The Potomac Aquifer Recharge Oversight Committee
Meeting Minutes
September 10, 2020

Electronic Meeting in Accordance with Chapter 1283 of the 2020 Acts of Assembly

In attendance: David Paylor, DEQ; Mark Bennett USGS; David Campbell, USEPA; Harold Post for Adil Godrej, OWML; Whitney Katchmark, HRPDC; William Mann, Governor Appointee; Marcia Degen for Norman Oliver, VDH; Doug Powell, Governor Appointee; Gary Schafran, PARML; and Mark Widdowson, PARML.

The Committee Chair, David Paylor, called the meeting to order at 1 pm.

Doug Powell made a motion to approve the minutes of the previous meeting as distributed; Marcia Degen seconded the motion; and it carried unanimously.

Gary Schafran, co-director of the Potomac Aquifer Recharge Monitoring Lab (PARML), made a presentation on the activities of the lab including renovation, hiring, instrument acquisition, development of technical working committees, and update to the 2021 work plan. Mr. Powell moved approval of the report and support of the formation of the technical committees; Dr. Mann seconded the motion.

Whitney Katchmark asked for clarification of the motion as to whether HRSD was to be considered a member or a resource of the technical committees. After a brief discussion, the motion was amended to agree to formation of the two committees with HRSD as a resource rather than a member of the committee. The motion passed without objection.

Charles Bott (HRSD) made a presentation on continued operations, data updates, update on research topics, and future planning at the SWIFT Research Center. Dr. Bott further explained biological fouling and recharge well installation in answer to committee member's question.

Jamie Mitchell (HRSD) provided an update on the status of the James River Treatment Plant full-scale SWIFT facility individual UIC permitting. She reviewed comments received from National Water Research Institute (NWRI) and the Virginia Department of Health (VDH) that will require significant changes to the draft permit; reviewed aquifer monitoring plan comments and outlined next steps. The comment responses and modified draft permit documents will be available for Committee review by September 18. Dr. Degen asked about the size of the private wells that were reviewed. Jamie Mitchell and Dan Holloway responded the wells were less than 35-feet deep, non-potable irrigation wells.

Lauren Zuravnsky (HRSD) provided an update on the SWIFT Full-Scale schedule and implementation plan.

The Potomac Aquifer Recharge Oversight Committee
Draft Meeting Minutes
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Dan Holloway (Jacobs) provided an update on modeling background, process, scenarios, observations and results. He further explained daily recharge rate and assumption of 75% level of performance, and the break-even rate.

There were no public comments.

A poll will be sent to members for availability for the next meeting date.

The meeting adjourned at 3:13 pm.

Approved: David K Paylor

David Paylor, Committee Chair

Date: 1/20/2021

Committee Members:

- David Paylor, Director of Virginia DEQ
- Dr. Norman Oliver, Virginia State Health Commissioner
- Dr. William Mann, Governor Appointee
- Doug Powell, Governor Appointee
- Whitney Katchmark, HRPDC
- Adil N. Godrej, PhD, PE, Co-Director Occoquan Watershed Monitoring Laboratory
- Mark Widdowson, Co-Director of the Potomac Aquifer Recharge Monitoring Lab
- Gary Schafran, Co-Director of the Potomac Aquifer Recharge Monitoring Lab
- Mark Bennett, Director of Virginia and West Virginia Water Science Center
- Dave Campbell, Director of the US EPA Region 3 Laboratory Services and Applied Science Division

Potomac Aquifer Recharge Monitoring Laboratory Update

Gary Schafran and Mark Widdowson
PARML Co-Directors

September 10, 2020

Update:

- Laboratory renovation
- PARML hiring
- Laboratory instrument acquisition
- Development of technical working groups
- Workplan

PARML Water Quality Laboratory – Renovation Schedule

- Bidding & Contract Awarded – May 2020 ☑
- Construction & Inspections – June ☑
- Casework Installed – July/August ☑
- Projected Completion – August ☑


Summer 2019


Fall 2019


September 3, 2020

New Hires

PARML Research Associate

Seyyedhadi “Hadi” Khatami, Ph.D.

B.S. and M.S. in Chemical Engineering
Ph.D. in Chemistry and Biochemistry

Strong background in organic analytical chemistry including GC-FID, GC-MS, Solid and liquid’s NMR, ESI-FTICR-MS, FTIR, EA and HPLC

PARML Research Faculty – Senior Research Associate

Eduardo “Ed” Mendez, Ph.D.

B.S. (UNH) and M.S. (VT) in Environmental Engineering
Ph.D. in Civil Engineering (VT)

Extensive experience in developing computer tools and models for solving groundwater problems, programming languages, and building groundwater applications

Proposal to Develop Informal Technical Advisory/Working Groups

As we have moved forward with establishing the laboratory we have recognized the value of engaging key players (e.g., VDH, DEQ, USGS, HRSD, other technical experts) in this effort. We feel that if we did so in a more intentional manner, that significant benefit to the PARML mission would accrue from collaborative dialogues.

- Two working groups envisioned each with 10 members, or less;
- Meetings would be concise, agenda driven, and bimonthly to quarterly;
- Participants would include those with technical and/or regulatory backgrounds relevant to water reuse and aquifer recharge and able to help guide decision making for current and future monitoring, modeling, research, and analytical development.

Water Quality/Analytical Technical Advisory Group

- Issues related to monitoring across the SWIFT treatment process train and changes in composition;
- Recommend priority order of WQ monitoring (parameters) as laboratory capability ramps up;
- Method development for disinfection byproducts not currently regulated – but possibly headed in that direction;
- Identify future CECs potentially headed for regulatory action.

Members: PARML, VDH, DEQ, HRSD, PAROC

Groundwater Technical Advisory Working Group:

- Review groundwater sampling and monitoring plans for the SWIFT RC and full-scale SWIFT recharge at James River
- Identify data gaps and evaluate options for improved monitoring of the Potomac Aquifer
- Coordinate efforts on regional monitoring and data analysis

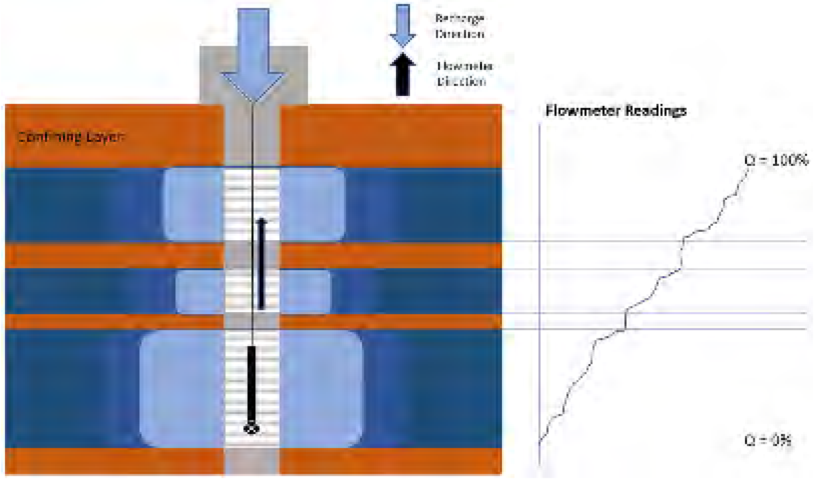
Members: PARML, DEQ, USGS, VDH, HRSD, PAROC

Work Plan 2021 (Slides from last PAROC Mtg)

- Develop laboratory analytical capabilities
  - Instrumentation acquisition and method development
- Sampling and analysis of SWIFT WATER and SWIFTRC groundwater
  - Comparison to HRSD monitoring data
- Website Development
  - Public outreach
  - Regional groundwater levels
- Develop methodology and capability for archiving water and aquifer samples

Work Plan 2021 (Continued)

- Groundwater Investigations at SWIFTRC
  - Bromide tracer test September 28th ?
  - Analysis of groundwater monitoring data
  - Flowmeter testing



Questions?

Operations Update

Sustainable
Water Initiative
for Tomorrow

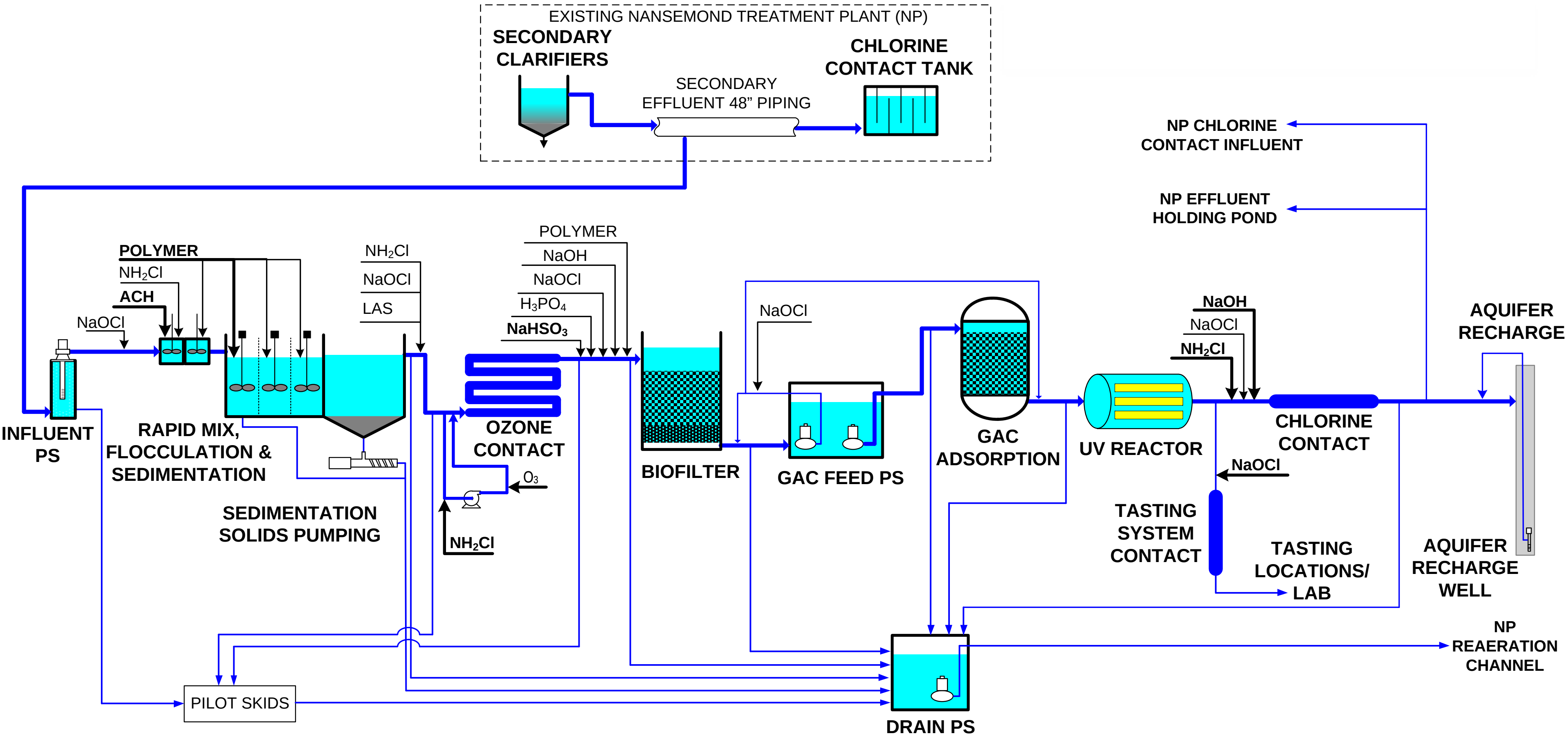
SWIFT Research Center (SRC)

(1.0 MGD AWT + recharge well + monitoring wells + public outreach and education center + research facilities + operations staff training center)

Agenda

- Some SRC Data Updates
- TW-1 injectivity & RW-1 project
- 1,4-Dioxane & propane plans

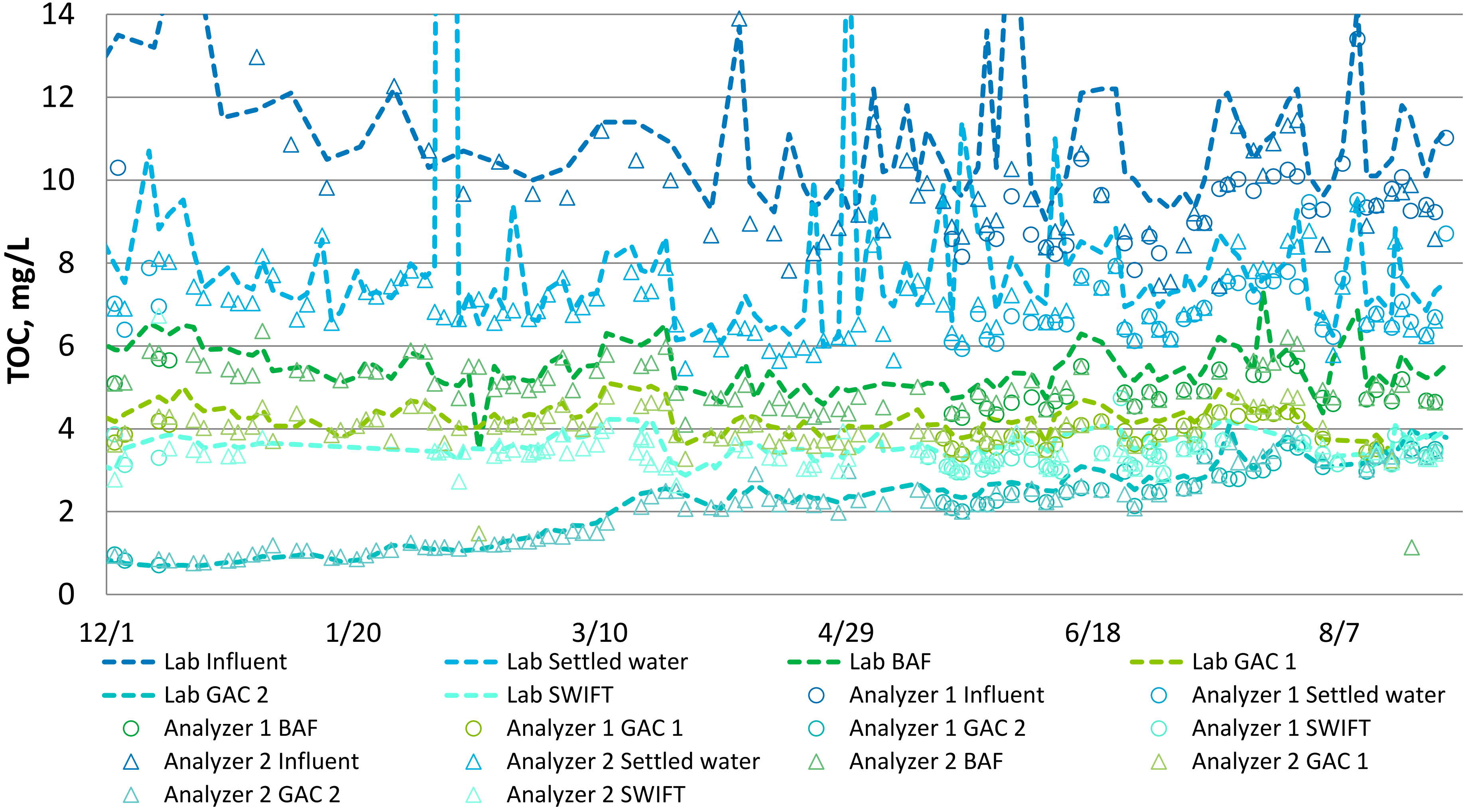
SWIFT Research Center – Process Flow Diagram



SWIFT RESEARCH CENTER PROCESS FLOW DIAGRAM

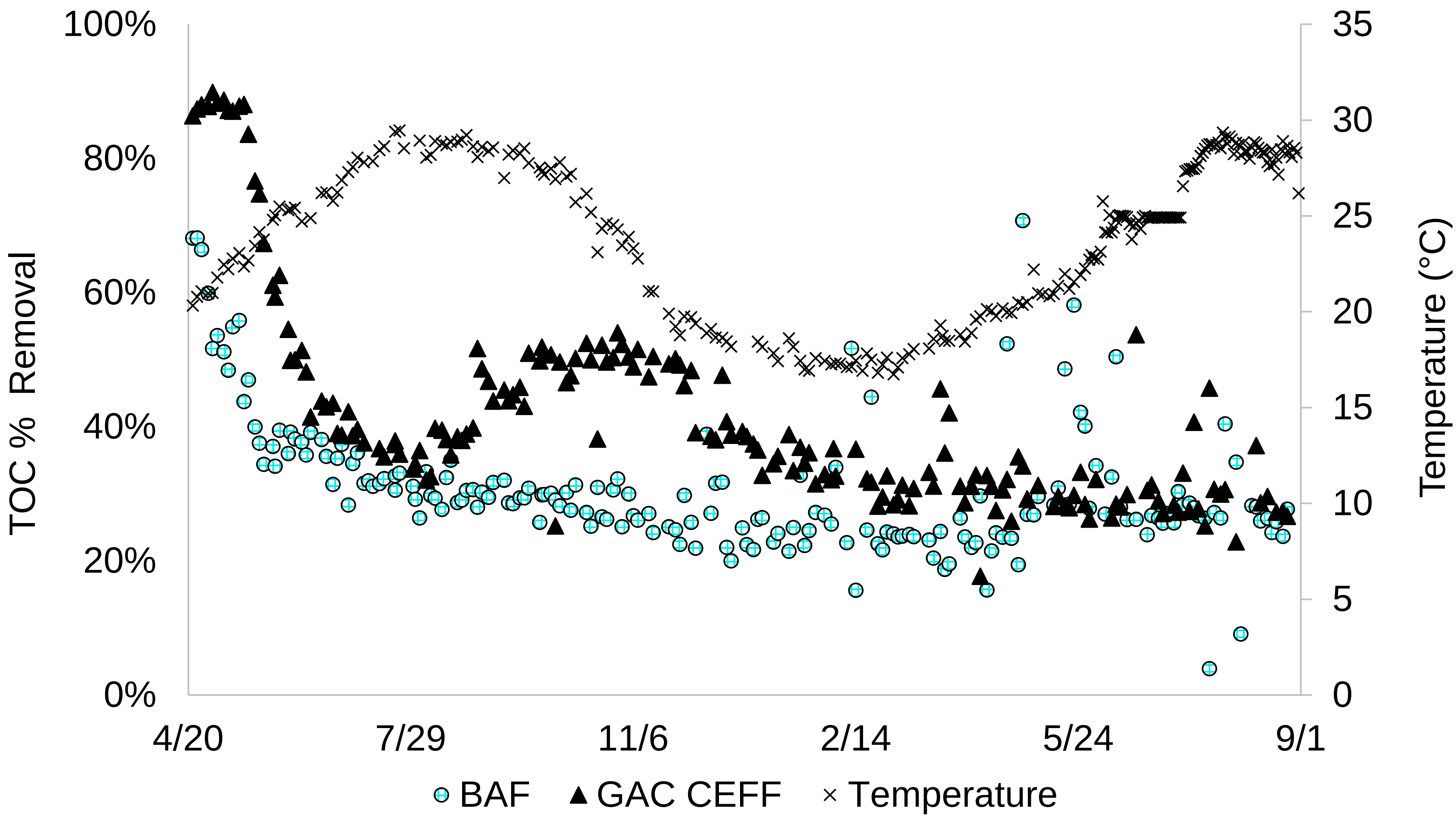
Sustainable Water Initiative for Tomorrow

SRC TOC

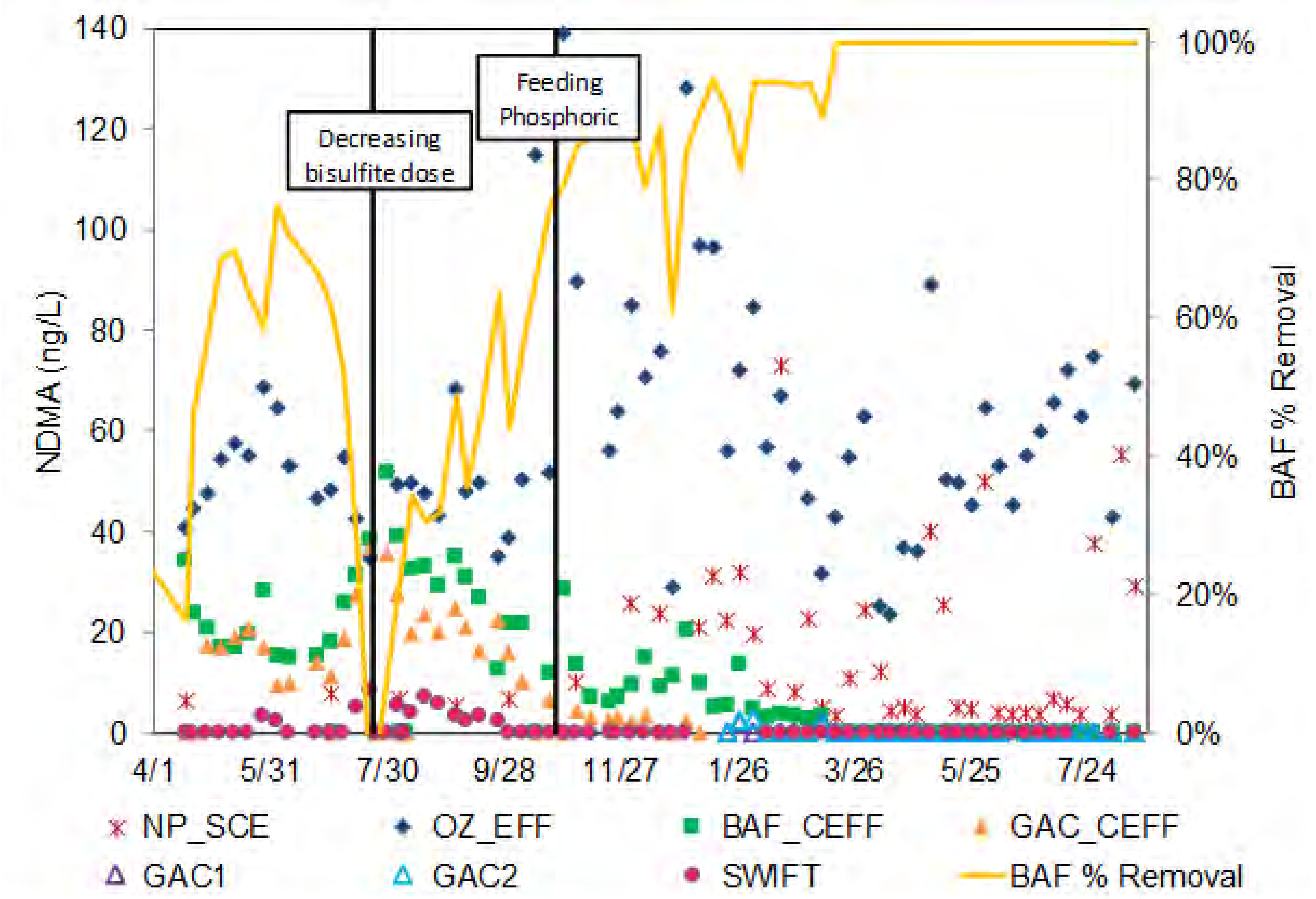


TOC, mg/L
14
12
10
8
6
4
2
0
12/1
1/20
3/10
4/29
6/18
8/7
Lab Influent
Lab Settled water
Lab BAF
Lab GAC 1
Lab GAC 2
Lab SWIFT
Analyzer 1 Influent
Analyzer 1 Settled water
Analyzer 1 BAF
Analyzer 1 GAC 1
Analyzer 1 GAC 2
Analyzer 1 SWIFT
Analyzer 2 Influent
Analyzer 2 Settled water
Analyzer 2 BAF
Analyzer 2 GAC 1
Analyzer 2 GAC 2
Analyzer 2 SWIFT

TOC Removal – BAF and GAC

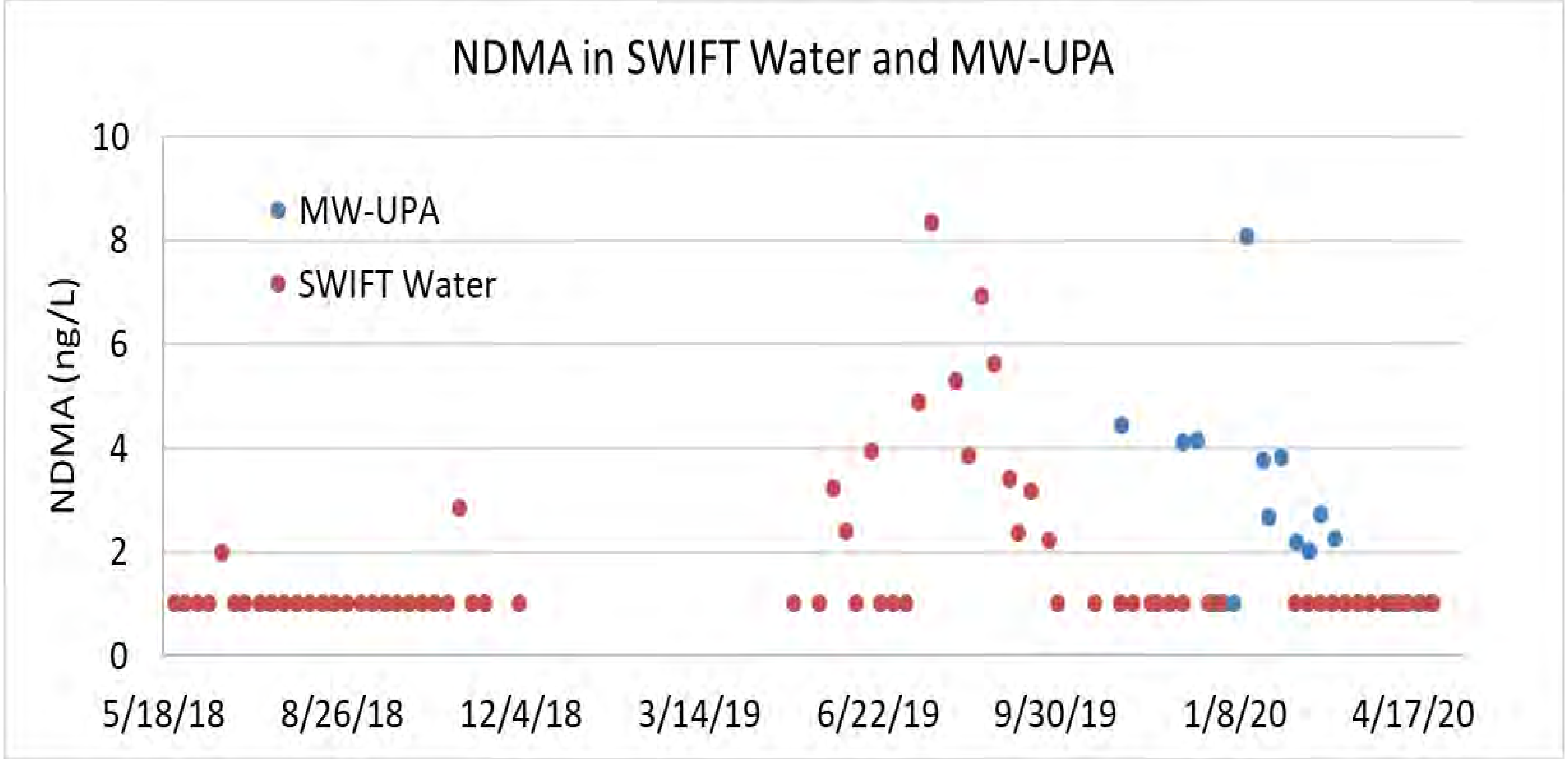


NDMA

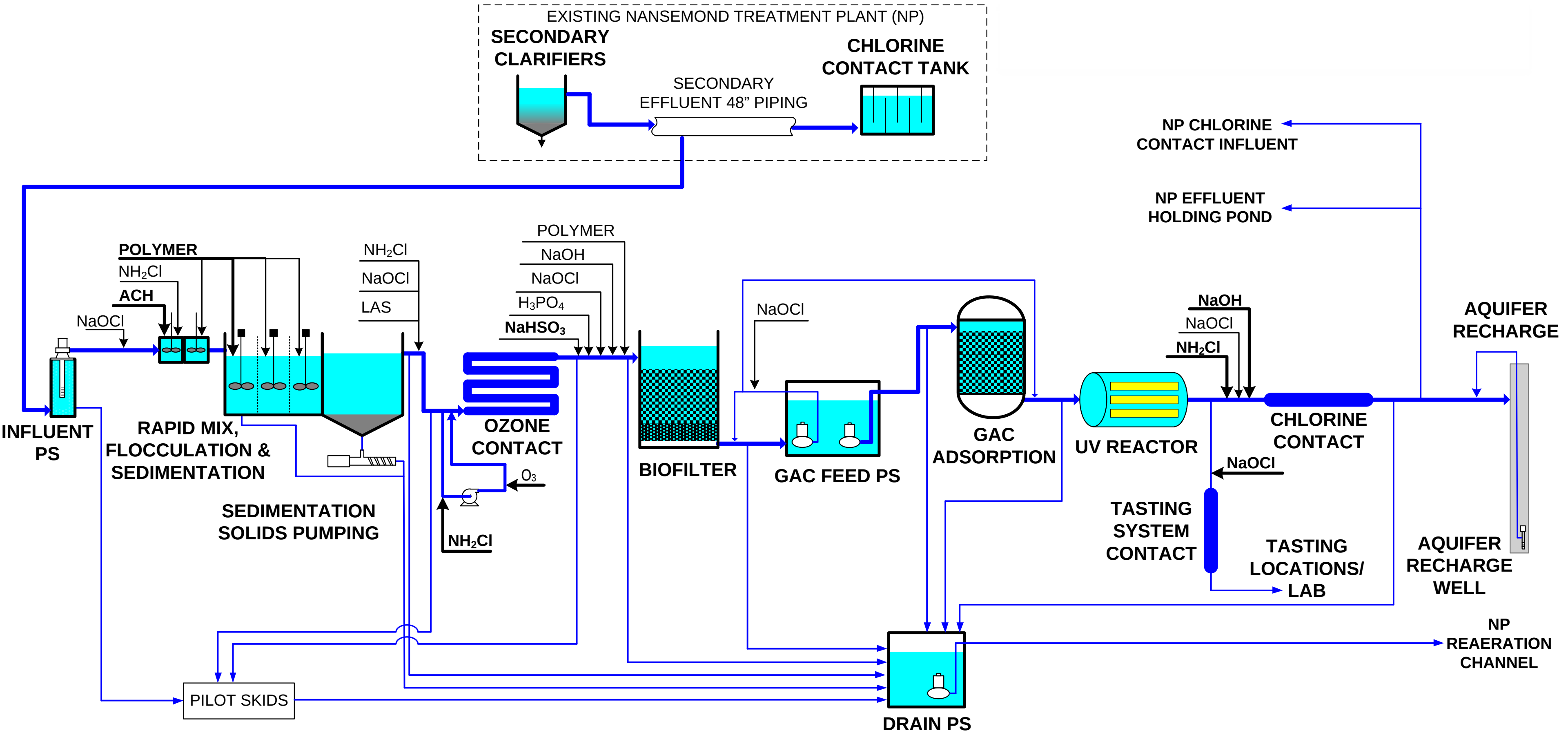


140
120
100
80
60
40
20
0
NDMA (ng/L)
100%
80%
60%
40%
20%
0%
BAF % Removal
Decreasing bisulfite dose
Feeding Phosphoric
4/1
5/31
7/30
9/28
11/27
1/26
3/26
5/25
7/24
NP_SCE
OZ_EFF
BAF_CEFF
GAC_CEFF
GAC1
GAC2
SWIFT
BAF % Removal

