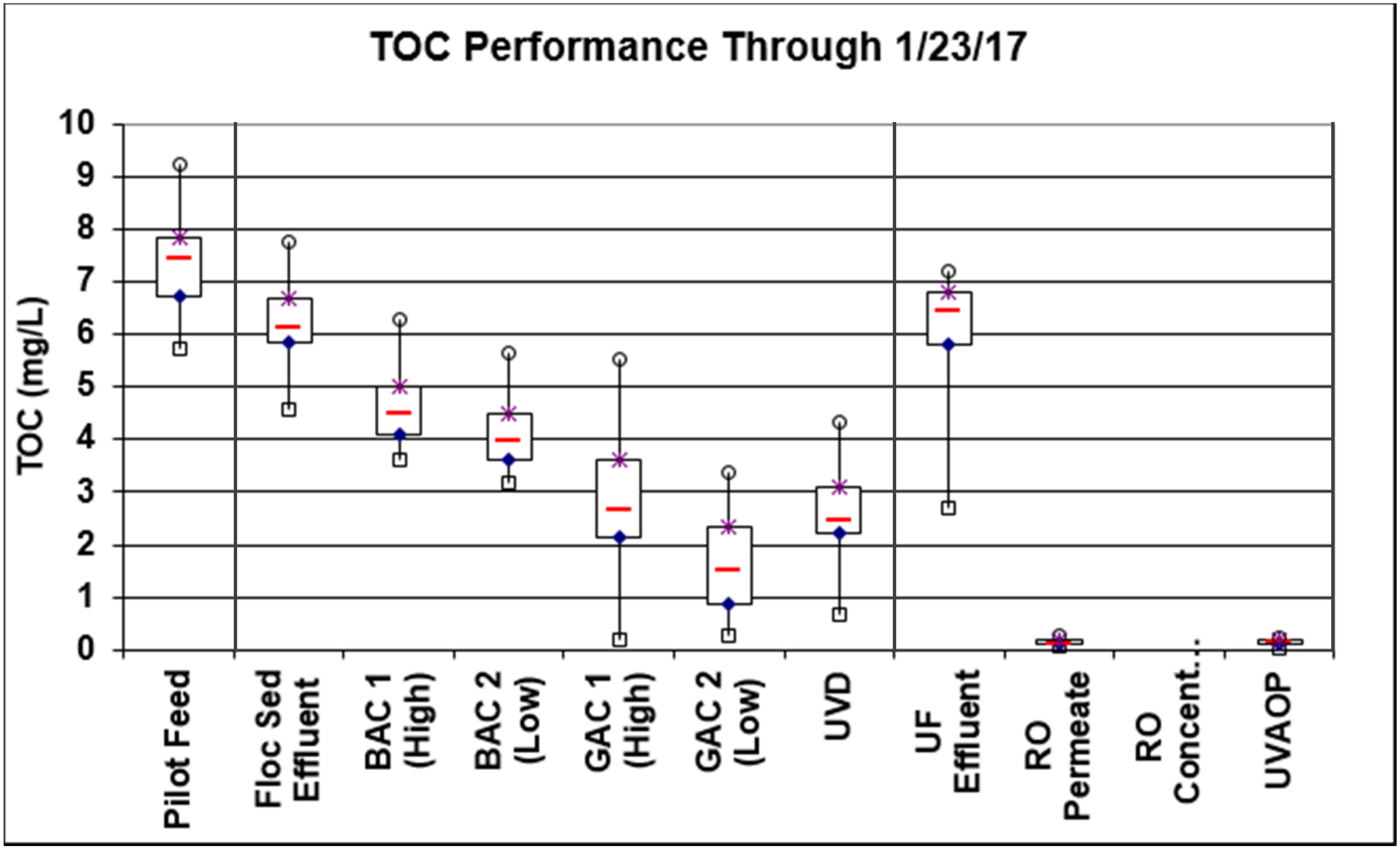


BAC and GAC

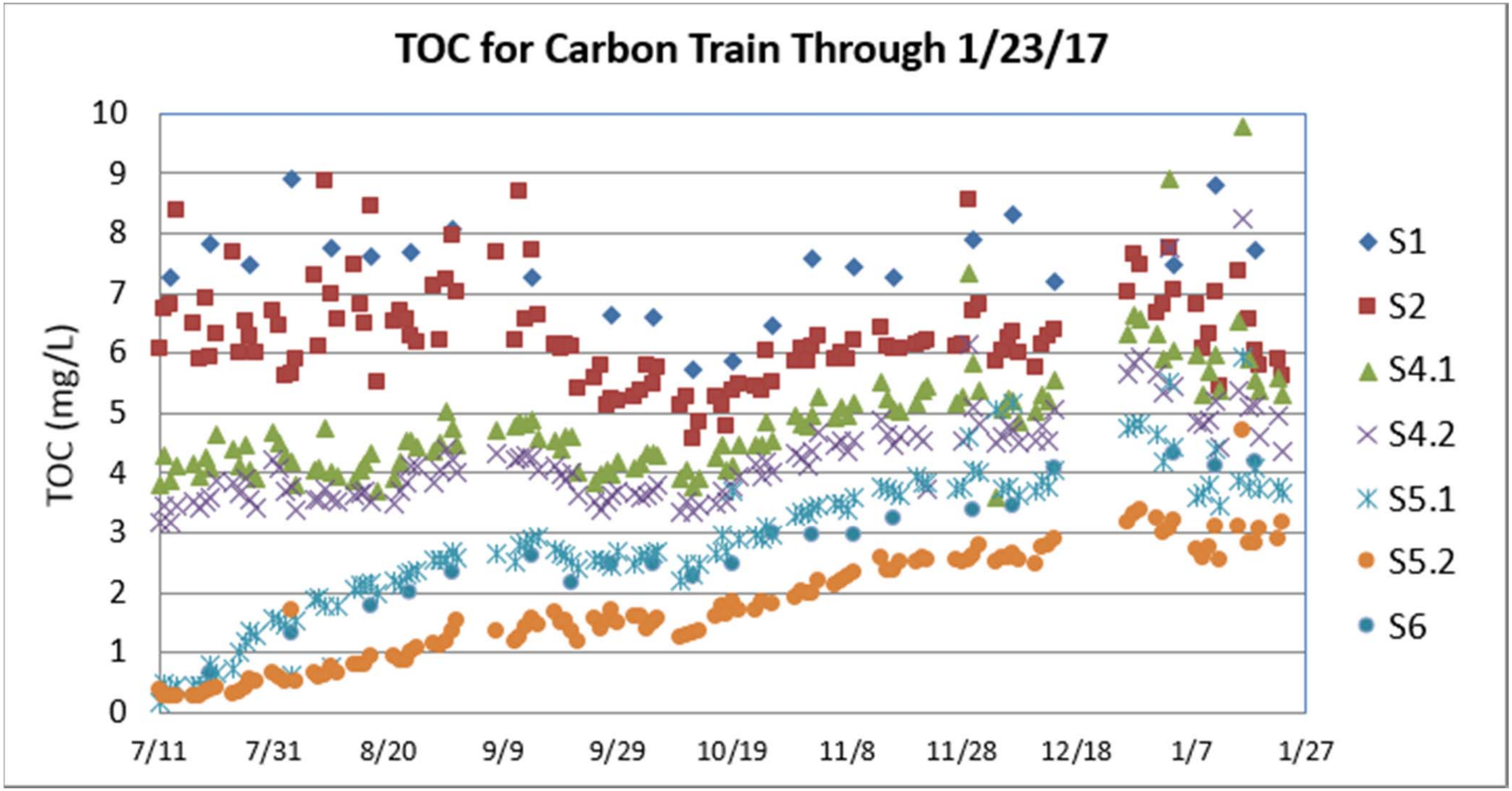
Overall performance



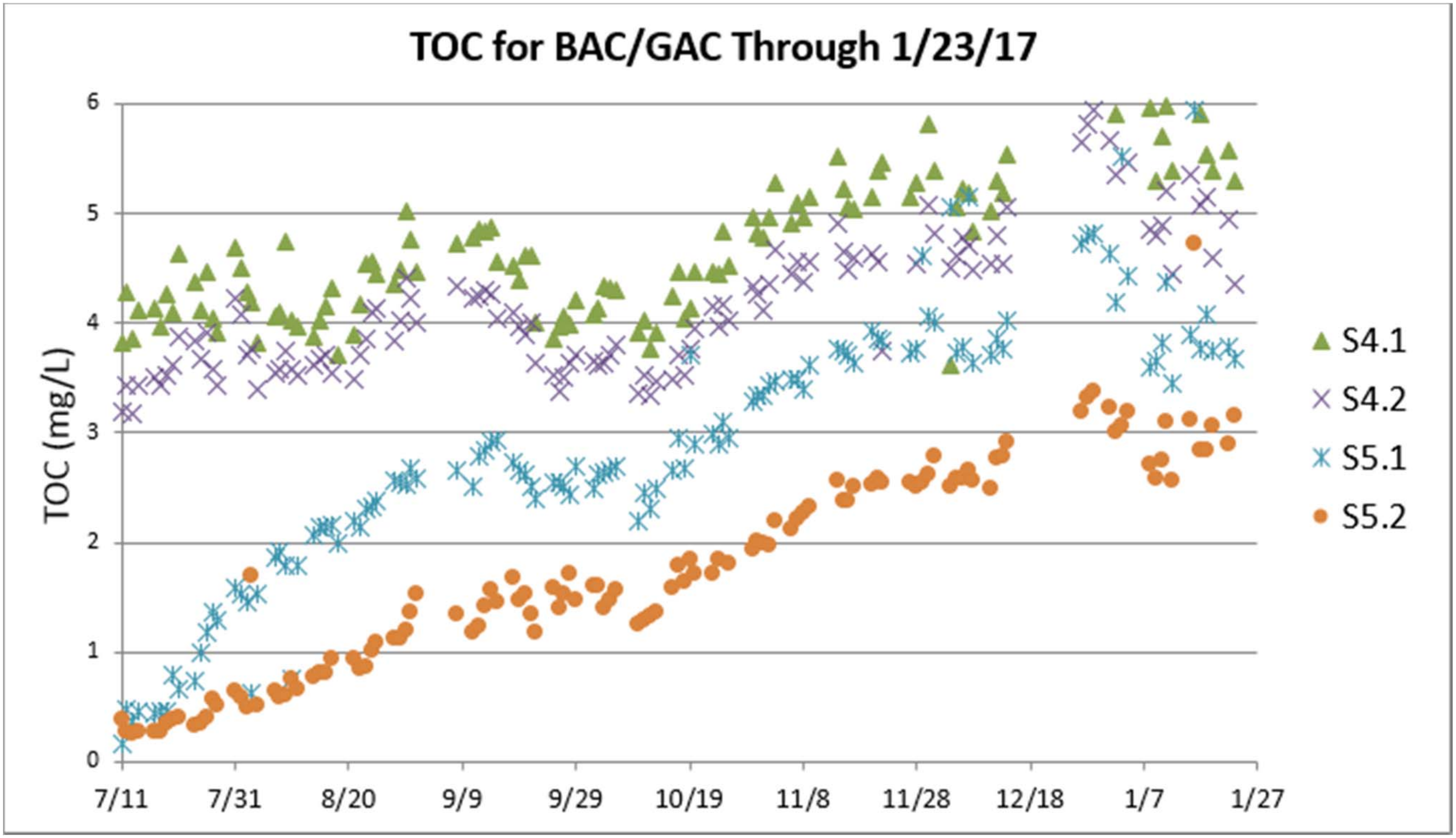
TOC Performance



TOC Performance: Carbon-Based



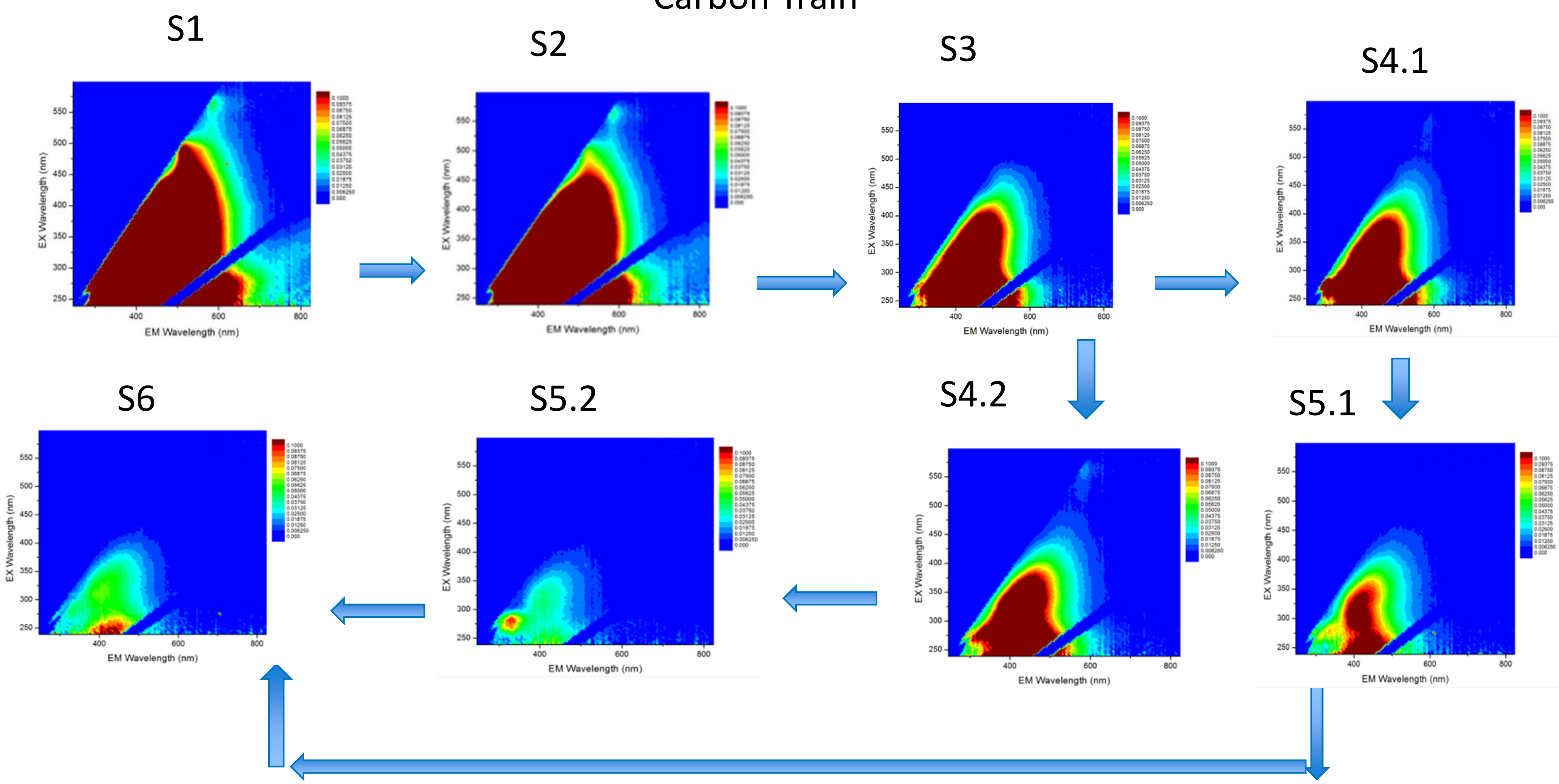
TOC Performance: Carbon-Based



