

HRSD's Vision for Managed Aquifer Recharge in Eastern Virginia

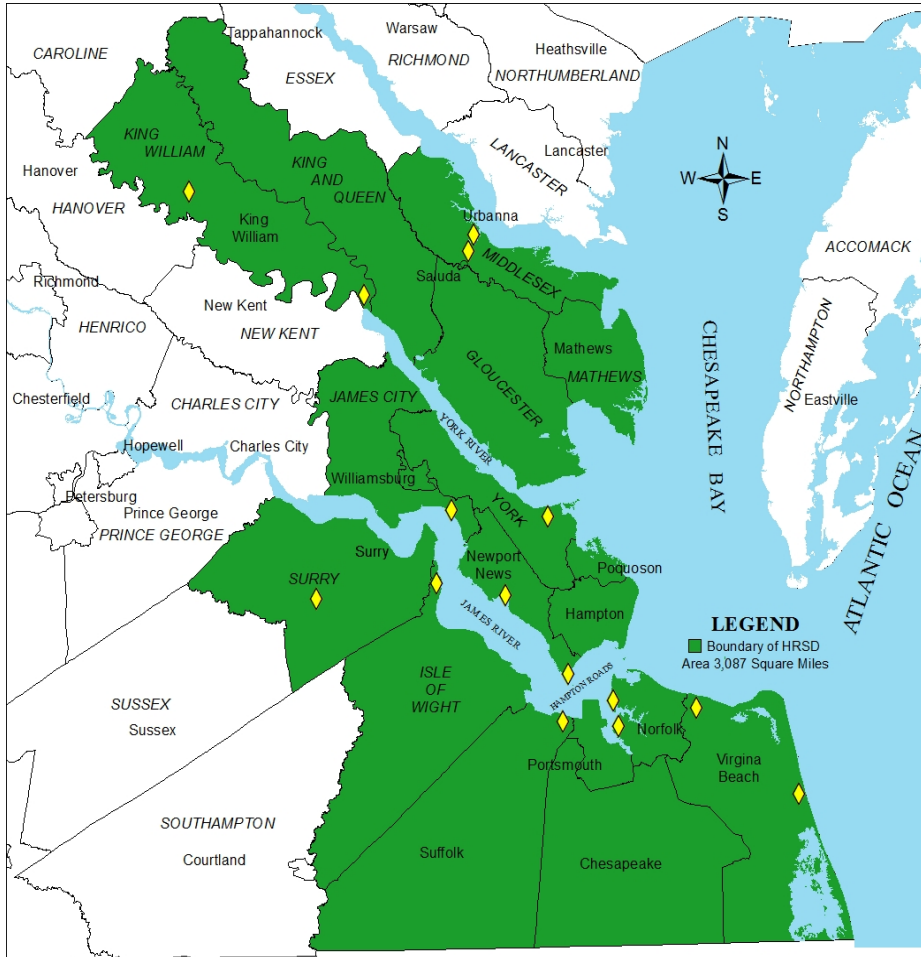


Jamie Heisig-Mitchell
Chief of Technical Services

Charles B. Bott, PhD, PE, BCEE
Director of Water Technology and Research

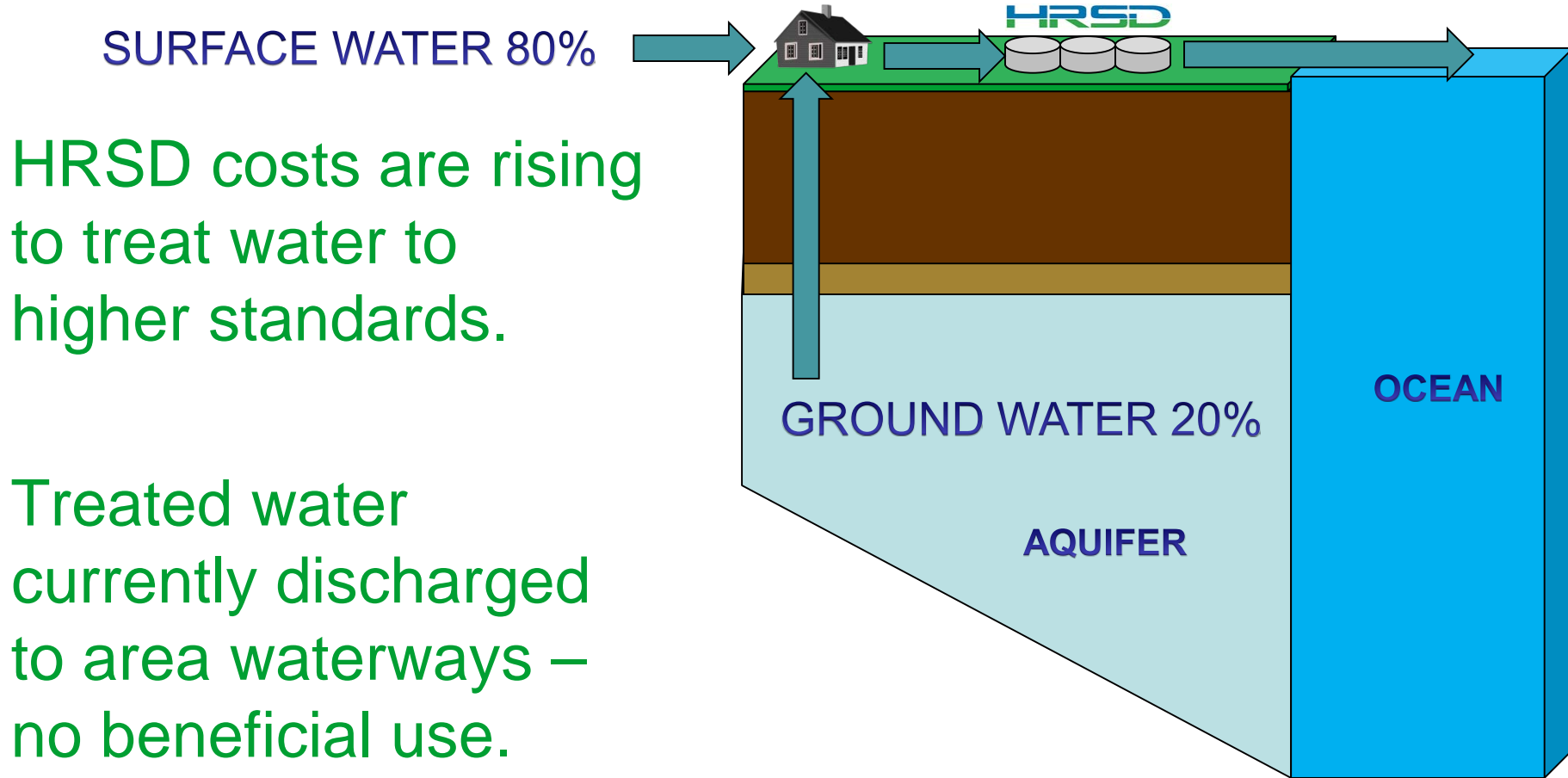


Who/What is HRSD?



- 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

Current state of wastewater in Hampton Roads



HRSD costs are rising to treat water to higher standards.

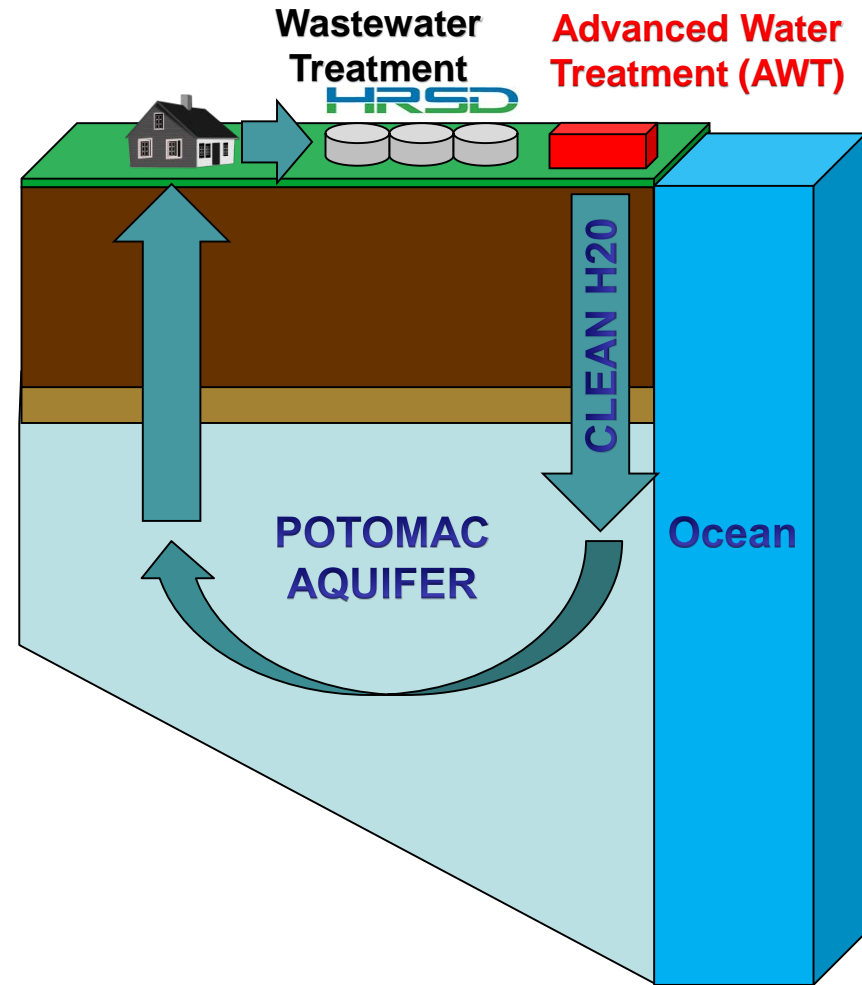
Treated water currently discharged to area waterways – no beneficial use.

The Challenges/Opportunities for HRSD

- ~\$750M in Nutrient Removal Upgrades by 2021
- ~\$2B in Consent Decreed Mandated Upgrades to Reduce Sanitary Sewer Overflows
- Very large managed aquifer recharge effort pending
 - Indirect potable reuse?
 - ~120 MGD
 - ~\$1B

