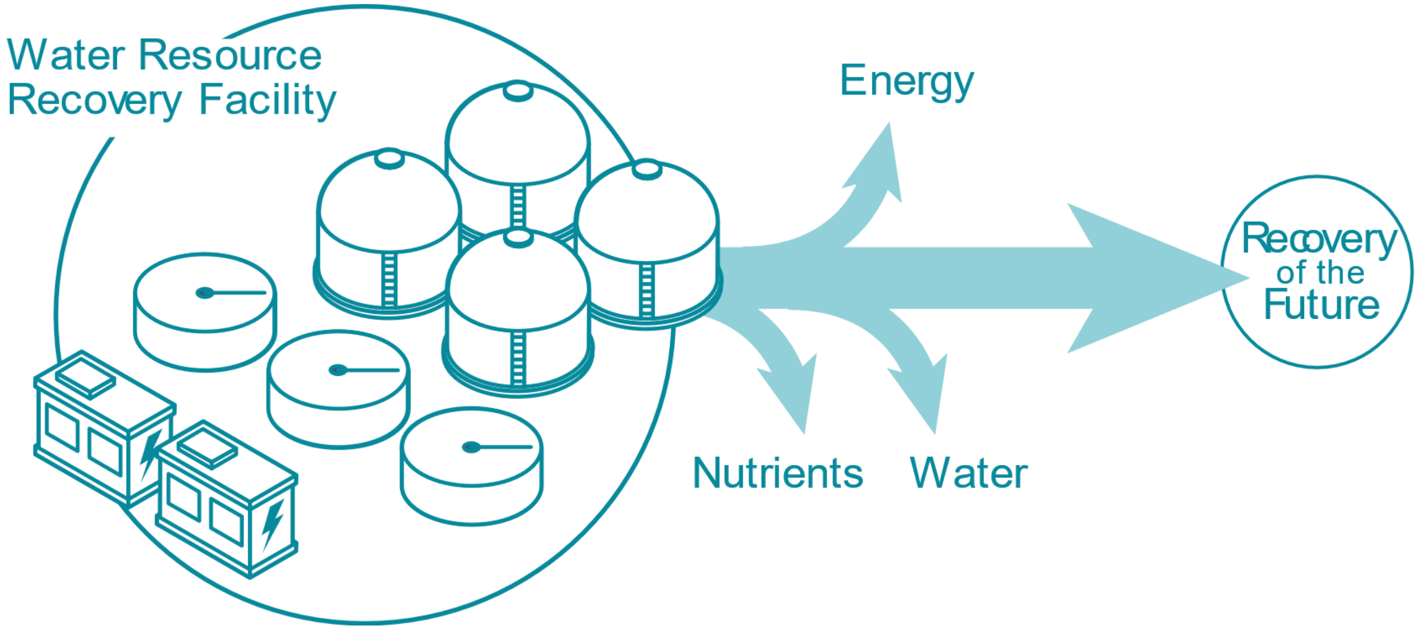
Hazen

Resource Recovery

Your Path to Doing More with Less

Brandt Miller, PE and Dwayne Amos, PE

“The resource recovery paradigm considers that most, if not all, materials in wastewater can be recovered and commoditized” – WE&RF



Recovery of Nutrients

Two Primary Drivers

1. Environmental / regulatory

2. Struvite nuisance

The fate of phosphorus

Effluent

Limit TP = 0.08 mg/L

Precipitation

Biosolids

The fate of phosphorus

Effluent

Limit TP = 0.08 mg/L

Nutrient Recovery

Biosolids

Recovery of Nutrients

Two Reliable Means of Removing Phosphorus

1 Chemical Removal

Metal salt binds with phosphorus – removed in biosolids

2 Struvite crystallization

Using a specially designed reactor to form struvite crystals that can be harvested

Struvite Formation Basics

$$Mg^{+2} + NH_4^{+} + PO_4^{-3} + 6H_2O \rightarrow MgNH_4PO_4 \bullet 6\,H_2O \text{ (solid)}$$

- ↑ Mg^{+2}: Mg in influent WW and released from Bio-P WAS
- ↑ NH_4^{+}, PO_4^{-3}: Anaerobic Digestion nutrient release from WAS
- ↑ →: pH increase

Sidestream Can Contribute a Significant Nutrient Load

Benefits of removing nutrients in the sidestream:

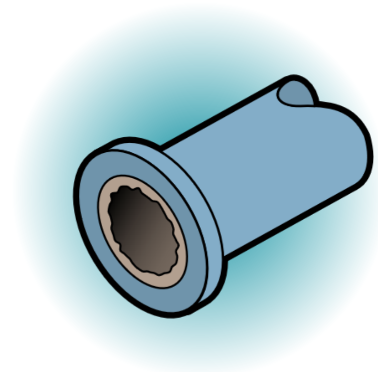
- Concentrated nutrient load
- Small flow (1% of Qin typ.)
- Can often reuse existing infrastructure to reduce costs
- Usually economical to meet stringent effluent limits when sidestreams contribute:
  - ≥15% of the influent TN
  - ≥20% P load

Commercial options for struvite recovery

Name of Technology	Ostara Pearl®	AirPrex	Multiform Harvest	Phospaq	NuReSys
Name of product recovered	Crystal Green ®	struvite fertilizer	struvite fertilizer	struvite fertilizer	BioStru®
% efficiency of recovery from sidestream	80-90% P 10-40% NH_3-N	80-90% P 10-40% NH_3-N	80-90% P 10-40% NH_3-N	80% P 10-40% NH_3-N	>85% P 5-20% N
Product marketing/resale	Ostara	N/A	Multiform Harvest	N/A	N/A
# of full-scale installations in design/operation	14	8	3	9	9
Configuration	Post-dewatering	Pre-dewatering	Post-dewatering	Post-dewatering	Post- and/or Pre-dewatering

Observed benefits with phosphorus recovery

Reduction of operating costs



Operation and Maintenance

Recovery of Nutrients

Nansemond Treatment Plant (NTP)

- Hampton Roads Sanitation District (HRSD), Suffolk, VA
- 30 mgd facility
- Treated effluent discharges into the James River, ultimately into the Chesapeake Bay
- 5-Stage BNR Process
- Installed Ostara Pearl process

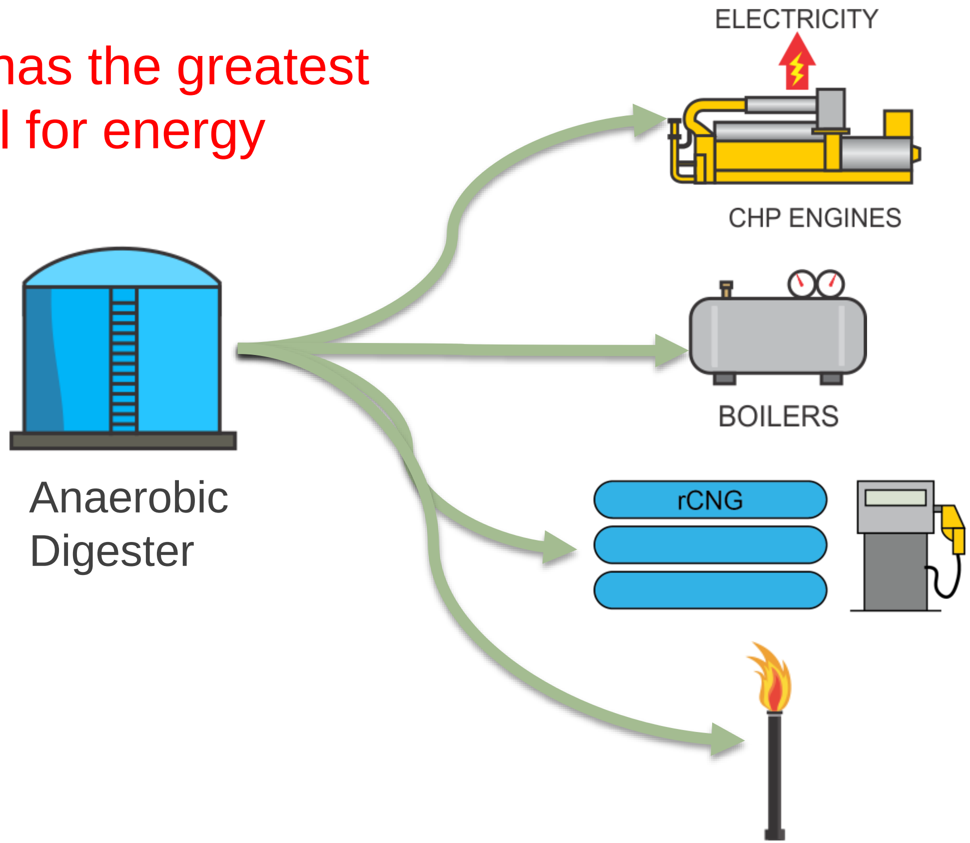
Recovery of Nutrients

Struvite recovery was most favorable treatment option

Cost Description	Do Nothing	Side Stream Chem Trmt	Ostara
Total Annual Savings	0	0	528,000
Total Annual Operating Costs	(392,000)	(429,000)	(91,000)
Net Annual Costs	(392,000)	(429,000)	437,000
Capital Costs			3,926,000
Net Present Worth @ 10 years	(3,027,000)	(3,313,000)	(552,000)
Net Present Worth @ 20 years	(4,885,000)	(5,346,000)	1,520,000