Fluorescence Spectroscopy

Total Fluorescence through treatment process

Carbon Train

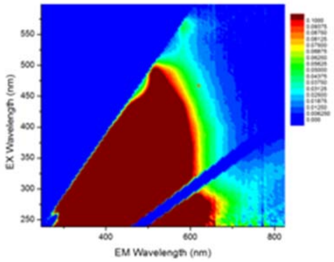


Fluorescence Spectroscopy

Total Fluorescence through treatment process

Membrane Train

S1



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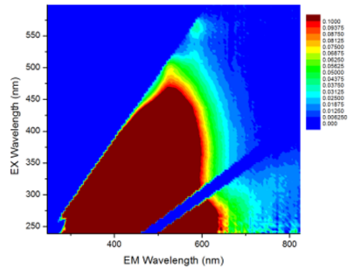

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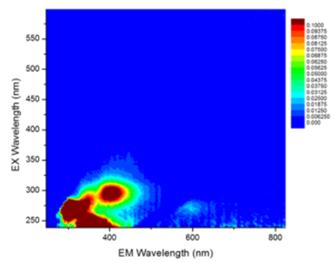

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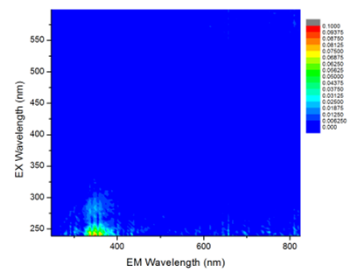
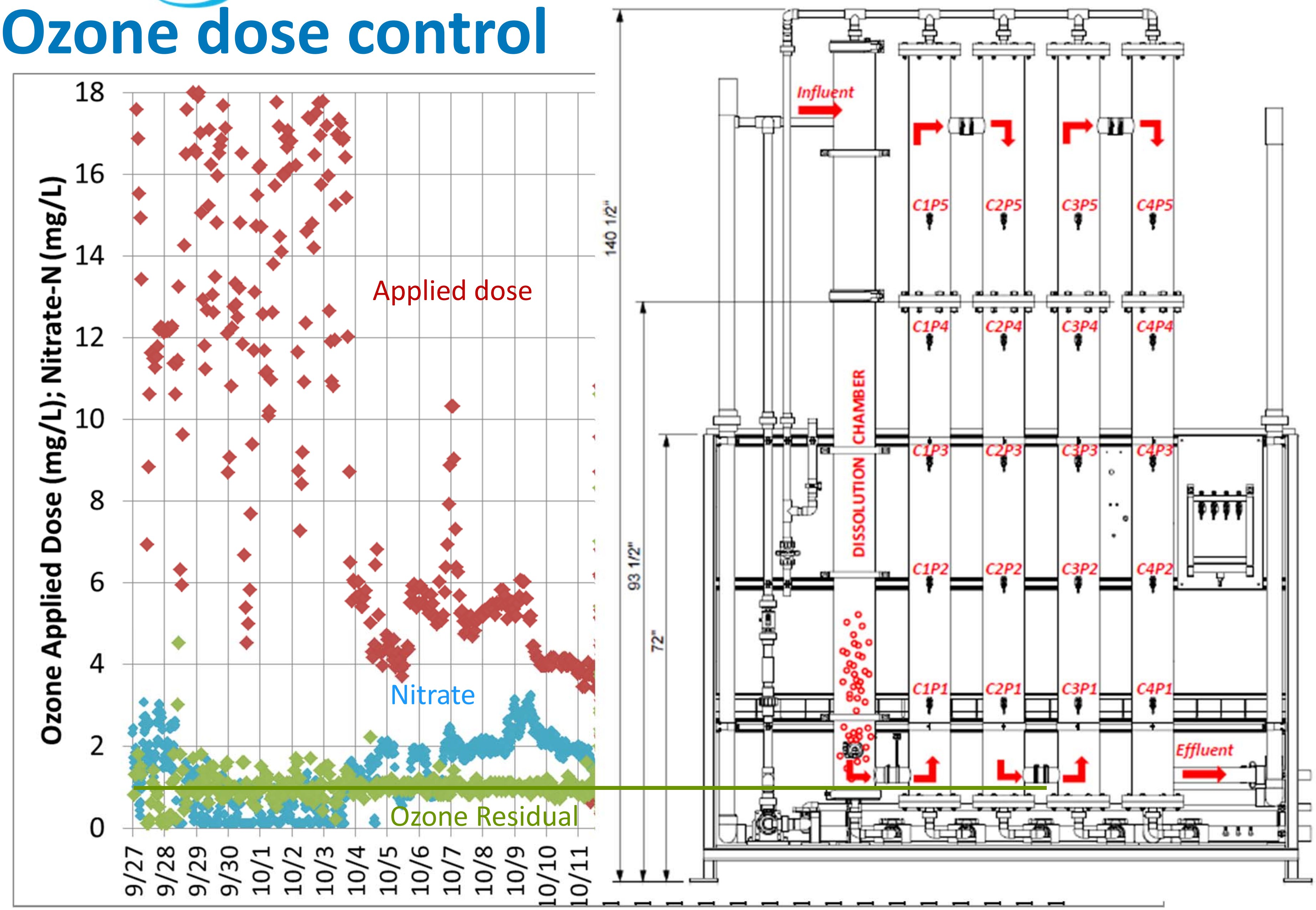