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



Hydrogeologic Section: Coastal Plain of Virginia

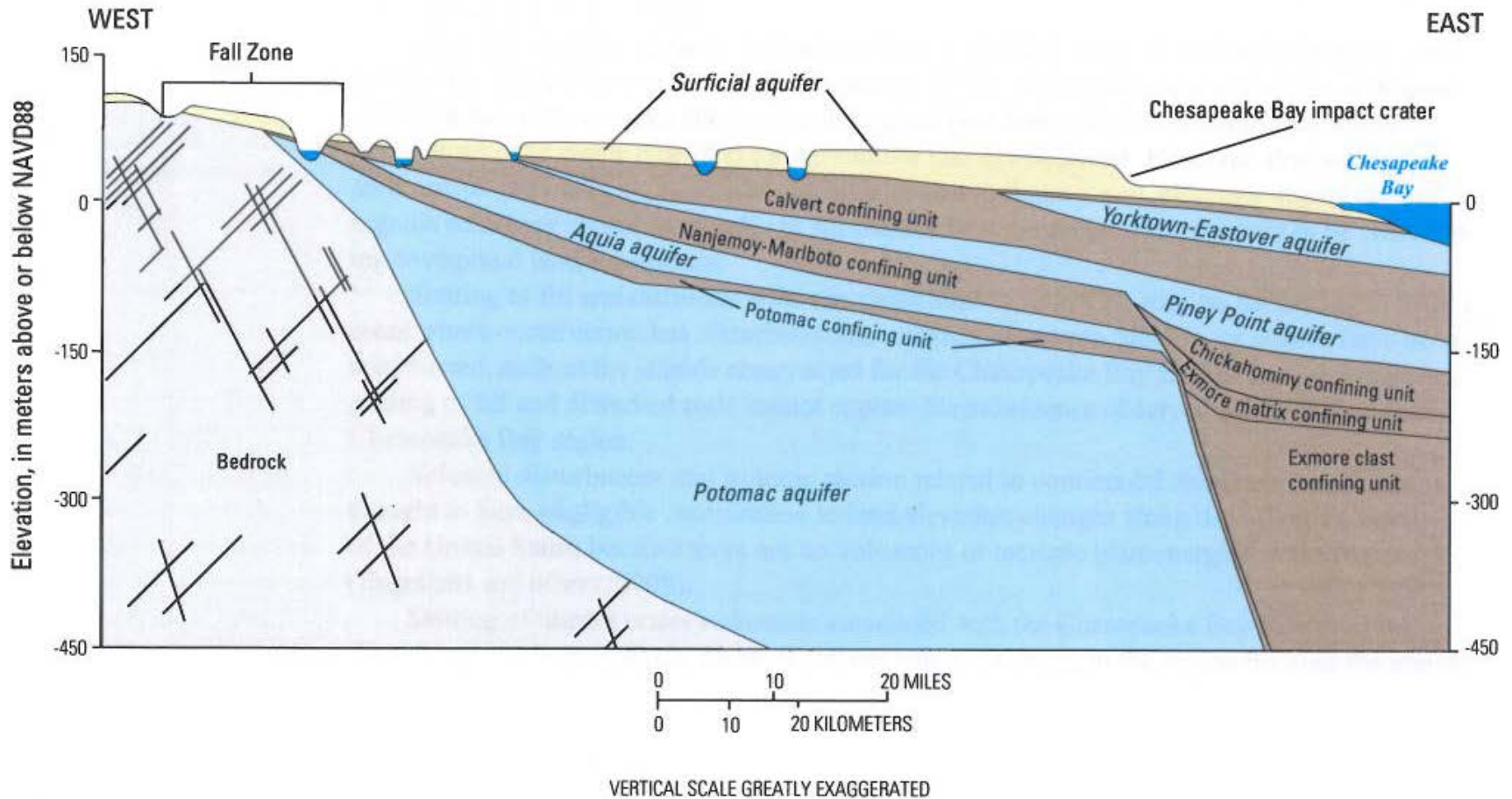
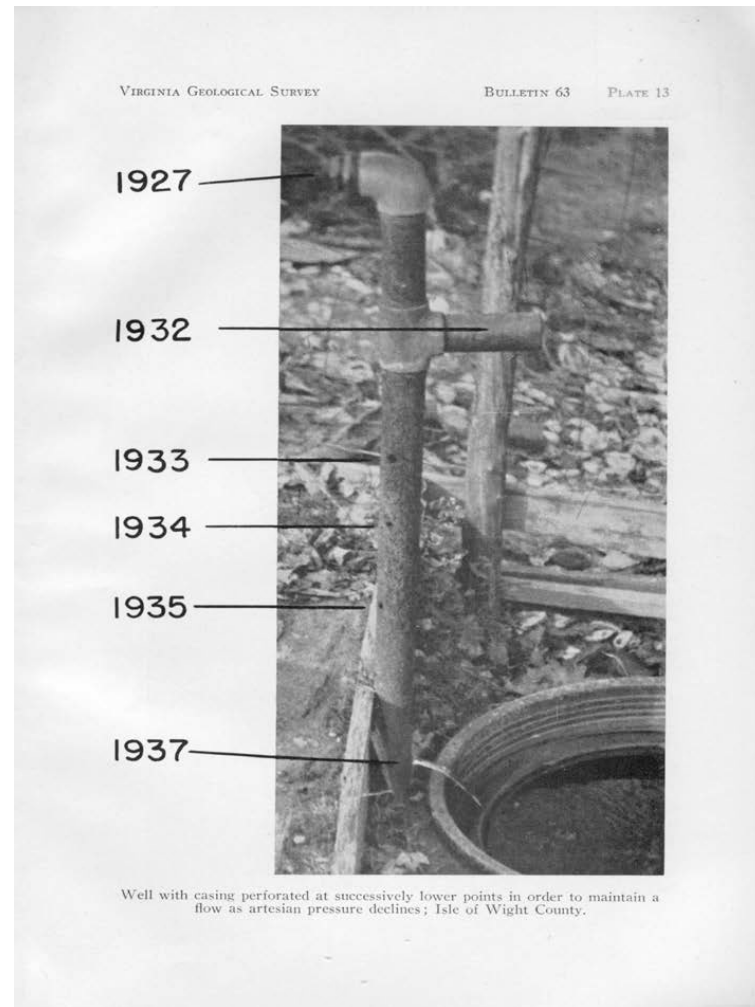


Figure 11. Section illustrating layering in the Virginia Coastal Plain aquifer system from west to east. Elevation relative to North American Vertical Datum of 1988 (NAVD88). Modified from McFarland and Bruce (2006).

Groundwater depletion has been rapid



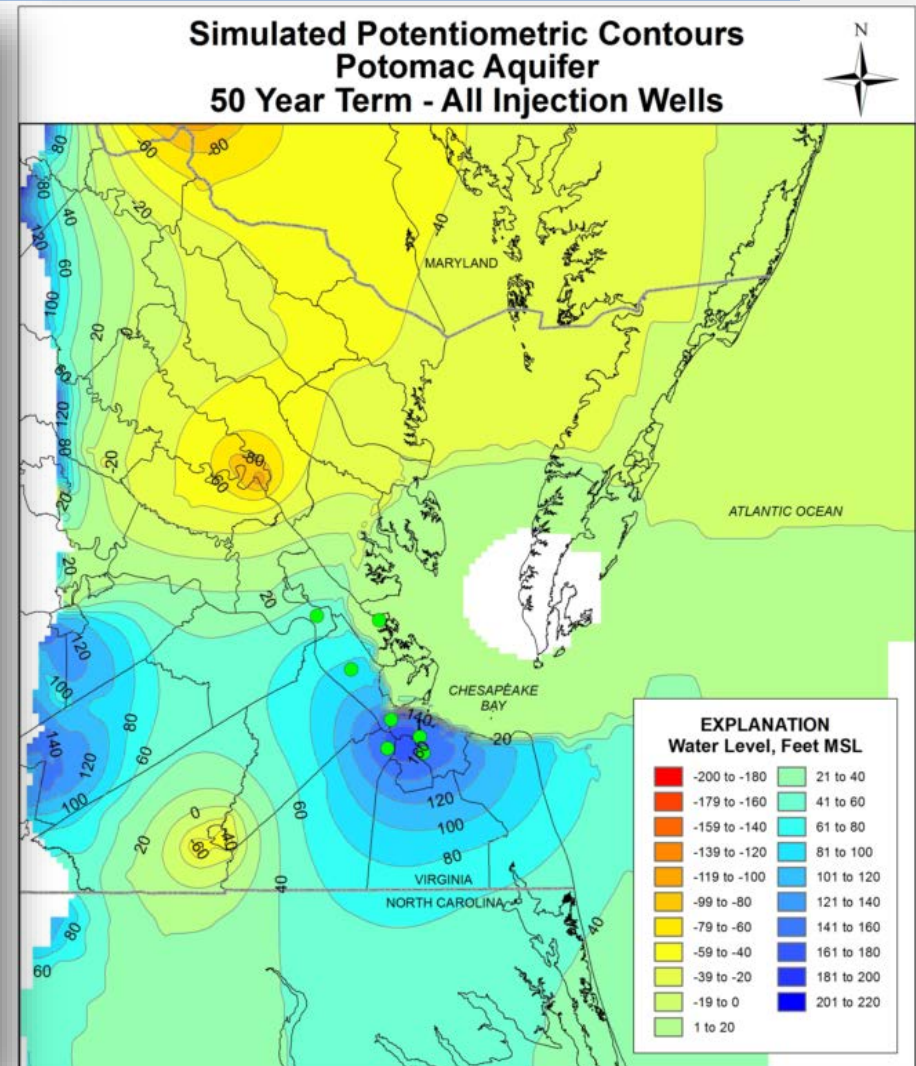
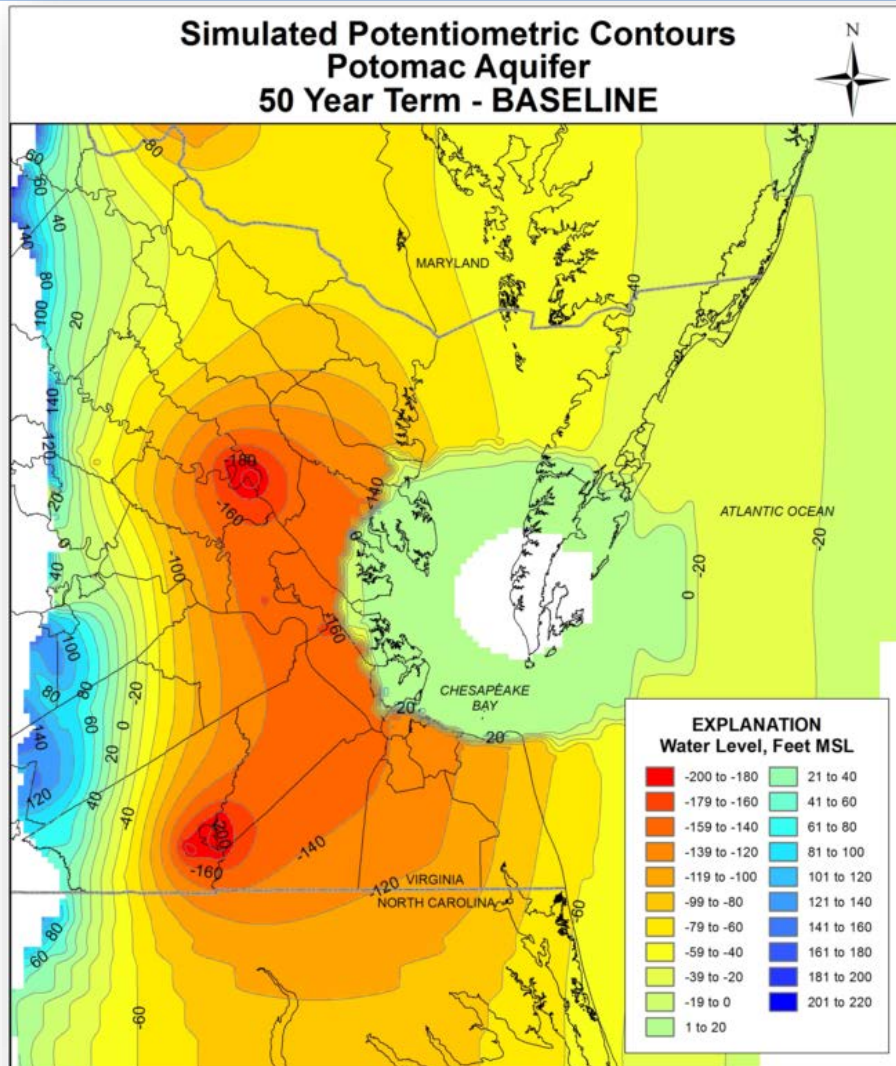
A, Overflow from artesian well in Isle of Wight County is wasted.



Well with casing perforated at successively lower points in order to maintain a flow as artesian pressure declines; Isle of Wight County.

- 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.