Recovery of Energy

Biogas has the greatest potential for energy



35% Electricity
40% Heat Recovery

80% Heat Recovery

80% - 90% Fuel Conversion

0% Energy Recovery

Generating Value from Biogas

Technology	Energy Type	Pathway	Markets
Combined Heat and Power (CHP)	Electricity/Heat	**Offset** electrical and thermal energy	• Electricity • Natural Gas • Renewable Energy Credits (RECs)
Boilers	Heat	**Offset** thermal energy	• Natural Gas
Renewable Natural Gas (RNG)	Fuels	**Sales** of renewable fuels (typically in transportation sector)	• Compressed Natural Gas (CNG) • RIN Market • Low Carbon Fuels Markets

What is RNG?

Recovery of Energy

- RNG is biogas treated to Natural Gas standards
- RNG and Natural Gas have the same chemical makeup after treatment

Parameter	Typical Digester Gas	Typical Requirements
Moisture	Saturated	Dry
Carbon Dioxide	35% - 50%	3% Max
Methane	55% - 65%	98%
Oxygen-Nitrogen	~4%	0.2%
H2S	4000ppmv	4ppm
NH4	Varies	Non Detect
Total Si	Varies	Non Detect
VOC	0-500PPMV	Non Detect
BTU	600BTU/SCF	980BTU/SCF

Recovery of Energy

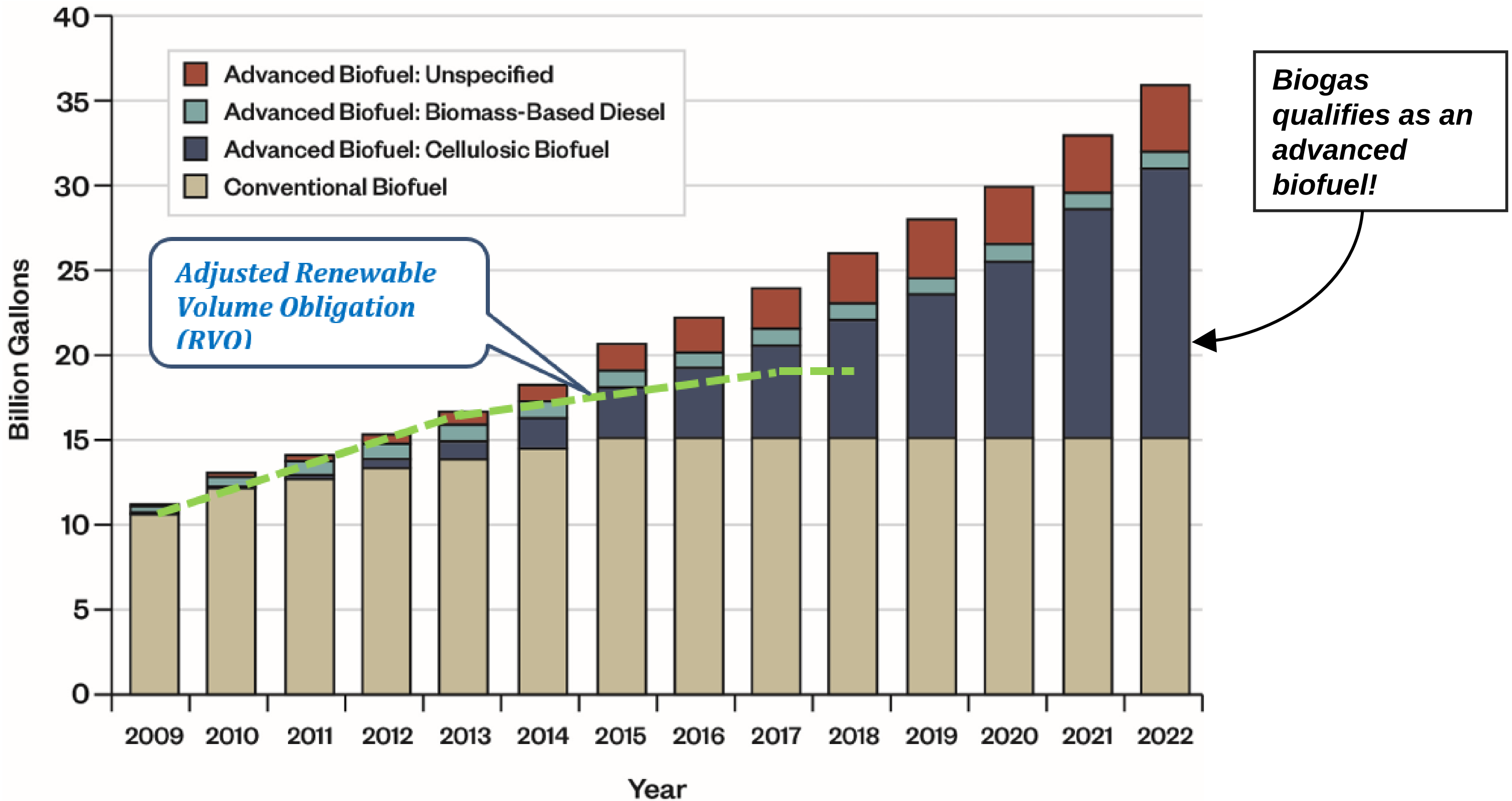
RNG Drivers

- Cities moving toward CNG vehicles
- Political and environmental incentives to use renewable fuels
- "Off-site" utilization lowers site emissions

Tampa turns to natural gas to fuel city's fleet

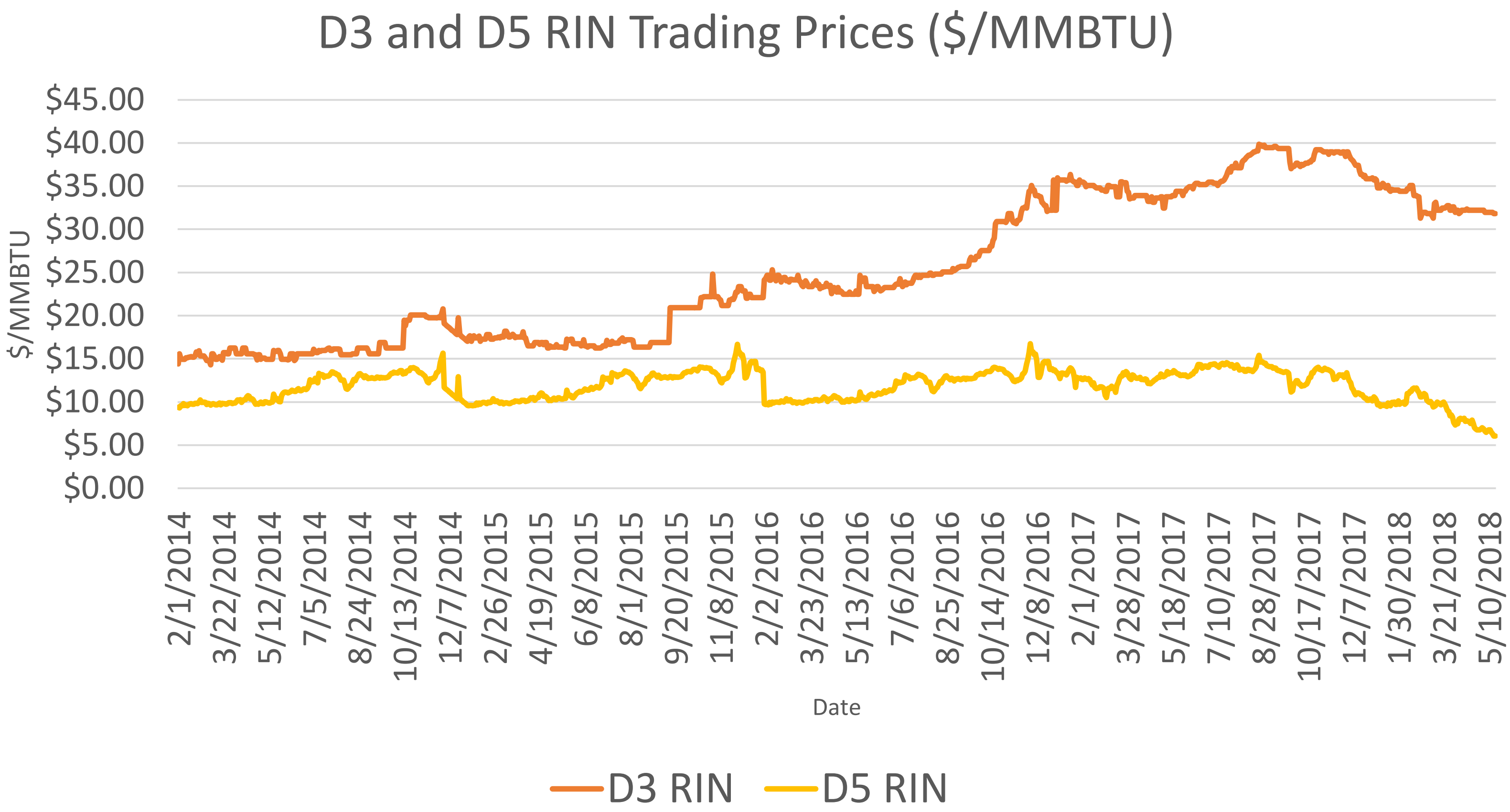
"Strong market for renewable transportation fuels"

Is there a Demand?