Ozone dose control



Pilot Plant Performance – Viruses

Pilot Influent Results from 7-10 Samples		
Virus	**Copies/100 ml**	**Notes**
Male-Specific Coliphage	3.72E+01	Non-Pathogenic
Somatic Coliphage	1.56E+03	Non-Pathogenic
Human Polyomavirus	0.00E+00	
Human Adenovirus	5.08E+02	
Enterovirus	1.24E+02	
Norovirus GI	8.48E+01	
Norovirus GII	1.98E+02	
Pepper Mild Mottle Virus	8.56E+05	Non-Pathogenic

Pepper Mild Mottle Virus Removal		
Location	**Copies/100 ml**	**LRV**
Influent	8.56E+05	-
Floc/Sed Eff.	1.96E+04	1.6
BAC1 Effl.	1.01E+02	3.9
BAC2 Eff.	1.15E+02	3.9
GAC1 Eff	6.11E+00	5.1
GAC2 Eff	0.00E+00	>5.9-log
UVD Eff	0.00E+00	>5.9-log

- Removal of all viruses present to below detection limits

Protozoa (Method 1623)

DATE	LOCATION	**GIARDIA** CYSTS/L	Volume L	**CRYPTOSPORIDIUM** CYSTS/L	Volume L
6/21/2016	AB FNE	3.96E+00	10	<0.01	10
6/21/2016	BH FNE	2.00E+00	10	8.40E+00	10
6/21/2016	JR FNE	8.00E-01	10	4.00E-01	10
6/21/2016	NP FNE	4.70E+00	10	1.00E+00	10
6/21/2016	VIP FNE	1.16E+01	10	1.00E+00	10
6/21/2016	WB FNE	7.00E+00	10	4.00E-01	10
6/21/2016	YR FNE	<0.01	10	<0.01	10

DATE	LOCATION	**GIARDIA** CYSTS/1 L	Volume L	**CRYPTOSPORIDIUM** CYSTS/1 L	Volume L
10/26/2016	S1	<0.01	10	<0.01	10
10/26/2016	S3	<0.01	10	<0.01	10
10/26/2016	S4.1	<0.01	10	<0.01	10
10/26/2016	S4.2	<0.01	10	<0.01	10
10/26/2016	S5.1	<0.01	10	<0.01	10
10/26/2016	S5.2	<0.01	10	<0.01	10
10/26/2016	S6	<0.01	10	<0.01	10
10/26/2016	S8	<0.01	10	<0.01	10
10/26/2016	S10	<0.01	10	<0.01	10

swift

Total Coliform and E. Coli

50% and 99% values for TC and EC

TC Sept 14 – Present EC

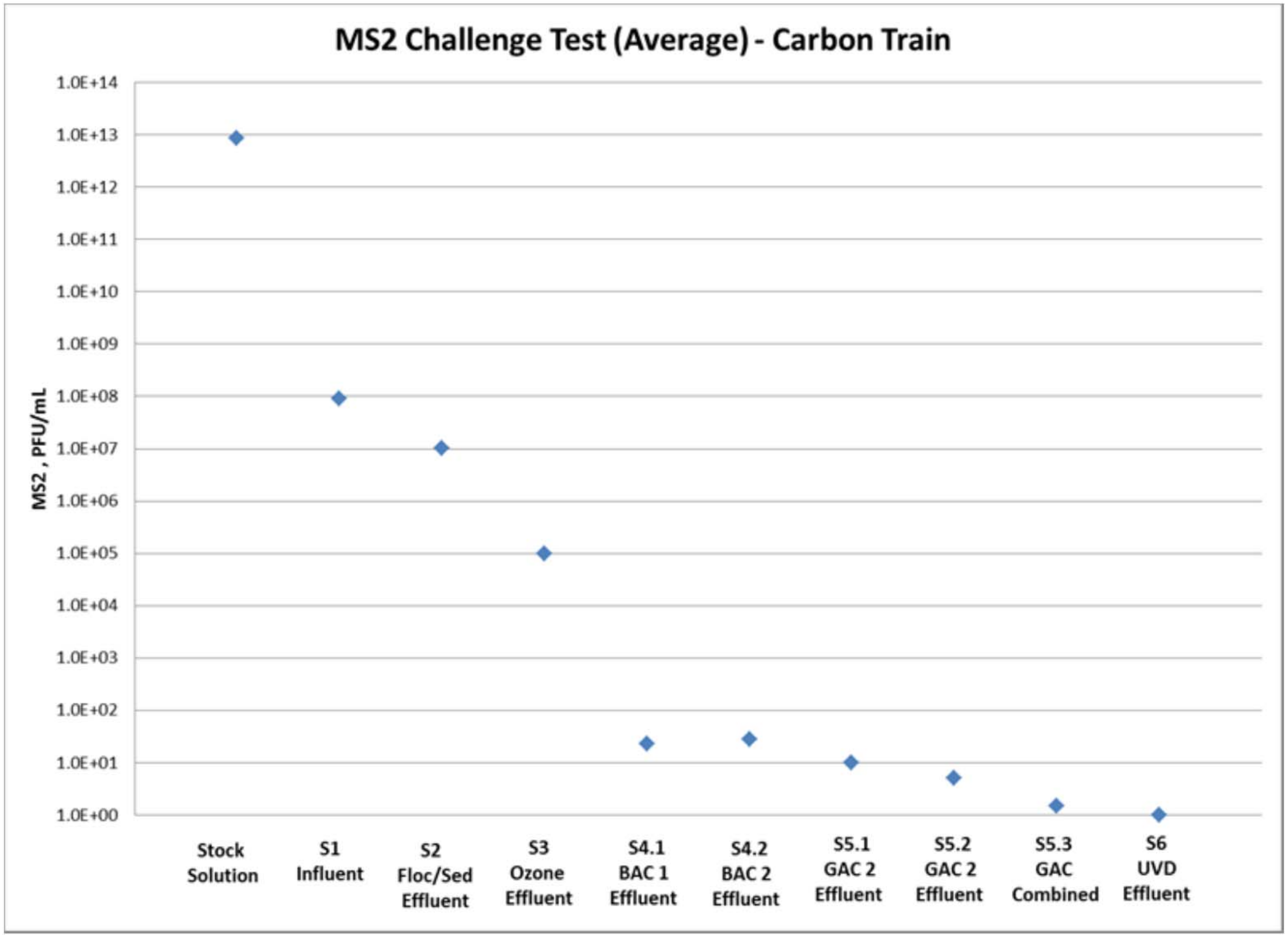
TC	n	50%	99%
S1	31	19400	101370
S2	31	17	240
S3	31	0	2
S4.1	30	0	6
S4.2	30	2	11
S5.1	30	2	12
S5.2	30	4	115
S5.3	30	0	29
S6	31	0	0
S7.1	28	22	2031
S7.2	31	0	476
S7	31	1	1141
S8	29	0	3
S10	30	0	1