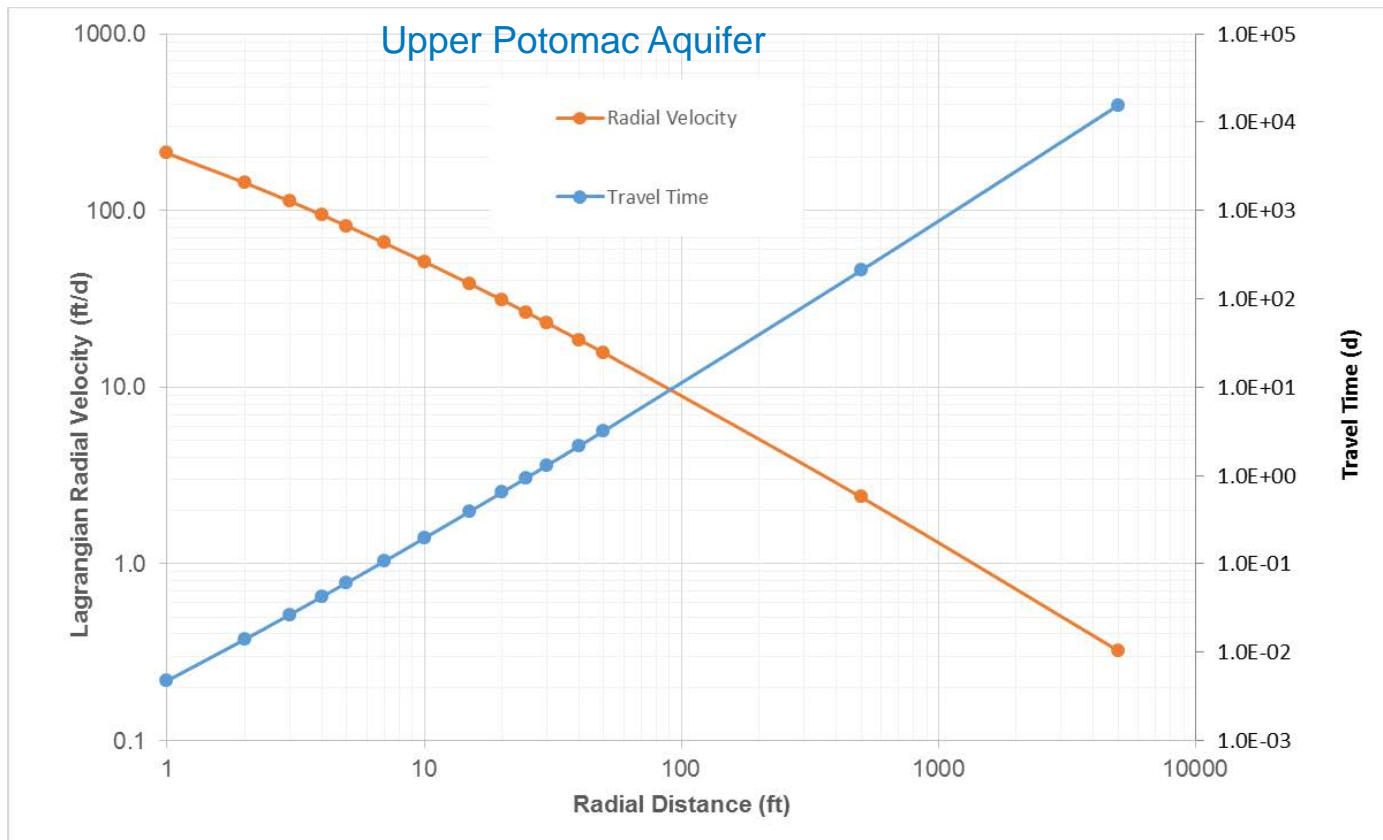
Modeled Potomac Aquifer water levels with and without SWIFT



What is the travel time of the injected water?

Approximately 180 years to travel one mile

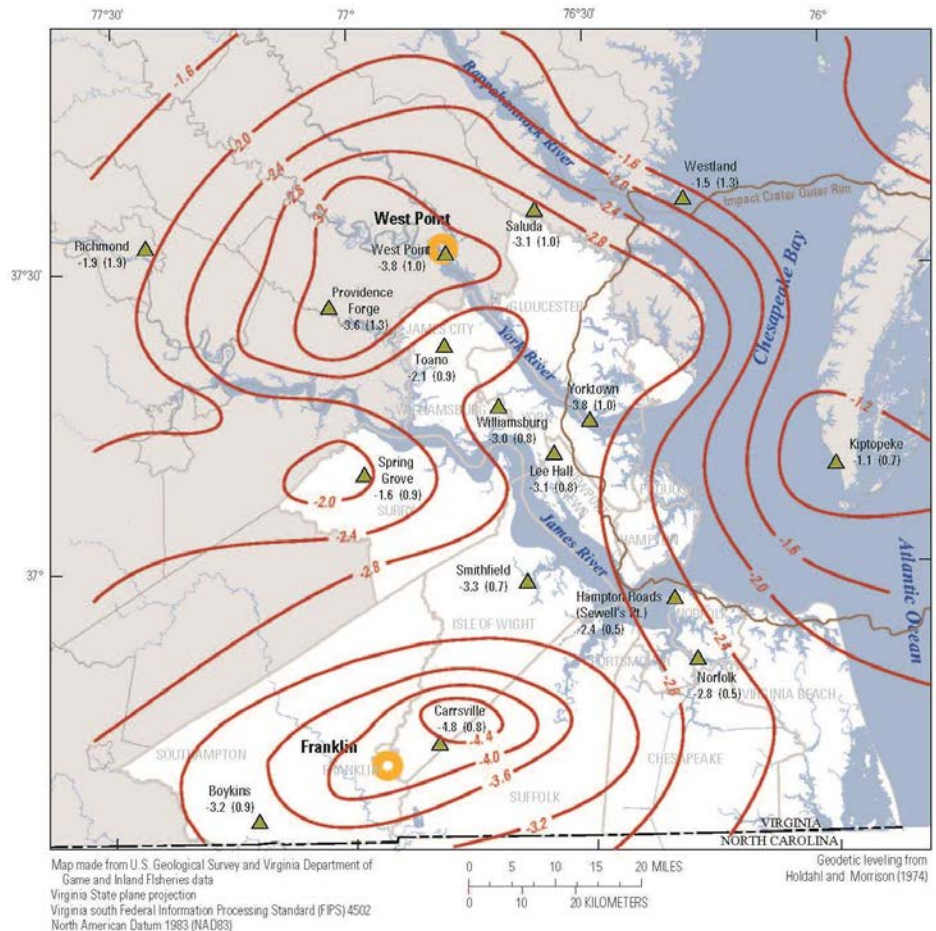
- Recharge water velocity decelerates rapidly as it moves from the injection site
- Model predictions range from 3 to 29 feet/year
- Data from the SWIFT Research Center → refinement of recharge velocities and travel times



Land subsidence – *we are sinking*

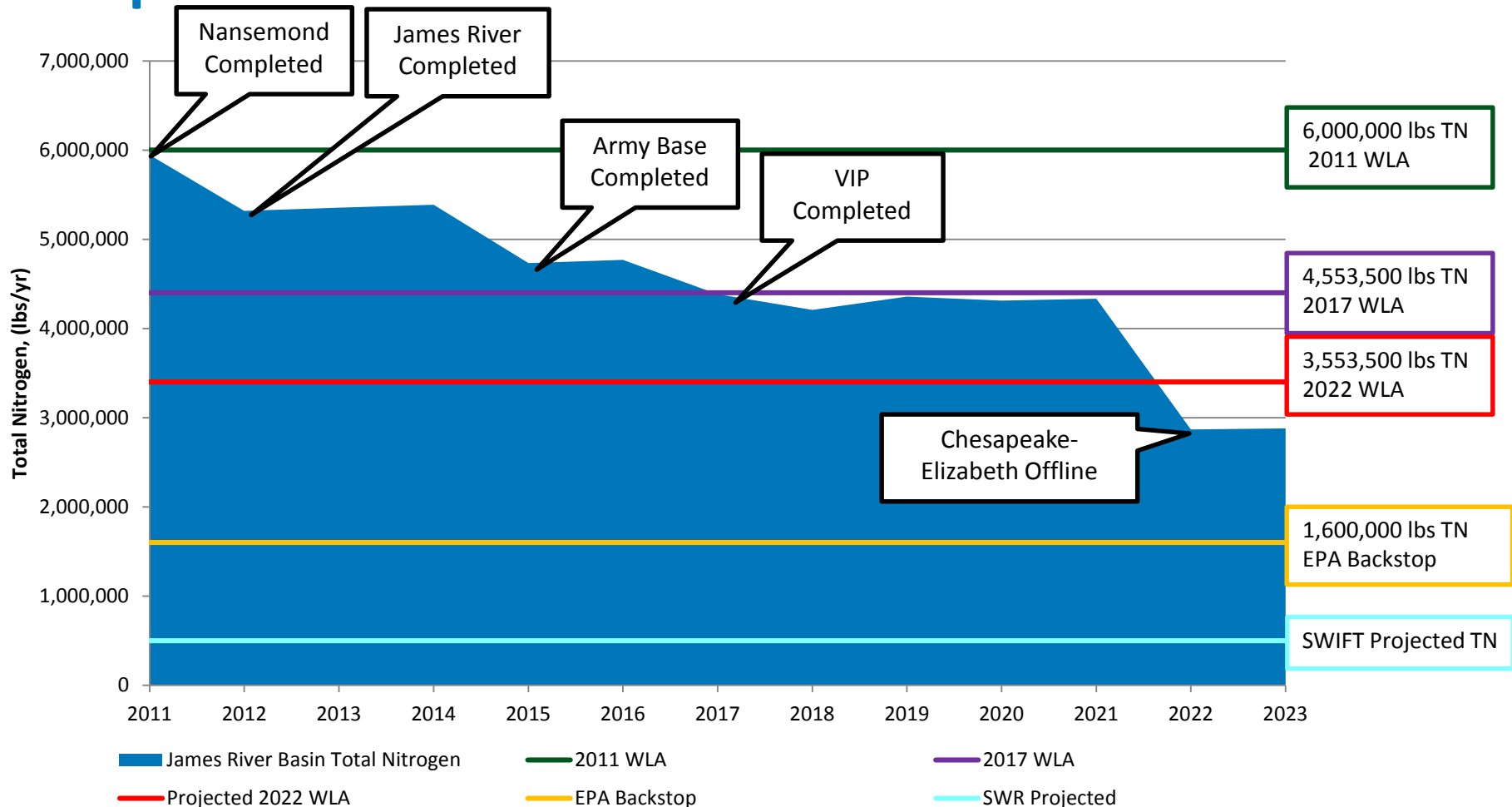
- According to USGS
 - Up to 50% of relative sea-level rise may be due to land subsidence
 - Up to 50% of land subsidence may be due to aquifer compaction