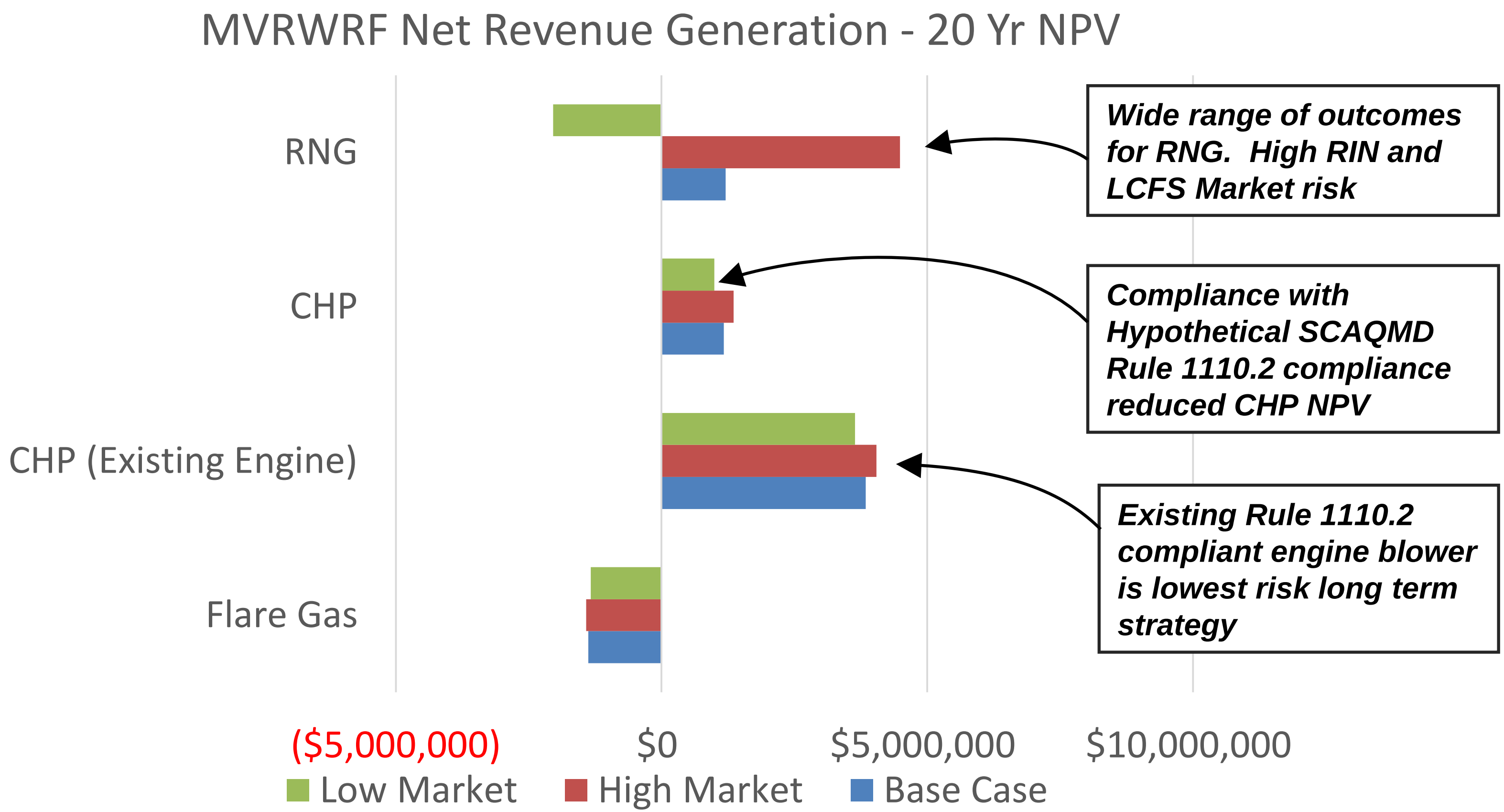
Is there a market?

Recovery of Energy



Eastern Municipal Water District, CA
Moreno Valley RWRF Alternatives Analysis

Recovery of Energy

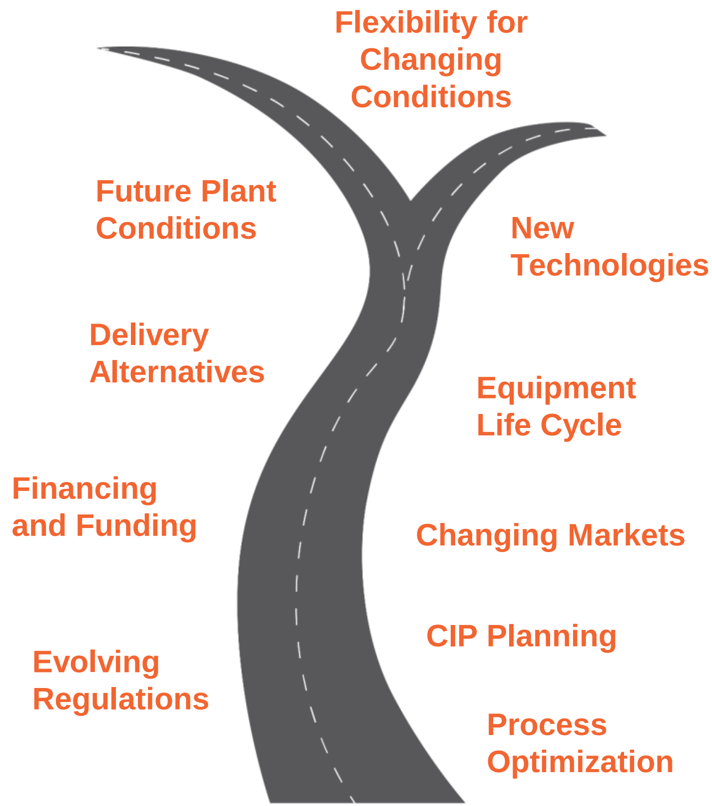


RIN Market Challenges

Recovery of Energy

- Cellulosic biofuels (D3) expected to continue to lag mandated levels.
- EPA is using their waiver authority to reduce requirements for obligated parties.
- Next year's RVOs adjustments are largely "unknown" during the current year.
- Waivers and RVOs are de-stabilizing the market.
- "Political Climate"

Long Term Biogas Utilization Planning



Flexible Long Term Road Map

Overview of a 1 MGD Advanced Water Treatment Demonstration Facility for Managed Aquifer Recharge

Recovery of Water

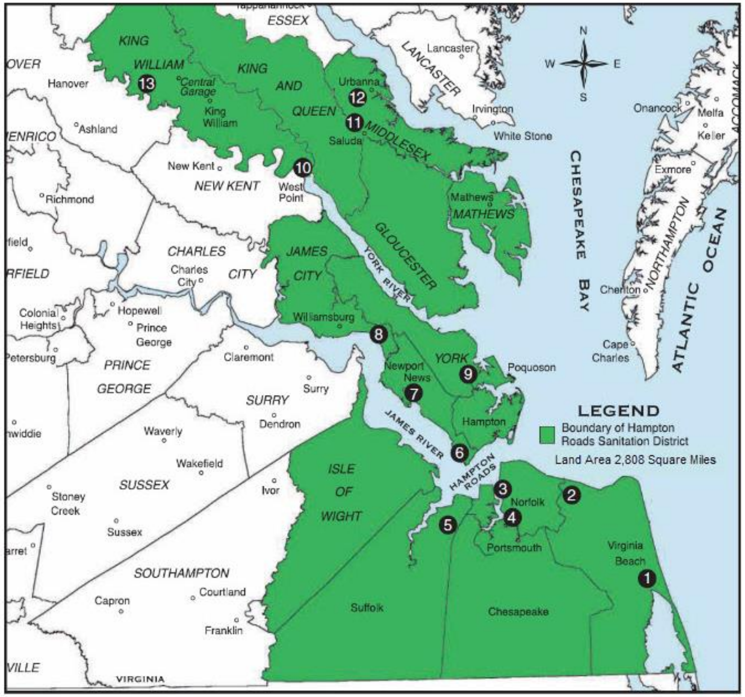
HRSD

- Provides wastewater treatment for 17 localities (250 mgd treatment capacity)
- Serves 1.7 million people (20% of all Virginians)