EC	n	50%	99%
S1	31	1320	12999
S2	31	0	1
S3	31	0	0
S4.1	30	0	1
S4.2	30	0	0
S5.1	30	0	0
S5.2	30	0	0
S5.3	30	0	0
S6	31	0	0
S7.1	28	0	0
S7.2	31	0	0
S7	31	0	0
S8	29	0	0
S10	30	0	0

- Positive hits on filters
- DOW and TORAY swapped but still continued to get hits

MS2 Challenge Test at Pilot Plant (8-log MS2)

Location	LRV
GAC TRAIN	
Floc/Sed	1
Ozone	2
BAC	3.5
GAC	>1
Cl2	N/A
UVD	N/A
RO TRAIN	
UF	3
RO	>5
UVAOP	N/A



Contaminants of Emerging Concern (CECs)

- Pilot has demonstrated good removal of CECs in both carbon- and membrane-based trains
- Total number of measured CECs, per sample date:

Date	Pilot Feed*	GAC1 Eff	GAC2 Eff	UVAOP Eff
6/22/2016	23	N/A	N/A	1
8/17/2016	24	0	0	1
8/31/2016	24	4	1	2
9/28/2016	27	4	1	2
10/12/2016	30	4	1	1
10/26/2016	20	3	2	2
11/9/2016	22	5	6	3
Total	170	20	11	12

*A total of 96 CECs are measured at each location on each sample date

Contaminants of Emerging Concern (CECs)

- Treatment case study for 8/31/16
- Multi-barrier approach is shown by decrease in concentration through the treatment process
- All values shown in ng/L

Contaminant	Pilot Feed	Ozone Eff	BAC1 Eff	BAC2 Eff	GAC1 Eff	GAC2 Eff	RO Eff	UVAOP Eff
Iohexal	7500	4000	1500	1400	15	<10	31	<10
Sucralose	43000	28000	17000	12000	<100	<100	140	130
TCPP	980	720	260	110	<100	<100	<100	<100
Primidone	130	46	28	21	<5	<5	<5	<5

swift

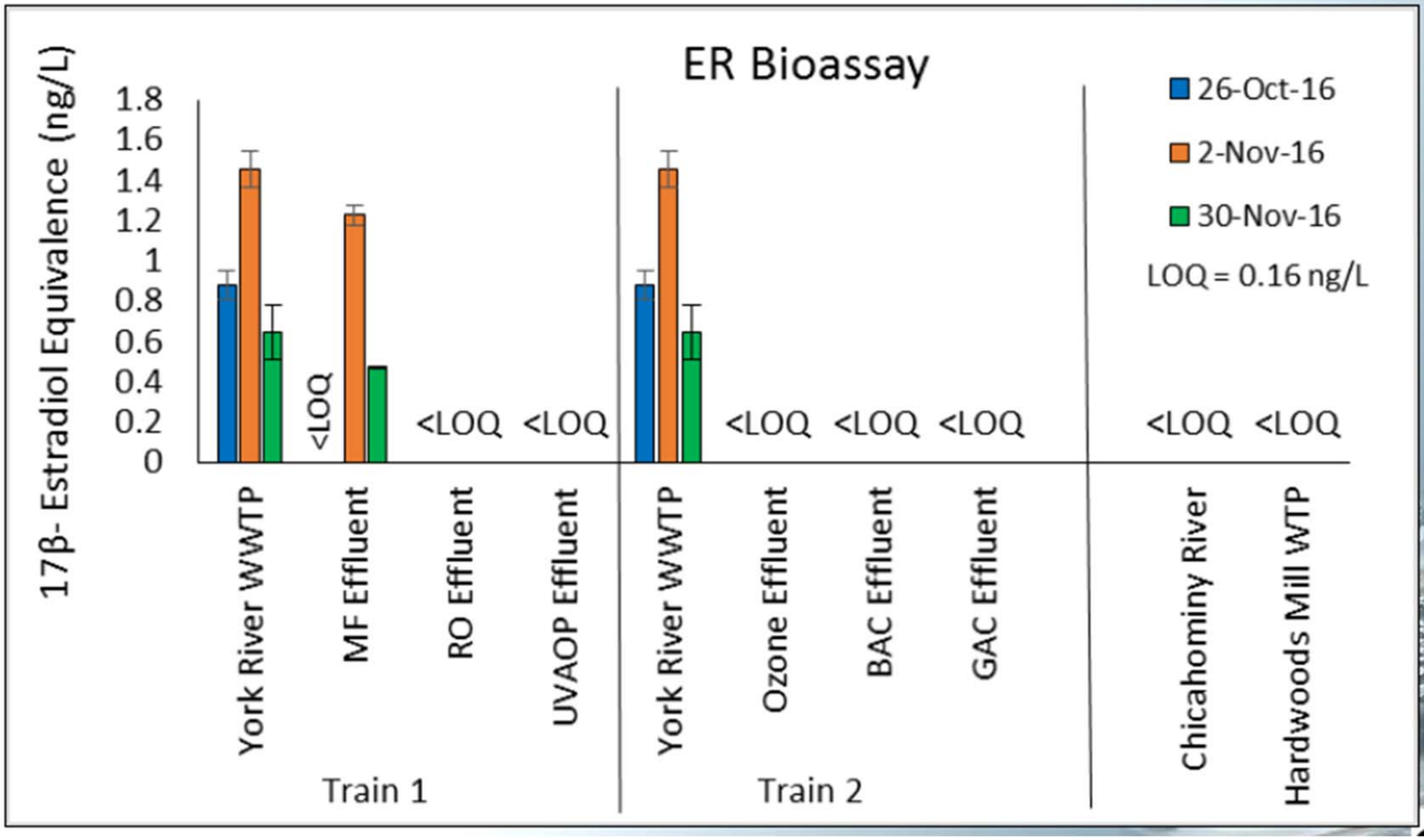
Contaminants of Emerging Concern (CECs)

Contaminant	Pilot Feed	GAC1 Eff	GAC2 Eff	UVAOP Eff
Sucralose	260000	61000	<100	<100
Sulfamethoxazole	4100	<5	7.9	<5
4-nonylphenol	2200	870	690	800
Acesulfame-K	2100	870	130	<20
Lidocaine	1800	<5	<5	<5
Theobromine	520	<10	<10	<10
Cimetidine	450	<5	<5	<5
TCPP	330	<100	<100	<100
TDCPP	220	<100	<100	<100
Dilantin	190	<20	<20	<20
4-tert-octylphenol	160	170	190	340
TCEP	130	<10	<10	<10
BPA	93	<10	52	<10
Atenolol	87	<5	<5	<5
Albuterol	41	<5	<5	<5
DEET	30	<10	<10	<10
Carisoprodol	18	<5	<5	<5
Testosterone	13	<5	<5	<5
Diuron	12	<5	<5	<5
DEA	11	<5	<5	<5
Andorostenedione	9.5	<5	<5	<5
Dehydronifedipine	5.9	<5	<5	<5