NDMA – SWIFT Water and MW-UPA



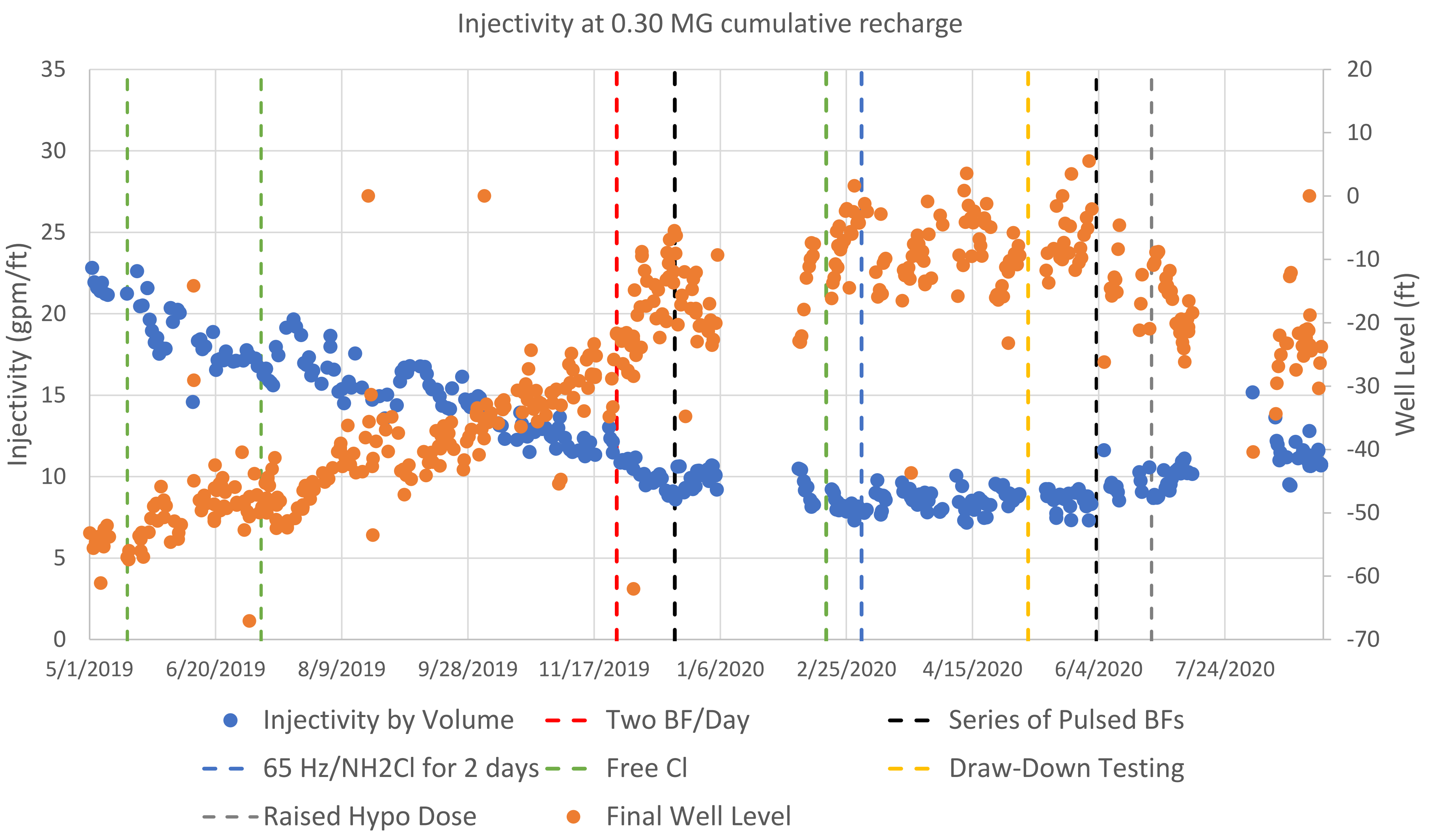
SWIFT Research Center – Process Flow Diagram



SWIFT RESEARCH CENTER PROCESS FLOW DIAGRAM

Sustainable Water Initiative for Tomorrow

TW-1 (SRC Recharge Well Injectivity)



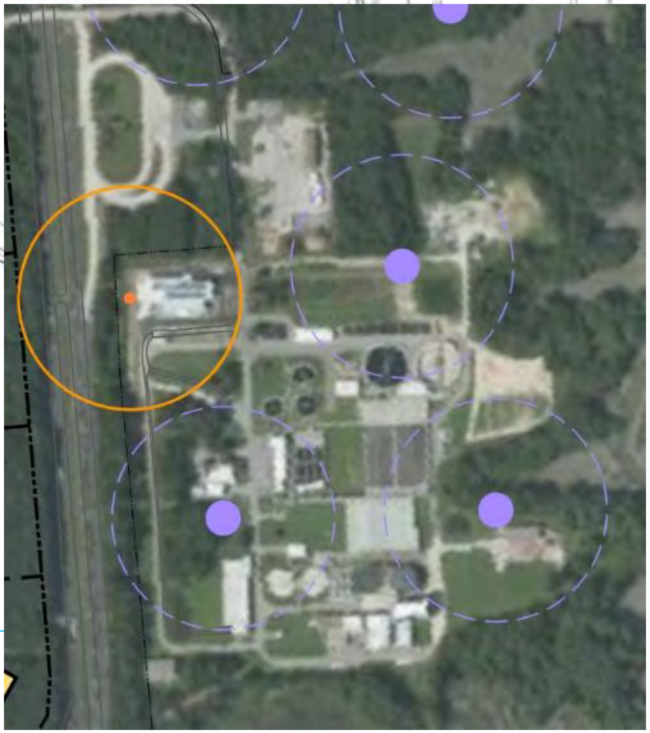
Preliminary conclusions:

- SWIFT Water "TSS or turbidity" is not the cause
- SWIFT Water Fe precipitation is not the cause – instant or delayed
  - There may have been short periods of elevated SWIFT Water Fe in 2018 and 2019 following GAC contactor shutdowns.
- Precipitation of other salts (e.g. $CaCO_3$) from SWIFT Water is unlikely
- Air entrainment in the well is unlikely
- Ineffective backflushing due to low flow rate may be a factor
- Remaining possibilities:
  - Biological fouling – new evidence suggests this is a strong possibility
  - Disruption of clay minerals
  - Interaction of SWIFT Water with aquifer materials resulting in precipitation of ?

- Approved by EPA to install new "full-scale" recharge well at Nansemond – RW-1
- Rehabilitate the existing recharge well (TW-1)
- No change in SWIFT Water flow (1 MGD)

RW-1 Proposed Location

Pros	Cons
Least amount of yard piping (~155')	Impacts previously permitted BMP
Proximity to research center	Proximity to TW-1 (~95')
Proximity to MW-SAT	Potential disruption to monitoring plan
	Potential disruption to operations

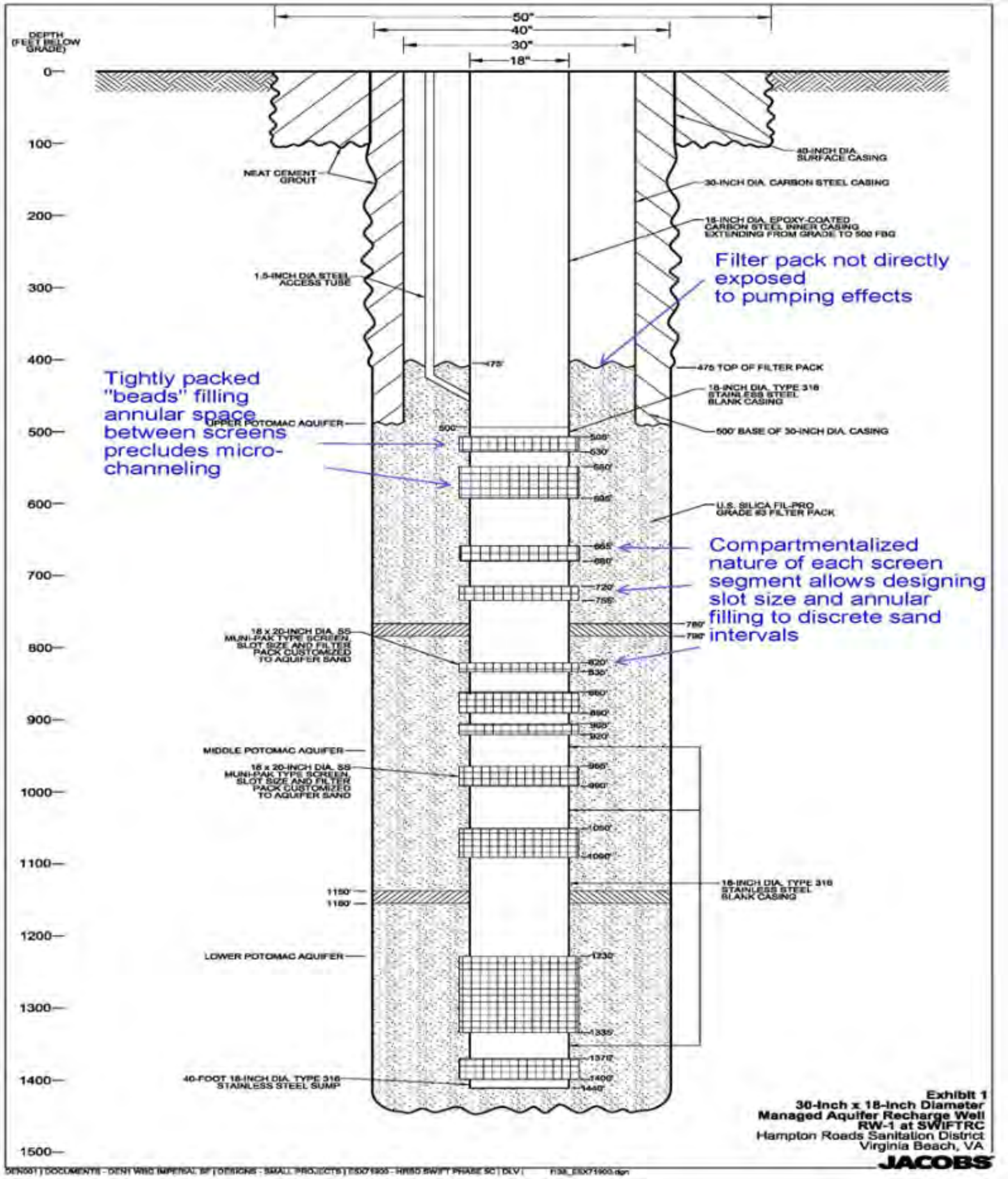


RW-1 Installation

- Drill pilot boring to 1,450
- Run geophysical log to total depth of pilot boring
- Collect formation sample for grain size distribution analysis
- Design well screen slot size, filling, and filter pack
- Ream pilot boring for 30-inch casing
- Install casing and run gyroscopic plumbness and alignment survey before grouting
- Drill 24-inch diameter borehole using reverse-circulation method
- Develop RW-1, mechanical, chemical, over-pumping, disinfection, and video survey
- Conduct step test, 24-hour constant rate test, and flowmeter logging
- Condition screen intervals using 0.1 M ACH solution & remove treatment solution
- Conduct post ACH step test and flowmeter log

RW-1 Design

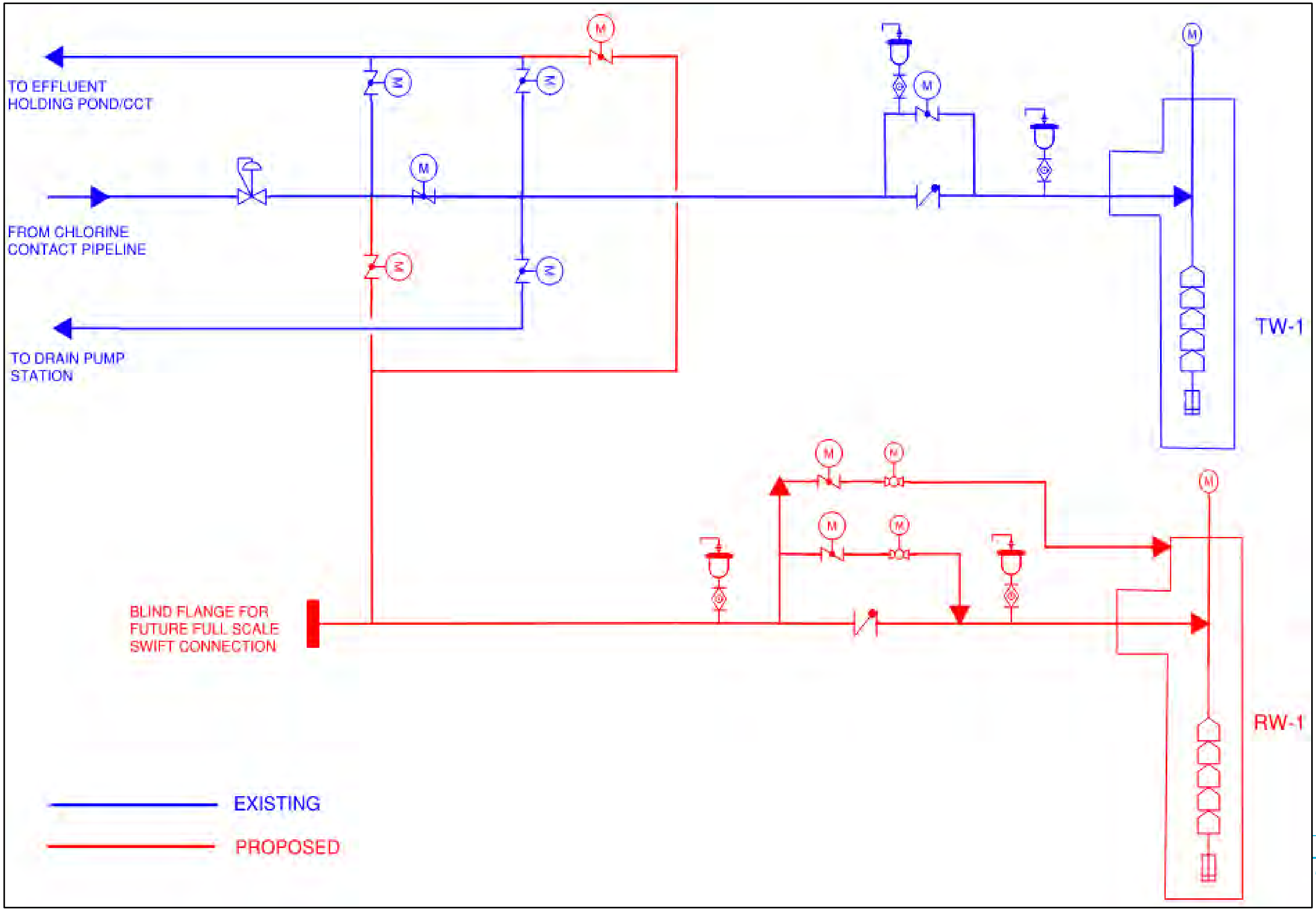
- Casing and screen assembly measures 18-inches in diameter
- Type 316 stainless steel casing
- Accommodates backflush pump capable of producing 1,800 to 2,100 gpm
- 18-inch casing accommodates 2 to 3 access tubes
- Also, an access tube will extend down outside of casing
- Muni-Pak type screen
- RW-1 screens same intervals as TW-1



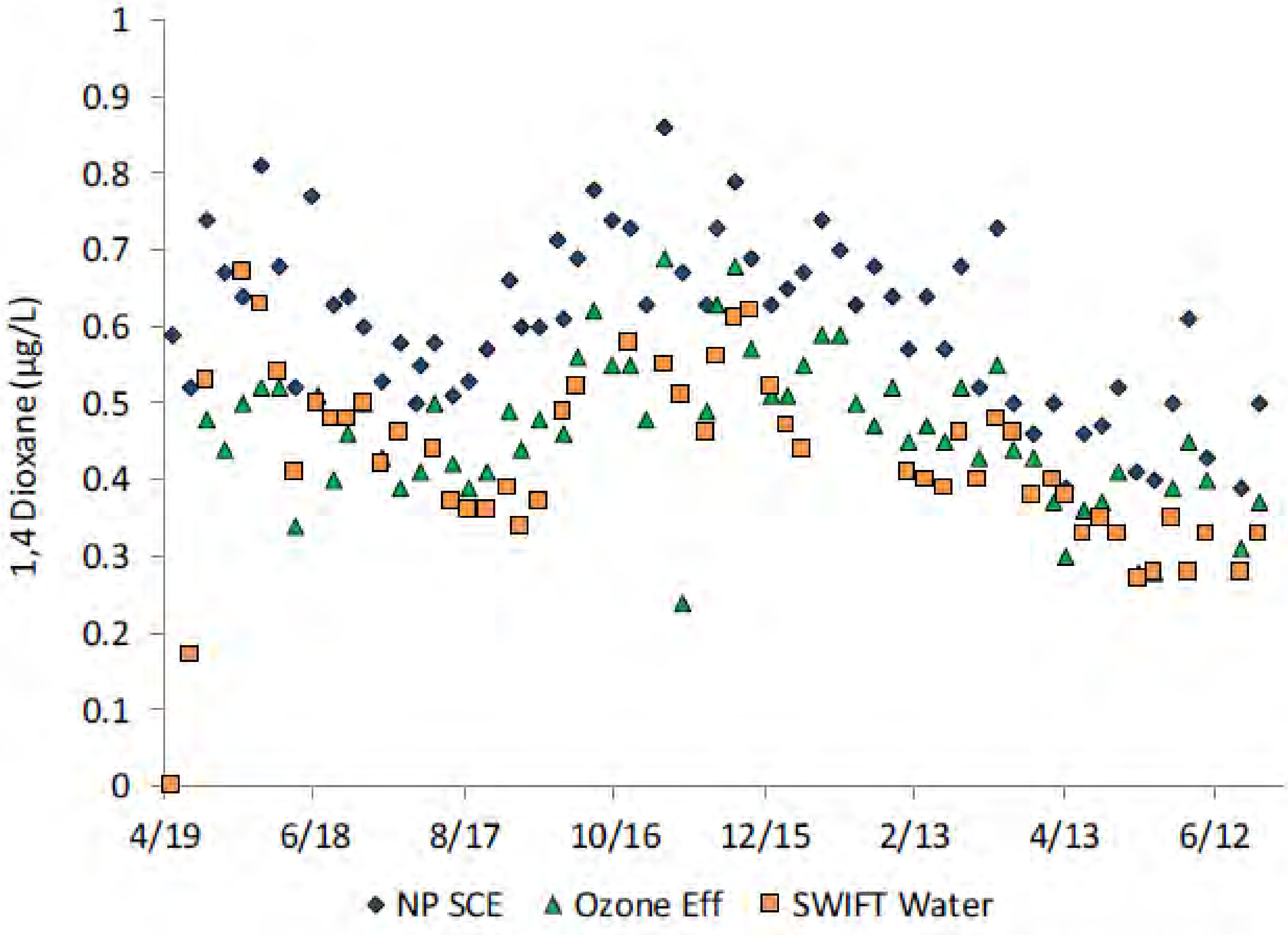
RW-1 Process Mechanical Arrangement

- Well column & well annulus recharge capability
- Orifice plate in lieu of downhole control valve for well column hydraulics control
- Borehole flow meter

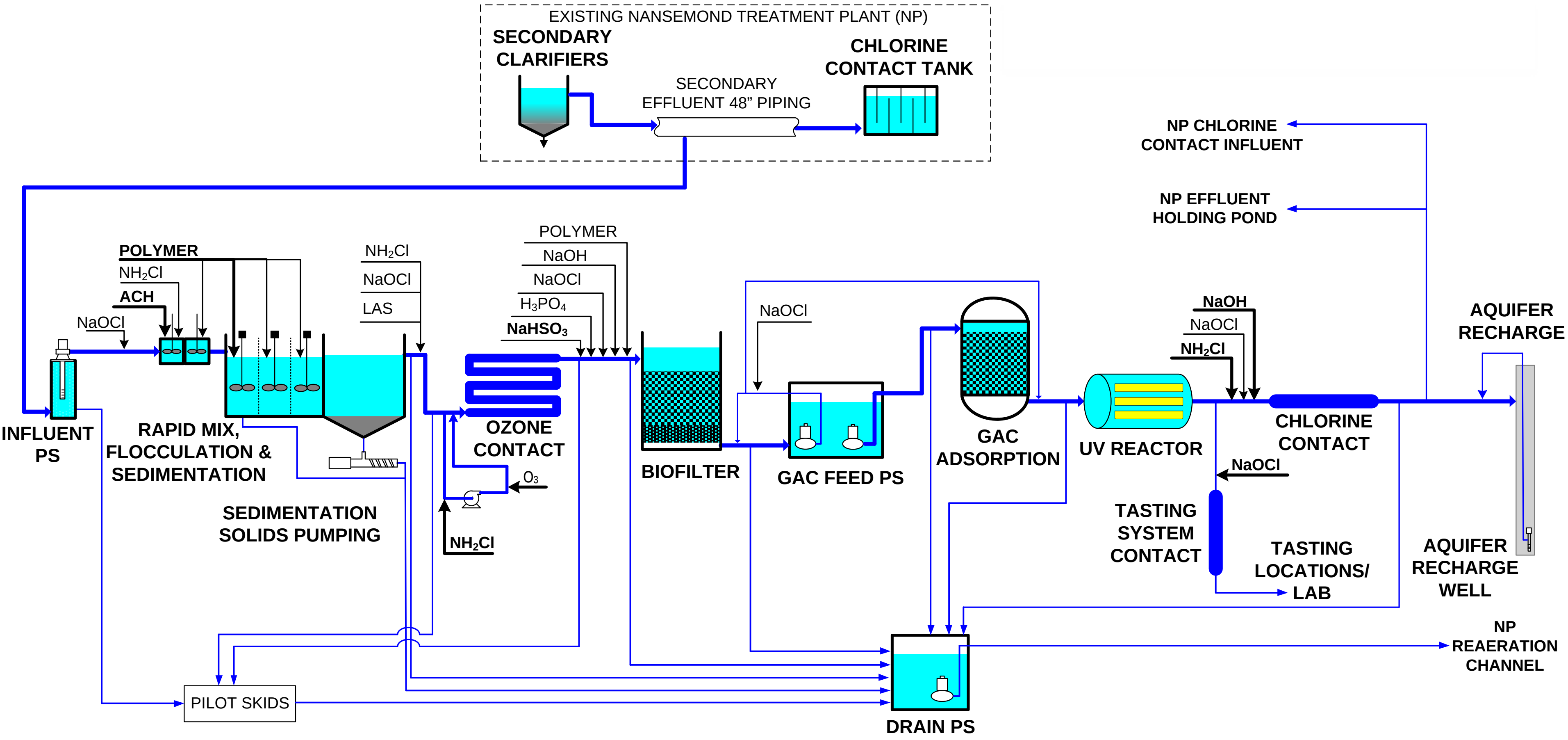
RW-1 Piping Integration



SRC 1,4-Dioxane Profile (2019-2020)

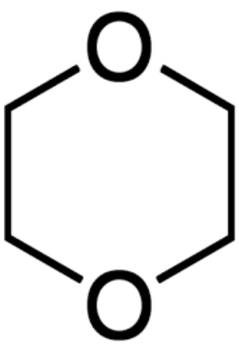


SWIFT Research Center – Improving 1,4-dioxane removal

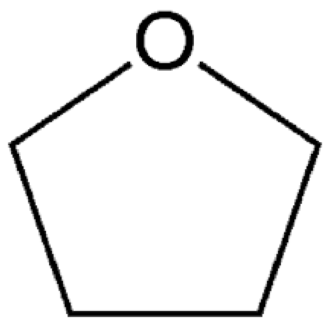


SWIFT RESEARCH CENTER PROCESS FLOW DIAGRAM

BAC/GAC Pilot – Co-metabolic removal of 1,4-dioxane using tetrahydrofuran or propane