Major facilities include the following treatment plants:

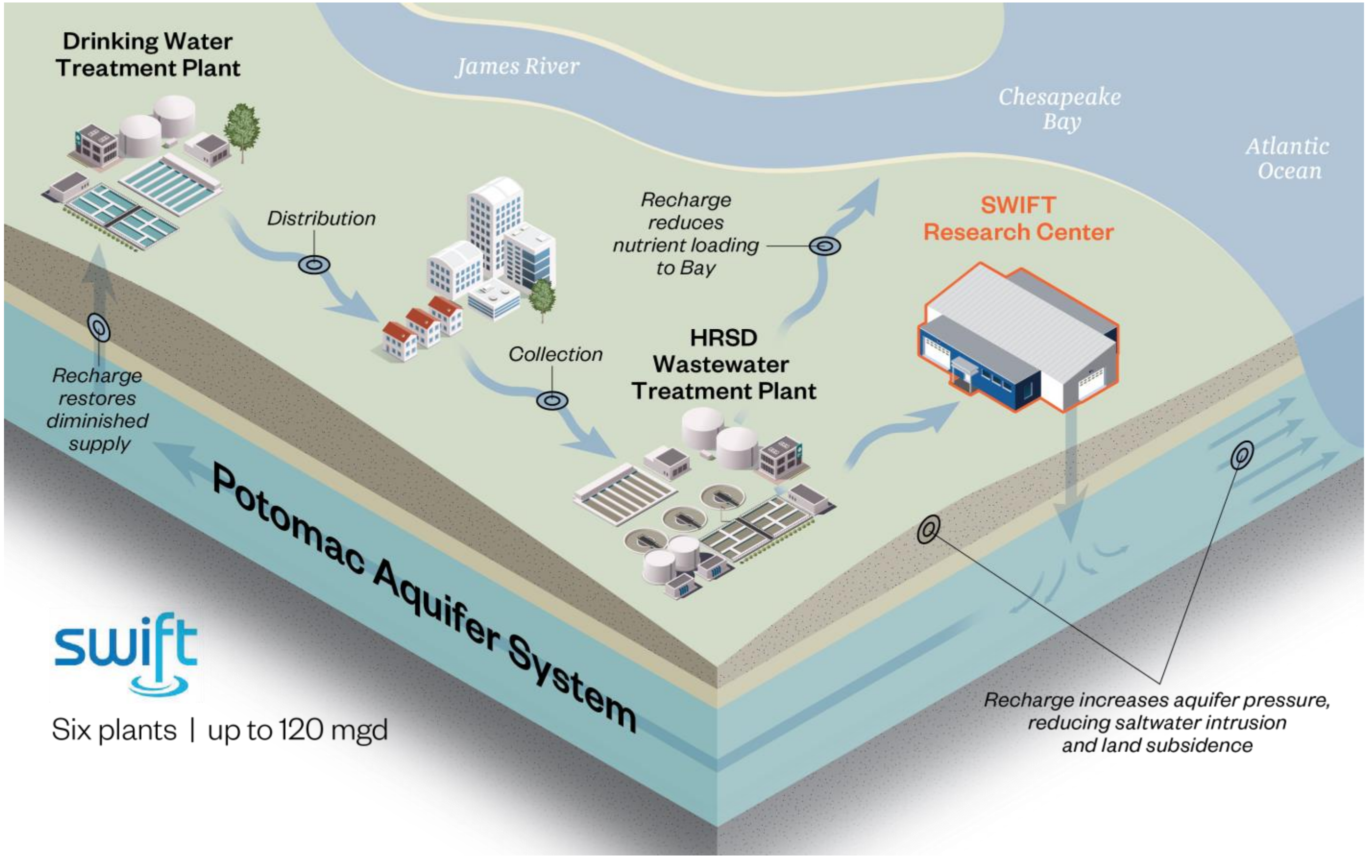
1. Atlantic, Virginia Beach
2. Chesapeake-Elizabeth, Va. Beach
3. Army Base, Norfolk
4. Virginia Initiative, Norfolk
5. Nansemond, Suffolk
6. Boat Harbor, Newport News
7. James River, Newport News
8. Williamsburg, James City County
9. York River, York County
10. West Point, King William County
11. Central Middlesex, Middlesex County
12. Urbanna, Middlesex County
13. King William, King William County

Serving the Cities of Chesapeake, Hampton, Newport News, Norfolk, Poquoson, Portsmouth, Suffolk, Virginia Beach, Williamsburg, and the Counties of Gloucester, Isle of Wight, James City King and Queen, King William, Mathews, Middlesex and York



2016

Advanced Water Treatment for Beneficial Recycle



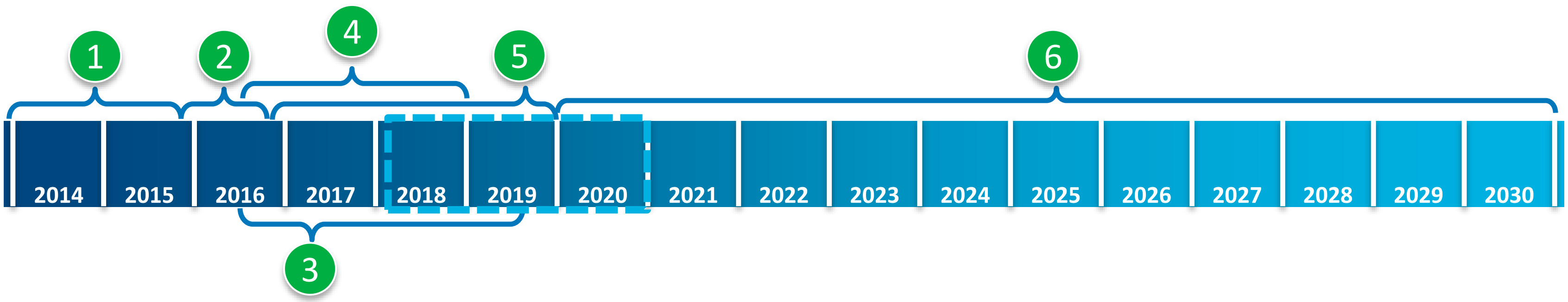
Drivers For SWIFT Program

SWIFT concept - replenish the aquifer with purified water to:

- Reduce nutrient discharges to the Chesapeake Bay
- Provide a sustainable supply of groundwater
- Reduce the rate of land subsidence (relative SLR)
- Protect the groundwater from saltwater contamination
- Integrated Planning - Wet weather sewer overflows IAW Federal enforcement action
- Managing wastewater operations cost effectively in a fluid regulatory environment

Recovery of Water

SWIFT Program Timeline



Phase 1 - Concept Feasibility

Phase 2 - Concept Development & Pilot Testing

Phase 3 - Concept Demonstration

Phase 4 - Facility Plan Development

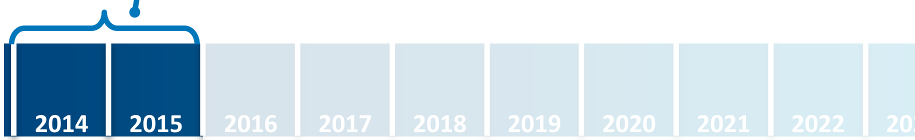
Phase 5 - Implementation Plan

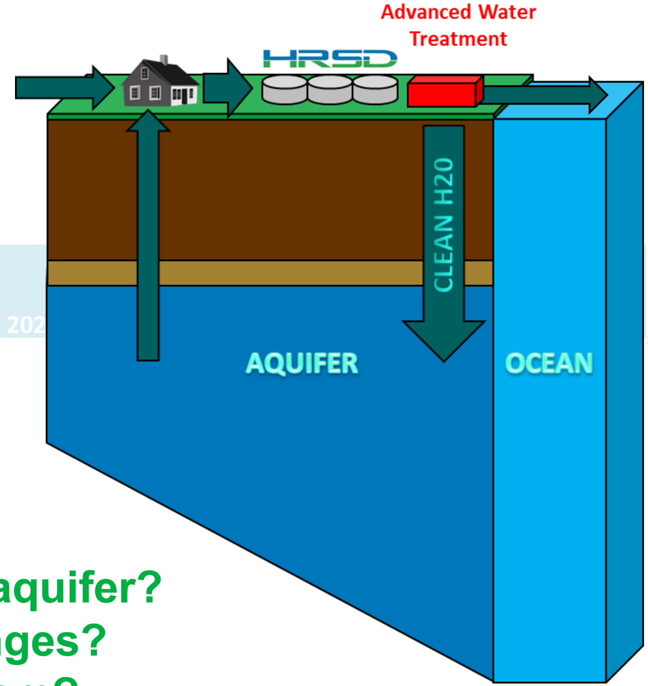
Phase 6 - Full Scale Facility Implementation