HAMPTON ROADS IS THE **#2** LARGEST POPULATION CENTER AT RISK





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

The Challenges/Opportunities for HRSD

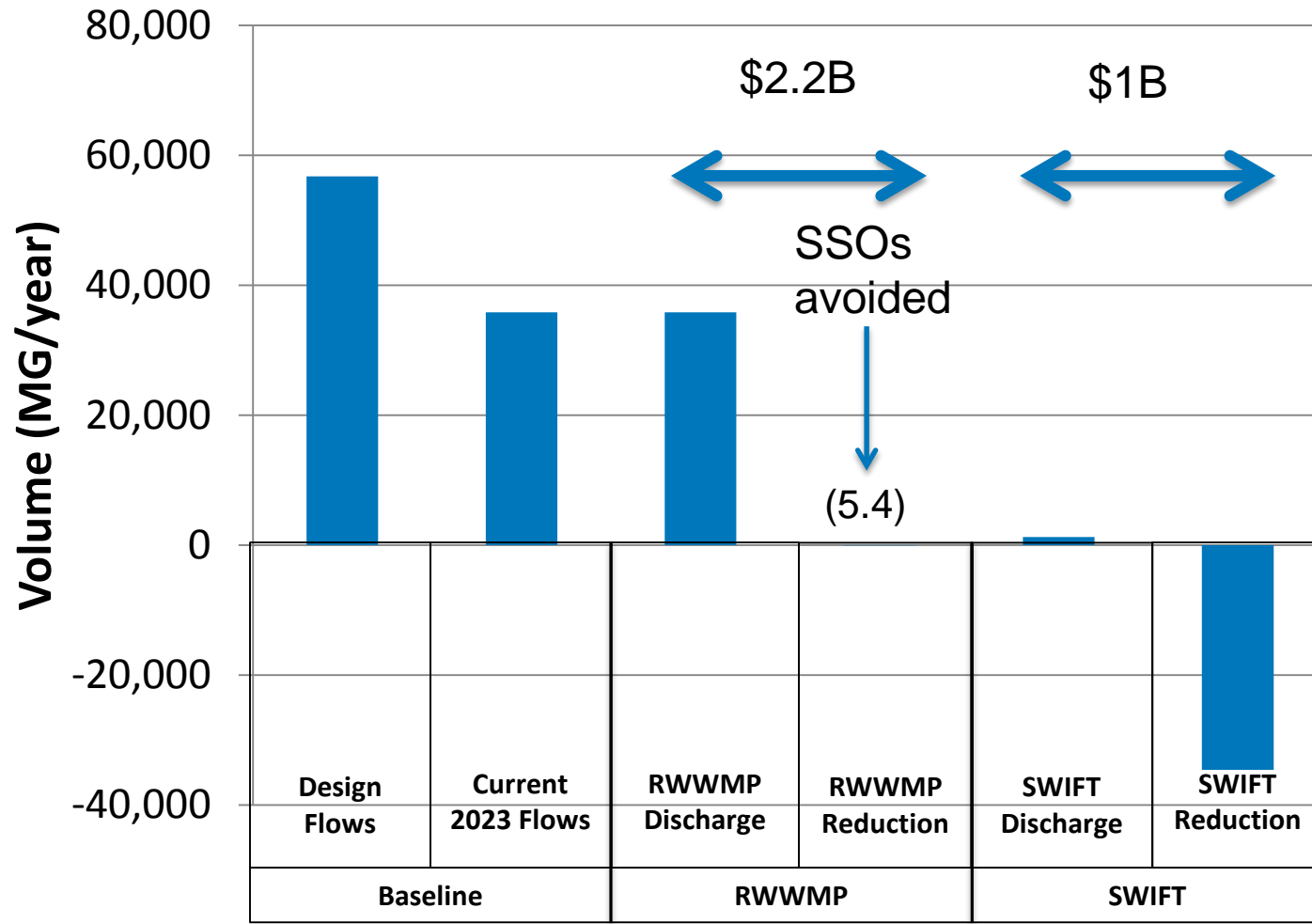
- ~\$750M in Nutrient Removal Upgrades by 2021
- ~\$2B in Consent Decreed Mandated Upgrades to Reduce Sanitary Sewer Overflows
 - **RWWMP in the form of an Integrated Plan, October 2017**
- Very large managed aquifer recharge effort pending
 - Indirect potable reuse?
 - ~120 MGD
 - ~\$1B (over 10 years)

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

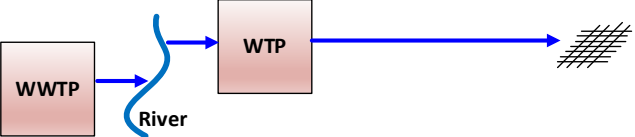
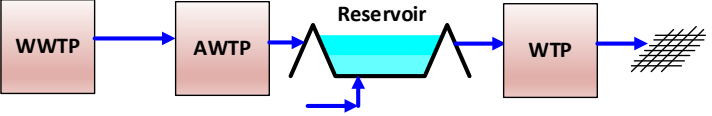
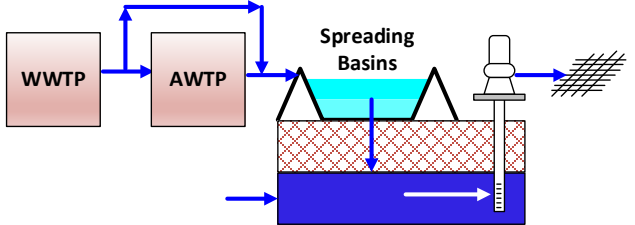
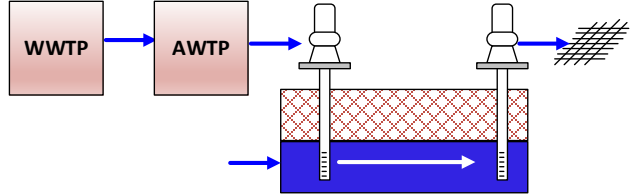


SSO Work Versus SWIFT – Volume Discharged



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

Water Supply Augmentation Approaches (Indirect Potable Reuse)

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

Typical Approach to Developing Finished Water Goals for Groundwater Recharge

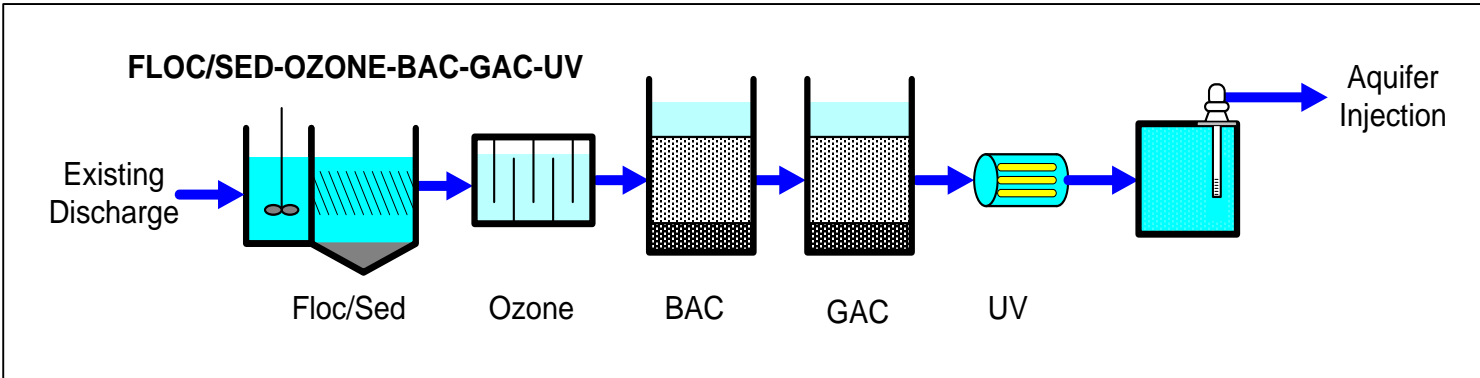
- Meet all primary Maximum Contaminant Levels (MCLs) regulated by the USEPA in the SDWA
- Provide multiple barriers to pathogens and organics (including chemicals)
- Aquifer compatibility
- Hazard Analysis and Critical Control Points
 - Action level exceedance will prevent water from entering the recharge well

Aquifer Compatibility: inject similar water quality to that in the aquifer:

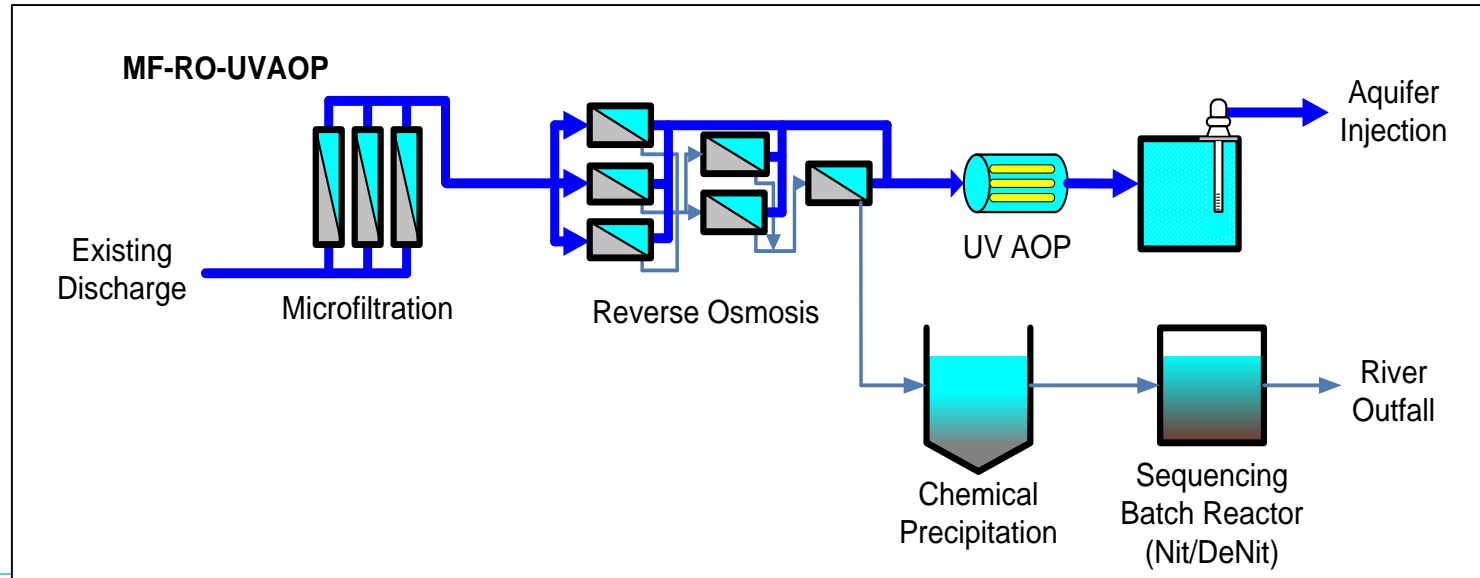
- Ionic strength/TDS - Prevent swelling, repulsion, and migration of clay mineral fragments
 - Within ½-order of magnitude of aquifer (TDS ~ 1,400 – 4,800 mg/L)
 - Major ions should match to prevent clay ion exchange
 - Calcium (~30 mg/L) and sodium (~1,000 mg/L)
- EPA secondary MCL for TDS = 500 mg/L
- Pilot values for Carbon-based AWT:
 - 50th Percentile: 541 mg/L
 - 99th Percentile : 635 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