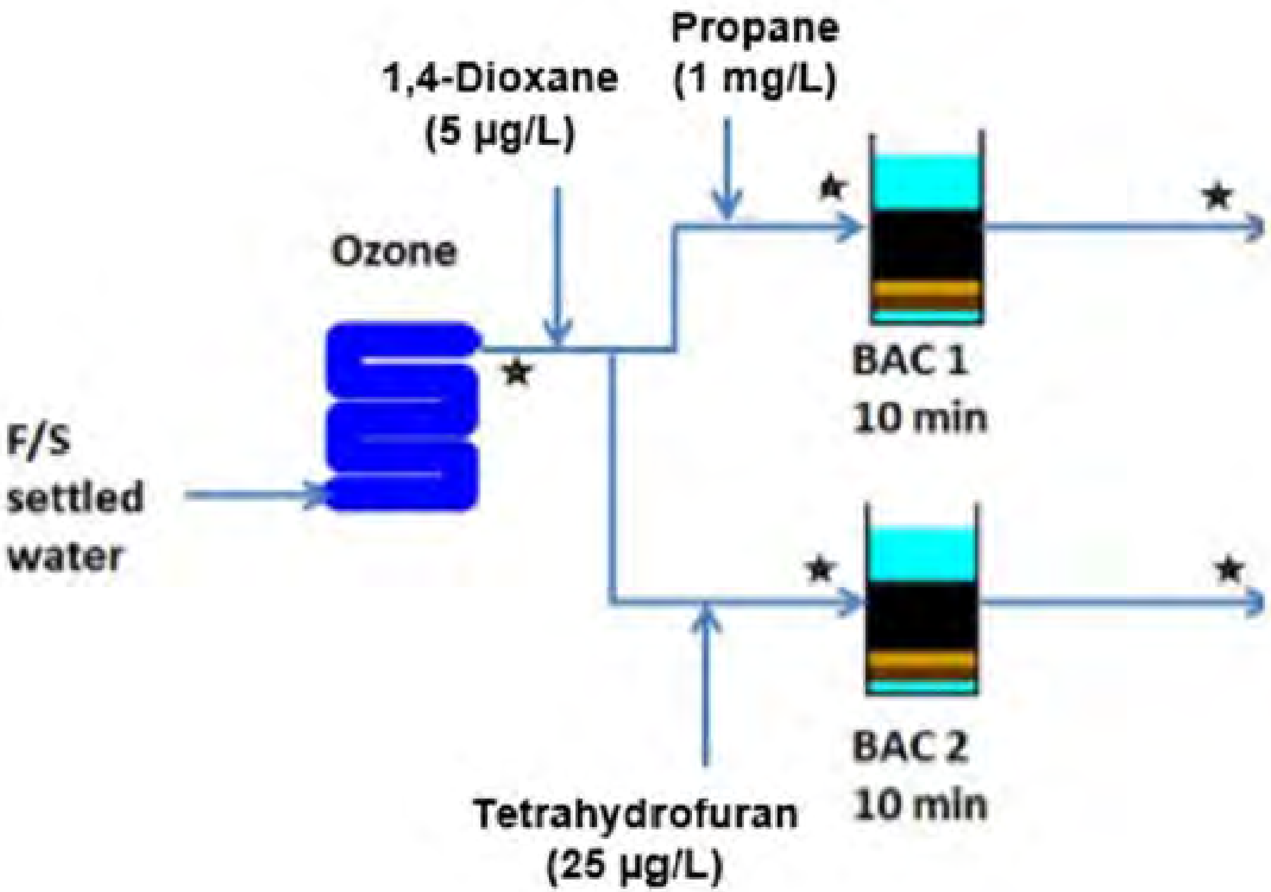
1,4-D



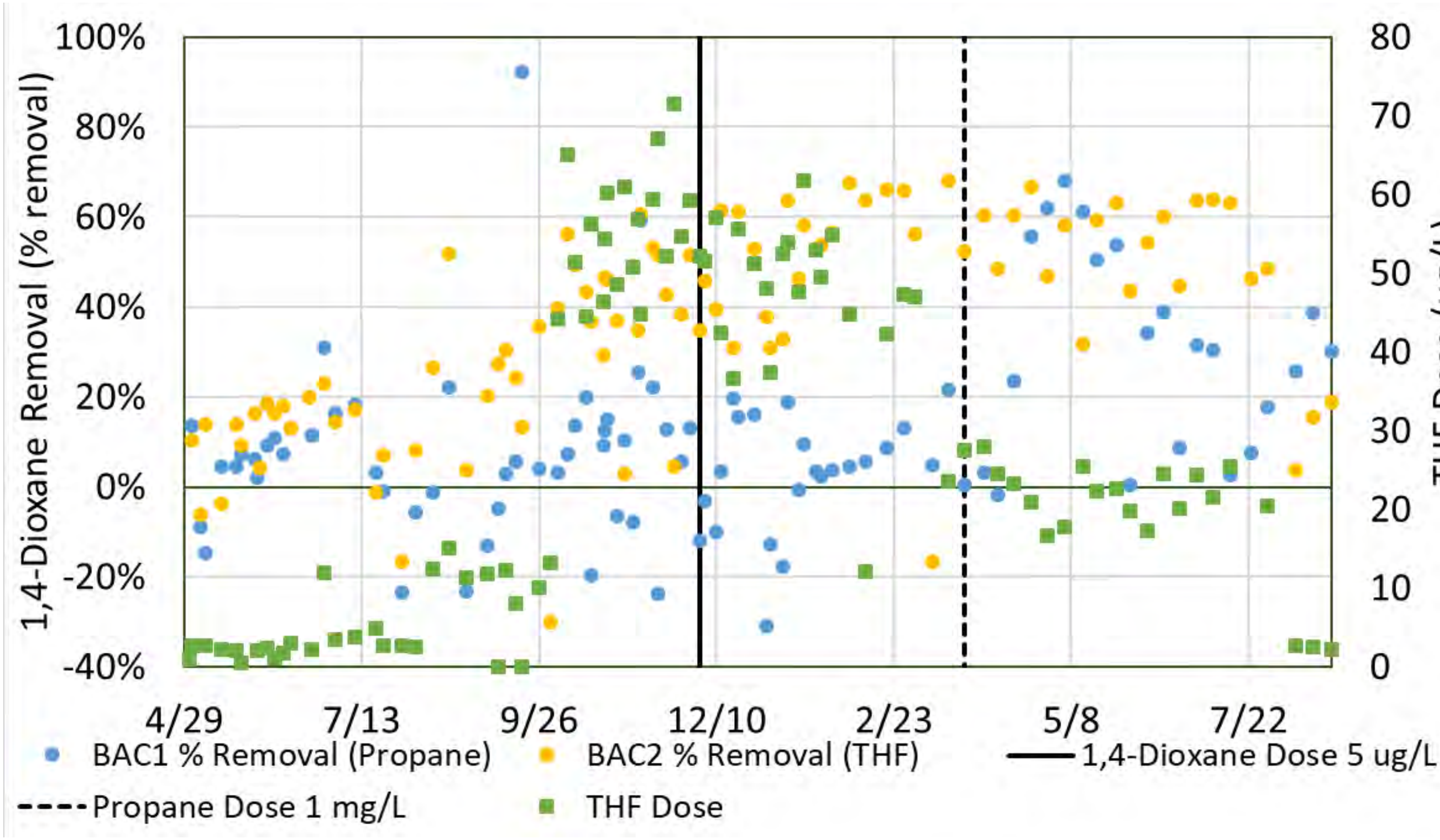
THF

Intuitech™

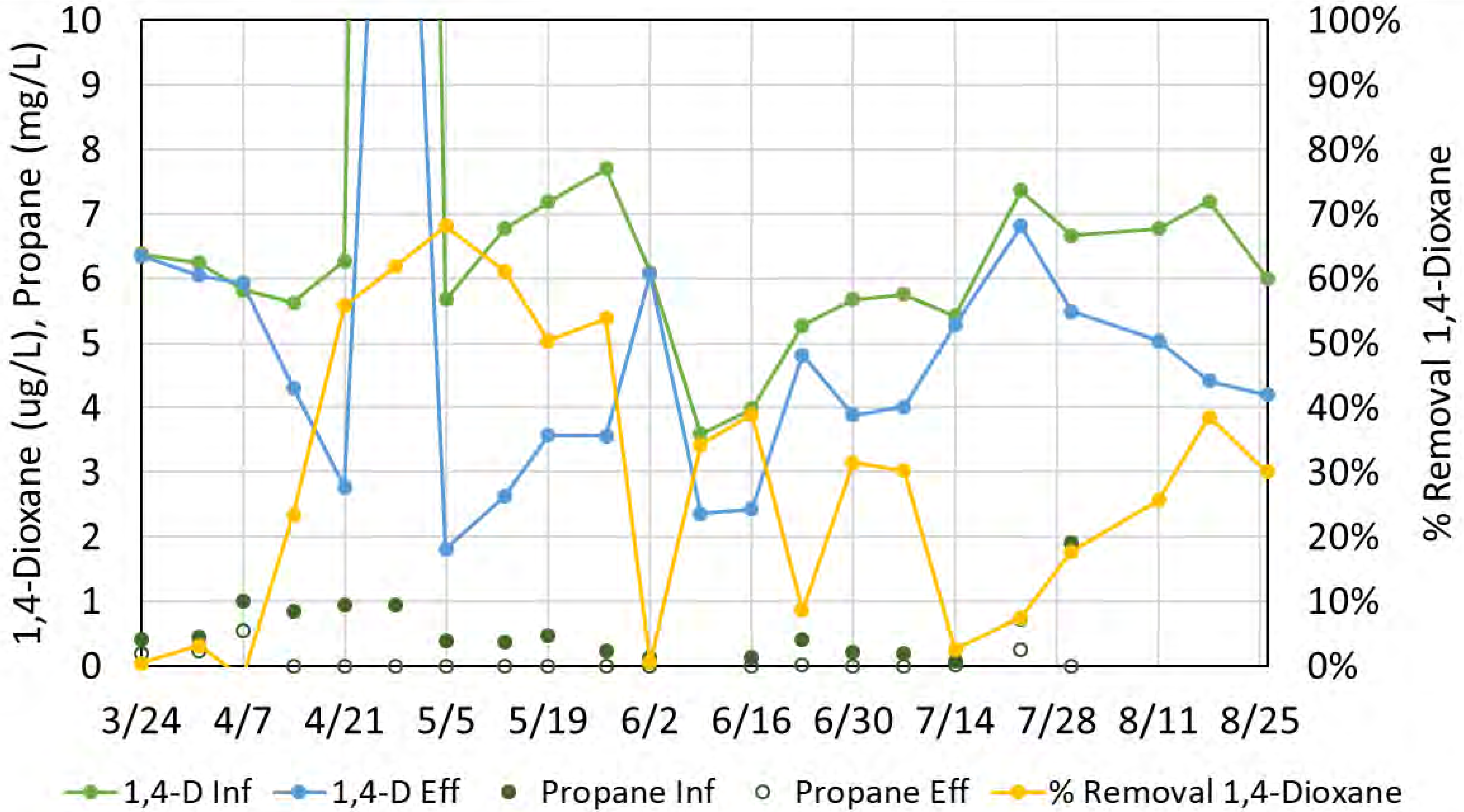
Pilot testing – Enhancing 1,4-dioxane removal with THF and propane addition



Preliminary propane data are very encouraging

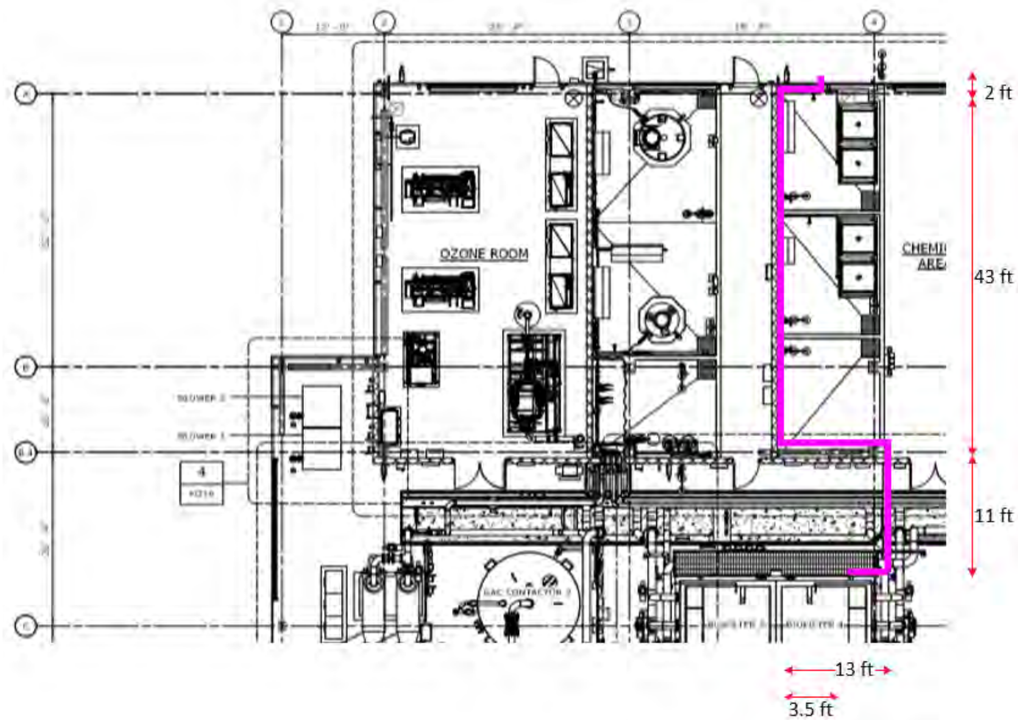


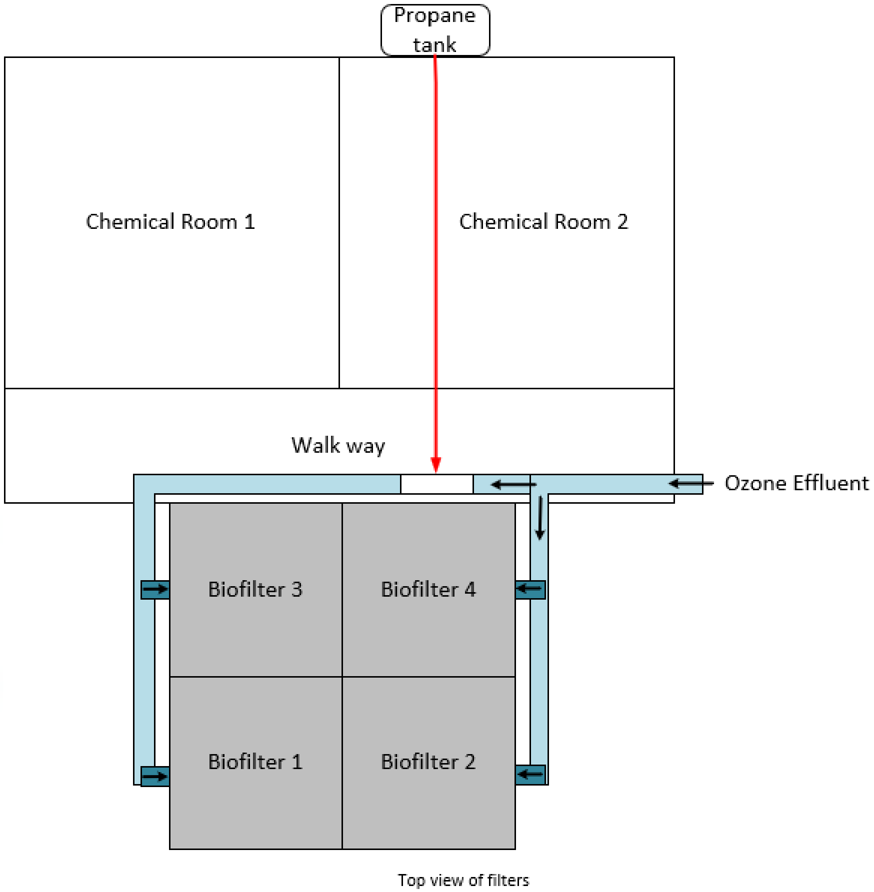
Biofilter Pilot – Propane Column



Propane Full Scale SRC Testing

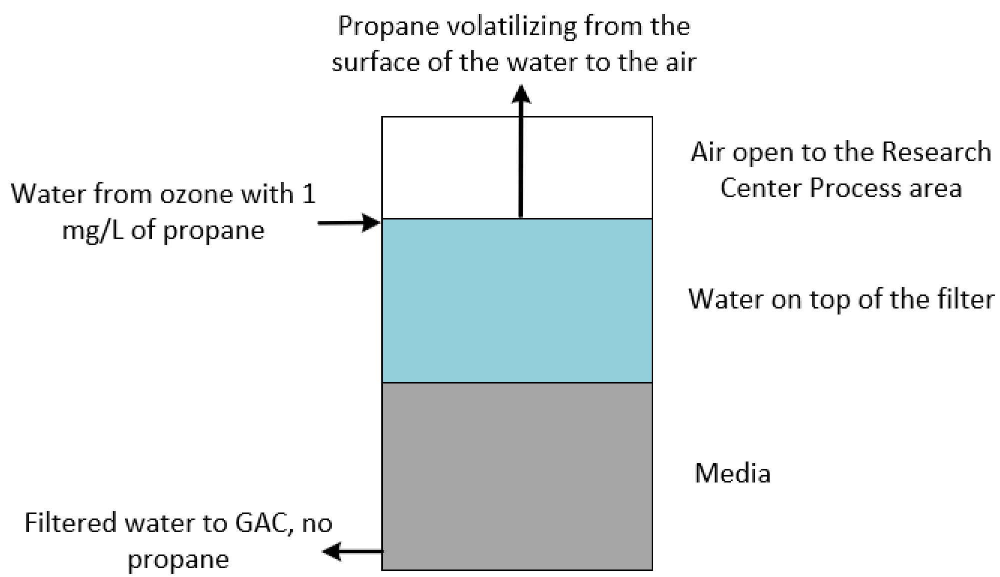
- Goal: Feed propane at a dose of 1-5 mg/L to Biofilters 1 and 3
- Use Biofilters 2 and 4 as controls
- Main concern: Volatilization of propane into the air





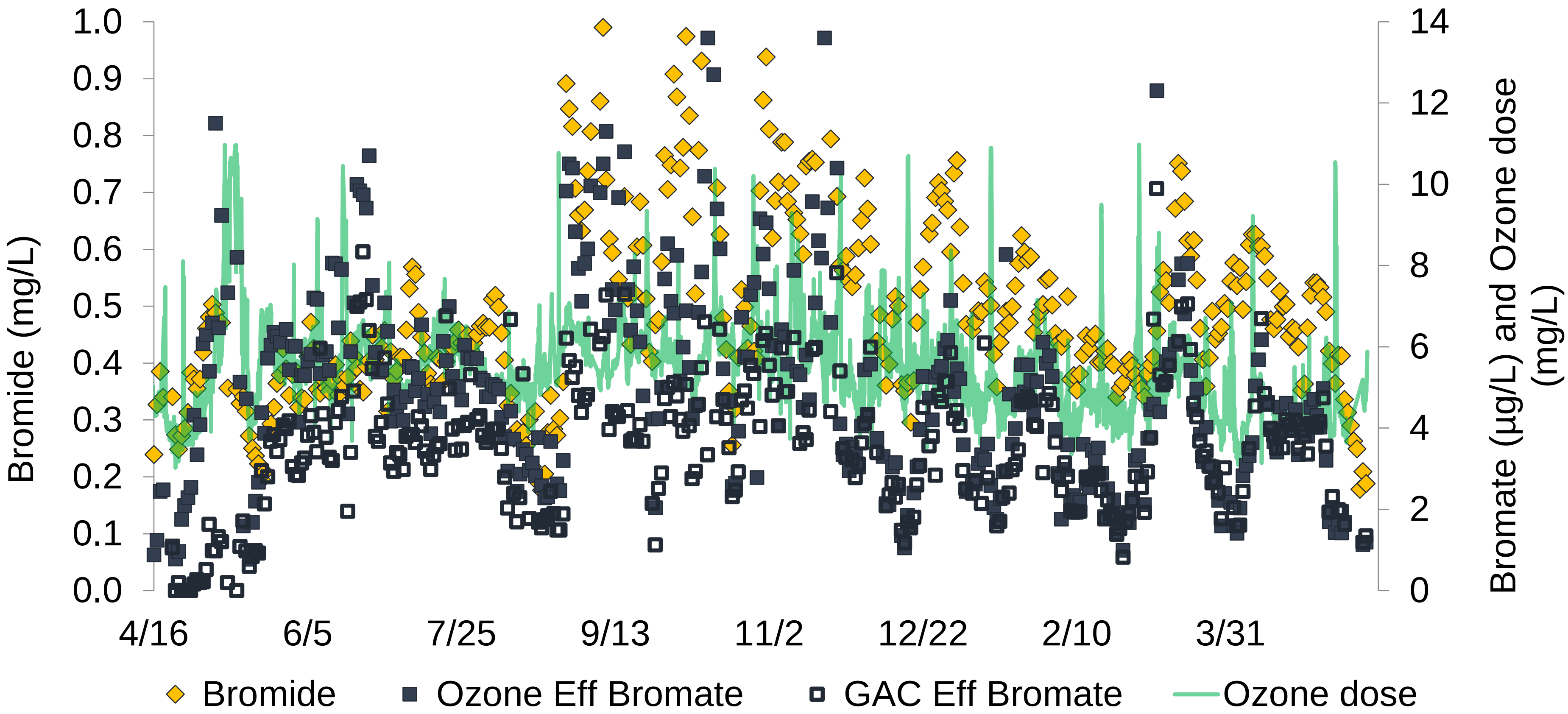
Propane Full Scale

- Modeled the steady state concentration of propane in the SRC building using analytical gas-liquid mass transfer assumptions
- Worst case scenario estimate: <1 ppmv
- NIOSH limit: 1,000 ppmv



Cross section of a biofilter

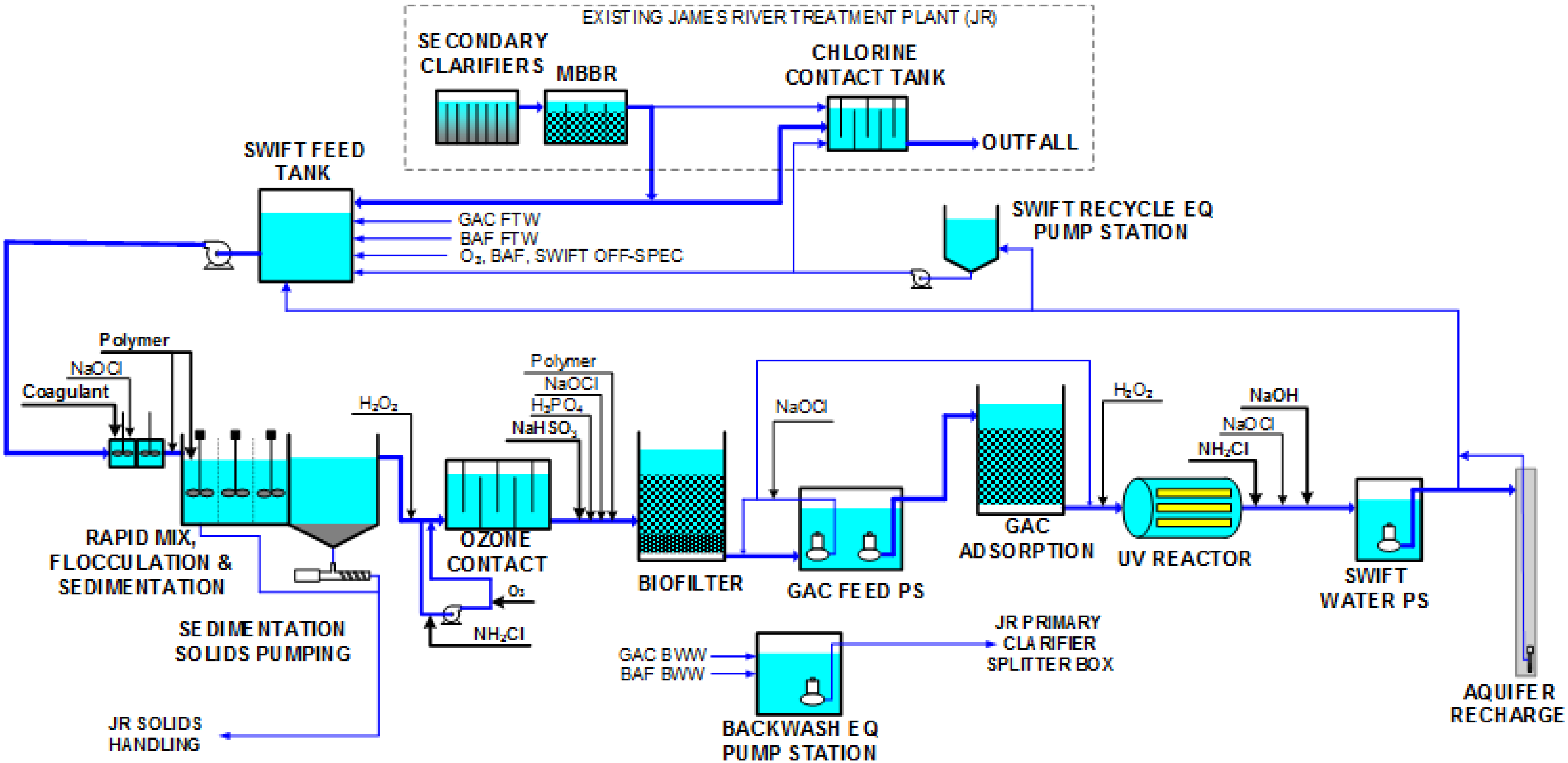
Bromate is well controlled at the SRC by the addition of preformed monochloramine, but this limits 1,4-dioxane removal through ozonation



HRSD 1,4-dioxane (µg/L) SCE data

	ABTP	BHTP	**JRTP**	VIPTP	WBTP	YRTP
Min	0.48	0.55	**0.74**	0.49	0.52	0.34
Max	0.68	0.74	**1.6**	2.2	0.71	0.66
Average	0.56	0.64	**1.12**	0.93	0.61	0.48

James River SWIFT – Improving 1,4-dioxane removal (0.35 µg/L treatment objective)

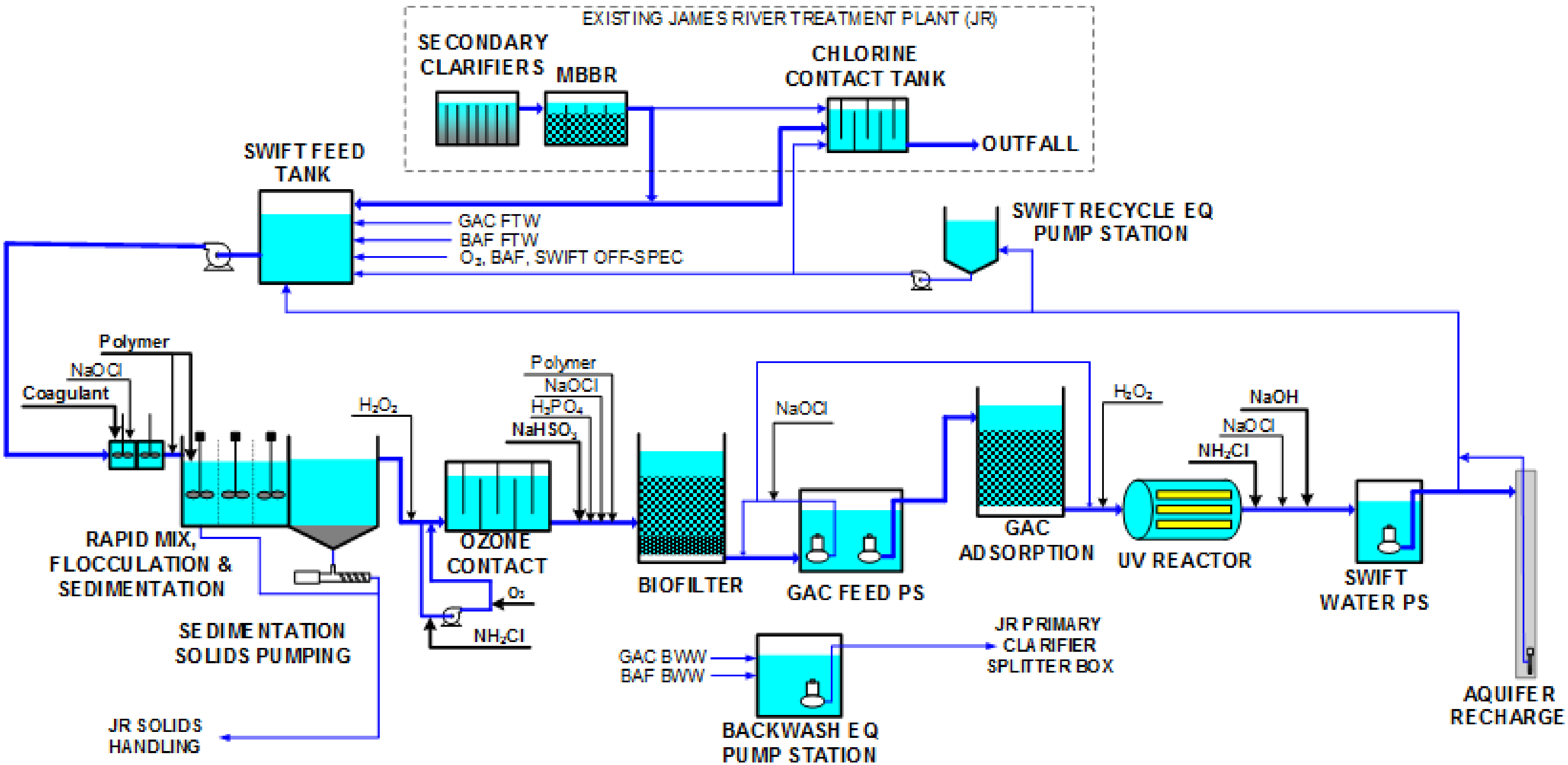


Results demonstrate value of Ozone/H_2O_2 for improving 1,4-dioxane removal while adequately controlling bromate formation. Also multi-point FBD should be considered.