- Treatment case study for 11/9/16
- All CECs measured in pilot feed are shown
- All values in ng/L

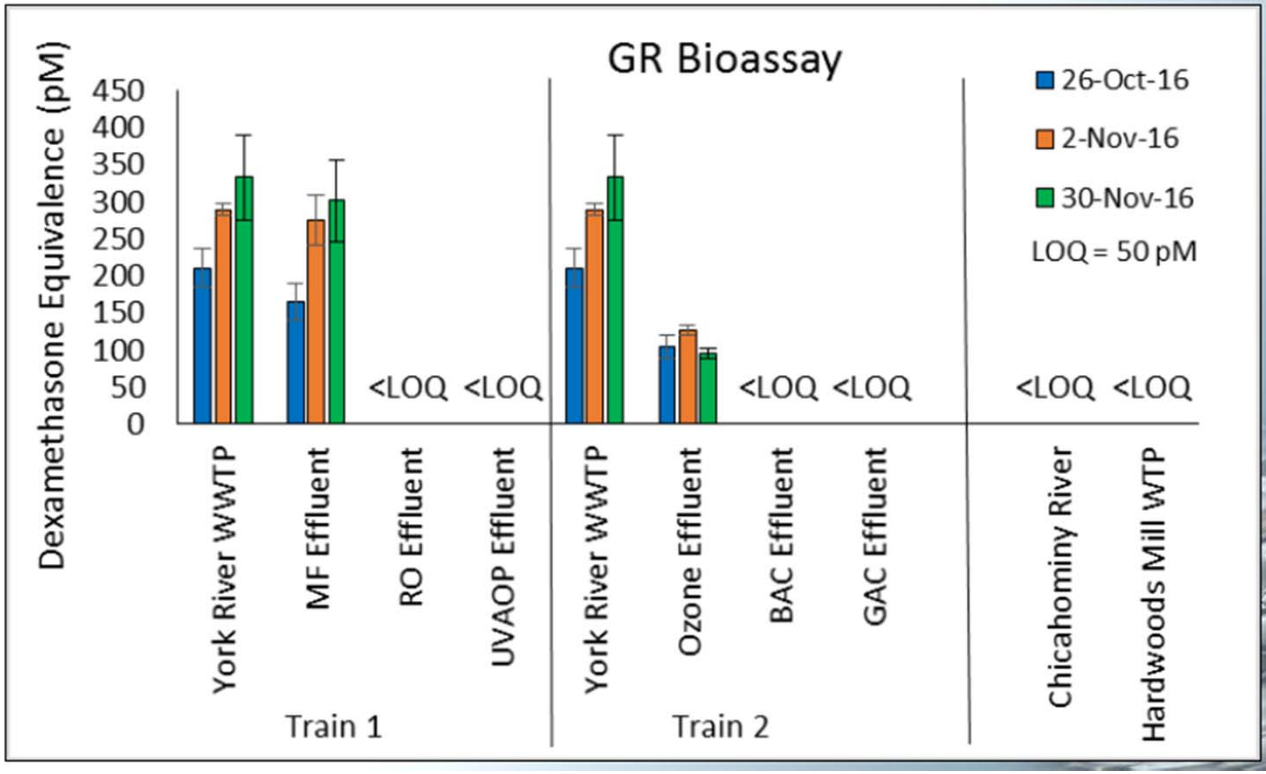
Preliminary Bioassay Results

- Estrogen Receptor Bioassay:
  - Response is fully attenuated after RO treatment
  - Response is fully attenuated after Ozone treatment



Preliminary Bioassay Results

- Glucocorticoid Receptor Bioassay:
  - Response is fully attenuated after RO treatment
  - Response decreases with ozone treatment and is fully attenuated after BAC treatment



Timeline

- Complete next phase of study with consultant by end of 2016
- Pilot AWT system – operating since June 2016
- 2018
  - SWIFT Demonstration facility
- 2020
  - Permits issued for full scale
- 2020 to 2030
  - Construction through phased implementation
- 2030 Fully operational
  - 120 MGD of clean water injected into the aquifer

HRSD

Why now?

- Consent Decree requires plan submittal with schedule to EPA October 2017
  - Lose financial ability to pursue water recycling project until 2037 at earliest
- Bay TMDL deadline is 2025
  - Will require more significant investments in nutrient and sediment removal without SWIFT
  - HRSD is backstop if Agriculture and Stormwater come up short
- Groundwater scarcity will continue to get worse
  - Will force development of additional water supplies by local governments
  - Chills development in eastern Virginia
  - Potential loss of water dependent industries
- Next regulation (viruses, emerging contaminants, ???) will require plant upgrades

The Virginian-Pilot
UP TO $148 IN COUPONS TODAY

Can your sinks and toilets fight sea-level rise?

SINKING LAND is part of the problem, as society guzzles groundwater. One solution is to pump treated wastewater back in.

Virginia GOP asks state to cancel "loyalty oath"

Daily Press
SUNDAY, OCTOBER 11, 2015

GROUNDWATER DRAIN: A BIG-DOLLAR DILEMMA

Groundwater water level decreases
From 1900 to 2008

PENINSULA CITIES IN ECONOMIC DOLDRUMS

Facing sluggish job growth, defense cuts, region fares poorly in national rankings

HRSD doesn't want to waste wastewater

By Dave Mayfield
The Virginian-Pilot

SEAFORD

Ted Henifin crouched next to a floor drain at the Hampton Roads Sanitation District's York County treatment plant. Into his palm ran a soft stream of clear water – clean enough, probably, to drink. But the lab results aren't back to confirm that. So, Henifin will hold off before he sips.

Waiting isn't exactly Henifin's style these days. He has dived into a project to prove that HRSD can turn what Hampton Roads flushes down

See WASTE, PAGE 10

recycled

The sanitation district wants to launch a $1 billion, decadelong project that would refill the region's aquifers with treated wastewater.

NO WASTING WATER

Following the lead of other regions, local plant tries treating wastewater

By Dave Ress

Online: See more photos and video at dailypress.com.

Top: Process engineering and research manager Chris Wilson is reflected in a window displaying the first step of the carbon-based advanced water treatment process at a conference at the York River Treatment Plant Thursday. Above: HRSD general manager Ted Henifin holds a glass of purified water during the conference at the plant.

See WATER/Page 8

Ted Henifin, Hampton Roads Sanitation District general manager, vowed to take the first gulp of HRSD's treated wastewater. He made good on his promise Thursday.