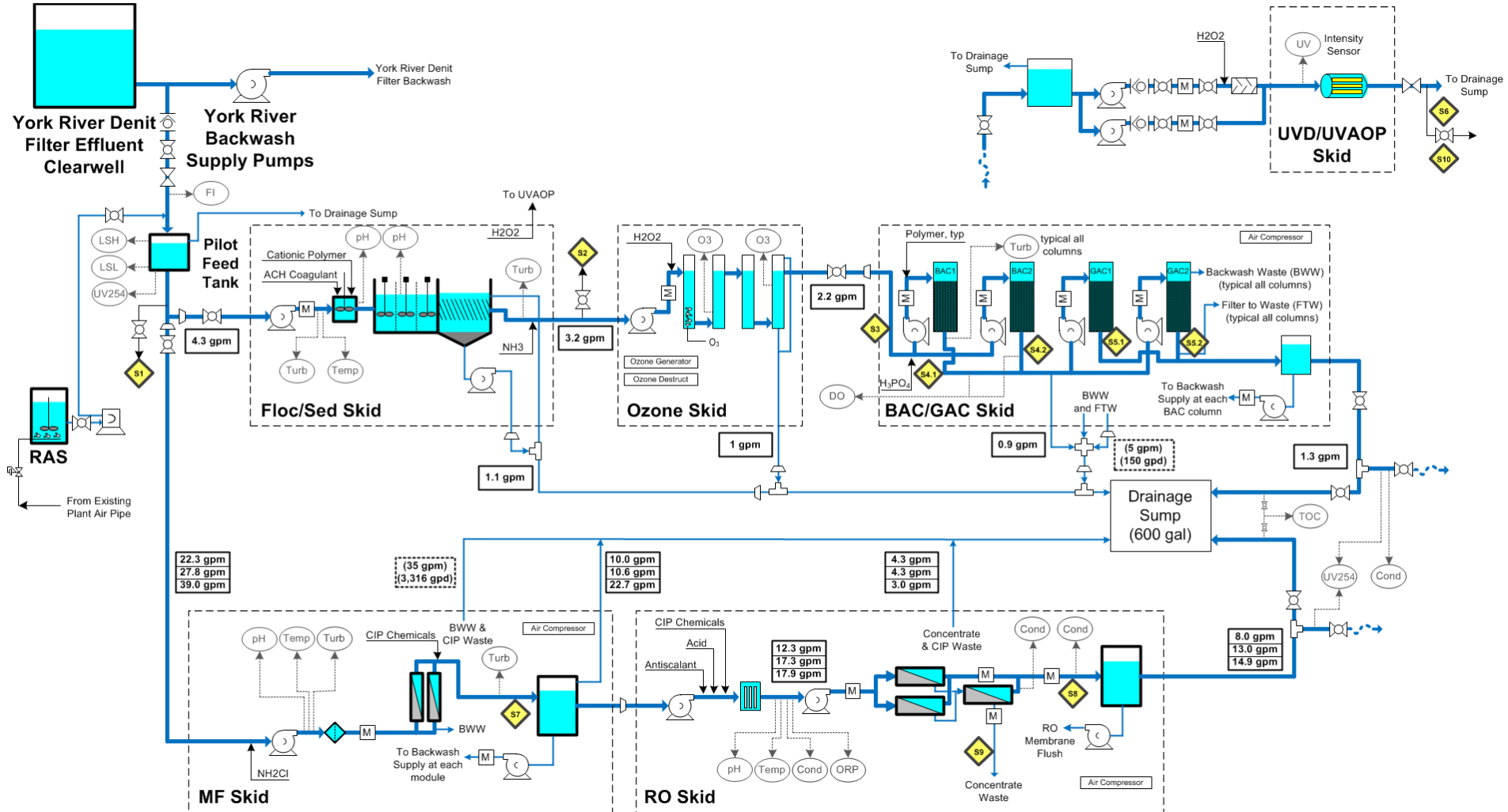
Membrane-Based Pilot



Carbon-Based Pilot



SWIFT Pilot Process Flow Diagram



Soil Columns to evaluate Soil Aquifer Treatment



SWIFT Pilot Testing Results

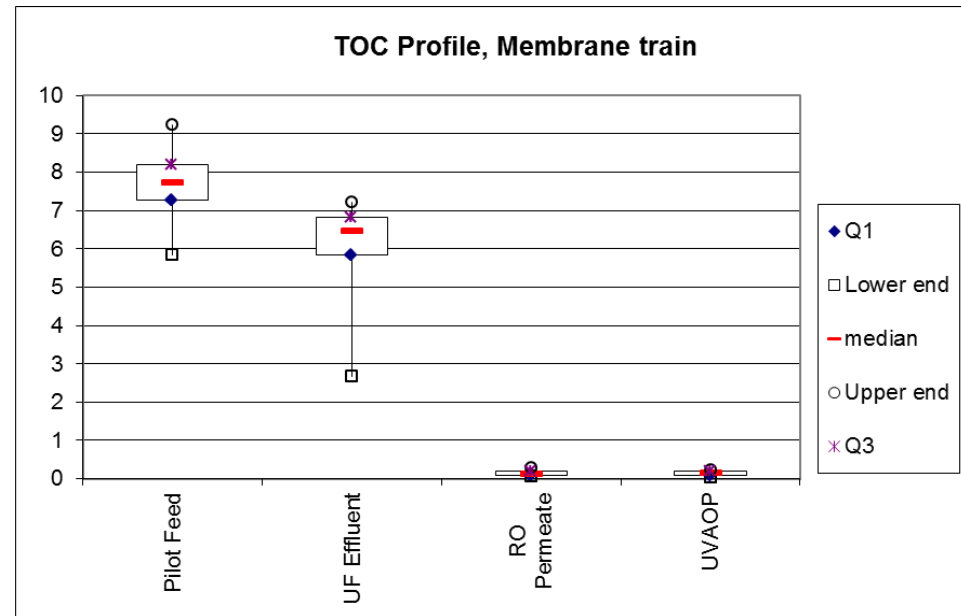
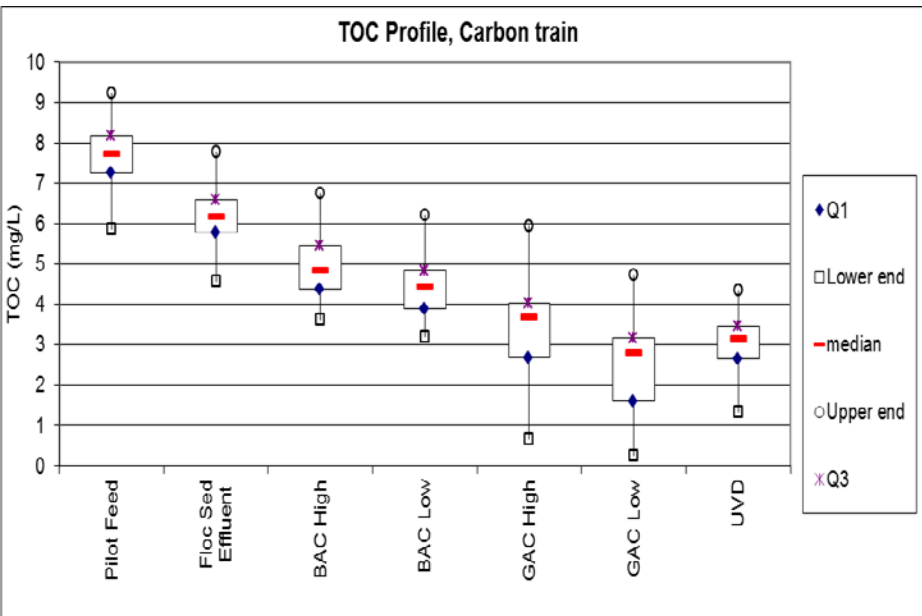
- Both trains meet drinking water quality standards
- All primary MCLs (regulated) are being met
- All secondary MCLs (aesthetics) are being met, except in the Carbon-based AWT system:
 - TDS (salt) is slightly above 500 mg/L (50%/95% = 523/550 mg/L)
 - Sulfate and chloride are consistently less than 250 mg/L
- Topics:
 - Pathogen removal
 - TOC
 - Emerging contaminants
 - Bromate, 1,4-dioxane, NDMA

Pilot Evaluation: Carbon vs Membrane Pathogens

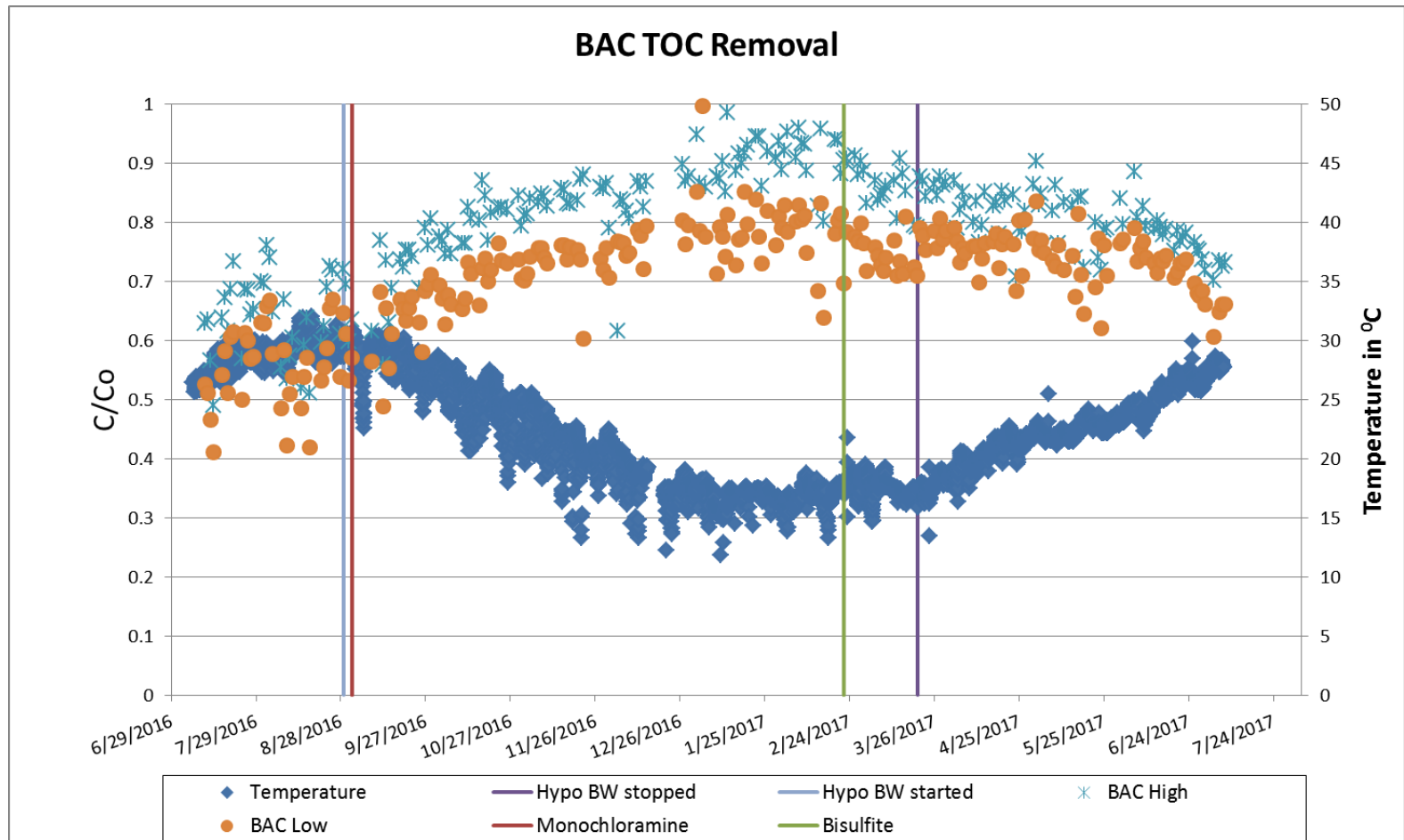
- Both trains provide similar quantifiable log removal credit for viruses, *Cryptosporidium*, and *Giardia*, and demonstrated complete removal of Male specific coliphage (virus) (>8 log removal) in challenge testing

Pathogen Indicators	Carbon Train Finished Water	Membrane Train Finished Water
Total coliform, 99th percentile	<1 MPN/100mL	1
E coli, 99th percentile	<1 MPN/100mL	<1 MPN/100mL
MS2 Challenge Test	> 8-log removal	> 8-log removal
Pepper Mild Mottle Virus	>5.9 log removal	>5.9 log removal

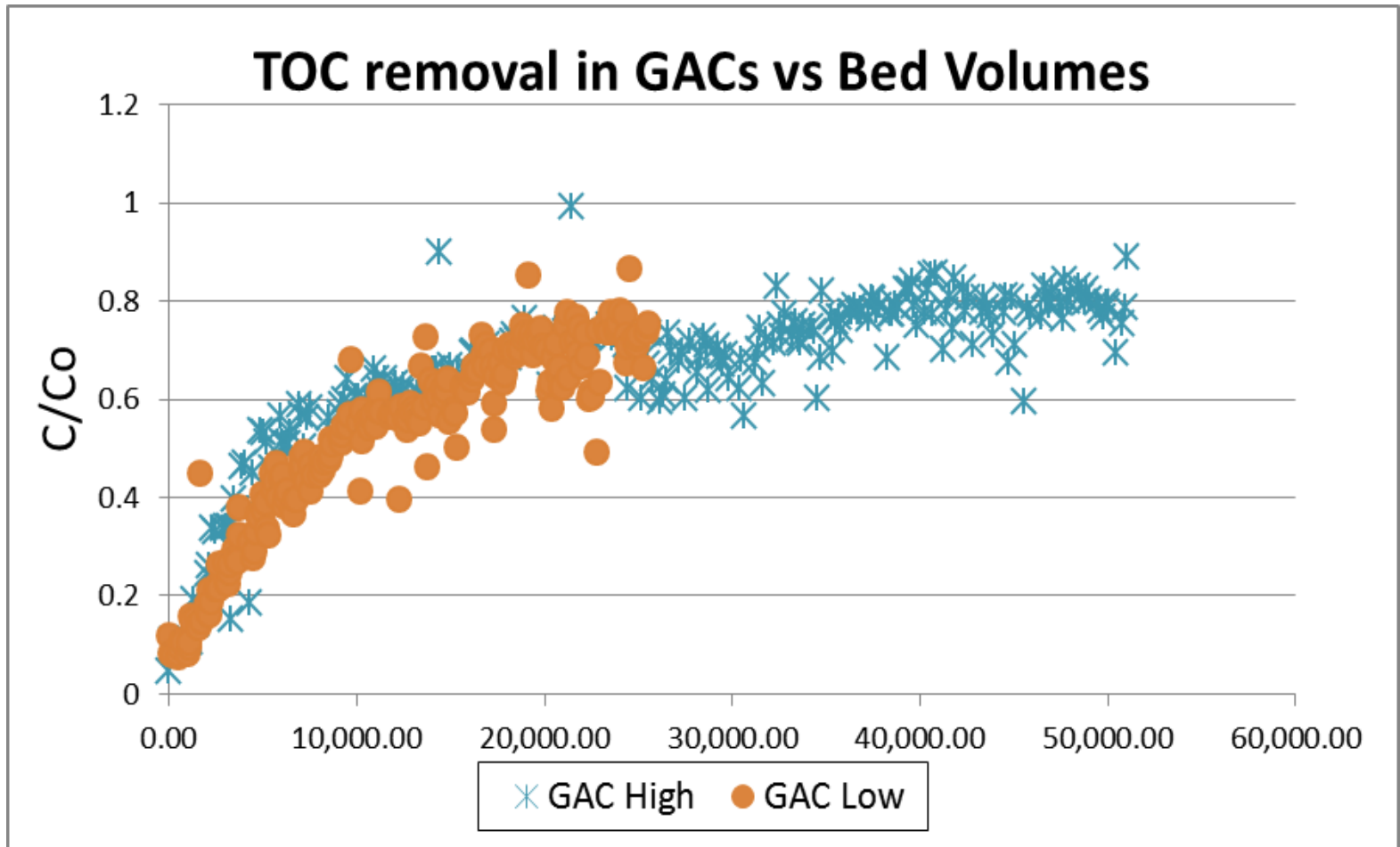
Average Total Organic Carbon (TOC) removal in both treatment processes during pilot operation