			Bromate Formed (µg/L)			1,4-dioxane % Removed		
		O3:TOC	0.5	0.8	1.1	0.5	0.8	1.1
Day 1- Br: 0.419 mg/L, TOC: 6.2 mg/L, Influent 1,4-dioxane: 2.5 µg/L	No Bromate control	Sidestream	5.84	16.9	42.4	24	48	60
		Fine Bubble	14.8	35.8	68.1	44	60	66.4
	3 mg/L Preformed Monochloramine	Sidestream	1.41	4.14	10.4	28	36	52
		Fine Bubble	1.29	5.82	11.9	28	36	48
	1.5:1 H2O2:O3	Sidestream	2.43	9.53	18.9	36	60	77.6
		1 Diffuser FBD	3.36	6.28	23.8	48	63.6	81.2
		2 Diffuser FBD	1.26	2.38	4.47	61.2	79.6	92.4
Day 2- Br: 0.389 mg/L, TOC: 6.6 mg/L, Inf 1,4-D: 1.36 µg/L	1:1 H2O2:O3	1 Diffuser FBD		*4.88*			51	
		2 Diffuser FBD		*4.56*			82	

Influent 1,4-dioxane spiked in feed tank (YR 1,4-dioxane has been ~0.4 µg/L lately)
YR bromide roughly 2x JR bromide, YR Denite TOC comparable to JR floc-sed effluent TOC
O_3:TOC is NO_2 corrected

James River SWIFT – Improving 1,4-dioxane removal



Permitting Update

swift

Sustainable
Water Initiative
for Tomorrow

JR UIC Draft Permit Development

SWIFT Water Quality Targets and the Aquifer Monitoring and Contingency Plan formed the basis of the permit application responses

- Document provided for review and comment to NWRI and the PAROC
- Next steps: finalize construction schematics for the recharge and monitoring wells
- Submit application by end of October

NWRI Comments

- Largely focused on areas of additional research at the SWIFT Research Center
  - Process unit validation of Log Reduction Values for viruses, Cryptosporidium and Giardia
  - HRSD had validated process units at the pilot scale in 2016 with challenge testing
    - Challenge testing difficult with an operational recharge well
    - Low concentrations in the feed to the SWIFT facility make it difficult to quantify the LRVs necessary for each unit process
    - In discussions with NWRI panelists, we identified tools that would support such an evaluation
      - Virus Indicator: Pepper Mild Mottle Virus
      - Evaluating Cryptosporidium and Giardia using different techniques and looking at Clostridium perfringens as a protozoan indicator

NWRI Comments

- In discussions with NWRI panelists, we identified tools that would support such an evaluation
  - Virus Indicator: Pepper Mild Mottle Virus
  - Evaluating Cryptosporidium and Giardia using different techniques and looking at Clostridium perfringens as a protozoan indicator
- Reminder of LRVs targeted. Very conservative using SDWA as a basis for pathogen crediting
- Acknowledge greater removal is likely occurring

Parameter	Floc/Sed (+BAF)	Ozone	BAF+GAC	UV	Cl2	SAT	Total
Enteric Viruses	2	0	0	4	0	6	12
Cryptosporidium	4	0	0	4	0	6	14
Giardia	2.5	0	0	4	0	6	12.5

NWRI Comments

- Significant Changes to UIC Documents
  - Provided additional narrative on the SWIFT program, piloting and the Research Center with emphasis on the scope of monitoring and areas of research
  - Added Male Specific and somatic coliphage as a monitoring requirement for SWIFT Water
  - Modified the monitoring well construction plan
    - Original included sampling from one targeted depth in the Upper Potomac and one targeted depth in the Middle Potomac
    - Panelists felt multi-depth sampling was important to capture recharge flow in case the flow paths were disrupted (e.g., clogging at the recharge well) – this was also a comment from the PAROC
    - The monitoring well screens will mirror the nearest recharge well

VDH Comments

- Significant Changes to UIC Documents
  - Additional monitoring added:
    - Unregulated Contaminant Monitoring Rule
    - Hexavalent chromium and additional PFAS monitoring related to the legislative action
    - NDMA formation potential (FP) monitoring
      - Frequency and duration of monitoring will vary depending on mode of well protection (free chlorine vs monochloramine)
      - Phased reduction contingent upon NDMA concentrations in monitoring wells and in FP tests remaining < 10 ng/L
      - All NDMA FP data will be evaluated by PARML and PAROC to ensure concurrence with phased reductions

VDH Comments

- NDMA FP frequency and duration
  - Monochloramine more likely to contribute to NDMA formation than free chlorine necessitating different approaches to NDMA FP monitoring frequency
    - Monochloramine:
      - Year 1: Monthly monitoring
      - Years 2 – 3: Quarterly monitoring
      - Years 4 – 10: Annual monitoring
    - Free chlorine
      - Monthly monitoring for 1st three months
      - Critical Control Point added to ensure ammonia is controlled at the GAC Combined Effluent
    - Phased reductions must meet the contingency requirements
    - Monitoring frequency resets if contingency requirements not met

VDH Comments

- PMCL Compliance
  - Modified language to ensure that in the event a sample result indicated the potential for a PMCL violation, that SWIFT Water was diverted from the recharge well until confirmation testing could be completed
  - PMCL compliance evaluation varies depending on if the parameters is evaluated on a Running Annual Average (RAA) or a Single Instance Limit
    - RAA: inorganic chemicals (antimony, arsenic, barium, beryllium, cadmium, chromium, fluoride, mercury, nickel, selenium, and thallium), asbestos, organic chemicals, and disinfection byproducts
    - Single Instance: nitrate and nitrite, radionuclides

VDH Comments

- RAA Calculations

- For constituent groups with a minimum sampling frequency period of "**Monthly**", the RAA will consist of an **average of 12 equally-weighted "single monthly values"**, with each single monthly value representing the average of all data points collected during the corresponding calendar month.

- For constituent groups with a minimum sampling frequency period of "**Quarterly**", the **RAA will consist of an average of 4 equally-weighted "single quarterly values"**, with each single quarterly value representing the average of all data points collected during the corresponding quarter.

VDH Comments

- Potential Exceedance: Next Steps

- HRSD will divert water from the recharge well and confirm the analysis
- If PMCL exceedance is confirmed, HRSD will notify EPA and the PAROC and initiate an investigation, take corrective action, and perform follow-up sampling to demonstrate that corrective actions have been effective and the RAA is reduced to below the PMCL
- Once a PMCL violation has occurred and SWIFT water has been diverted, HRSD may collect follow-up samples no more frequently than once per day. Each time a sample is measured, the single monthly value and RAA will be re-calculated. Once the RAA is reduced to below the PMCL, the facility is no longer in violation and may resume recharge (and submit a report to VDH and PAROC within 14 days).
  - Data collected during the PMCL shutdown is not to be omitted from future compliance calculations

Aquifer Monitoring Plan Comments

- Monitoring well design as mentioned previously
- Construction modification to include bentonite seals in annular space between the aquifers
- Area of Review figure:
  - Information on the well users in the vicinity of JR SWIFT
    - Further investigation with help of VDH concluded that only three of the private wells identified within the AOR were actually constructed and all wells were shallow wells

Next Steps

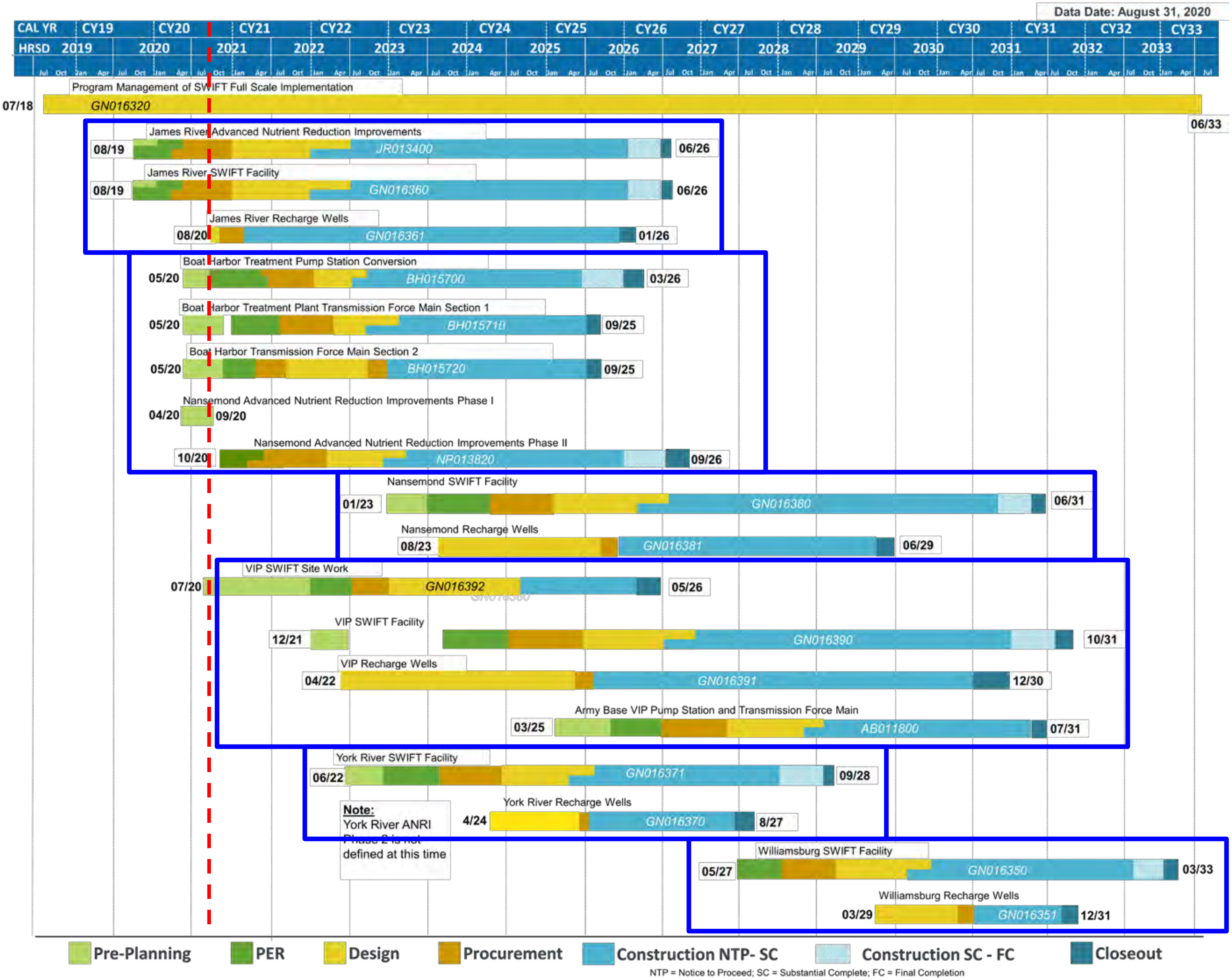
- Comments wrapped up
- Will send comment response document and modified documents for review by 9/18
  - Acknowledging that construction schematics from new well team still in progress
  - Well schematics will be sent to DEQ for review prior to submitting to EPA with the permit application

Full Scale Implementation Program Update

Lauren Zuravnsky, P.E.
Chief of Design & Construction - SWIFT

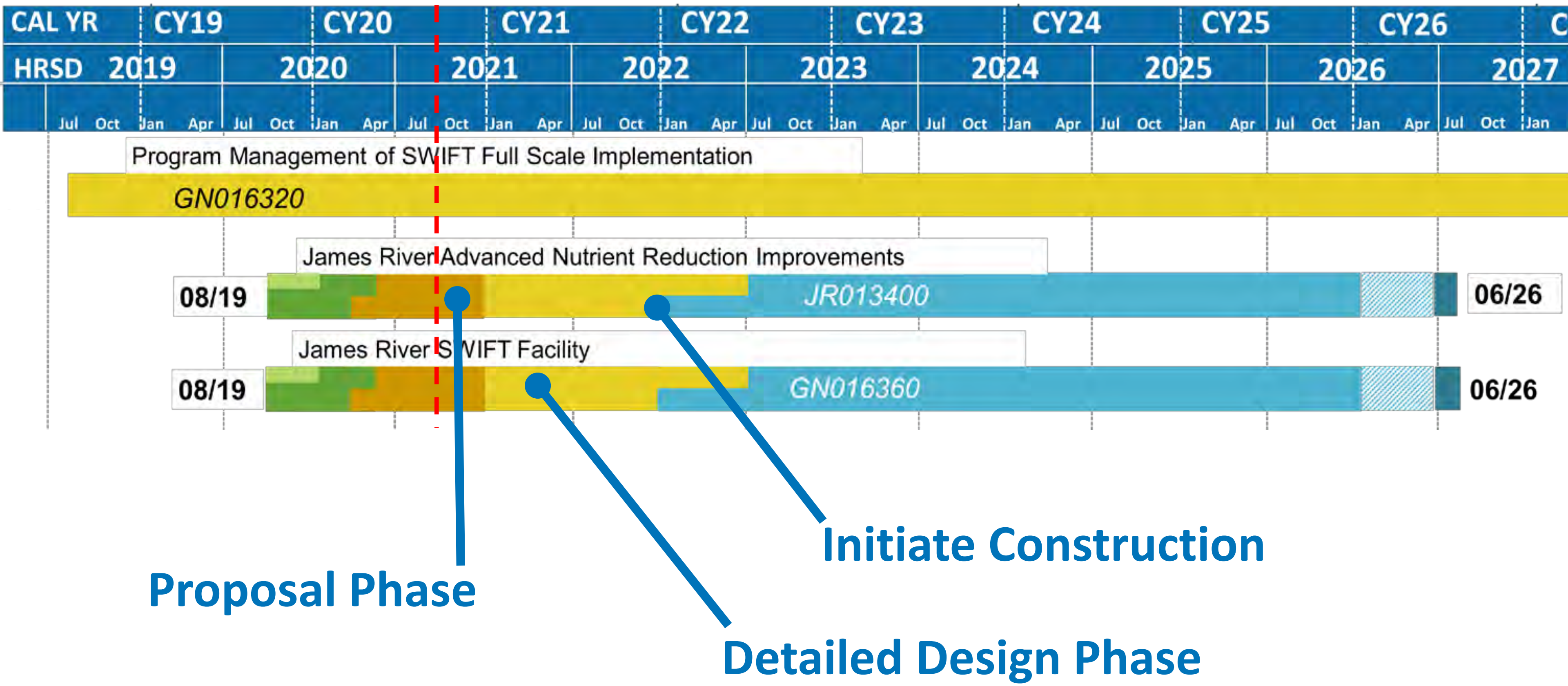
Potomac Aquifer Recharge Oversight Committee
September 10, 2020

8 MGD
WBTP
10 MGD
YRTP
Newport News
Poquoson
JRTP
16 MGD
Hampton
ABTP
BHTP
Isle of Wight
NP
VIP
Norfolk
38 MGD
33 MGD
Portsmouth
ATLANTIC OCEAN
Virginia Beach
Total Capacity Goal ~ 100 MGD
Southampton
Suffolk
Chesapeake
Franklin
swift



Data Date: August 31, 2020
CAL YR CY19 CY20 CY21 CY22 CY23 CY24 CY25 CY26 CY27 CY28 CY29 CY30 CY31 CY32 CY33
HRSD 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033
Program Management of SWIFT Full Scale Implementation
07/18 GN016320 06/33
James River Advanced Nutrient Reduction Improvements
08/19 JR013400 06/26
James River SWIFT Facility
08/19 GN016360 06/26
James River Recharge Wells
08/20 GN016361 01/26
Boat Harbor Treatment Pump Station Conversion
05/20 BH015700 03/26
Boat Harbor Treatment Plant Transmission Force Main Section 1
05/20 BH015710 09/25
Boat Harbor Transmission Force Main Section 2
05/20 BH015720 09/25
Nansemond Advanced Nutrient Reduction Improvements Phase I
04/20 09/20
Nansemond Advanced Nutrient Reduction Improvements Phase II
10/20 NP013820 09/26
Nansemond SWIFT Facility
01/23 GN016380 06/31
Nansemond Recharge Wells
08/23 GN016381 06/29
VIP SWIFT Site Work
07/20 GN016392 05/26
VIP SWIFT Facility
12/21 GN016390 10/31
VIP Recharge Wells
04/22 GN016391 12/30
Army Base VIP Pump Station and Transmission Force Main
03/25 AB011800 07/31
York River SWIFT Facility
06/22 GN016371 09/28
York River Recharge Wells
4/24 GN016370 8/27
Note:
York River ANRI Phase 2 is not defined at this time
Williamsburg SWIFT Facility
05/27 GN016350 03/33
Williamsburg Recharge Wells
03/29 GN016351 12/31
Pre-Planning
PER
Design
Procurement
Construction NTP- SC
Construction SC - FC
Closeout
NTP = Notice to Proceed; SC = Substantial Complete; FC = Final Completion

Reaching the end of best value, design-build procurement for combined James River projects.




Well Location
Pipe Line Routes
HRSD James River
Treatment Plant

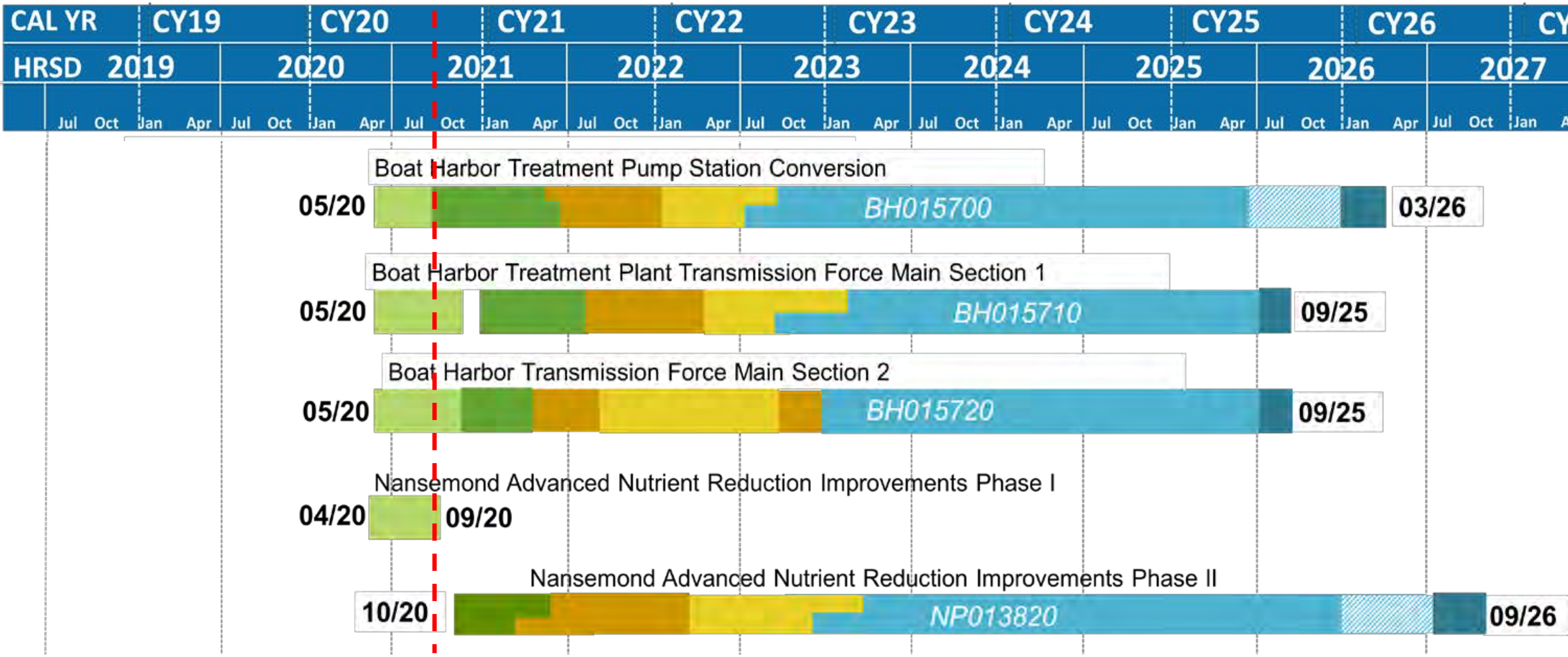
Well services design team has been added to SWIFT Full-Scale Implementation Program structure.

HRSD
Cleaning wastewater every day for a better Bay.

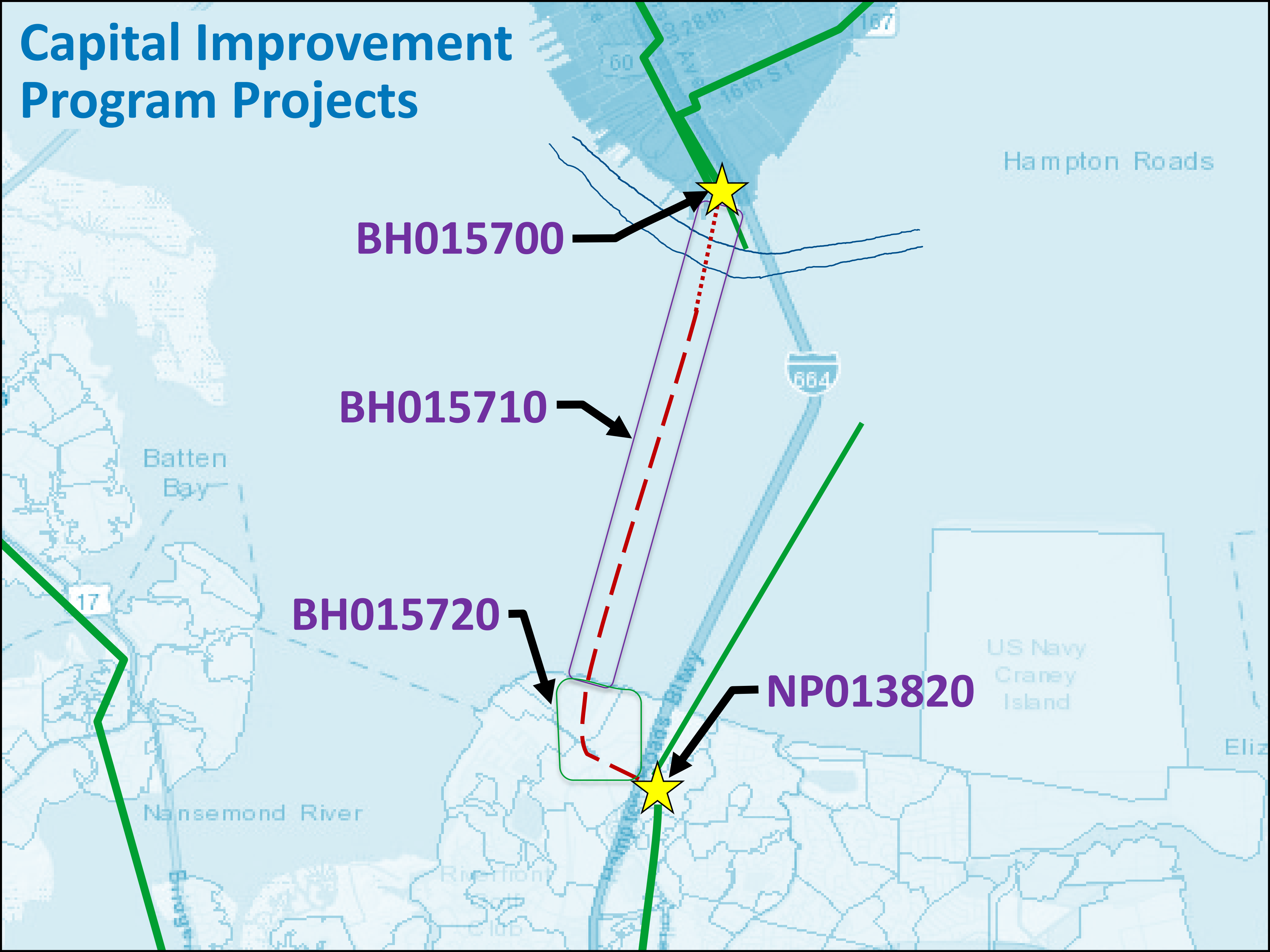
Chief of Design & Construction - SWIFT

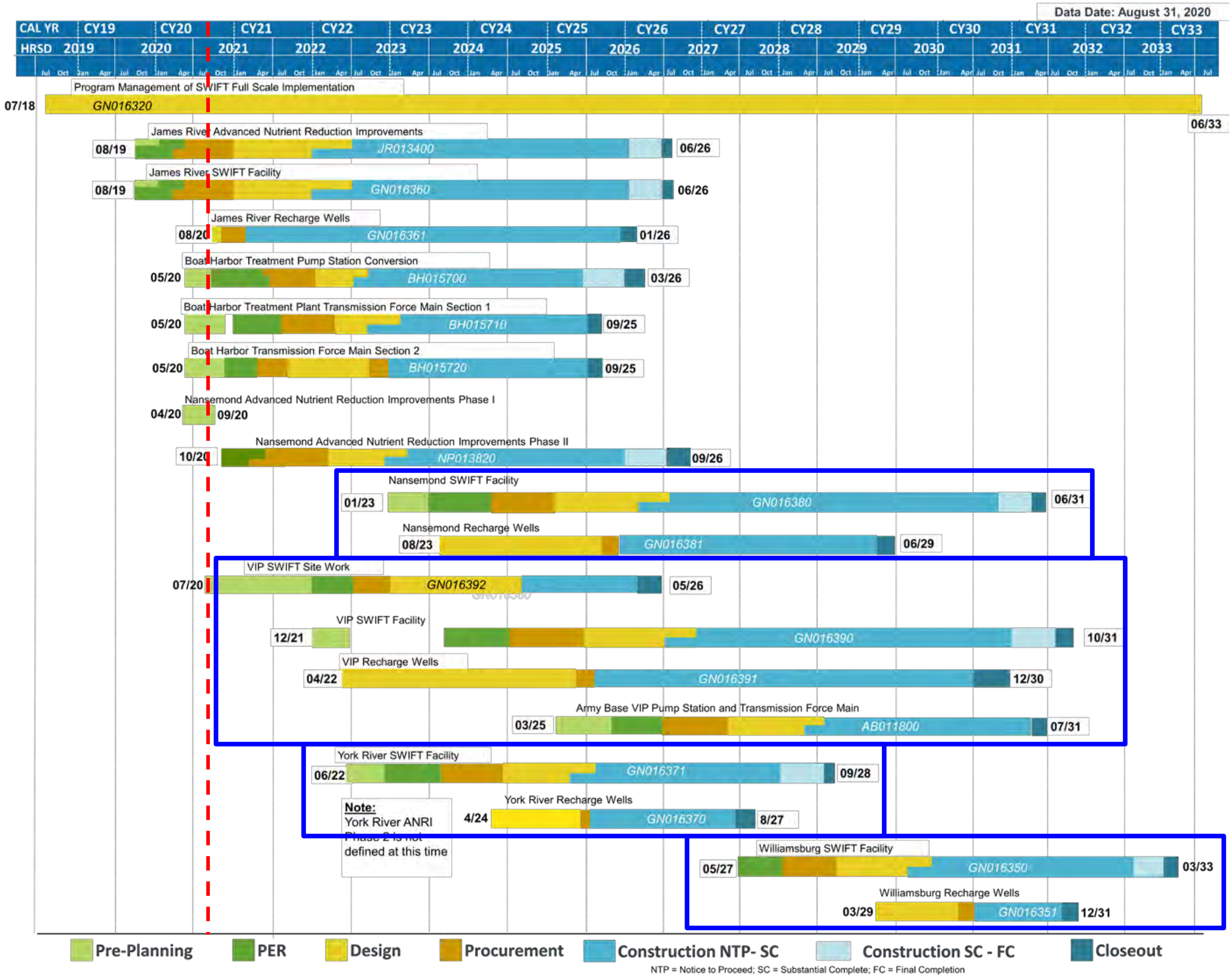
- **Owner's Technical Advisor** — JACOBS
  - Dan Holloway, Groundwater Technical Lead
- **Owner's Consultant** — AECOM, Hazen
  - Full-Scale Implementation Program Management Team
- **Recharge Wells Designer** — Earth Data Incorporated