Recovery of Water

Phase 1 – Concept Feasibility

Feasibility Study (Complete)

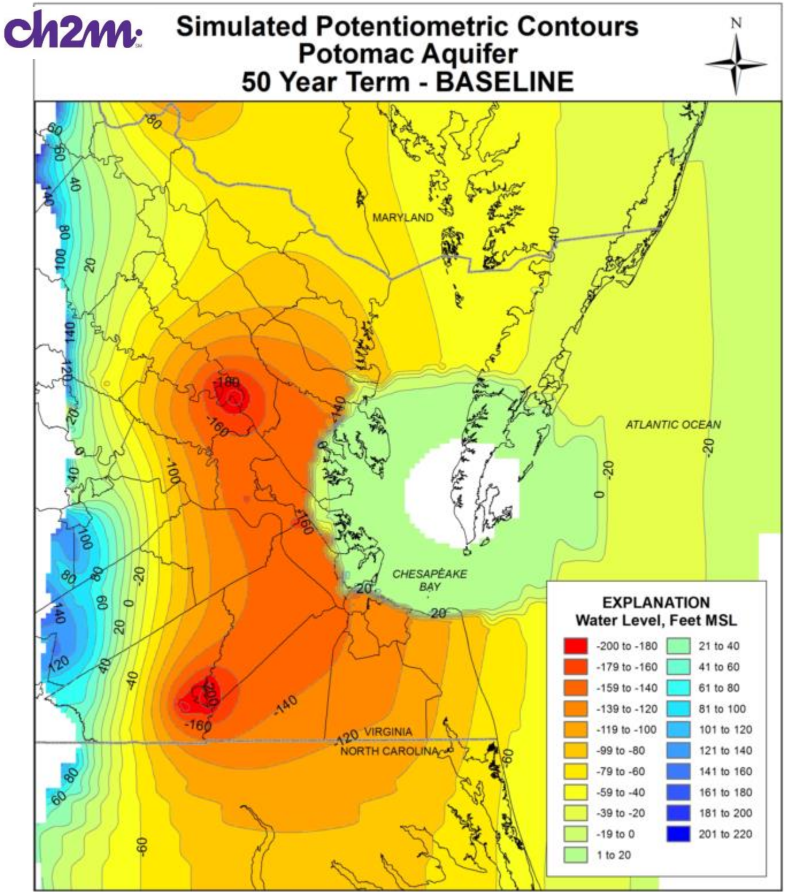


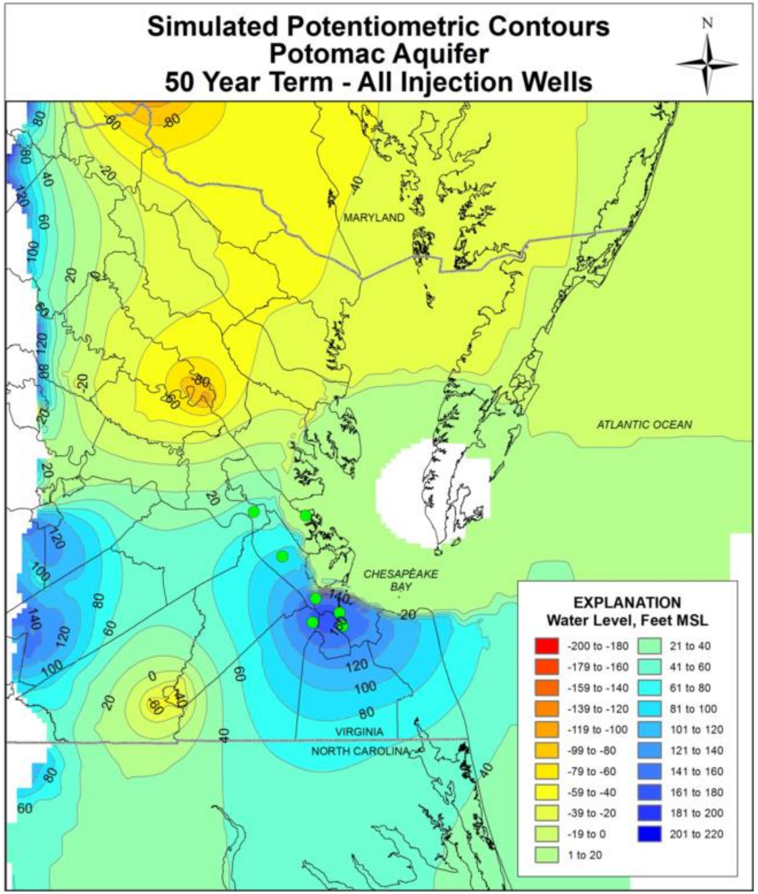


Can HRSD…
- … meet treatment targets?
- … get the purified water into the aquifer?
- … address regional water challenges?
- … afford to implement this program?

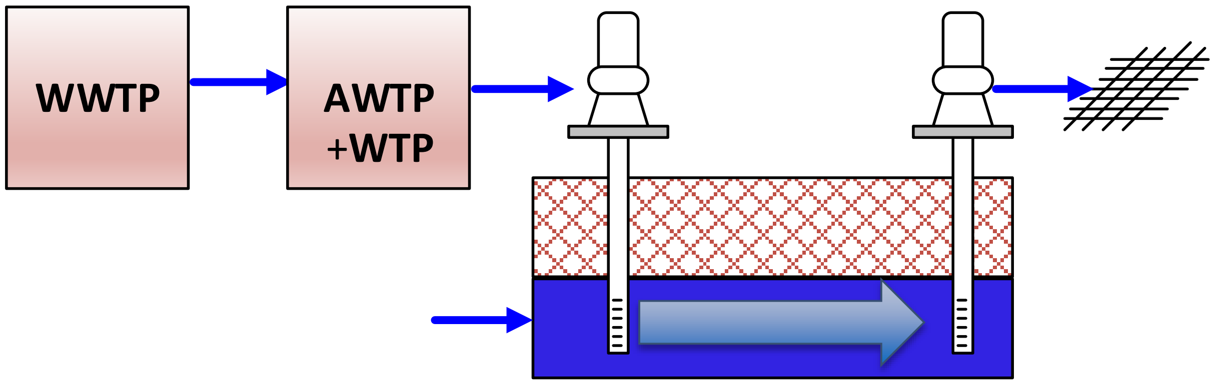
Modeled Potomac Aquifer Water Levels With And Without SWIFT

Recovery of Water





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

Phase 2 – Concept Development and Pilot Testing

Recovery of Water

Operation of Parallel Pilot Scale Treatment Skids (complete)

Continued Pilot Scale Research

2014 | 2015 | **2016** | **2017** | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030

Extensometer Construction at NTP

National Water Resources Institute (NWRI) Panel Review

Test Well Construction at Nansemond TP

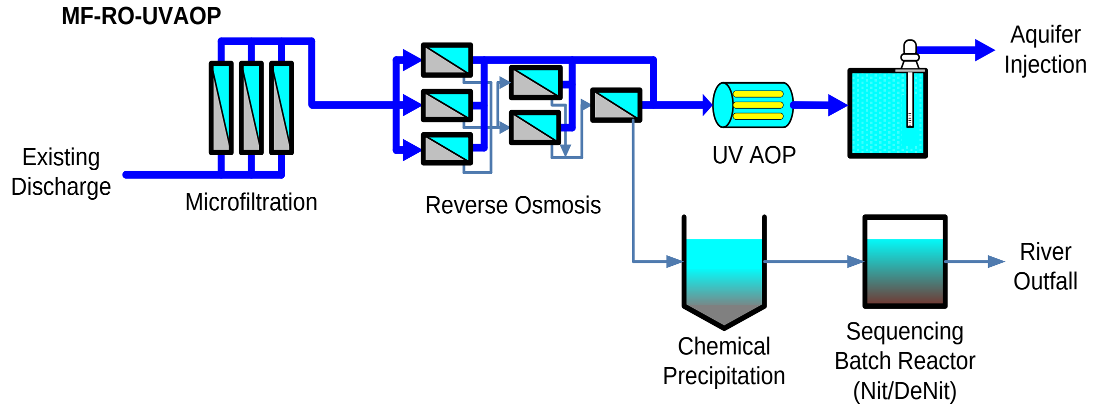
Water Quality Goals – Pathogen Inactivation