Effect of temperature on TOC removal in BAC



TOC removal in GACs showing GAC High close to exhaustion but still achieving 20% removal



Pilot Evaluation: Carbon vs Membrane Contaminants of Emerging Concern

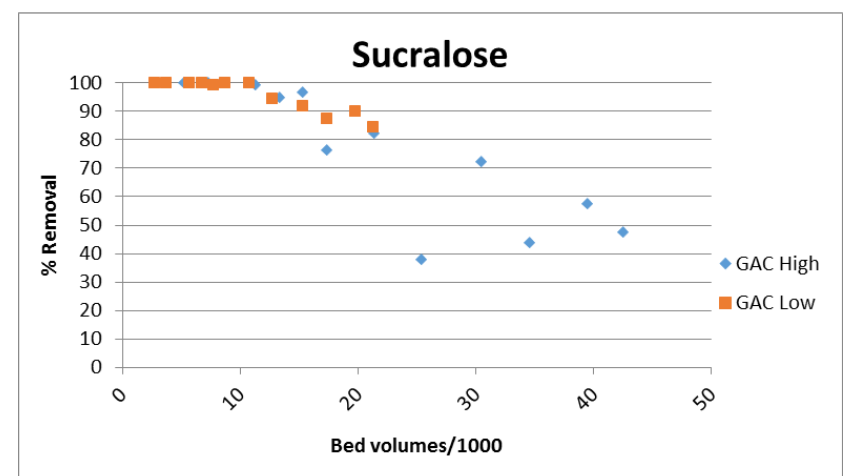
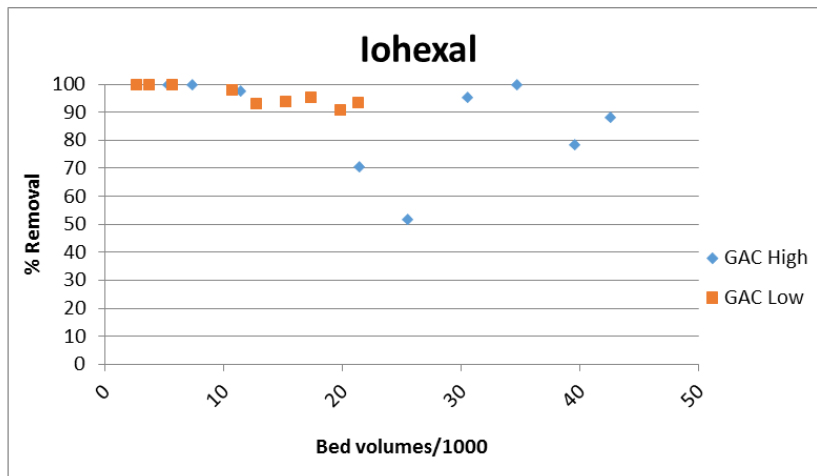
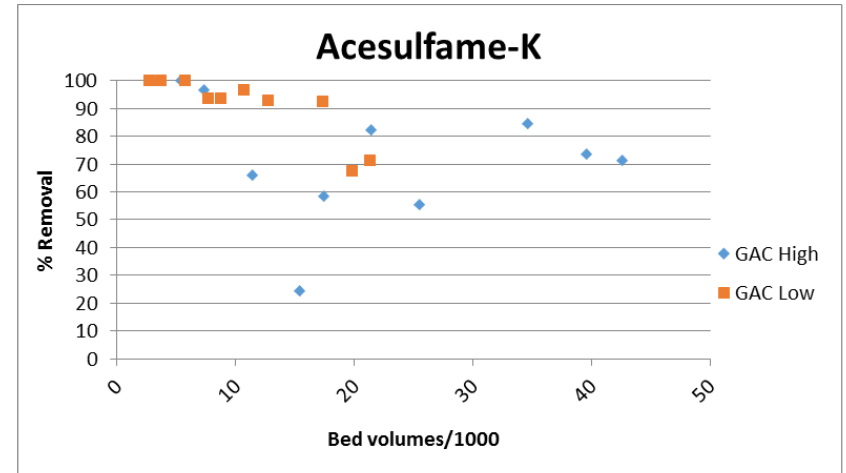
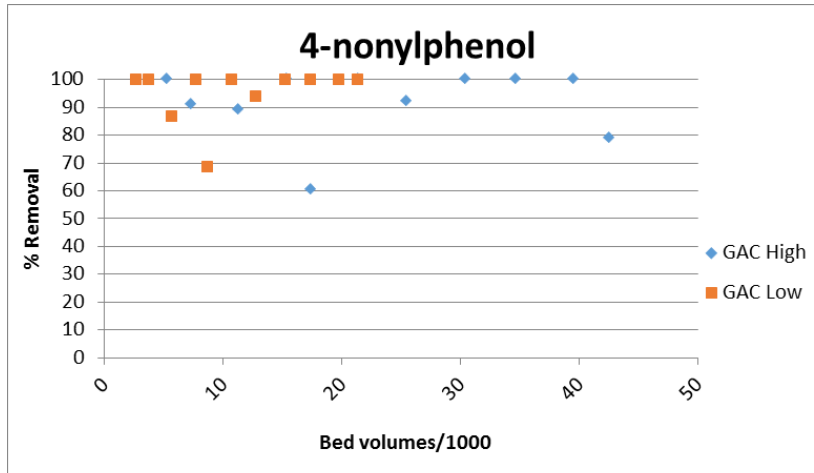
- A suite of 96 CECs analyzed in both treatment processes
- Treatment case study for 8/31/16
 - Only constituents detected by analysis are displayed in chart
- Multi-barrier approach is shown by decrease in concentration through the treatment process
- All values shown in ng/L (parts per trillion)

Contaminant	Pilot Feed	Carbon Train			Membrane Train	
		O3 Eff	BAC Low	GAC Low	RO Eff	UVAOP Eff
4-nonylphenol	1100	320	<100	<100	100	<100
Acesulfame-K	1100	360	290	<20	<20	<20
Iohexal	7500	4000	1400	<10	31	<10
Sucralose	43000	28000	12000	<100	140	130
Primidone	130	46	21	<5	<5	<5
TCEP	140	130	45	<10	<10	<10

Average number of CECs detected

CECs (ng/L)	S1	S3	S4.1	S4.2	S5.1	S5.2	S8	S10
	Pilot Feed	O3 Eff	BAC1 Eff	BAC2 Eff	GAC1 Eff	GAC2 Eff	RO Eff	UVAOP Eff
n (sampling events)	15	5	5	5	13	13	3	9
Average # detected throughout operation	25	16	11	10	6	3	2	1

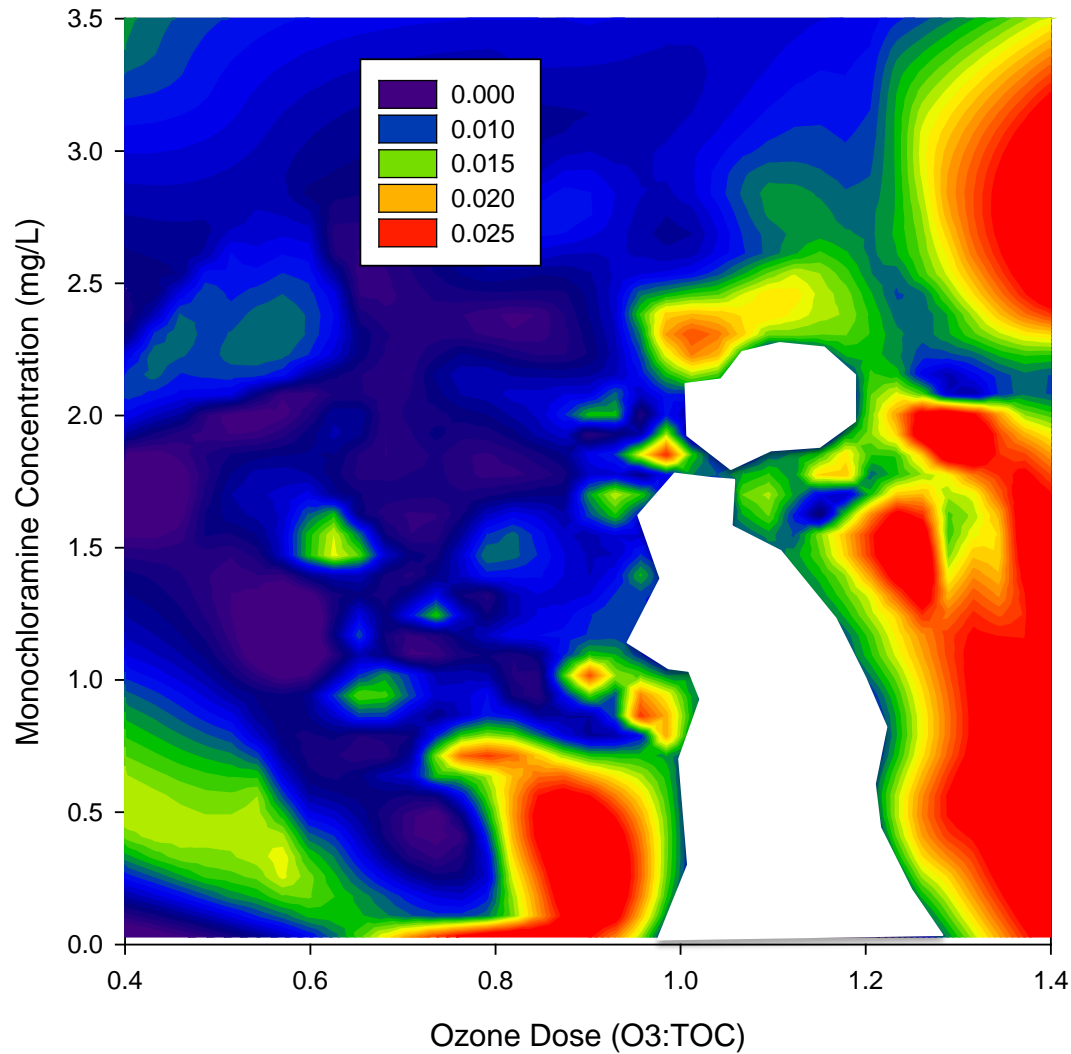
Removal of CECs consistently detected in both GAC vessels Vs bed volumes