Initiating preliminary design phase to convey and treat Boat Harbor wastewater at Nansemond TP



Capital Improvement Program Projects

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CAL YR CY19 CY20 CY21 CY22 CY23 CY24 CY25 CY26 CY27 CY28 CY29 CY30 CY31 CY32 CY33
HRSD 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033
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Pre-Planning
PER
Design
Procurement
Construction NTP- SC
Construction SC - FC
Closeout
NTP = Notice to Proceed; SC = Substantial Complete; FC = Final Completion

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Sustainable Water Initiative for Tomorrow

2020 Regional Modeling Presentation to Potomac Aquifer Recharge Oversight Committee

HRSD

June 2020

Agenda

- Purpose/objects of meeting
- Model background
- Modeling process
- Model scenarios
- Results

Purpose: Update modeling with latest information

- Previous modeling was performed in Phase 1 (2014) and Phase 2 (2015)
  - Fatal Flaw Analysis – 7 SWIFT sites, on all at once
  - Prior to 2016/17 Groundwater Withdrawal Permit reductions
- New model runs provide updated conditions
  - Latest model calibration incorporated (Dec 2019)
  - Latest Reported Use withdrawals incorporated
  - Latest permit amounts (2016/17 reductions incorporated)
  - Changes in understanding of SWIFT
    - 5 SWIFT sites
    - 75% Recharge Up-time
    - Phased start-up

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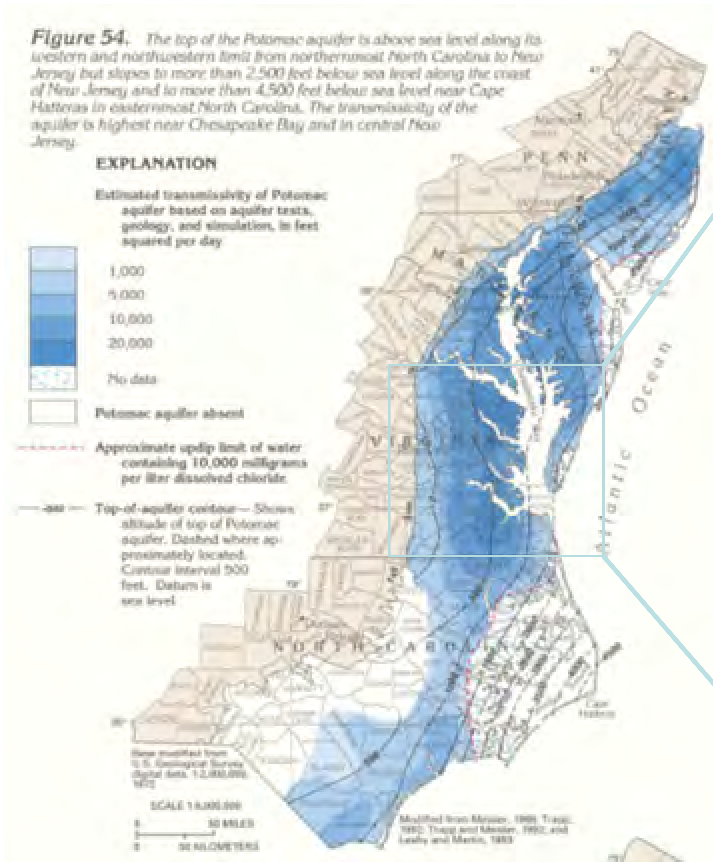
Background

- Coastal Plain Aquifer System
- Groundwater flow
- Coastal Plain Model

North Atlantic Coastal Plain Aquifer System

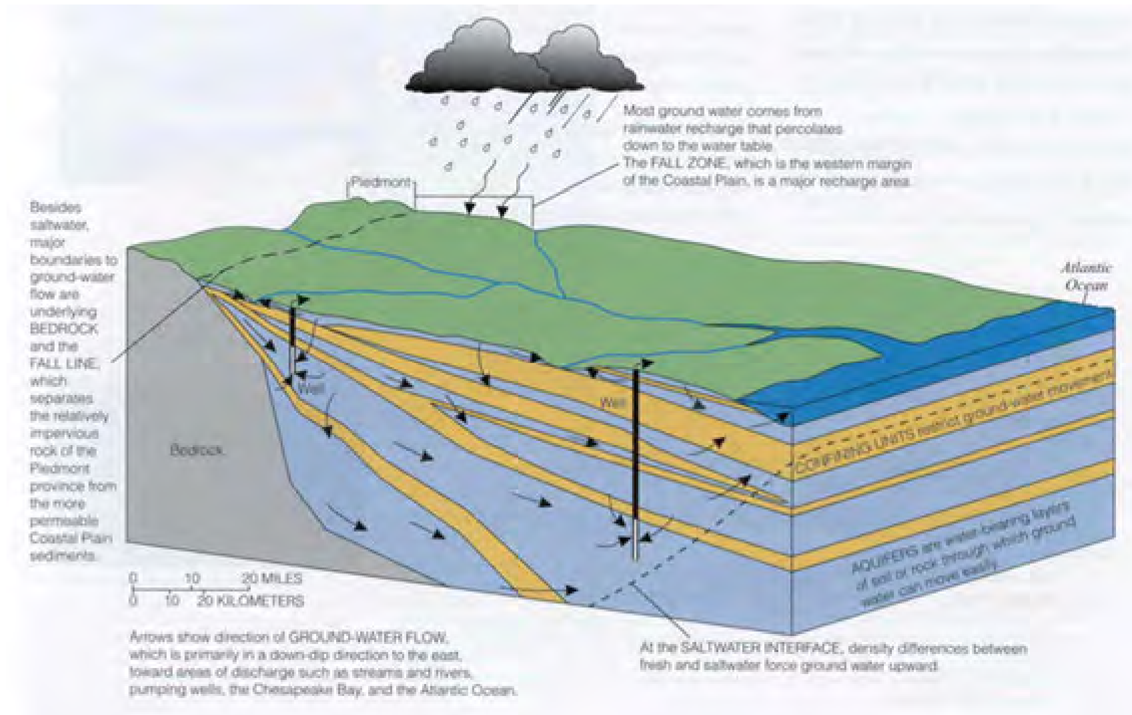


Source: USGS Groundwater Atlas of the US

Source: VA DEQ

Virginia Coastal Plain Aquifer System Geometry

- Fall Zone to the Ocean
- Wedge shaped that widens and dips toward the east
- “Layer Cake” geology
- 2,000 feet of unconsolidated sediments (gravels, sands, silts, clays, shells).
- Horizontally stacked aquifers
  - Unconfined
  - Confined



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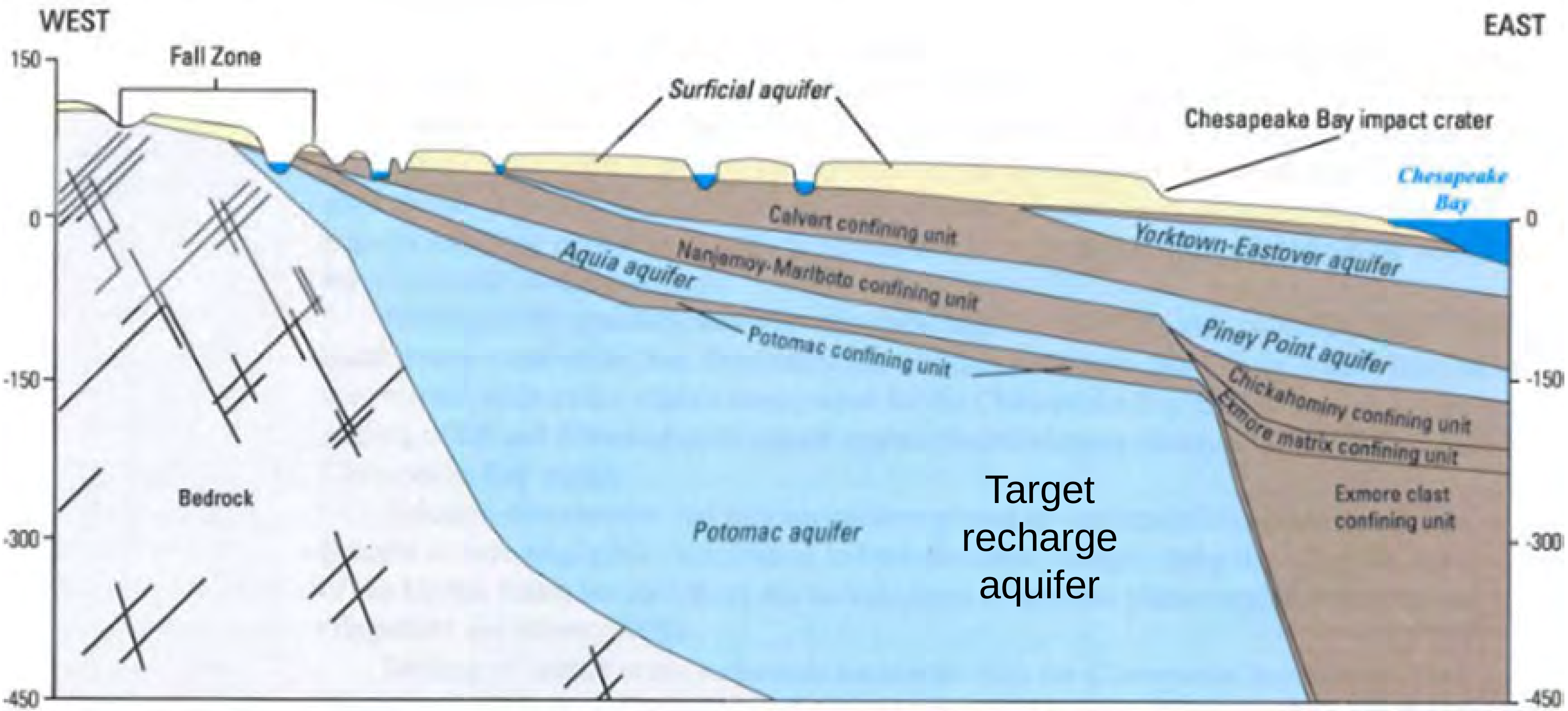
Virginia Coastal Plain Aquifer System



Source: USGS McFarland and Bruce, 2006

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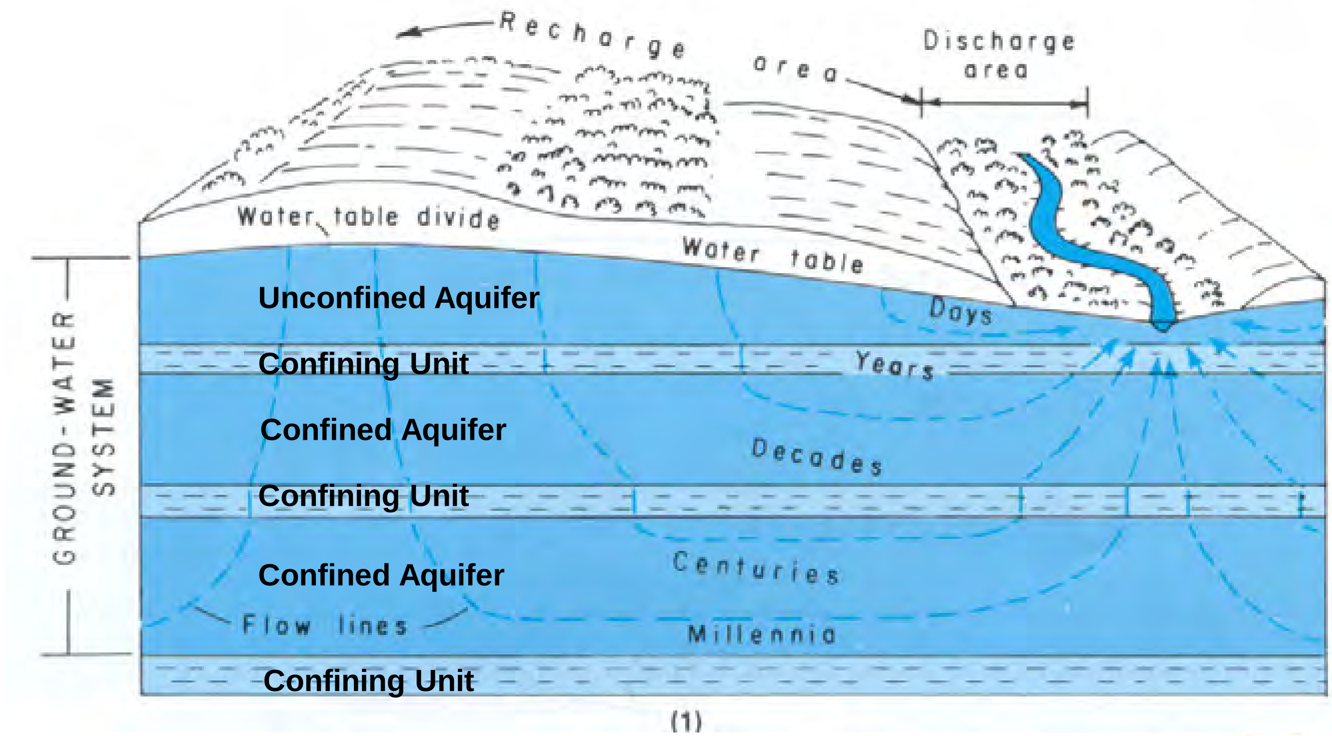
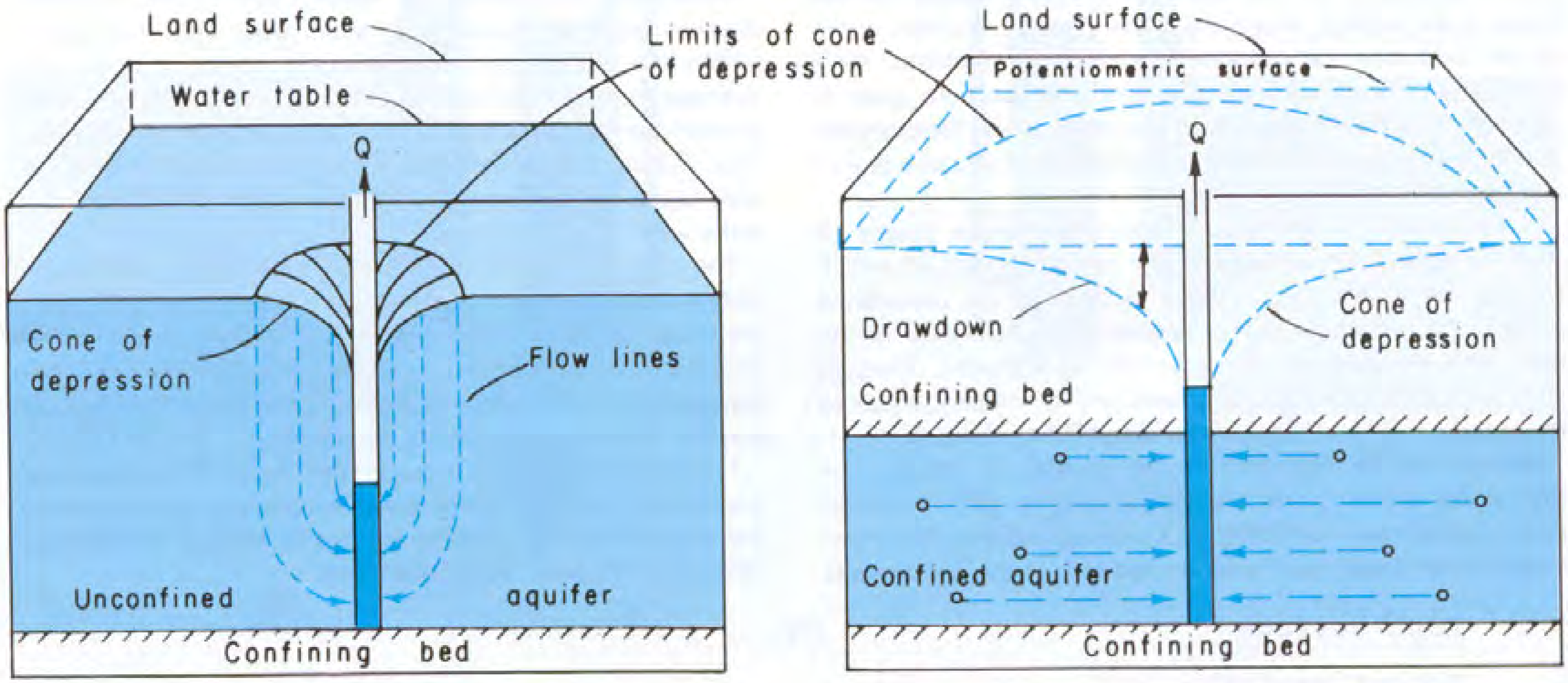
Ground Water Hydrology



USGS, Basic Groundwater
Hydrology, 1982

Hydraulics in the Coastal Plain Aquifers



USGS, Basic Groundwater
Hydrology, 1982

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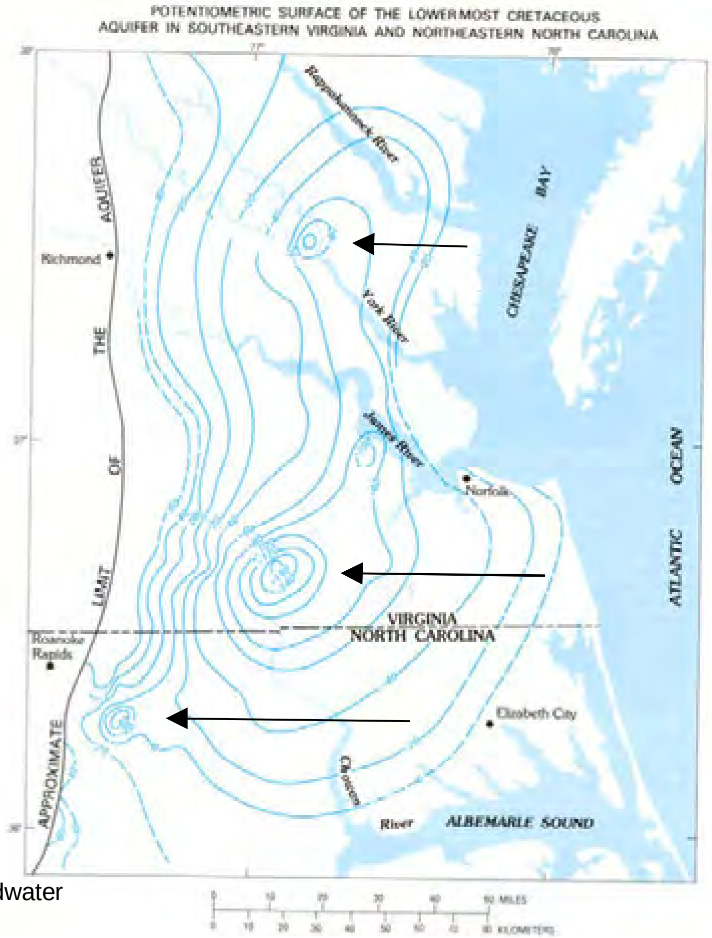
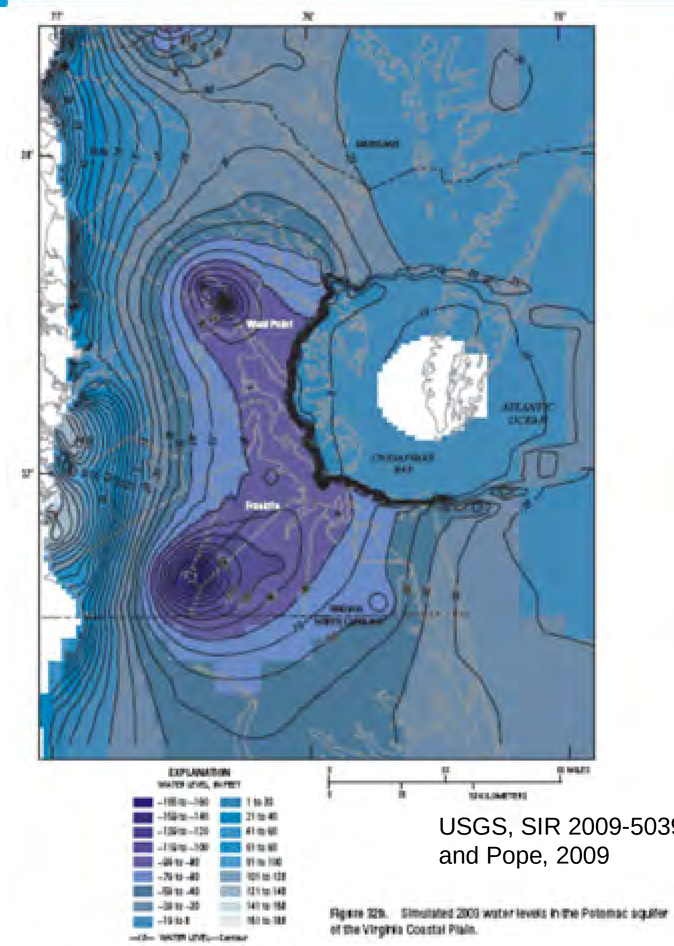
Potomac Aquifer Cones of Depression



USGS, Basic Groundwater Hydrology, 1982



USGS, SIR 2009-5039, Heywood and Pope, 2009

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Groundwater Flow Modeling

- Model represents a real system
- Conceptual Model of the groundwater system
- Numerical Model used to make predictions/understand stresses on the groundwater system - i.e. MODFLOW

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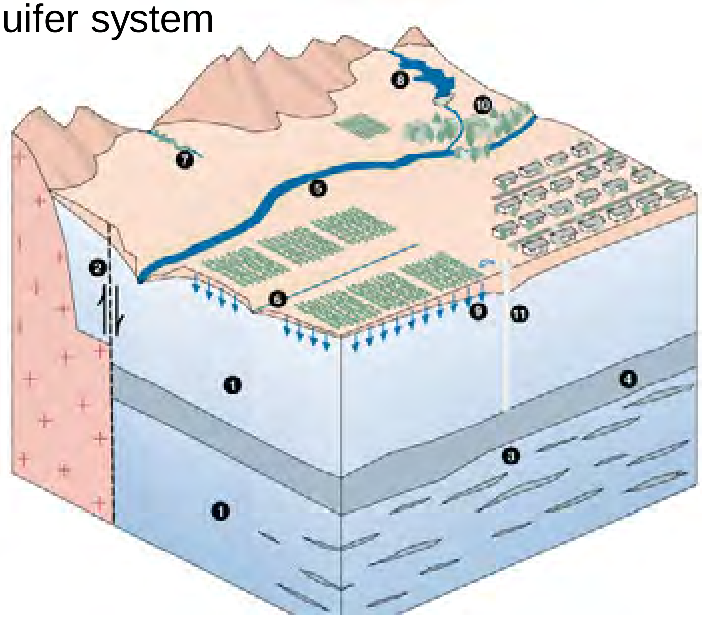
Coastal Plain Ground Water Model

- Physical configuration of aquifer system
  - Location
  - Aerial extent
  - Aquifer thickness
- Hydraulic Properties
  - Transmissivity
  - Storage Coefficient
  - Leakance
- Boundary Conditions
  - Recharge
  - No flow
  - Lateral flow
- Ins and Outs
  - Withdrawal wells
  - Recharge zones



Conceptual model

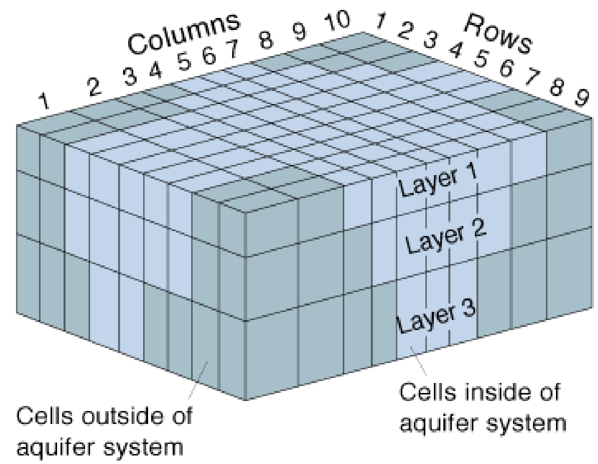


Figure 2. Example of model grid for simulating three-dimensional ground-water flow.