Sip shape

Hampton Roads Sanitation District's treated sewage water tastes great, say officials, and could shore up the area's sea level rise and bay cleanup issues

By Dave Mayfield
The Virginian-Pilot

YORK COUNTY

Earlier this year, as the Hampton Roads Sanitation District ramped up plans to make its wastewater clean enough to drink, general manager Ted Henifin vowed he'd take the first gulp.

On Thursday at the HRSD's York County treatment plant, Henifin made good on the promise, leading dozens of employees and invited guests in downing glasses of water that came from a sewage stream fed by sinks and toilets.

"Great!" he proclaimed after his first sip. "Ahhh."

To Henifin, it was no mere stunt. It was an early demonstration of the potential for an ambitious initiative to turn what goes down Hampton Roads'

See HRSD, BACK PAGE

HRSD

Hopes that wastewater can conserve land in coastal Va.

BY DARRYL FEARS

SEAFORD, VA. — It looks like a mad scientist's lab, something straight out of a sci-fi novel. Valves turn in every direction. Tubes are stacked halfway to the ceiling. Tiny bubbles dance in large vats of water.

But what's happening in a hangar of the York River Treatment Plant is real, part of a grand experiment that could help keep this coastal region from continuing to subside and eventually being claimed by the rising sea. Over the next 15 months, tests will determine whether millions of gallons of wastewater can be purified to drinking water quality and injected into the ground.

If successful, the project of the Hampton Roads Sanitation District could start to replenish a giant aquifer that thousands of industries and half a million households in the area are sucking dry. Over the past five decades, they have collectively pumped out so much water that land here is falling 4 millimeters a year — or more than 1½ inches by 2026.

Ted Henifin's jaw-dropping, eyebrow-raising idea was proposed in 2015, and last month the sanitation district general manager kicked off the pilot phase to stop what some scientists have called a nightmare in super slow motion.

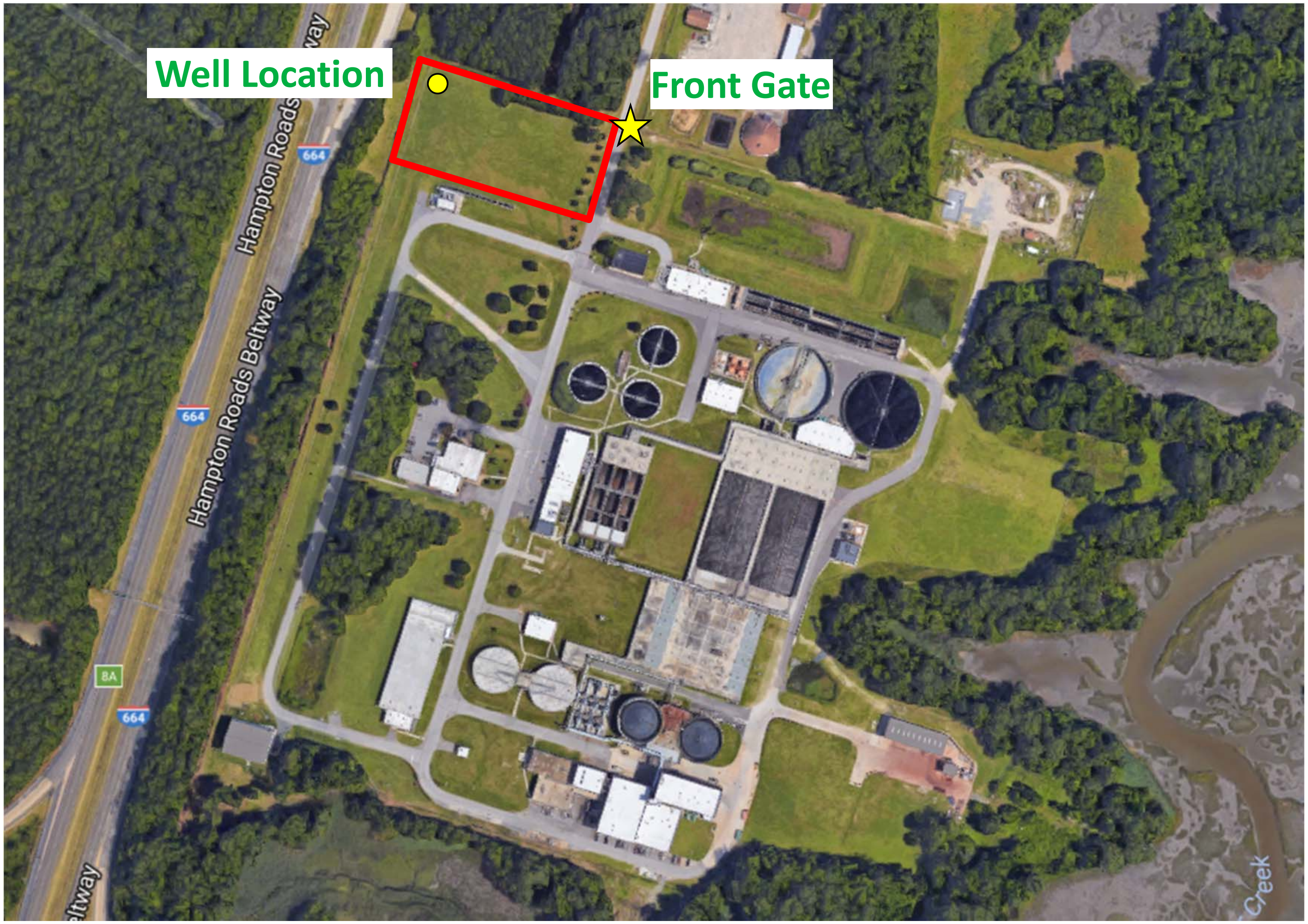
Aquifers big and small exist under Hampton Roads in muddy