Recovery of Water

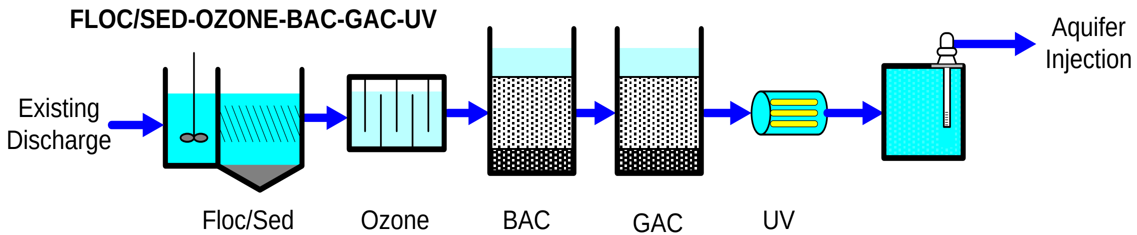
Parameter	Floc/Sed & BAF[1]	Ozone[2]	BAF & GAC	UV[3]	Cl2	SAT	Total
Enteric Viruses	2	3	0	4	0-4	6	12-19
Cryptosporidium	4	0	0	6 (4 Allowed)	0	6	14-16
Giardia lamblia	2.5	1.5	0	6 (4 Allowed)	0	6	12.5-16