Numerical model

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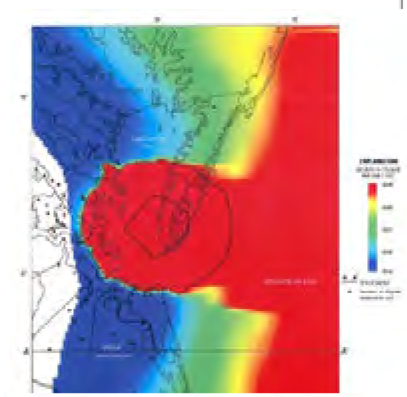
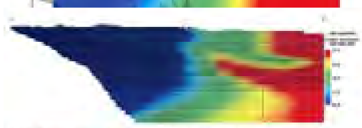
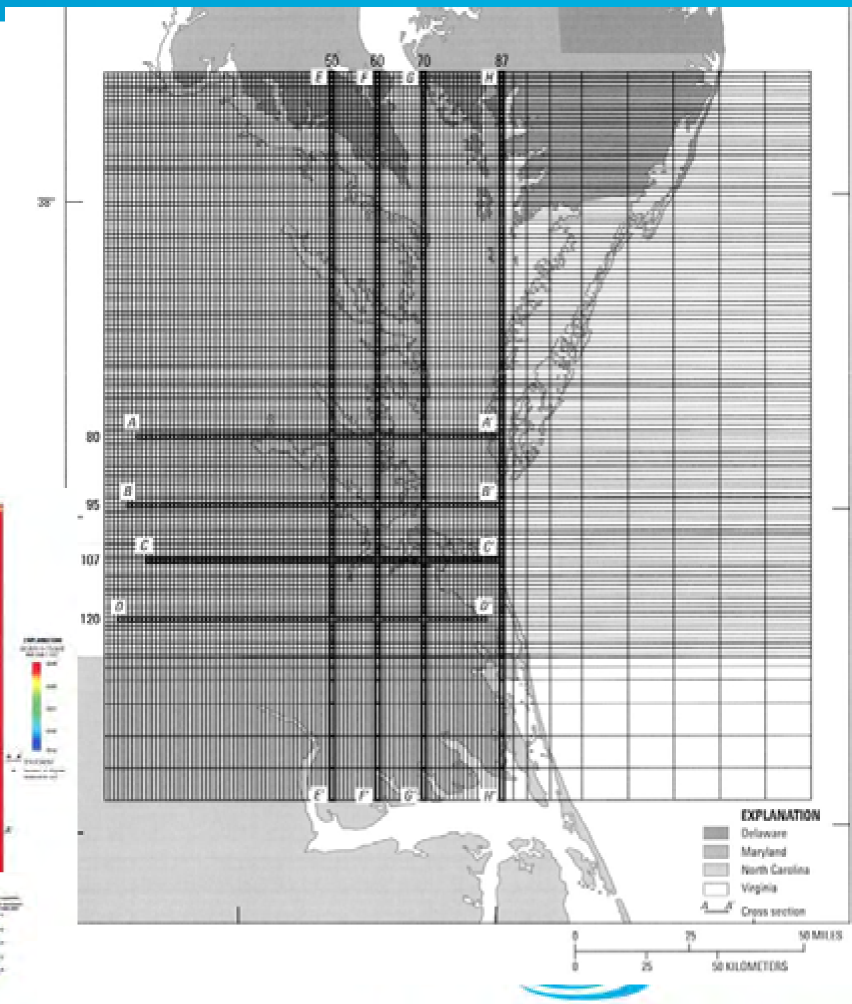
Current Coastal Plain Ground Water Model

- USGS new model in 2009 (Heywood and Pope)
  - USGS updated Hydrogeology in 2006 (McFarland and Bruce)
  - Higher resolution
  - CBIC implicit
  - Density dependent module (simulate saltwater migration
- DEQ (Aquaveo) modified for GW Permit Program







Modeling Process

- Model baseline withdrawal scenarios
  - 2018 Reported Use
  - Total Permitted Use
- Run SWIFT recharge scenarios with one of the withdrawal scenarios
- Evaluate the benefits/impacts of SWIFT Recharging scenarios against baseline
  - Water level impacts
  - Critical surface impacts

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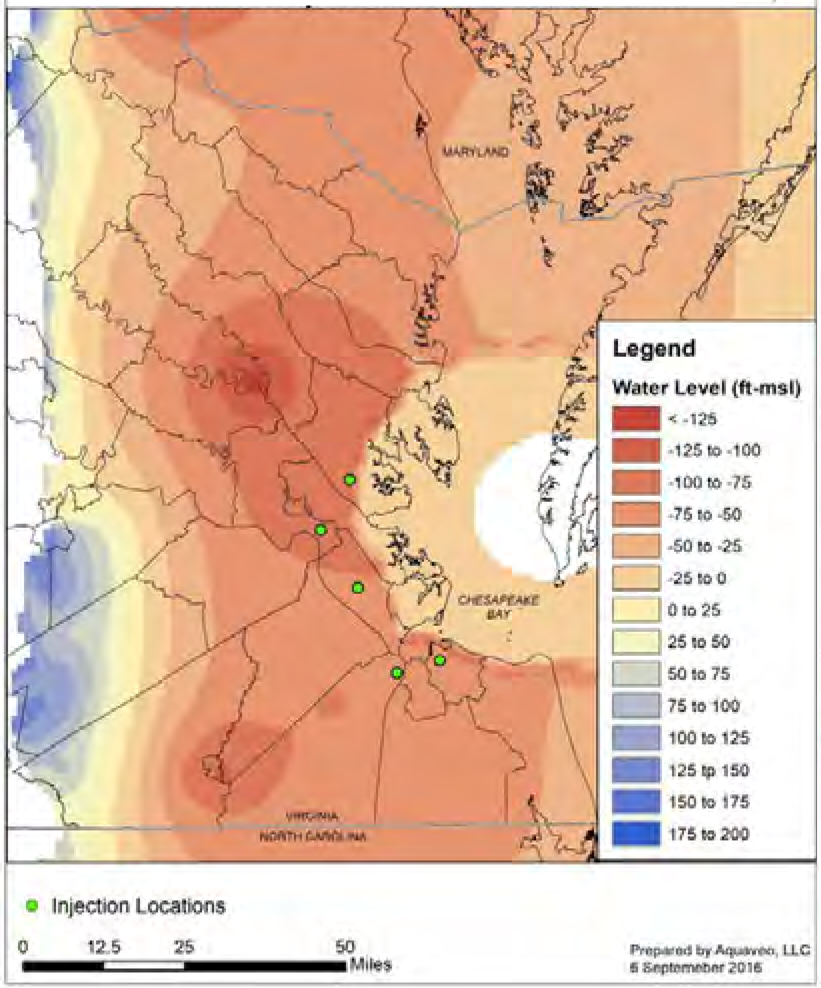
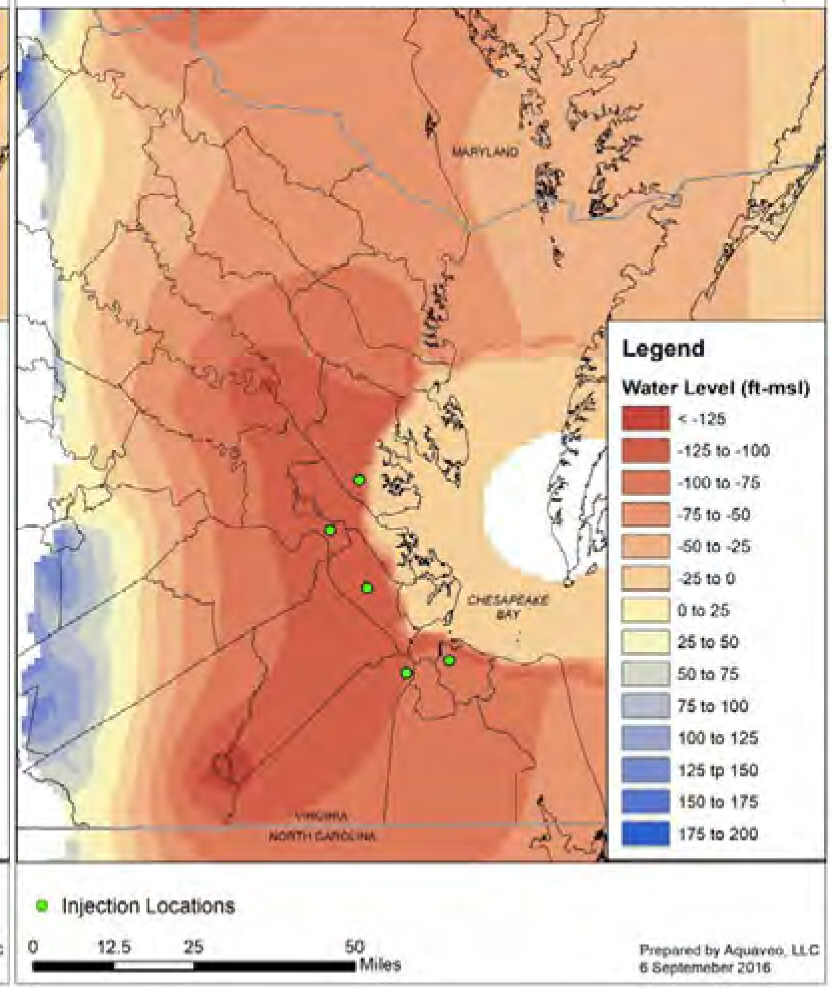
Baseline Scenarios

- Withdrawal scenarios used for comparison
- 2018 Reported Use
- Total Permitted
- Both include un-permitted, NC, MD
- Both transient model runs from 1890 to 2070
- Both hold withdrawals constant from 2018 on

2018 Reported Use Baseline Scenario



Total Permitted Use Baseline Scenario



SWIFT 2020 Modeling Scenarios

- All scenarios are modeled with phased start-up
- All SWIFT sites are recharging at 75% of the target capacity
- All scenarios are transient (time steps) – run 180 yrs and extend 50 years into the future (2070)
- All scenarios are modeled under withdrawal conditions
  - Total Permitted scenarios are using the currently permitted capacity for permitted withdrawals (no ramp up in withdrawals)
  - 2018 Reported Use scenarios are using the reported use for permitted withdrawals (with no increase in withdrawals)

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SWIFT 2020 Modeling Scenario Descriptions

1) 2018 Reported Use Scenario with SWIFT.

3) Total Permitted Scenario with SWIFT.

2) Total Permitted Use with JCSA and West Point at previous (2014) permitted amounts with SWIFT.

2 a) 2018 Reported Use Scenario with JCSA and West Point at previous (2014) permitted amounts with SWIFT.

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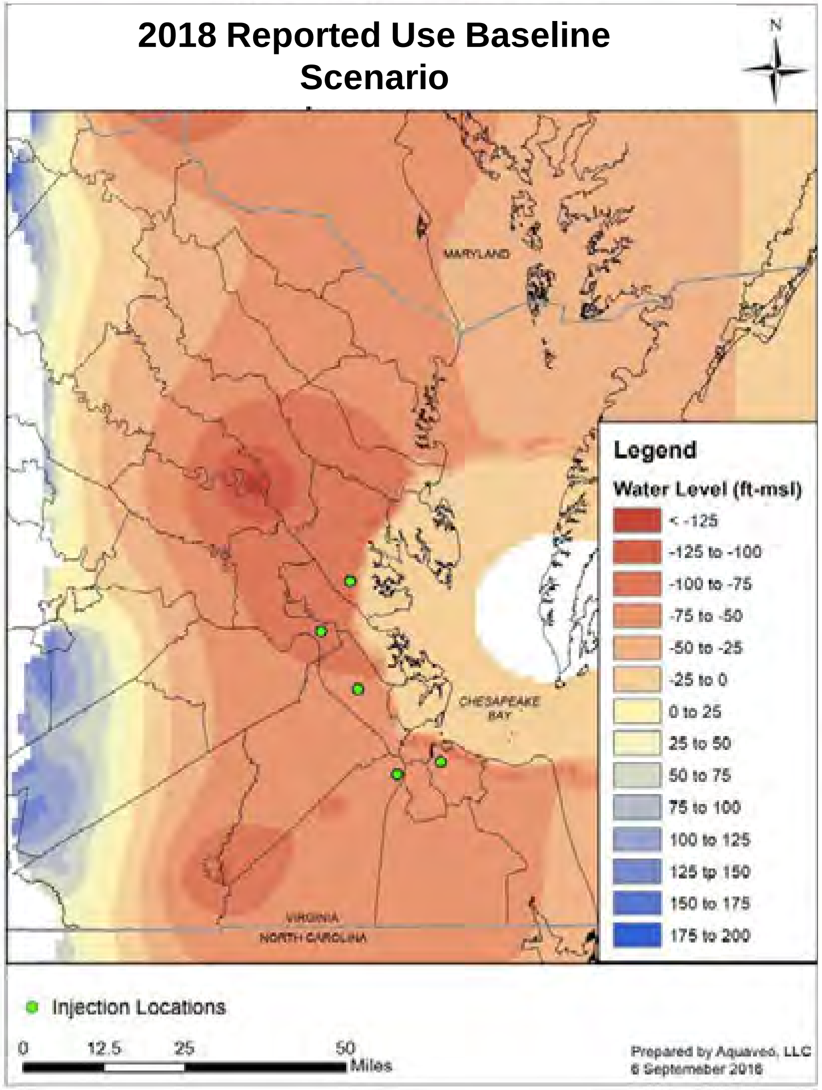
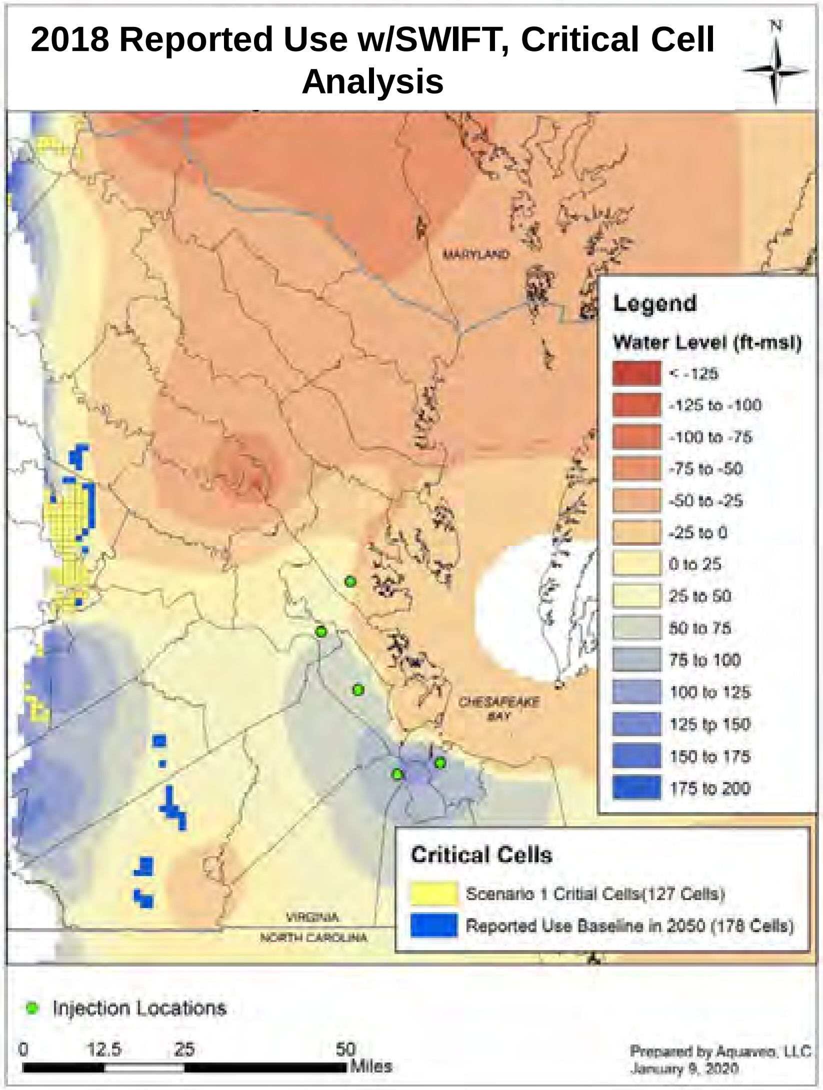
SWIFT Scenario 1

2018 Reported Use with SWIFT

2018 Reported Use w/SWIFT





- Alleviates pressure issues
- Key Critical Cells resolved
- **Note:** critical cell failures are not in location of deepest water levels

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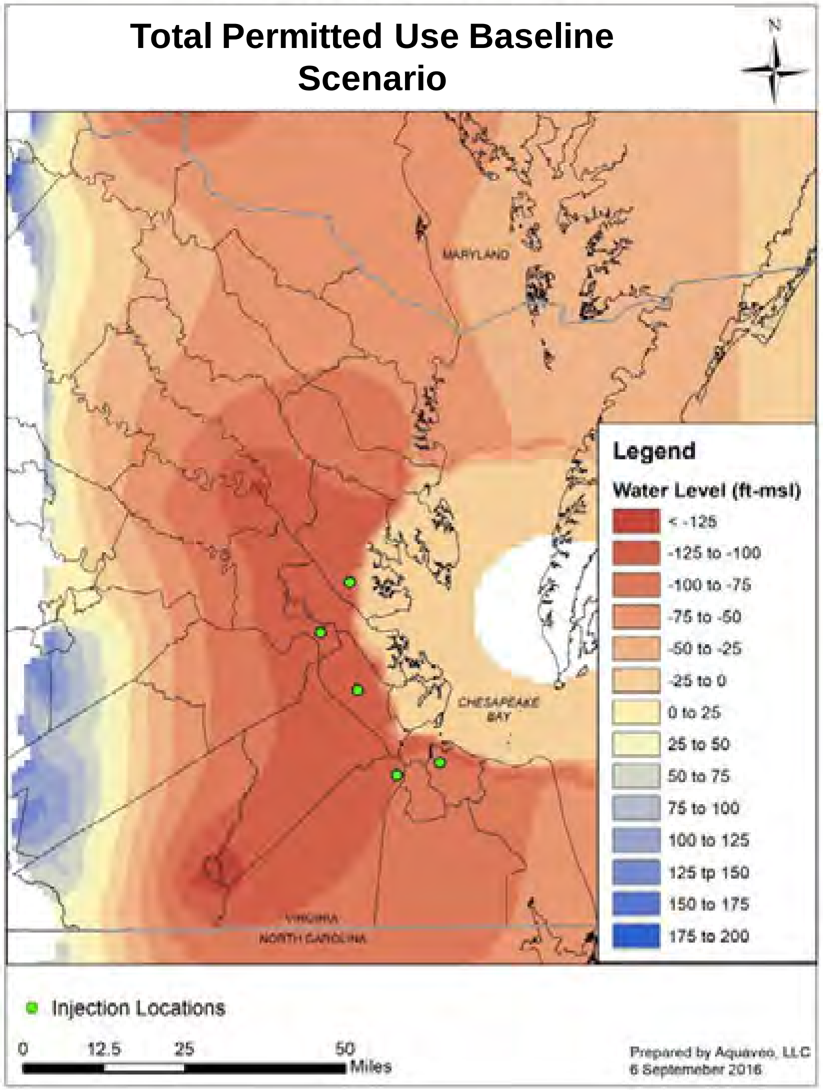
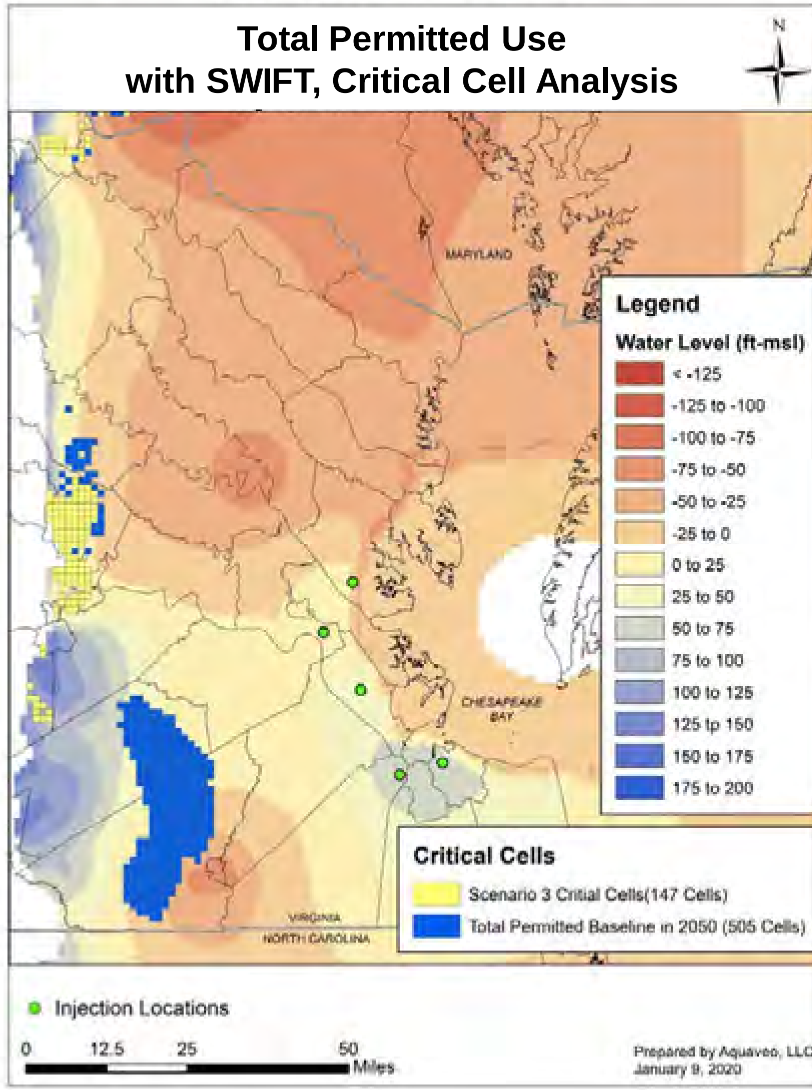
SWIFT Scenario 3

Total Permitted Use with SWIFT

Total Permitted Use w/SWIFT





- Alleviates pressure issues
- Key Critical Cells resolved
- Note: critical cell failures are not in location of deepest water levels

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SWIFT Scenario 2 and 2A

JCSA/West Rock scenarios

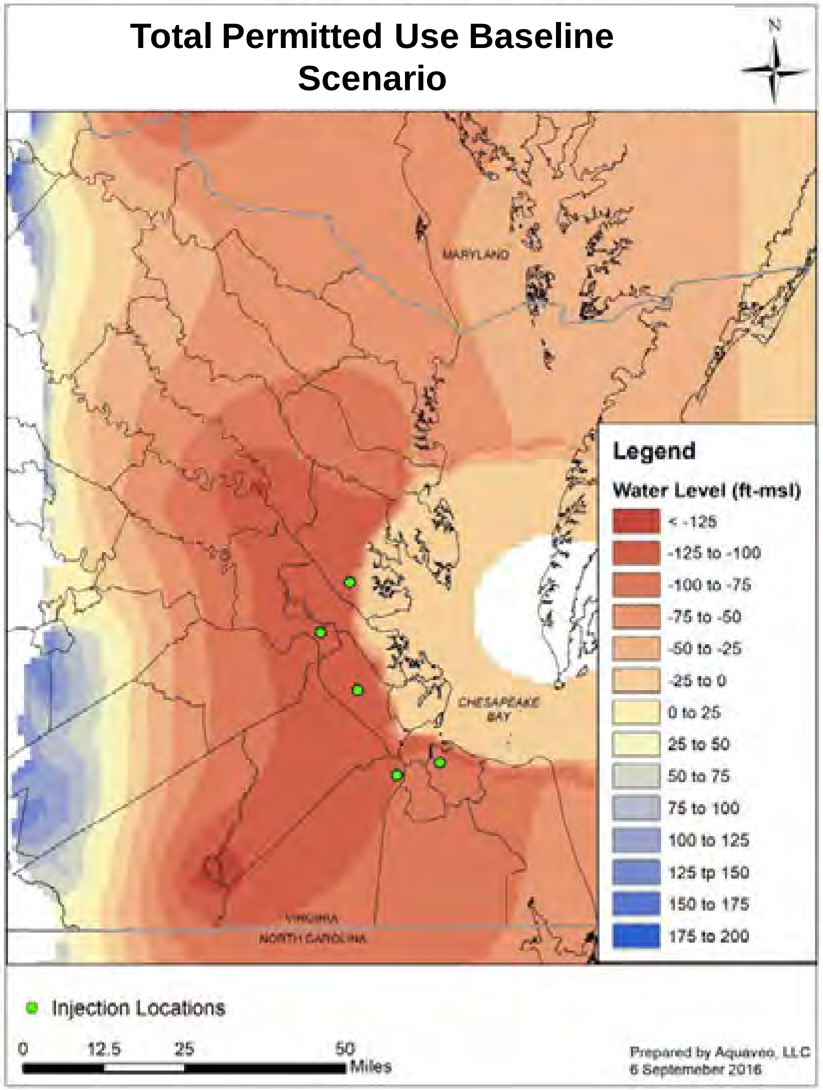
SWIFT Scenario 2 and 2a

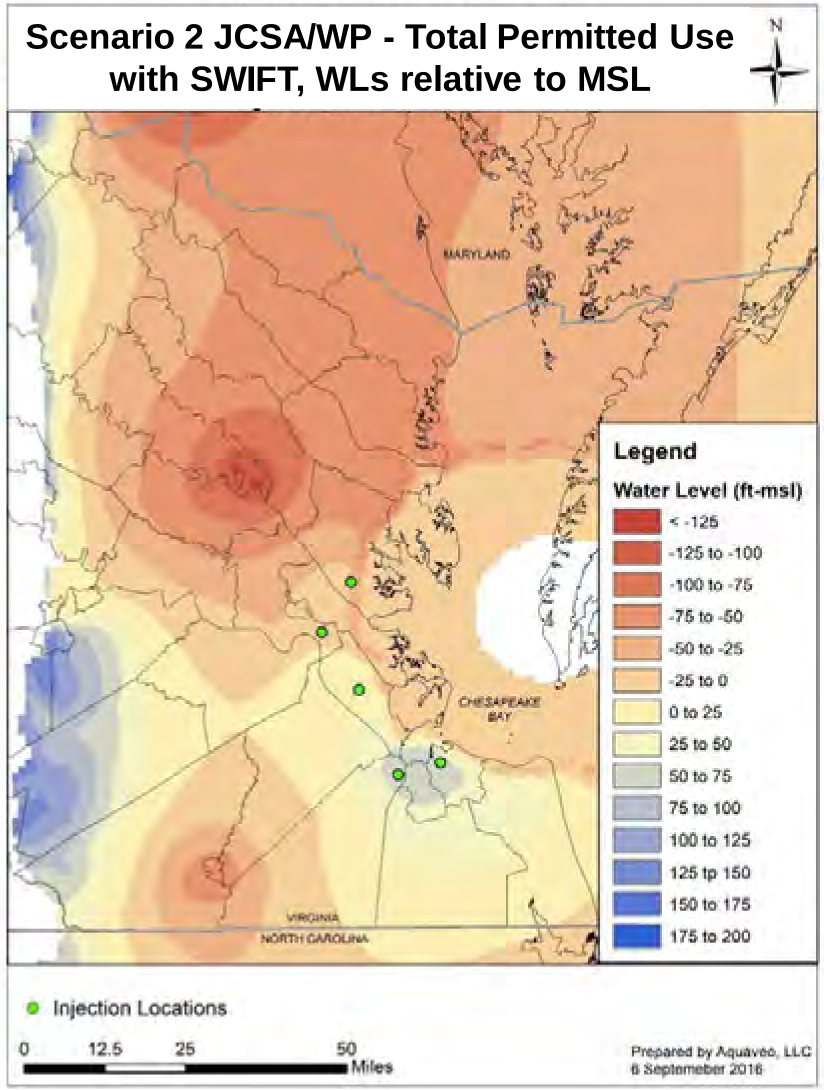
- Large Groundwater Withdrawal Permit reductions in 2016/17, mostly paper cuts
- JCSA and West Point permitted withdrawal amounts were lowered with 2016/17 Groundwater Withdrawal Permits (by end of permit term)
- Scenarios 2 and 2a model JCSA and West Point at their withdrawal permit limits ***previous*** to the 2016 reductions (2014 permit limits)
- Scenario 2 – uses a Total Permitted Use withdrawals
- Scenario 2a – uses 2018 Reported Use withdrawals

SWIFT Scenario 2

JCSA/West Rock at 2014 Permitted amounts all others at Total Permitted withdrawal amount

Scenario 2: JCSA, West Point Total Permitted Use w/SWIFT





- Potentiometric Surface at the end of 70 yr model run
- Alleviates pressure issues