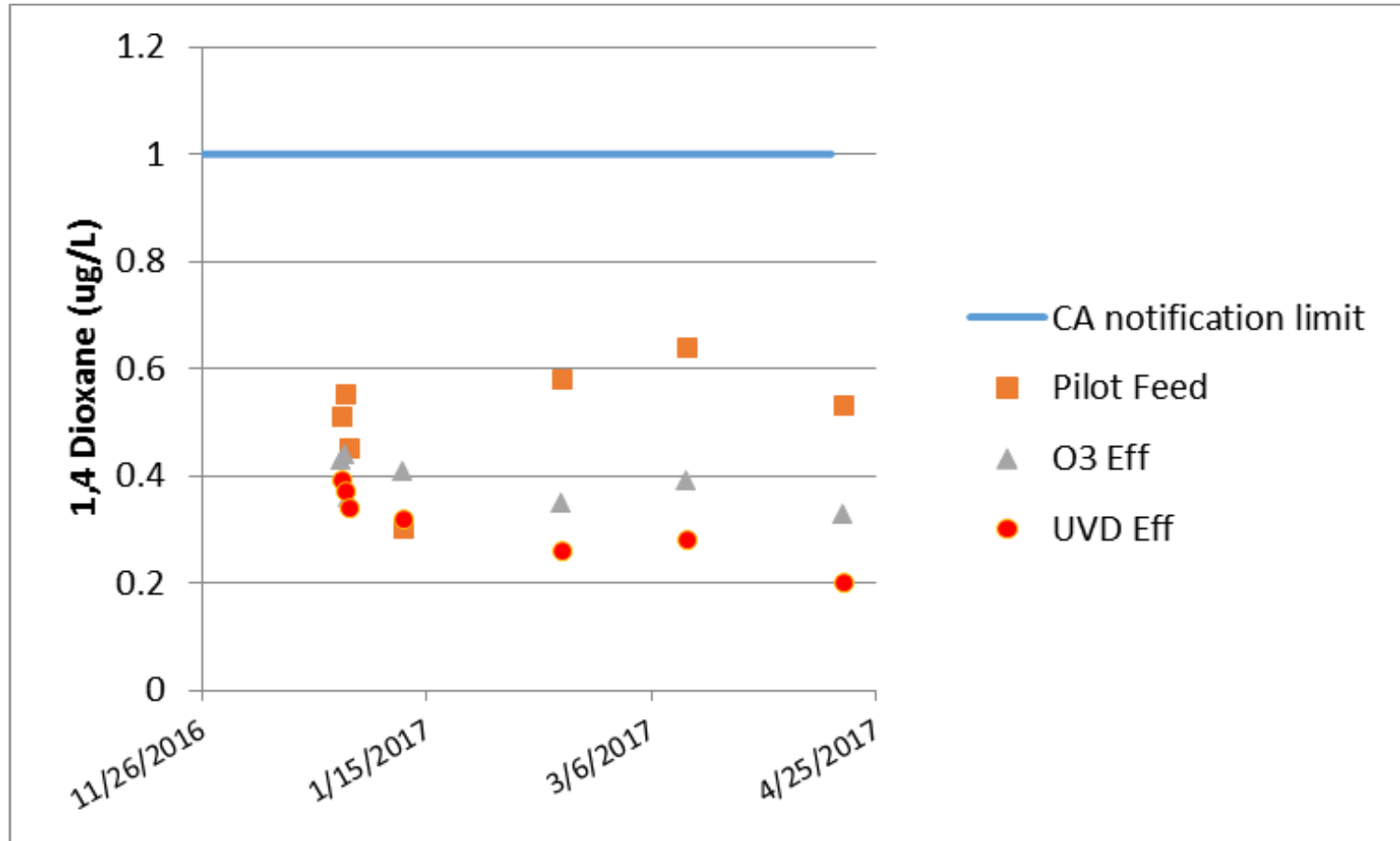
CECs detected in GAC effluent are well below CEC action levels

CECs	Action level (ng/L)	GAC High			GAC Low		
		n=12			n=12		
		Min	Max	Average	Min	Max	Average
Estradiol	TBD	0	8	1	0	2	0
Estrone	320,000	0	0	0	0	0	0
Sucralose	150,000,000	0	61,000	13,568	0	6,400	1,869
Triclosan	2,100,000	0	0	0	0	0	0
Atenolol	4,000	0	0	0	0	0	0
Carbamazepine	10,000	0	0	0	0	0	0
Cotinine	1,000	0	15	1	0	0	0
DEET	200,000	0	0	0	0	0	0
Meprobamate	200,000	0	10	1	0	0	0
Primidone	10,000	0	21	4	0	5	0
TCEP	5,000	0	36	8	0	0	0
Dilantin (Phenyltoin)	2,000	0	0	0	0	0	0

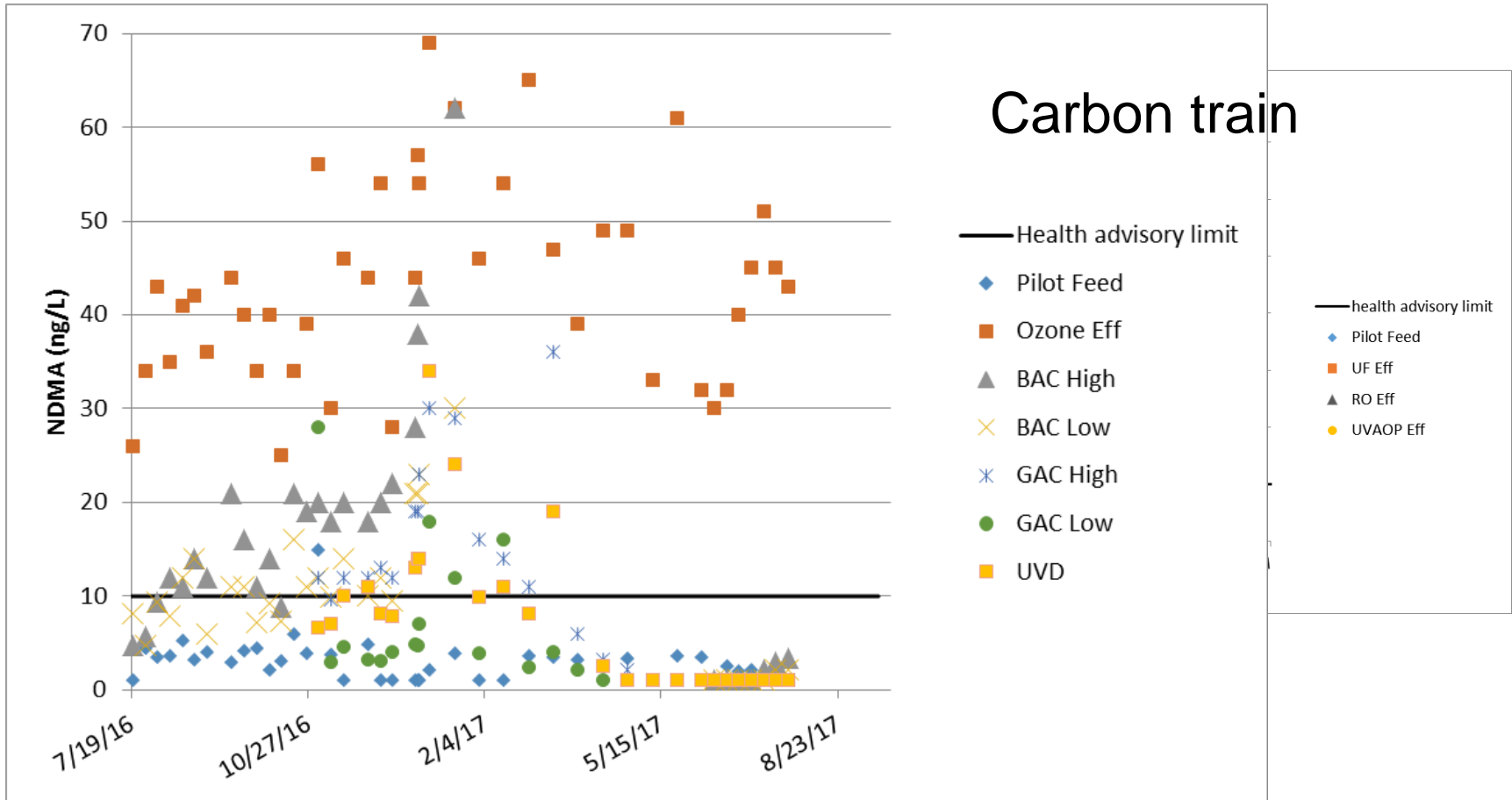
Bromate Formation: Monochloramine and Ozone Dose



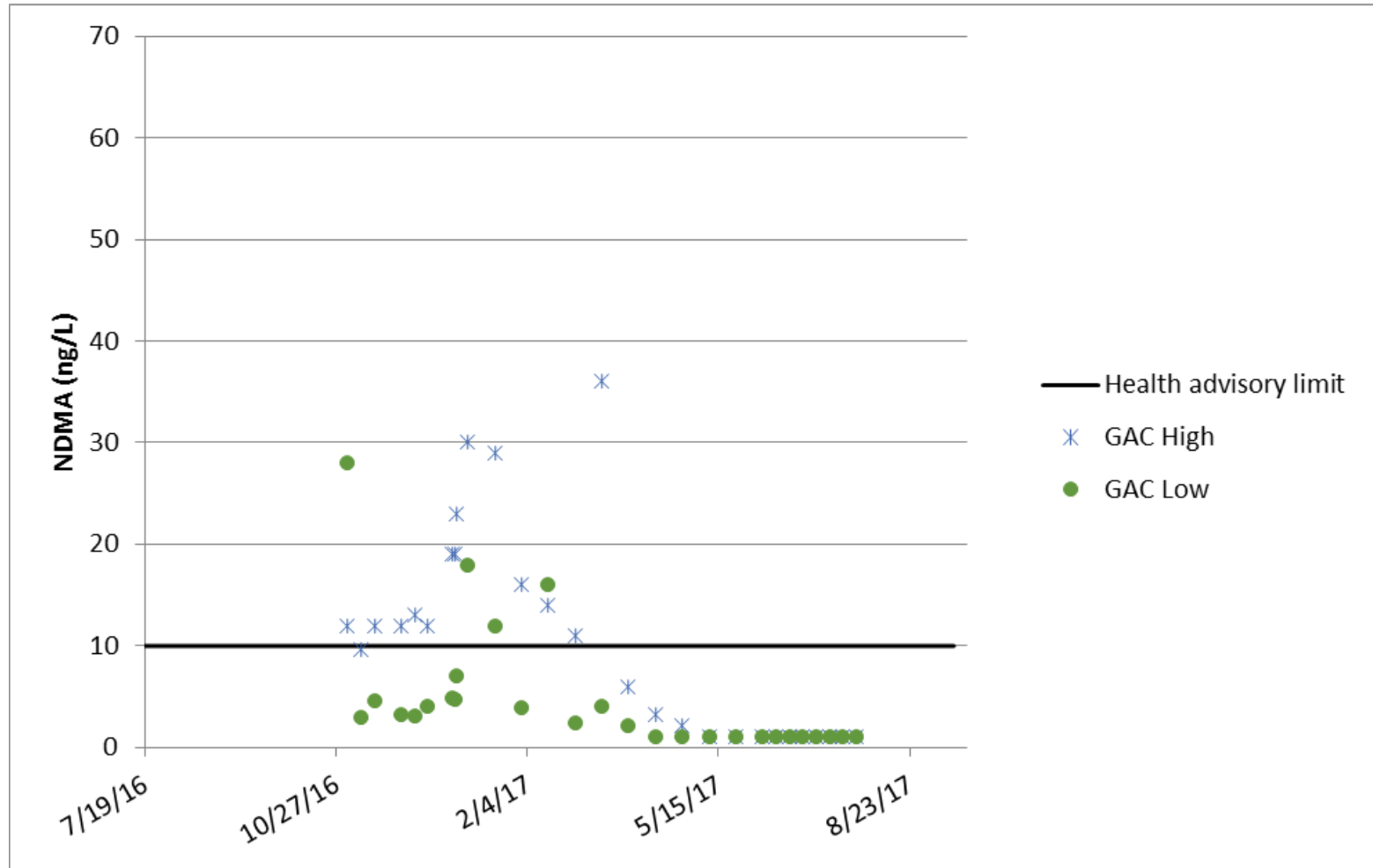
1,4 Dioxane removal in Carbon-based AWT



N-Nitrosodimethylamine (NDMA) removal in carbon and membrane processes emphasizing importance of BAC and GAC EBCT