Advanced water treatment alternatives

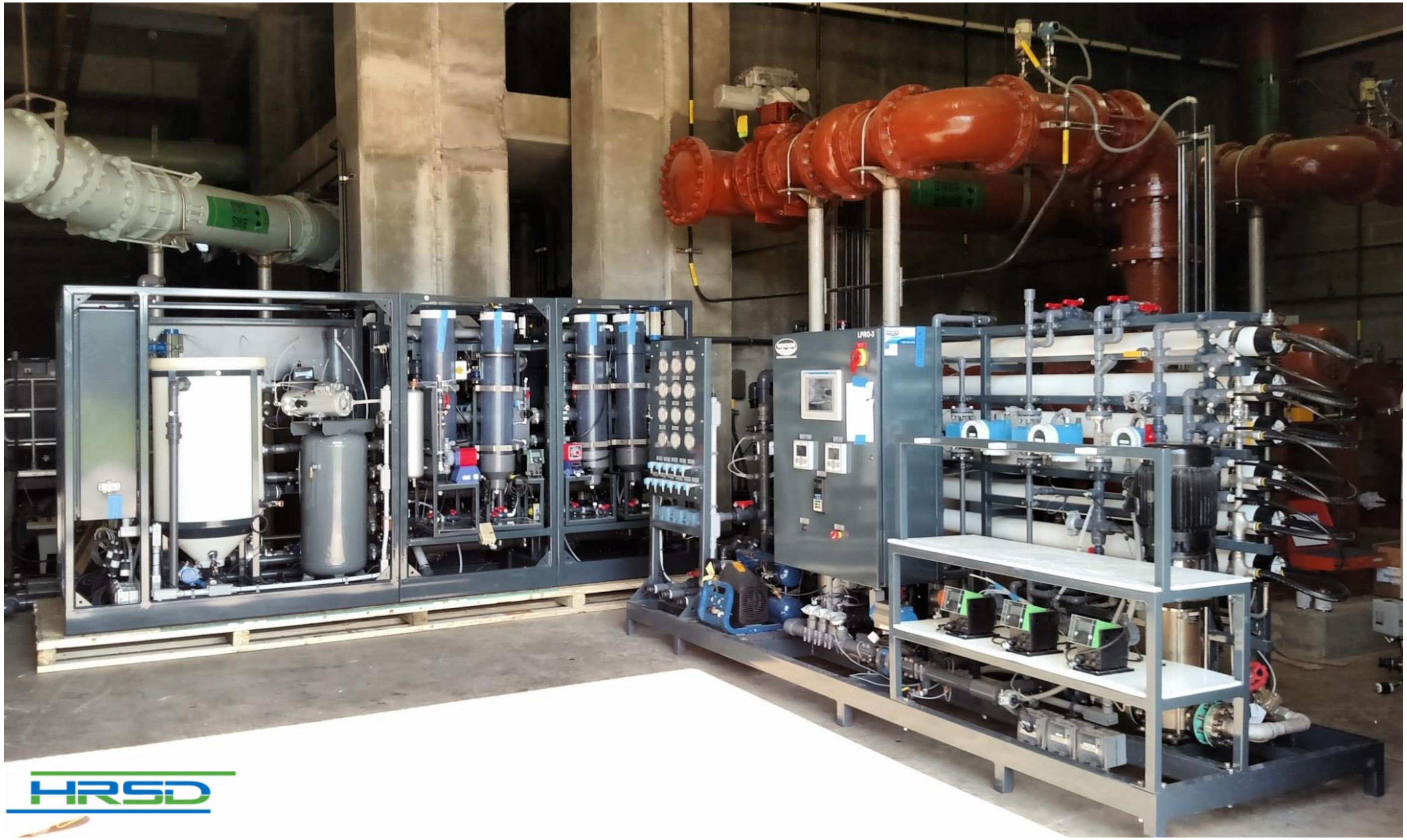
Membrane Based



Carbon Based



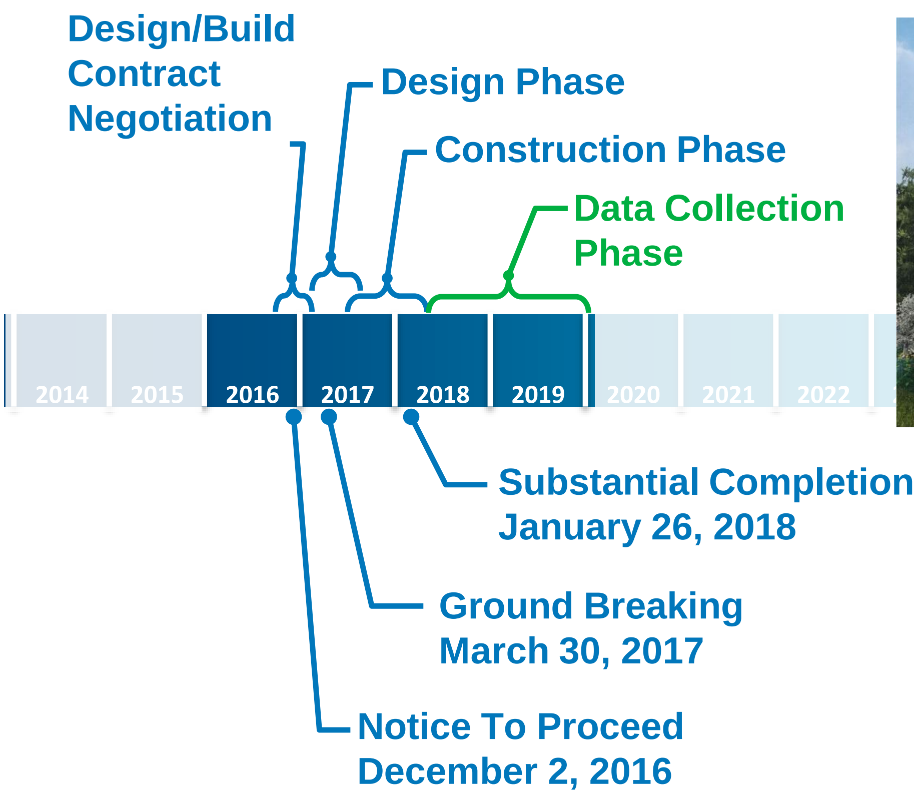
MF/RO/UVAOP Pilot Systems



Recovery of Water

SWIFT Research Center

Phase 3 – Concept Demonstration



Design / Build
CCL: $25,650,000

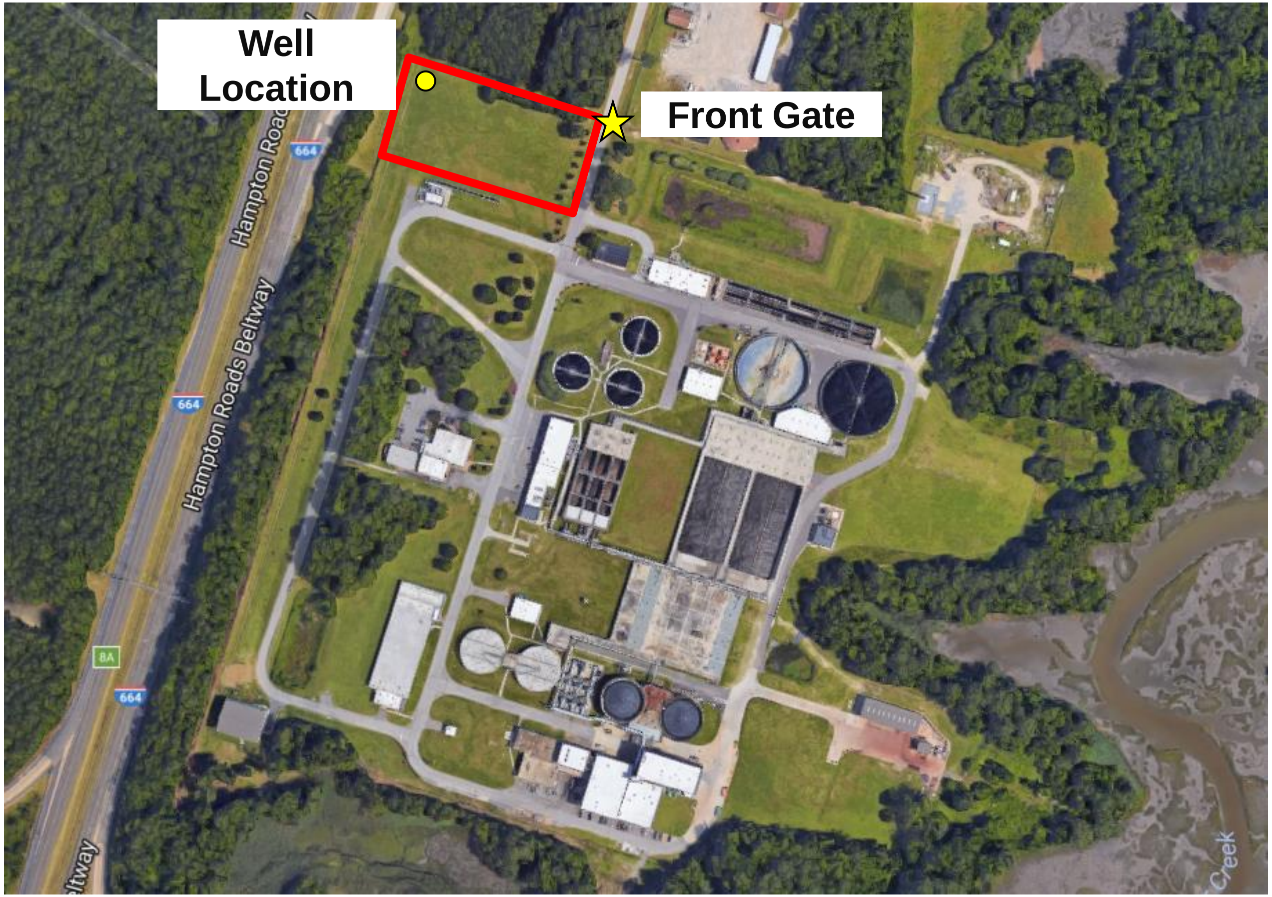
CROWDER CONSTRUCTION COMPANY Hazen

SWIFT Research Center Objectives

- 1 MGD Aquifer Recharge Flow
- Meets Primary Drinking Water Standards
- Compatible with the receiving aquifer
    - No clogging
    - No mobilization of aquifer constituents

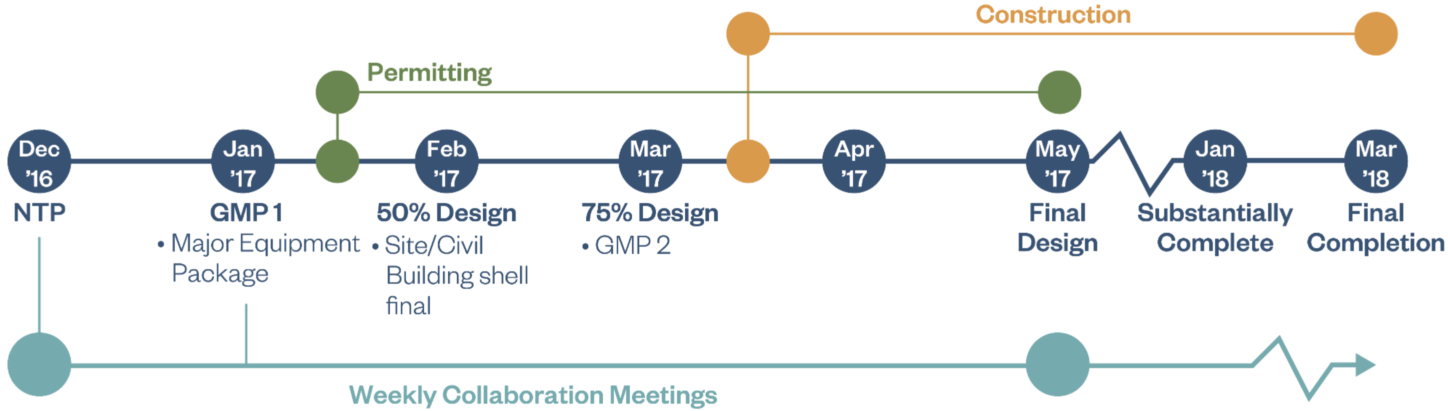
- Define permitting requirements for full scale
- Staff/operator training
- Public education

Location of Facility within Nansemond TP Site



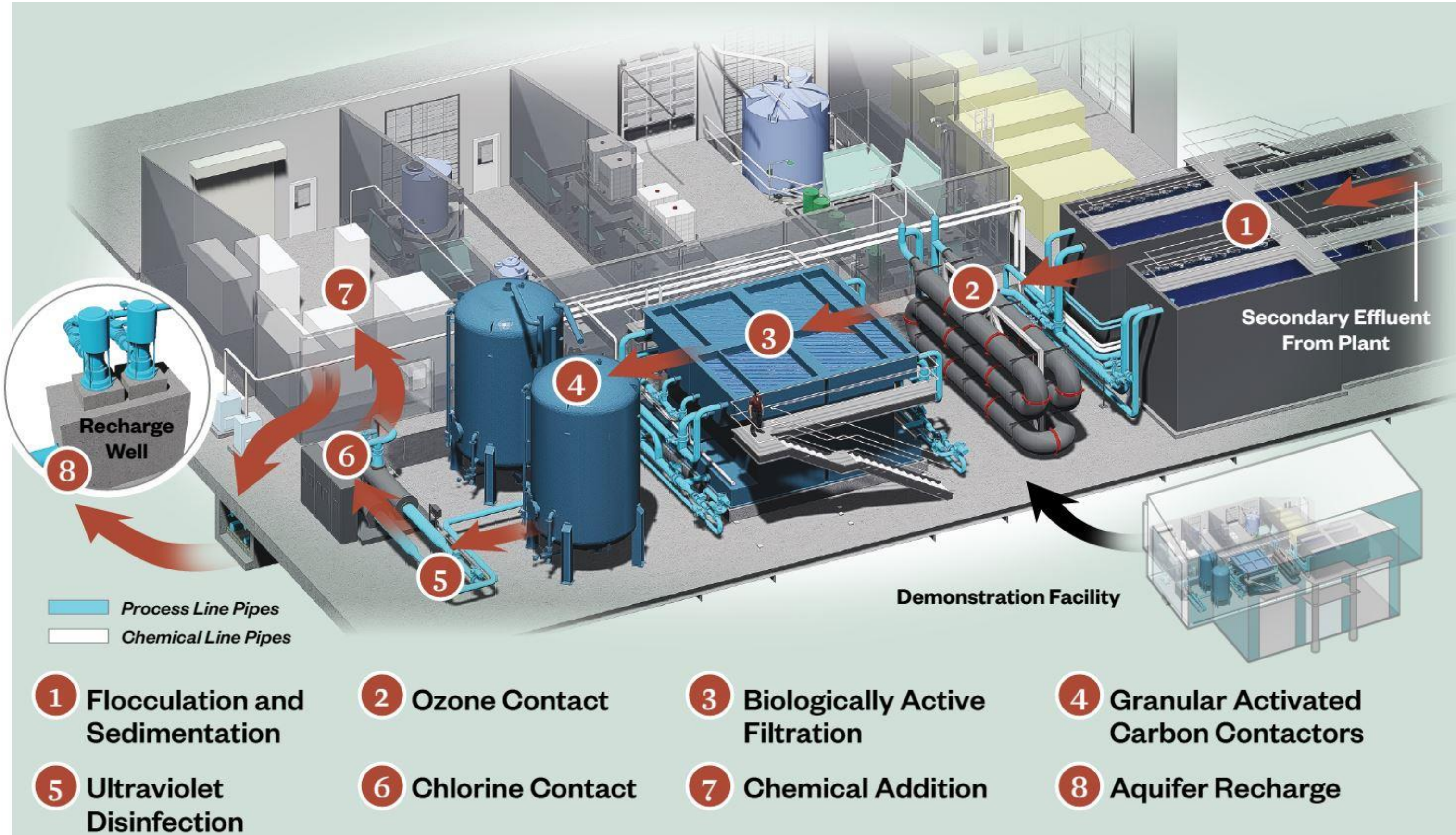
Schedule

- Met the aggressive design schedule. Pushed back from EPA backstop date
- Contractor/vendors/client/Jacobs/early decisions.
- Locked in process design
- Use of 3D tools effective for faster decision making