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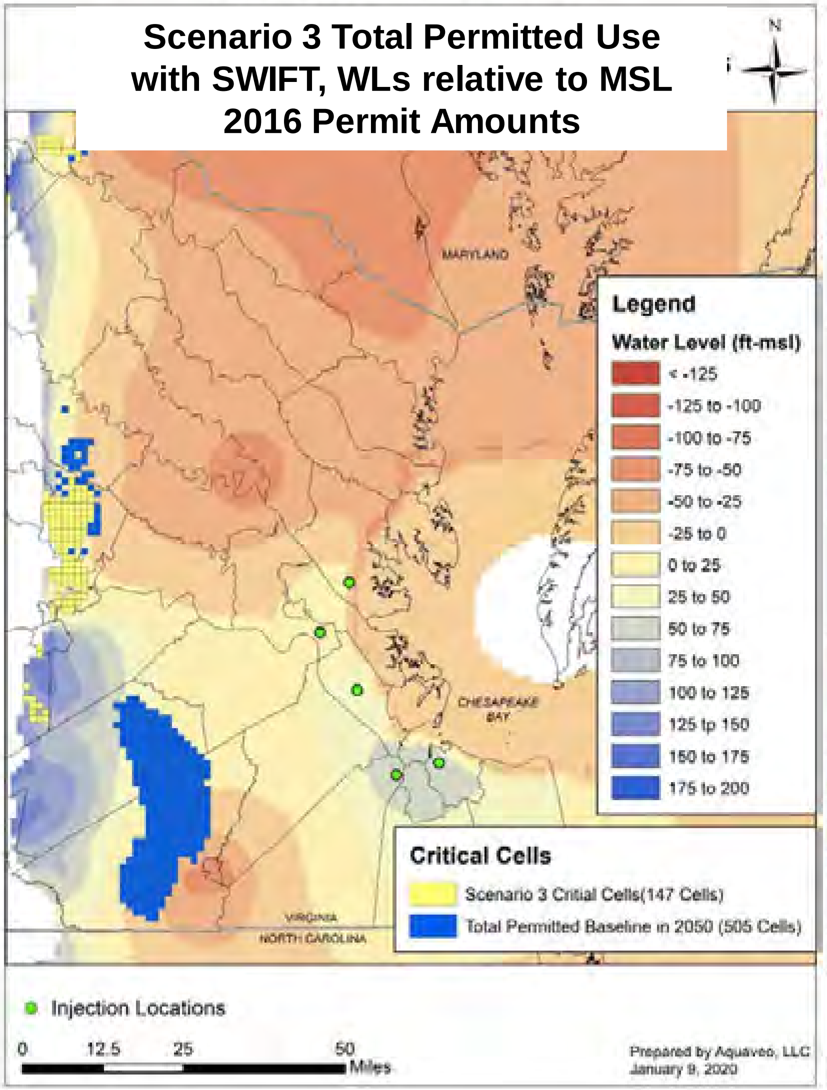
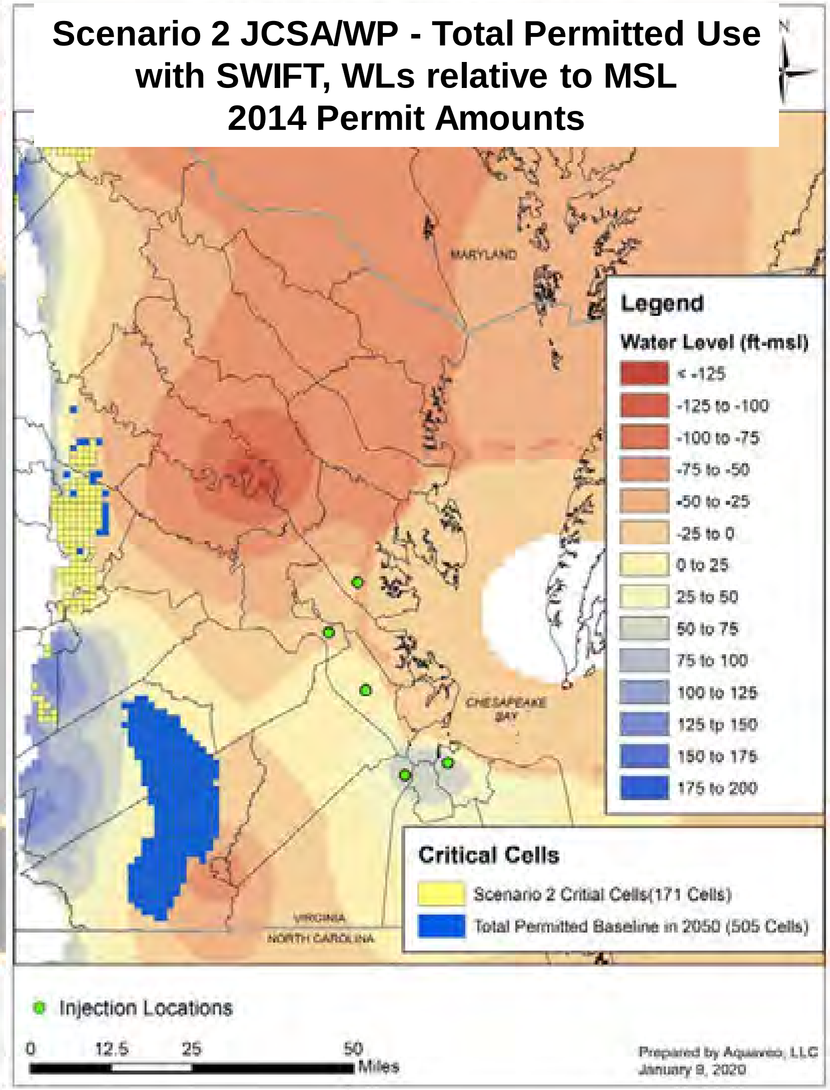
Scenario 2: JCSA, West Point
Total Permitted Use w/SWIFT



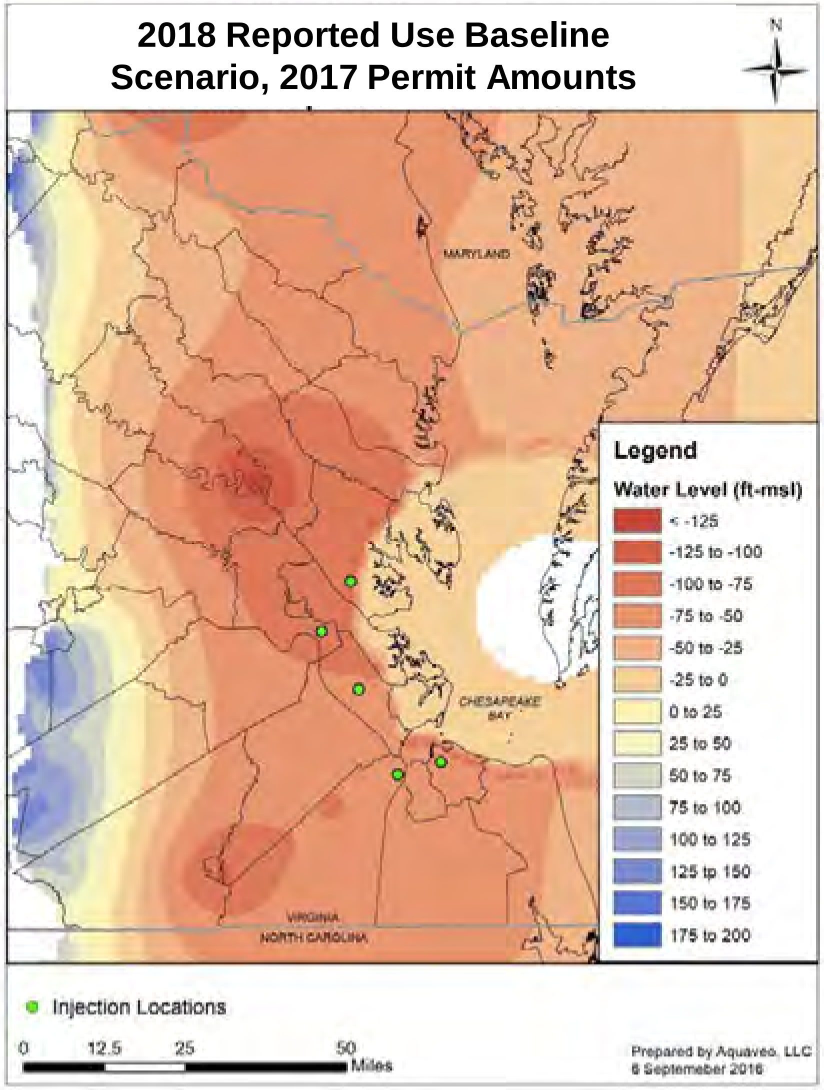


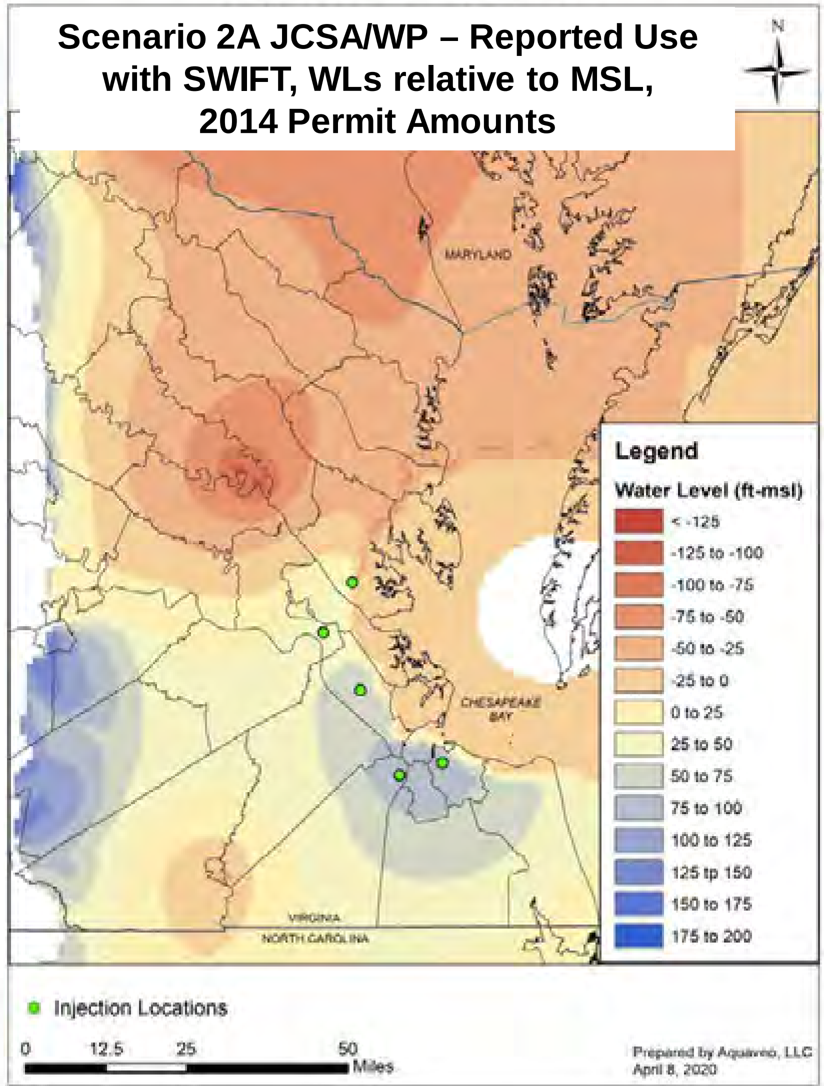
- Scenario 2 Impact to critical cells/benefit is materially identical to Scenario 3
- **Note:** critical cell failures are not in location of deepest water levels

SWIFT Scenario 2A

JCSA/West Rock at 2014 Permitted amounts all others at 2018 Reported Use withdrawal amount

Scenario 2A: JCSA, West Point TP Use w/SWIFT





- Potentiometric surface at the end of a 70 yr model run
- Alleviates pressure issues

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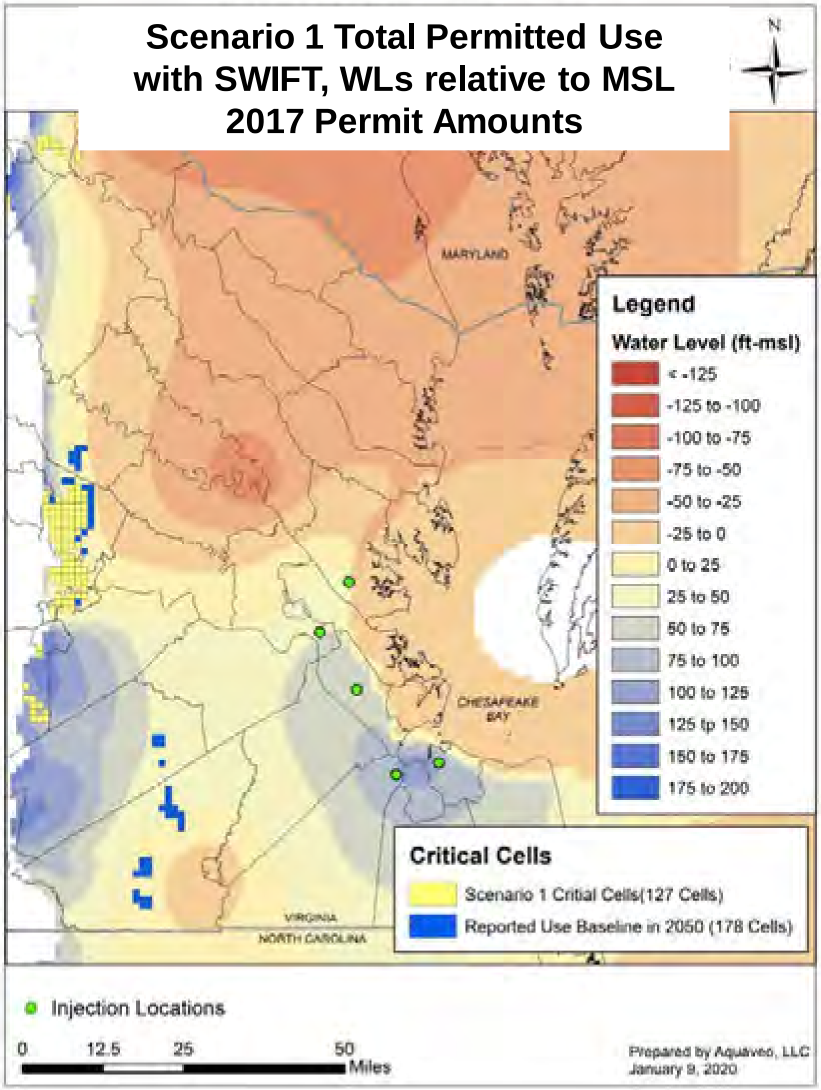
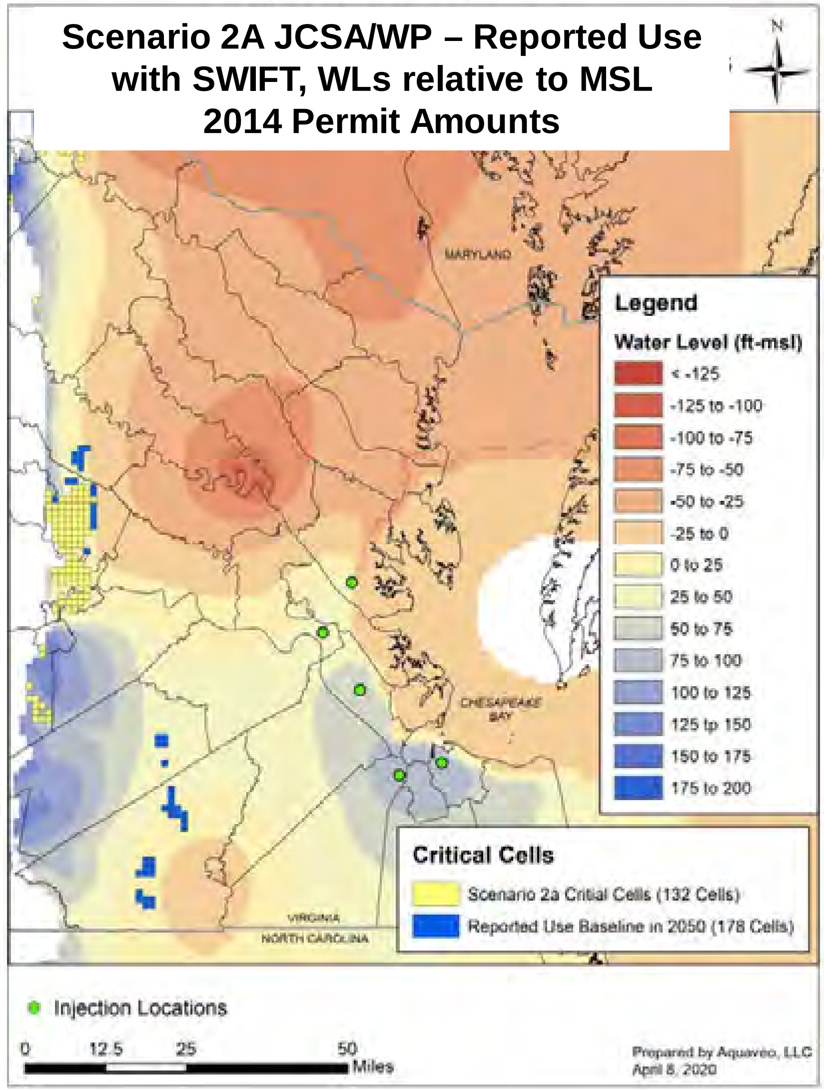
Scenario 2A: JCSA, West Point TP Use w/SWIFT





- Resolves Critical Cells
- Scenario 2A Impact to critical cells/benefit materially identical to Scenario 1

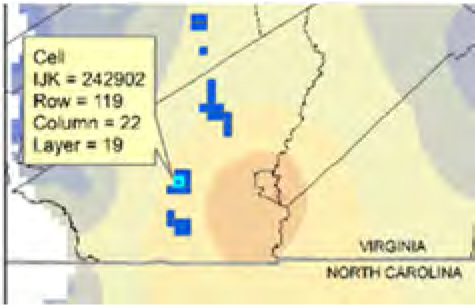
SWIFT Sustainable Water Initiative for Tomorrow

Observations

- Modeling indicates SWIFT is single largest beneficial impact to the Potomac Aquifer System pressure (all SWIFT scenarios)
  - Water levels
  - Critical cells
- Model scenarios 2 and 2A indicate that SWIFT resolves JCSA/West Point related critical cell failures

Hydrographs for JCSA/West Rock

Hydrograph at Critical Cell Failure near IP Pumping Center



- Includes all six scenarios
- Critical cell failure without SWIFT
  - Continues to 2070 under Total Permitted scenario
  - Improved but continues 2070 as failure under Reported Use scenario
- Critical cell failure relieved under all SWIFT scenarios
  - Reported Use scenarios by ~2030 (even with JCSA/WP at 2014 pumping)
  - Total Permitted Use scenarios by ~ 2038 (even with JCSA/WP at 2014 pumping)

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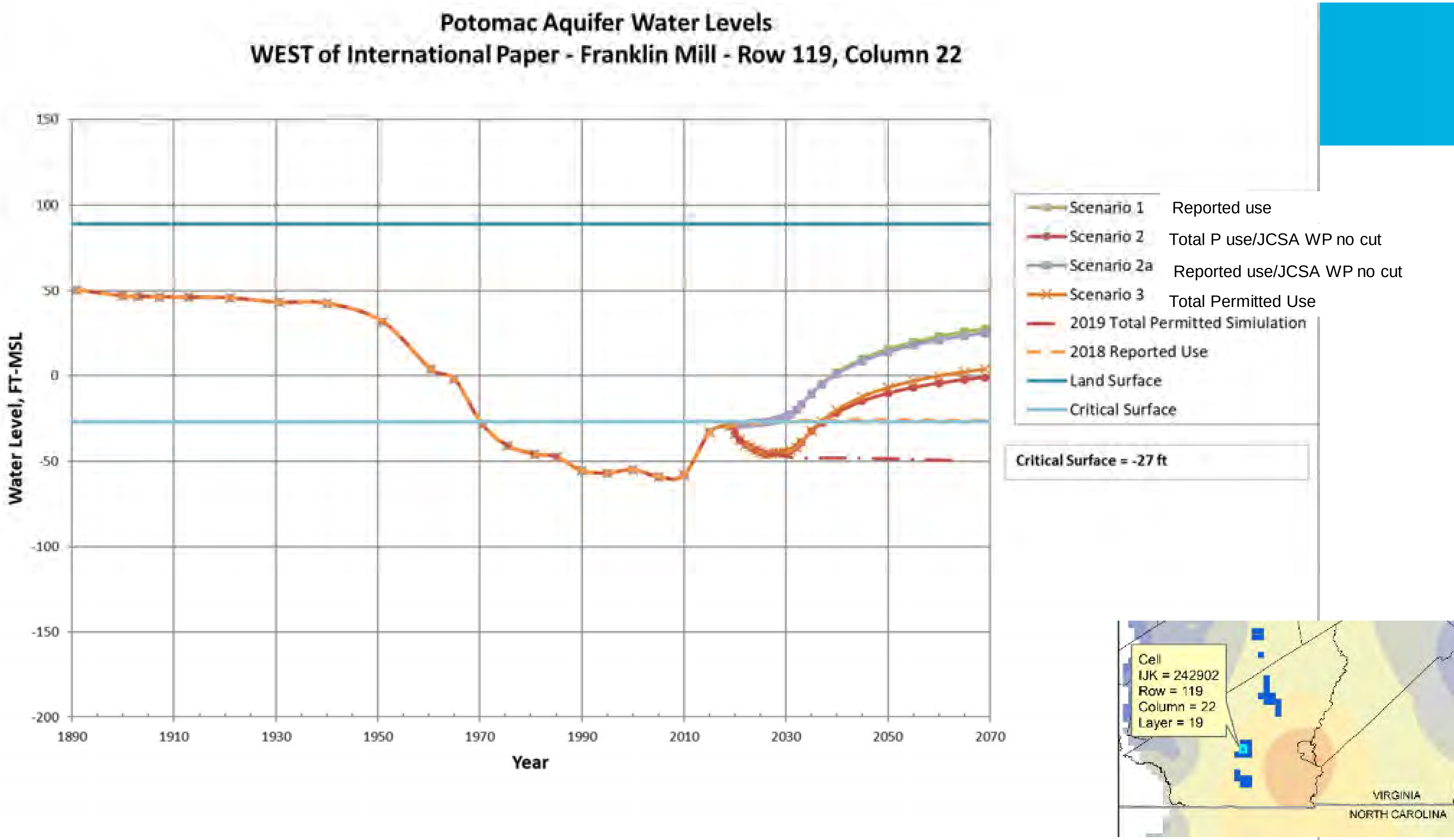
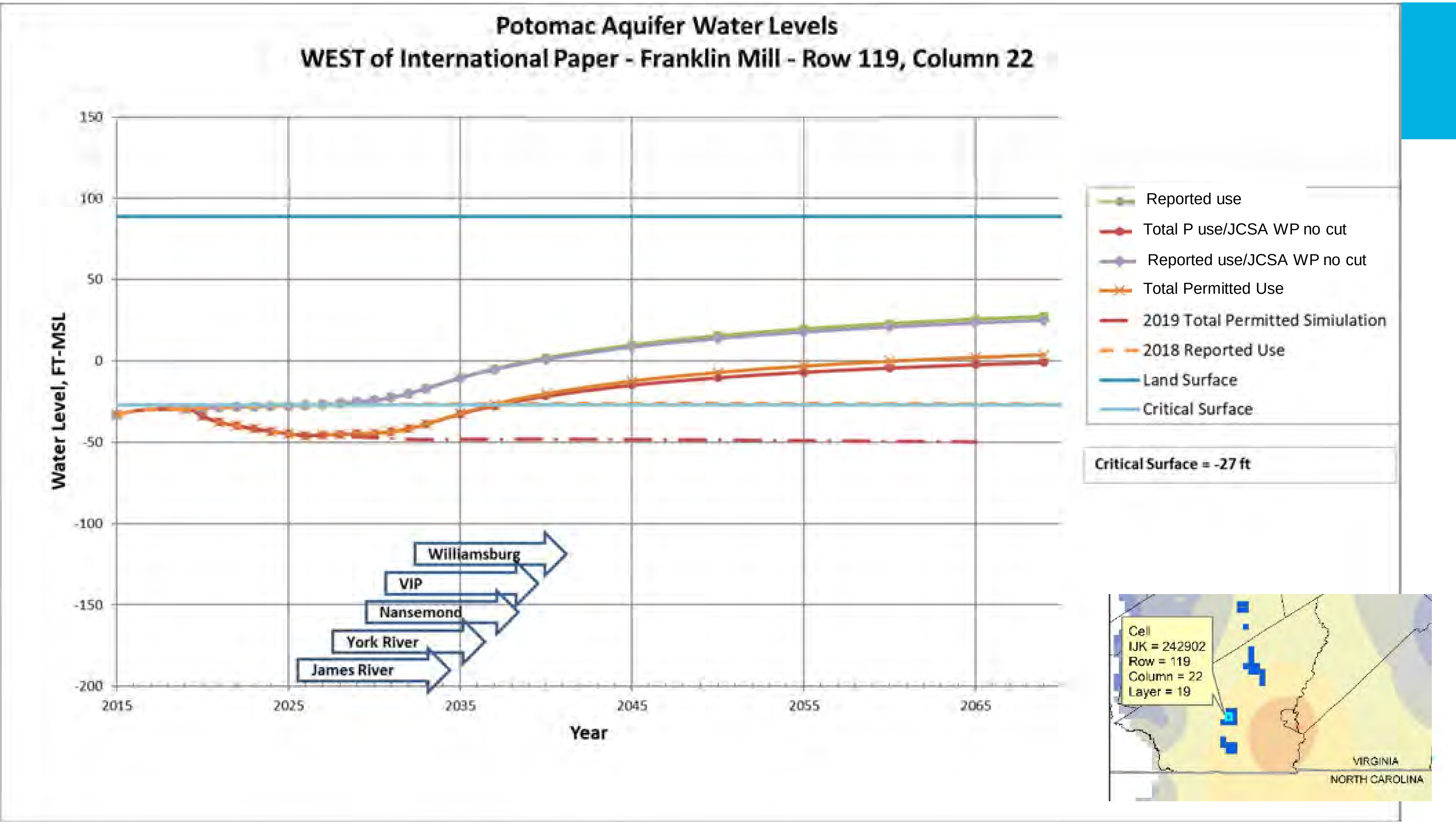


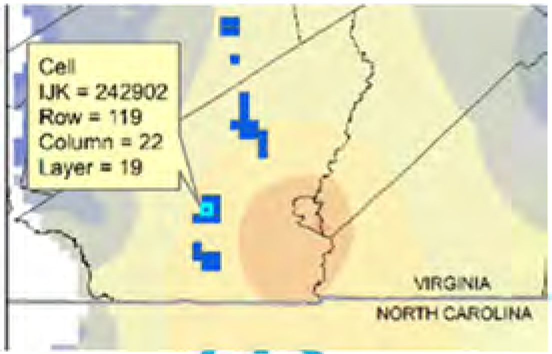
Potomac Aquifer Water Levels
WEST of International Paper - Franklin Mill - Row 119, Column 22
Water Level, FT-MSL
Year
150
100
50
0
-50
-100
-150
-200
1890
1910
1930
1950
1970
1990
2010
2030
2050
2070
Scenario 1
Reported use
Scenario 2
Total P use/JCSA WP no cut
Scenario 2a
Reported use/JCSA WP no cut
Scenario 3
Total Permitted Use
2019 Total Permitted Similation
2018 Reported Use
Land Surface
Critical Surface
Critical Surface = -27 ft
Cell
IJK = 242902
Row = 119
Column = 22
Layer = 19
VIRGINIA
NORTH CAROLINA