AQUIFER CONTINUED ON A16

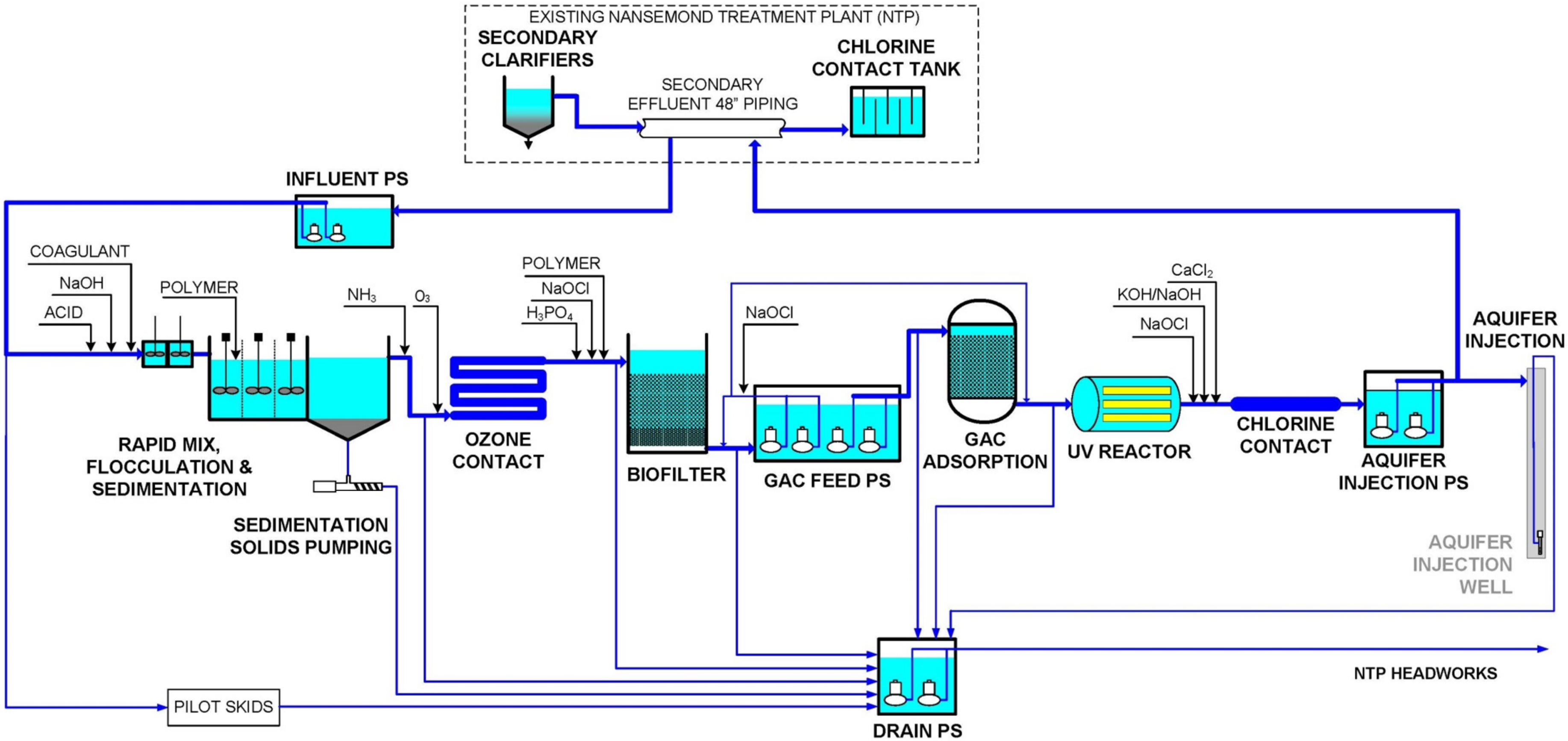
HRSD

SWIFT Demonstration Facility – 1 MGD with Injection Well

Location of facility within Nansemond TP site



Process Flow Diagram



Finished Water Quality Preliminary Targets

Parameter	Proposed Regulatory Limit	Water Quality Goal (non-regulatory)
MCLs	Meet all primary MCLs	N/A
Nitrate (NO3-N)	5 mg/L monthly average; 8 mg/L max daily	Secondary Effluent CCP Action Limit for TIN = 8 mg/L
Turbidity	IFE <0.15 NTU 95% & never > 0.3 NTU in two consecutive measurements	CCP Action Limit at 0.10 NTU
TOC	4 mg/L monthly average (TBD)	CCP Action Limit at ? mg/L (TBD)
Total coliform	< 2 CFU / 100 mL; 95th perc.	CCPs to achieve 12 LRV for viruses and 10 LRV for Crypto & Giardia
E. Coli	Non-detect	
Unregulated Chemicals	None	Monitor suite of chemicals and address as necessary
Total Dissolved Solids	None	None

Design to Achieve Expected Pathogen LRVs – 12/10/10 including SAT (NWRI Recommendation)

Operate to achieve using CCPs

Parameter	Log Reduction Credits								
	Coag/Sed (+BAC)	Ozone	BAC	GAC	UV (186 mJ/cm^2)	Cl_2	Total AWT	SAT	Total
Enteric Viruses	2	3	0	0	4	4	13	Up to 6	>12
Cryptosporidium	4	0	0	0	>6? (4 allowed)	0	10 (8)	>6	>10
Giardia	2.5	1.5	0	0	>6? (4 allowed)	0	10 (8)	>6	>10

Unregulated Chemical Constituents that are of Public Health Interest (*Final Report of an NWRI Independent Advisory Panel: Recommended DPR General Guidelines and Operational Requirements for New Mexico, 2016*)

Chemical	Criterion	Carbon-based Train Conc.	Notes
1,4-Dioxane	1 µg/L	0.34-0.39 µg/L[1]	CCL3; CA Notification limit
17-B-estradiol	TBD (ng/L range)	<0.005 µg/L[2]	CCL3
DEET	200 µg/L	<0.010 µg/L[2]	Minnesota Health guidance value
Ethinyl Estradiol	TBD (ng/L range)	<0.005 µg/L[2]	CCL3
NDMA	10 ng/L	6.6 -14 ng/L[3]	CCL3; CA Notification limit
Perchlorate	6 µg/L	< 4 µg/L[4]	CA Notification limit
PFOA +PFOS	70 ng/L	< 60 ng/L[5]	USEPA Health Advisory
TCEP	5 µg/L	<0.010 µg/L[2]	Minnesota Health guidance value

1. Based on 3 samples in finished water
2. Based on 8 samples in finished water
3. Based on 9 samples in finished water
4. Based on 4 samples in pilot feed
5. Based on 1 sample in finished water

Unregulated chemical constituents that provide information on the effectiveness of treatment (*Final Report of an NWRI Independent Advisory Panel: Recommended DPR General Guidelines and Operational Requirements for New Mexico, 2016*)

Chemical	Criterion[1]	Carbon-based Train FW Conc.	Notes
Cotinine	1 µg/L	<0.010 µg/L[2]	Surrogate for low MW, partially charged cyclics
Primidone	10 µg/L	< 0.005 µg/L[2]	
Phenyltoin	2 µg/L	No data	
Meprobamate	200 µg/L	< 0.005 µg/L[2]	High occurrence in WWTP effluent
Atenolol	4 µg/L	< 0.005 µg/L[2]	
Carbamazepine	10 µg/L	< 0.005 µg/L[2]	Unique structure
Estrone	320 µg/L	< 0.005 µg/L[2]	Surrogate for steroids
Sucralose	150 µg/L	Range: <0.1 to 61 µg/L (GAC1) Range: <0.1 to 0.32 µg/L (GAC2)	Surrogate for water soluble, uncharged chemicals, moderate MW
Triclosan	2100 µg/L	<0.010 µg/L[2]	Chemical of interest

1. In most cases, criterion based on drinking water equivalent concentration for lowest therapeutic dose divided by 1,000 or 10,000 to provide a safety factor.
2. Based on 8 samples in finished water

Questions?

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