N-Nitrosodimethylamine (NDMA) removal in carbon and membrane processes emphasizing importance of BAC and GAC EBCT

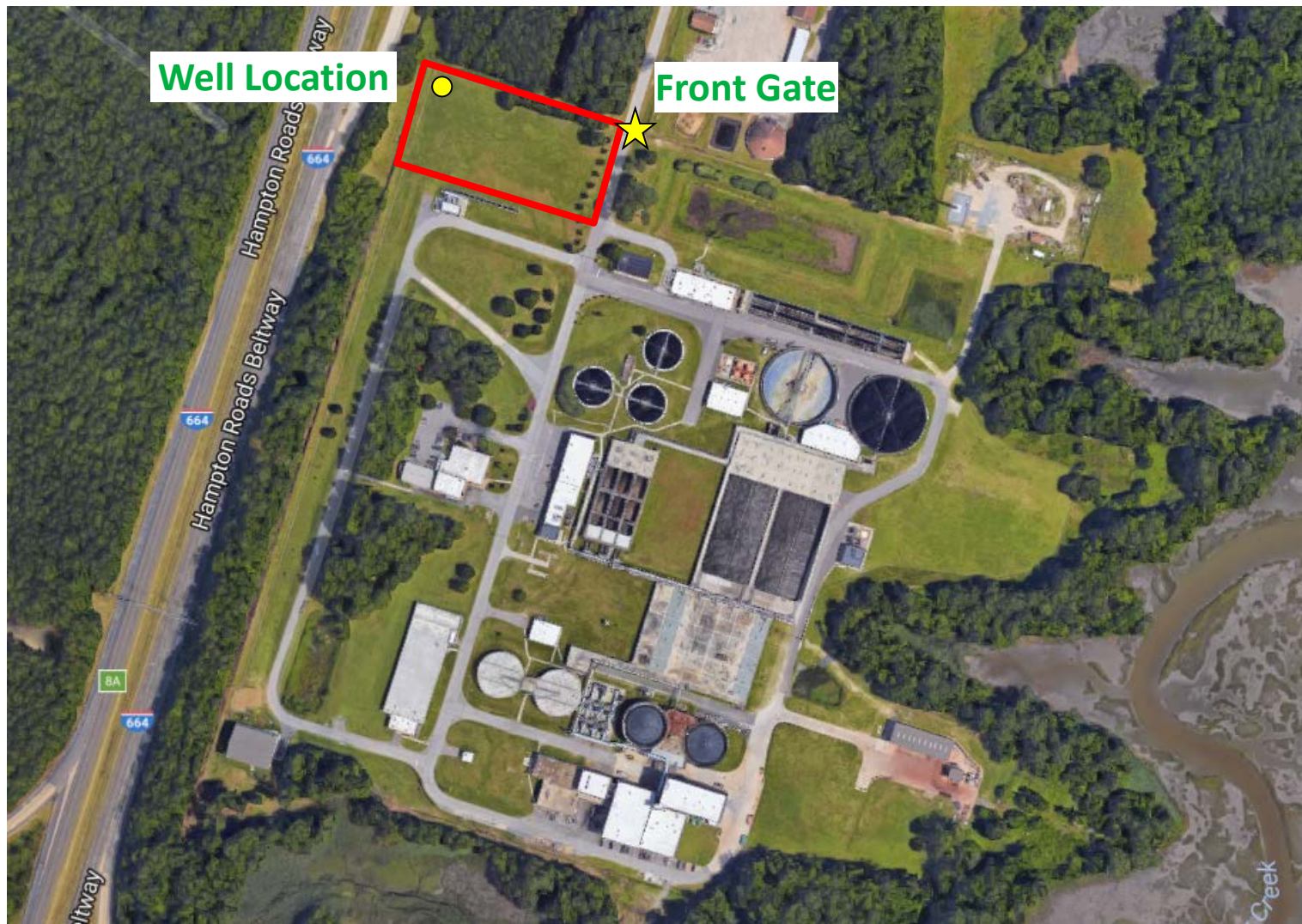




SWIFT Research Center – 1 MGD AWT with Injection Well

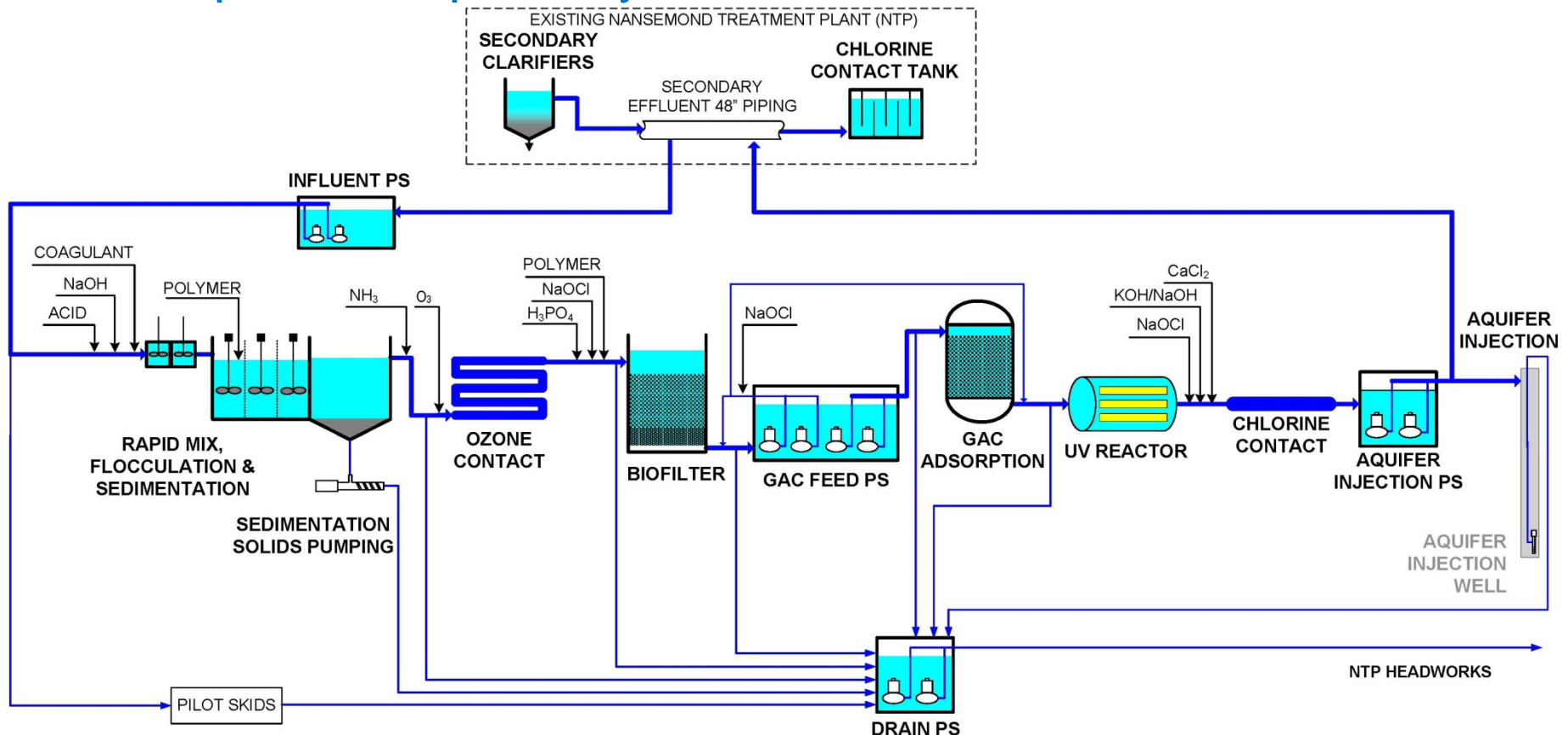


Location of facility within Nansemond TP site



Process Flow Diagram for SWIFT Research Center

- Carbon-based treatment process selected to ensure aquifer compatibility





Finished Water Quality Preliminary Targets

Parameter	Proposed Regulatory Limit	Water Quality Goal (non-regulatory)
MCLs	Meet all primary MCLs	N/A
TN	5 mg/L monthly average; 8 mg/L max daily	Secondary Effluent CCP Action Limit for TIN = 6 mg/L
Turbidity	IFE <0.15 NTU 95% of time & never > 0.3 NTU in two consecutive measurements	CCP Action Limit at 0.10 NTU to initiate backwash or place filter in standby
TOC	4 mg/L monthly average 6 mg/L maximum	COP Action Limit at 4 mg/L, laboratory 10 day average
Total coliform	< 2 CFU / 100 mL; 95% of time	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	Monitor PAS compatibility

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	0-4	9-13	Up to 6 (CA)	>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



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

By J. ELEAN O'NEAL

Can your sinks and toilets fight sea-level rise?

Virginia GOP asks state to cancel "loyalty oath"

recycling water

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



NO WASTING WATER

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

By Dave Hess
dhess@dailypress.com

gathering of state and local officials. Not that he expects anyone will be drinking it any time soon. The plan is to eventually inject 100 million gallons a day of treated water deep underground to begin replenishing the wedge of water-logged sand tapped by wells that serve hundreds of thousands of people and businesses. They're currently drawing about 100 million gallons a day from those wells, resulting in groundwater levels in parts of eastern Virginia dropping 300 feet over the past century.

Online
See more photos and video at dailypress.com

SEAFORD — With a sip of specially treated wastewater, Hampton Roads Sanitation District general manager Ted Henfin put his mouth where his money is — what could be a \$1 billion effort to replenish eastern Virginia's rapidly shrinking pool of groundwater.

A pilot program at the agency's York River Treatment Plant shows it is possible to clean the water Hampton Roads residents flush out of their homes and businesses so that it is safe to drink, he told a



JONATHAN SILVERMAN/DAILY PRESS PHOTOS
Ted Henfin, Hampton Roads Sanitation District general manager, 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 Henfin holds a glass of purified water during the conference at the plant.

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

STEVE LARLEY | THE VIRGINIAN-PILOT

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 Henfin vowed he'd take the first gulp.

On Thursday at the HRSD's York County treatment plant, Henfin made good on the prom-

ise, leading dozens of employees and invited guests in downing glasses of wastewater that came from a sewage stream fed by sinks and toilets.

"Great!" he proclaimed after his first sip. "Ahhh." To Henfin, 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 doesn't want to waste wastewater

By Dave Mayfield
The Virginian-Pilot

SEAFORD
Ted Henfin 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 results aren't back to confirm that. Henfin will hold off before he sips these days. He has dived into a project to prove that HRSD can turn what Hampton Roads flushes down

recycled

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

See WASTE, PAGE 10

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



swift

Timeline

- Now
 - Pilot AWT system operating since June 2016
 - Soil column tests to evaluate soil aquifer treatment
 - Working with VA Dept of Health to identify existing private wells around recharge sites
 - Preparing for full-scale implementation
 - MS4 trade agreements with Hampton Roads localities
 - NWRI independent panel transitioning to SWIFT oversight and monitoring entity
- 2018
 - SWIFT Research Center with 1 MGD recharge well
- 2020
 - Permits issued for full scale facilities
- 2020 to 2030
 - Construction through phased implementation
- 2030 Fully operational
 - ~120 MGD of clean water recharging the aquifer



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

SWIFTVA.COM

cbott@hrsd.com

jmitchell@hrsd.com