Potomac Aquifer Water Levels
WEST of International Paper - Franklin Mill - Row 119, Column 22
150
100
50
0
-50
-100
-150
-200
Water Level, FT-MSL
2015
2025
2035
2045
2055
2065
Year
Williamsburg
VIP
Nansemond
York River
James River
Reported use
Total P use/JCSA WP no cut
Reported use/JCSA WP no cut
Total Permitted Use
2019 Total Permitted Simiulation
2018 Reported Use
Land Surface
Critical Surface
Critical Surface = -27 ft
Cell
IJK = 242902
Row = 119
Column = 22
Layer = 19
VIRGINIA
NORTH CAROLINA

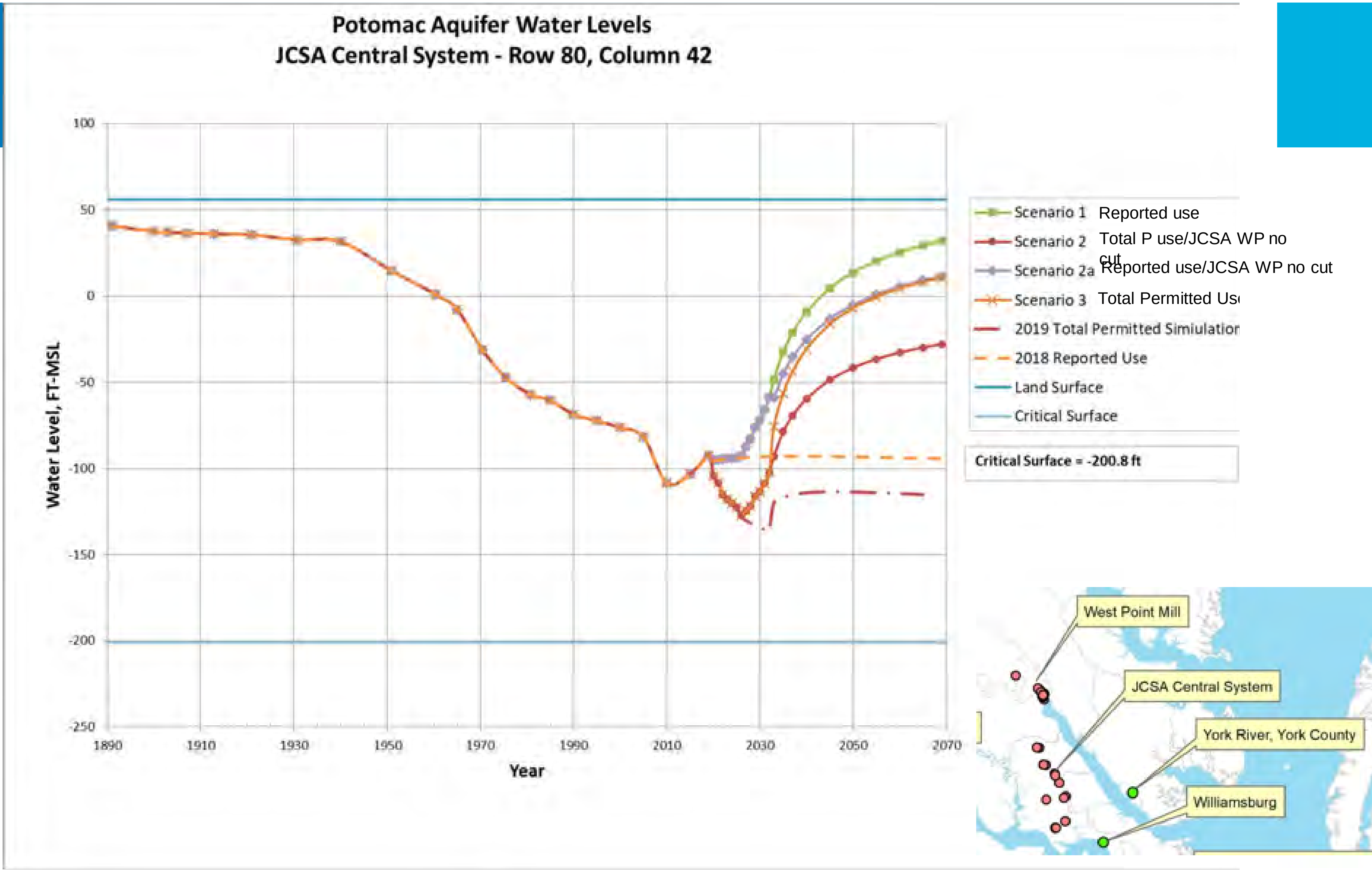
Hydrograph at Critical Cell Failure near IP Pumping Center

- Almost identical response for Total Permitted withdrawal Scenarios (1 and 2)
- Almost Identical response for Reported Use withdrawal Scenarios (3 and 2A)
- Model indicates the temporal impact of SWIFT is the same for with/without 2014 permit reductions for JCSA and West Point
- Model indicates the magnitude of the benefit is the same for with/without 2014 permit reductions for JCSA and West Point

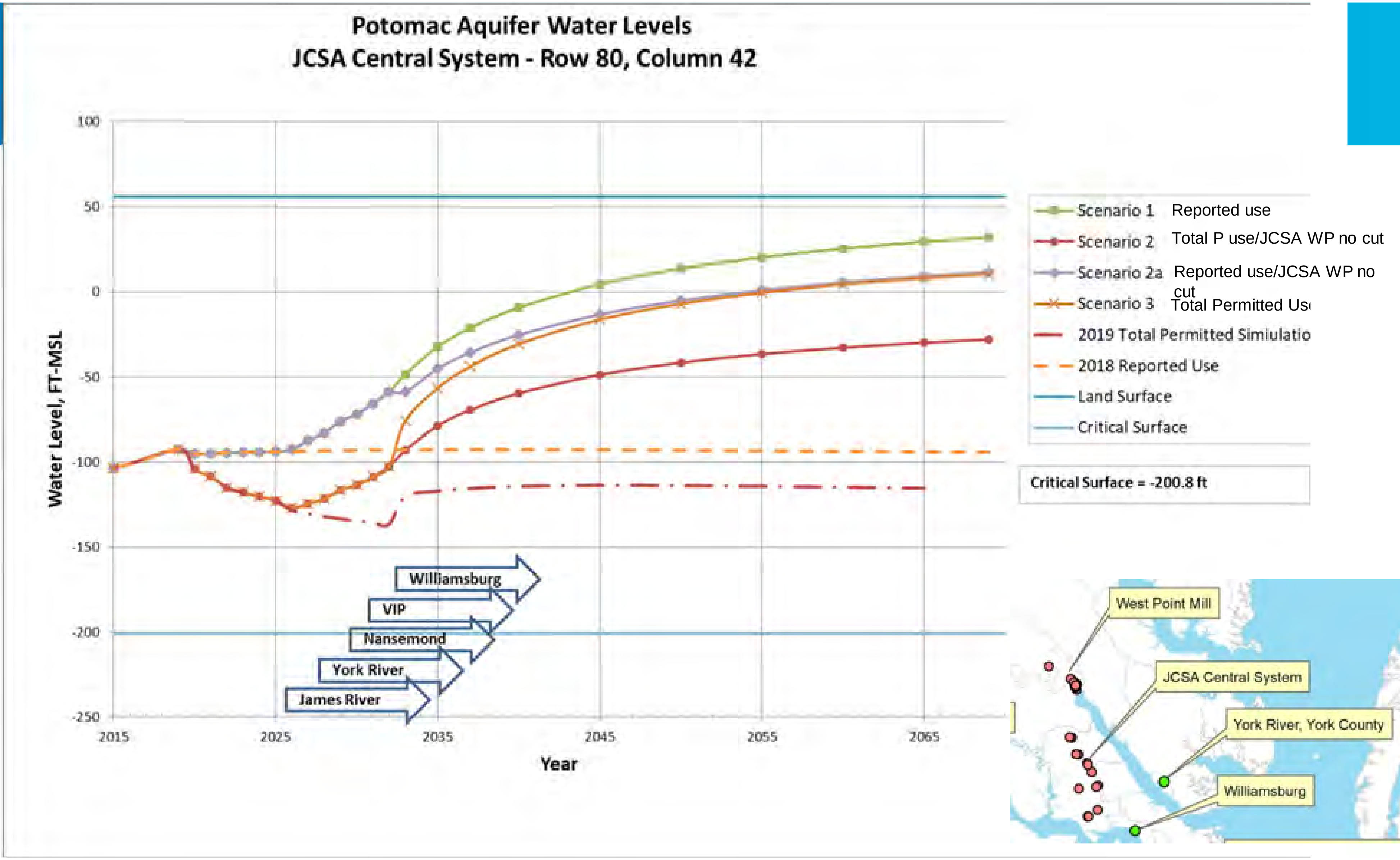


Hydrograph at JCSA Pumping Center

- Includes all six scenarios
- No critical cell failure



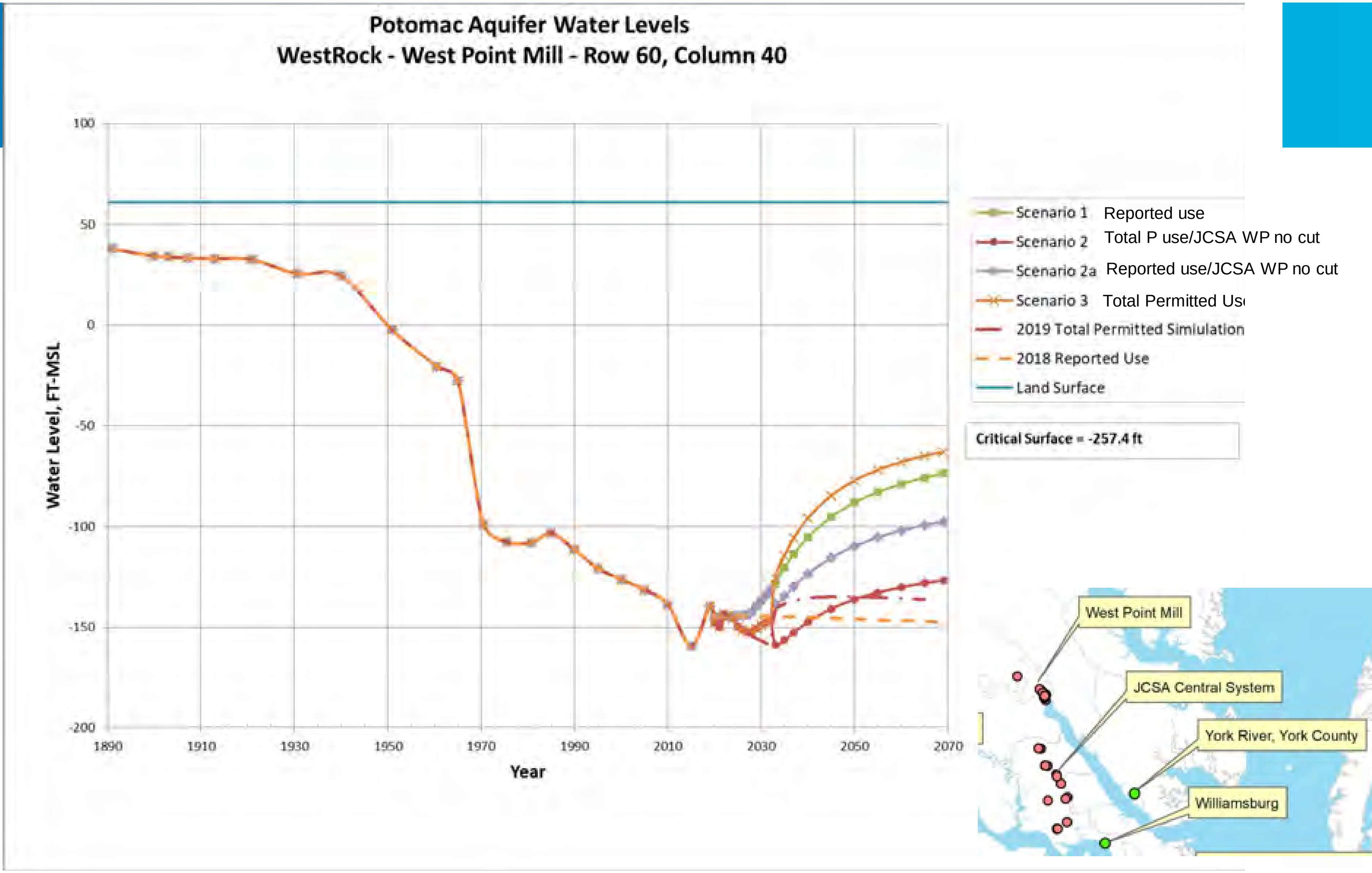
Potomac Aquifer Water Levels
JCSA Central System - Row 80, Column 42
Water Level, FT-MSL
100
50
0
-50
-100
-150
-200
-250
1890
1910
1930
1950
1970
1990
2010
2030
2050
2070
Year
Scenario 1 Reported use
Scenario 2 Total P use/JCSA WP no cut
Scenario 2a Reported use/JCSA WP no cut
Scenario 3 Total Permitted Us
2019 Total Permitted Simiulatior
2018 Reported Use
Land Surface
Critical Surface
Critical Surface = -200.8 ft
West Point Mill
JCSA Central System
York River, York County
Williamsburg

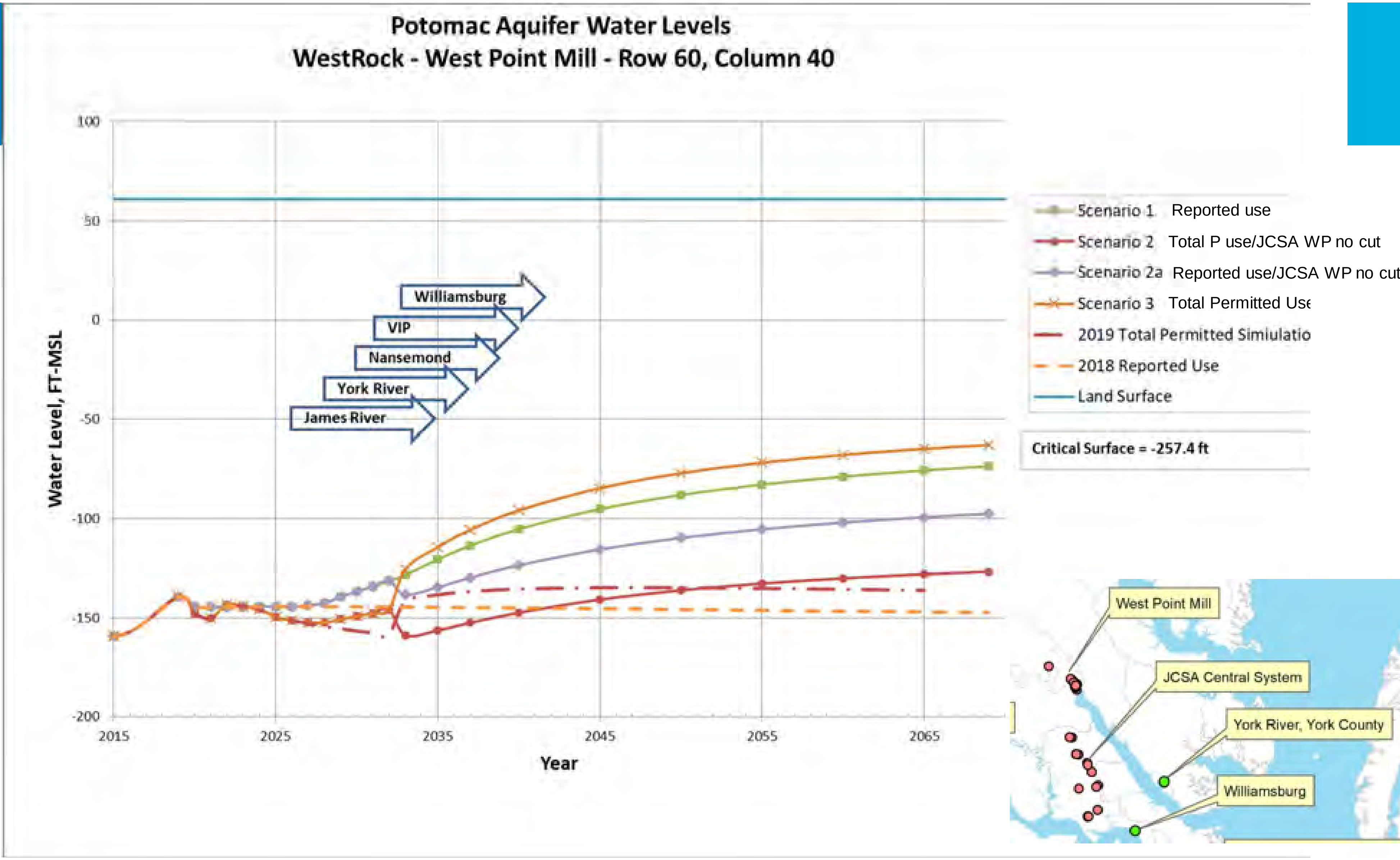


Potomac Aquifer Water Levels
JCSA Central System - Row 80, Column 42
Water Level, FT-MSL
Year
100
50
0
-50
-100
-150
-200
-250
2015
2025
2035
2045
2055
2065
Scenario 1 Reported use
Scenario 2 Total P use/JCSA WP no cut
Scenario 2a Reported use/JCSA WP no cut
Scenario 3 Total Permitted Us
2019 Total Permitted Simiulatio
2018 Reported Use
Land Surface
Critical Surface
Critical Surface = -200.8 ft
Williamsburg
VIP
Nansemond
York River
James River
West Point Mill
JCSA Central System
York River, York County
Williamsburg

Hydrograph at West Rock Pumping Center

- Includes all six scenarios
- No critical cell failure

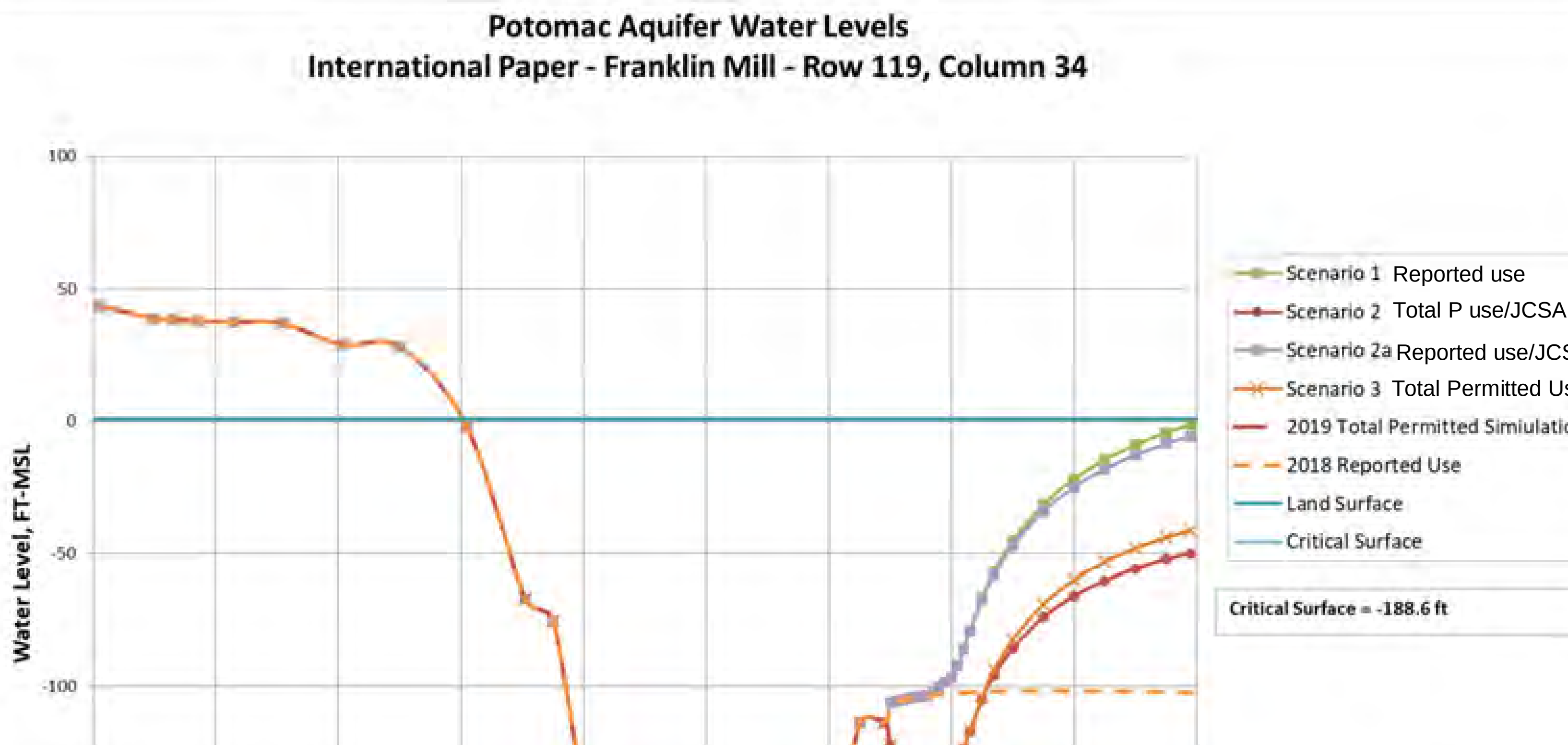

Potomac Aquifer Water Levels
WestRock - West Point Mill - Row 60, Column 40
Water Level, FT-MSL
Year
100
50
0
-50
-100
-150
-200
1890
1910
1930
1950
1970
1990
2010
2030
2050
2070
Scenario 1 Reported use
Scenario 2 Total P use/JCSA WP no cut
Scenario 2a Reported use/JCSA WP no cut
Scenario 3 Total Permitted Us
2019 Total Permitted Simulation
2018 Reported Use
Land Surface
Critical Surface = -257.4 ft
West Point Mill
JCSA Central System
York River, York County
Williamsburg

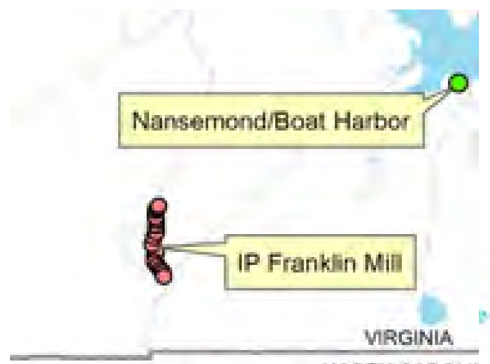


Potomac Aquifer Water Levels
WestRock - West Point Mill - Row 60, Column 40
Water Level, FT-MSL
100
50
0
-50
-100
-150
-200
2015
2025
2035
2045
2055
2065
Year
Williamsburg
VIP
Nansemond
York River
James River
Scenario 1 Reported use
Scenario 2 Total P use/JCSA WP no cut
Scenario 2a Reported use/JCSA WP no cut
Scenario 3 Total Permitted Use
2019 Total Permitted Simiulatio
2018 Reported Use
Land Surface
Critical Surface = -257.4 ft
West Point Mill
JCSA Central System
York River, York County
Williamsburg

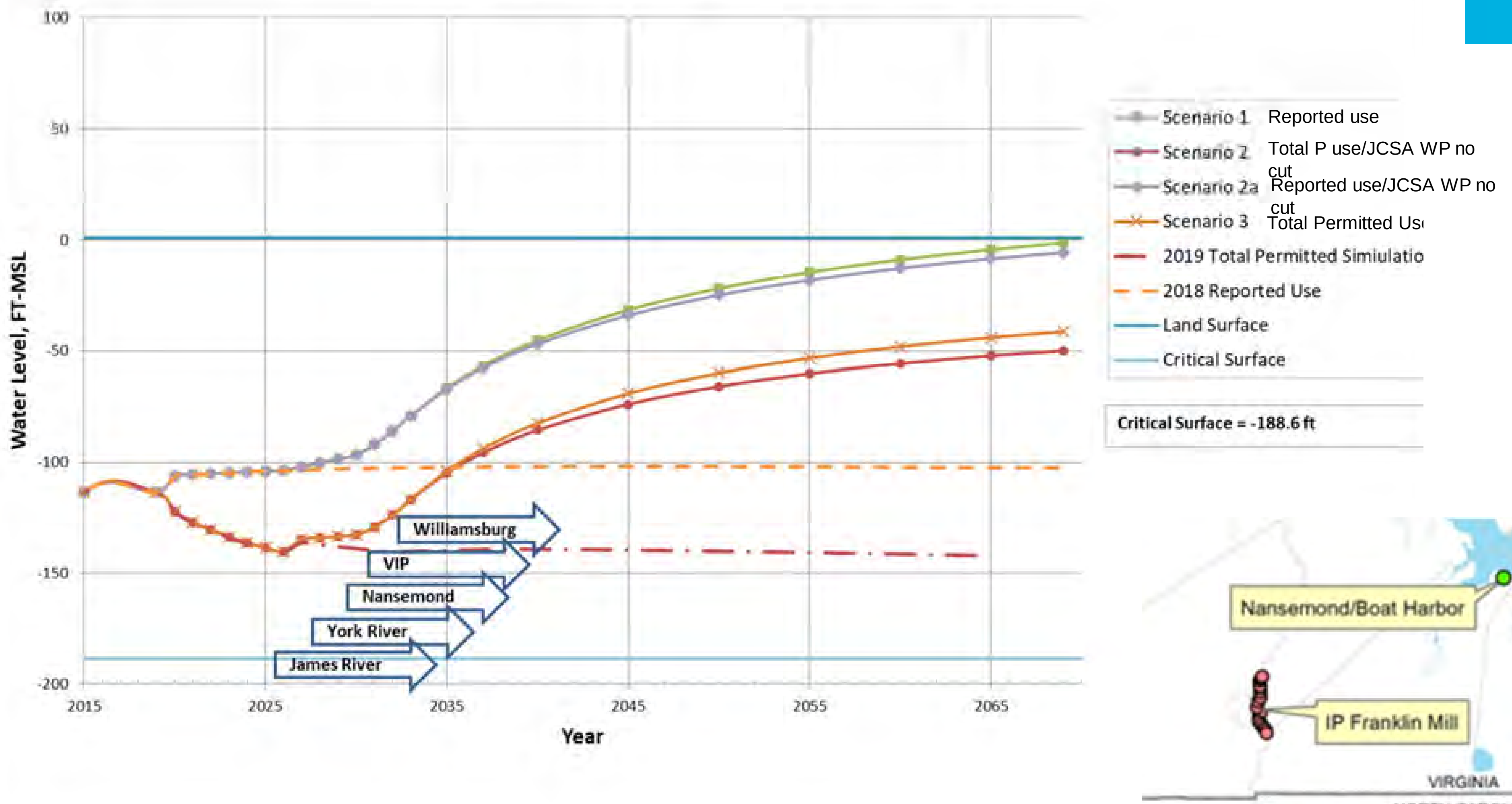
Hydrograph at International Paper Pumping Center

- Includes all six scenarios
- No critical cell failure


Potomac Aquifer Water Levels
International Paper - Franklin Mill - Row 119, Column 34
Water Level, FT-MSL
100
50
0
-50
-100
-150
-200
1890
1910
1930
1950
1970
1990
2010
2030
2050
2070
Year
Scenario 1 Reported use
Scenario 2 Total P use/JCSA WP no cut
Scenario 2a Reported use/JCSA WP no cut
Scenario 3 Total Permitted Us
2019 Total Permitted Simiulatio
2018 Reported Use
Land Surface
Critical Surface
Critical Surface = -188.6 ft


Nansemond/Boat Harbor
IP Franklin Mill
VIRGINIA

Potomac Aquifer Water Levels
International Paper - Franklin Mill - Row 119, Column 34



- WITHOUT SWIFT – water levels appear to be stable, but show no recovery after 2017
- Modeling indicates that critical cell failure is avoided with SWIFT for either withdrawal condition – Reported Use or Total Permitted Use
- Modeled beneficial impacts of SWIFT are identical for both JCSA/West Rock withdrawal scenarios (2017 permit limits, 2014 permit limits)
- Recovery starts 2026-2027
- S-curve water level recovery observed

Questions?

swift Sustainable Water Initiative for Tomorrow