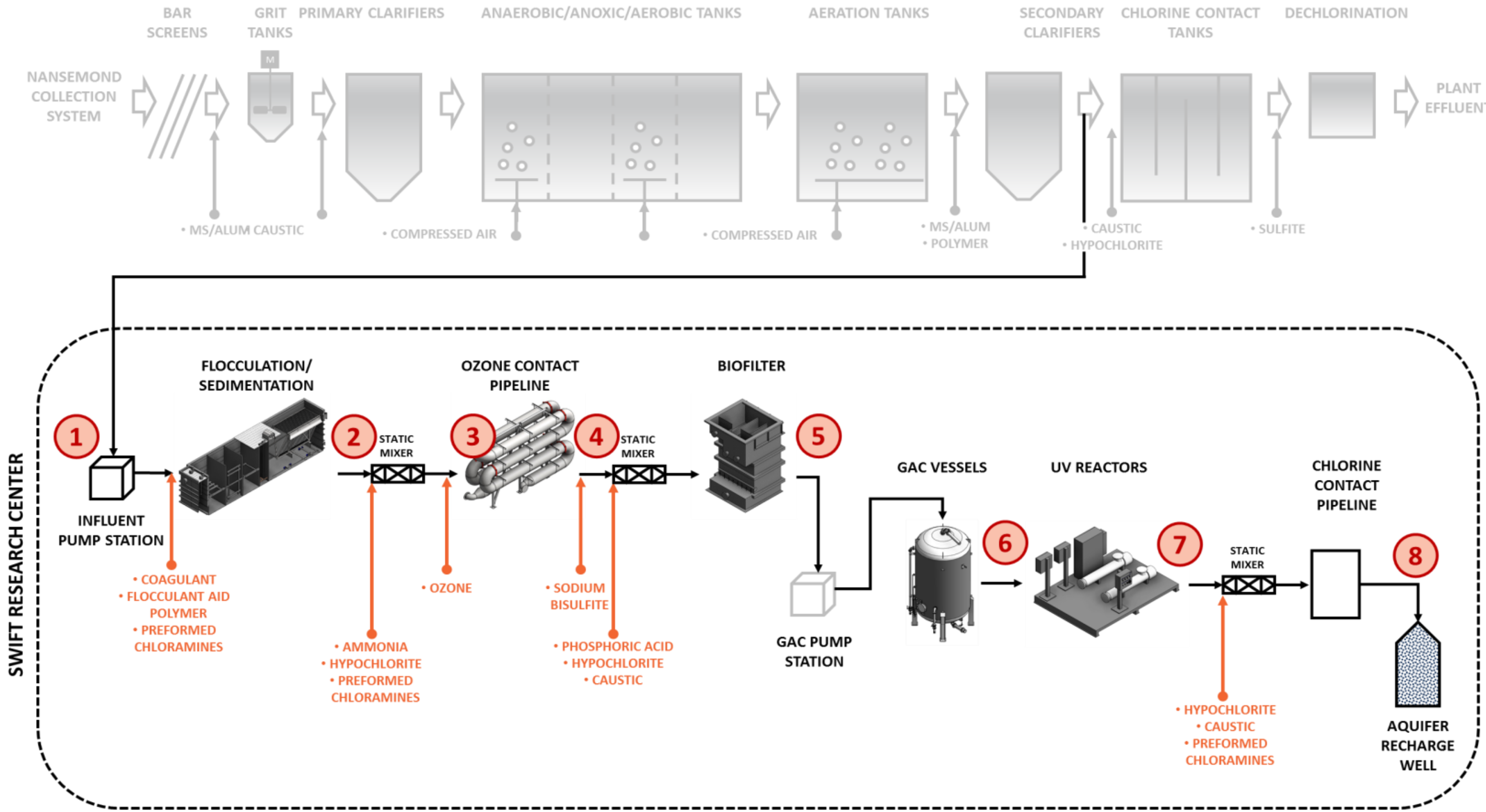
Recovery of Water

Research Center Treatment Approach



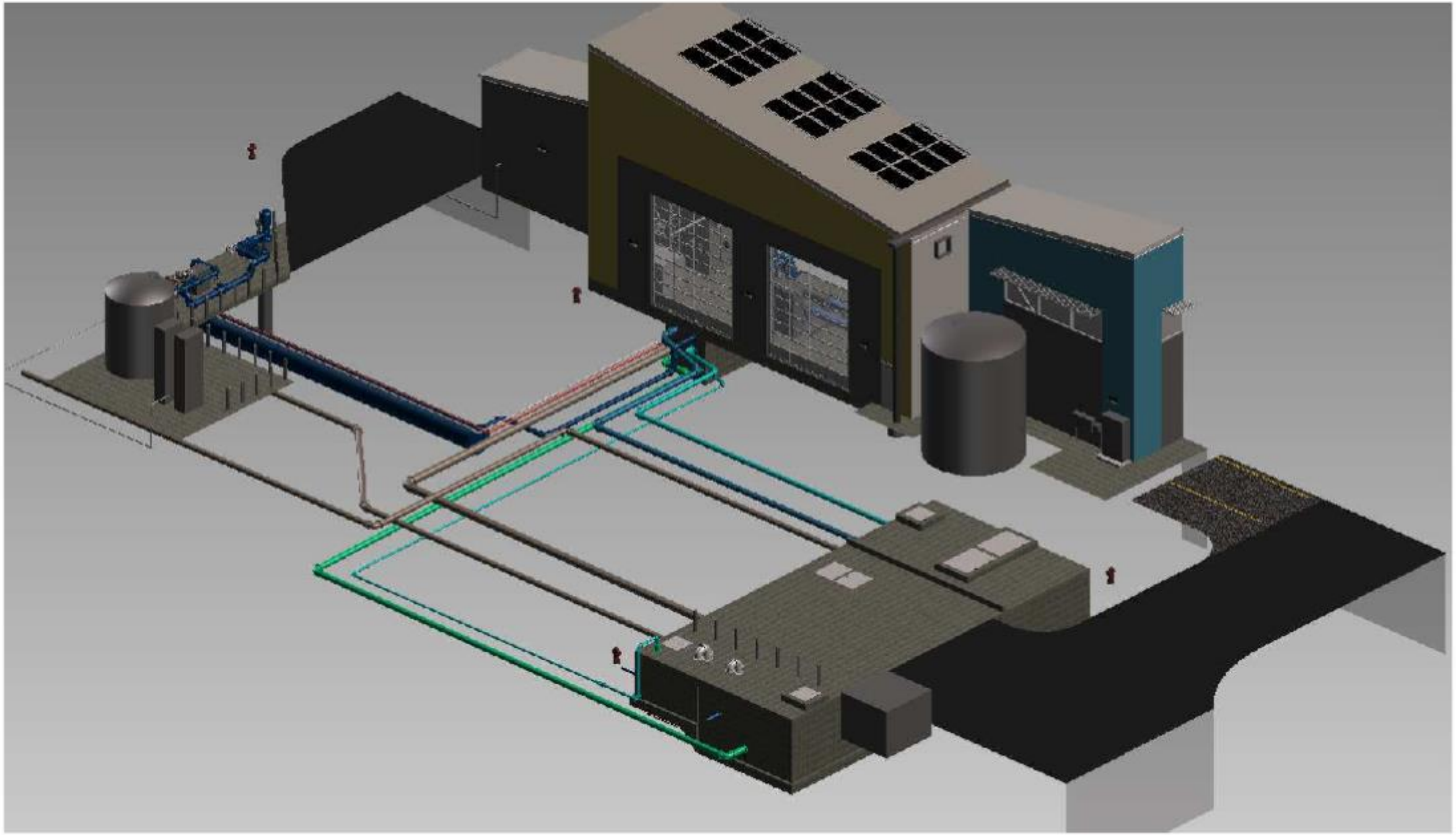
HACCP - Critical Control Point Selection

Recovery of Water



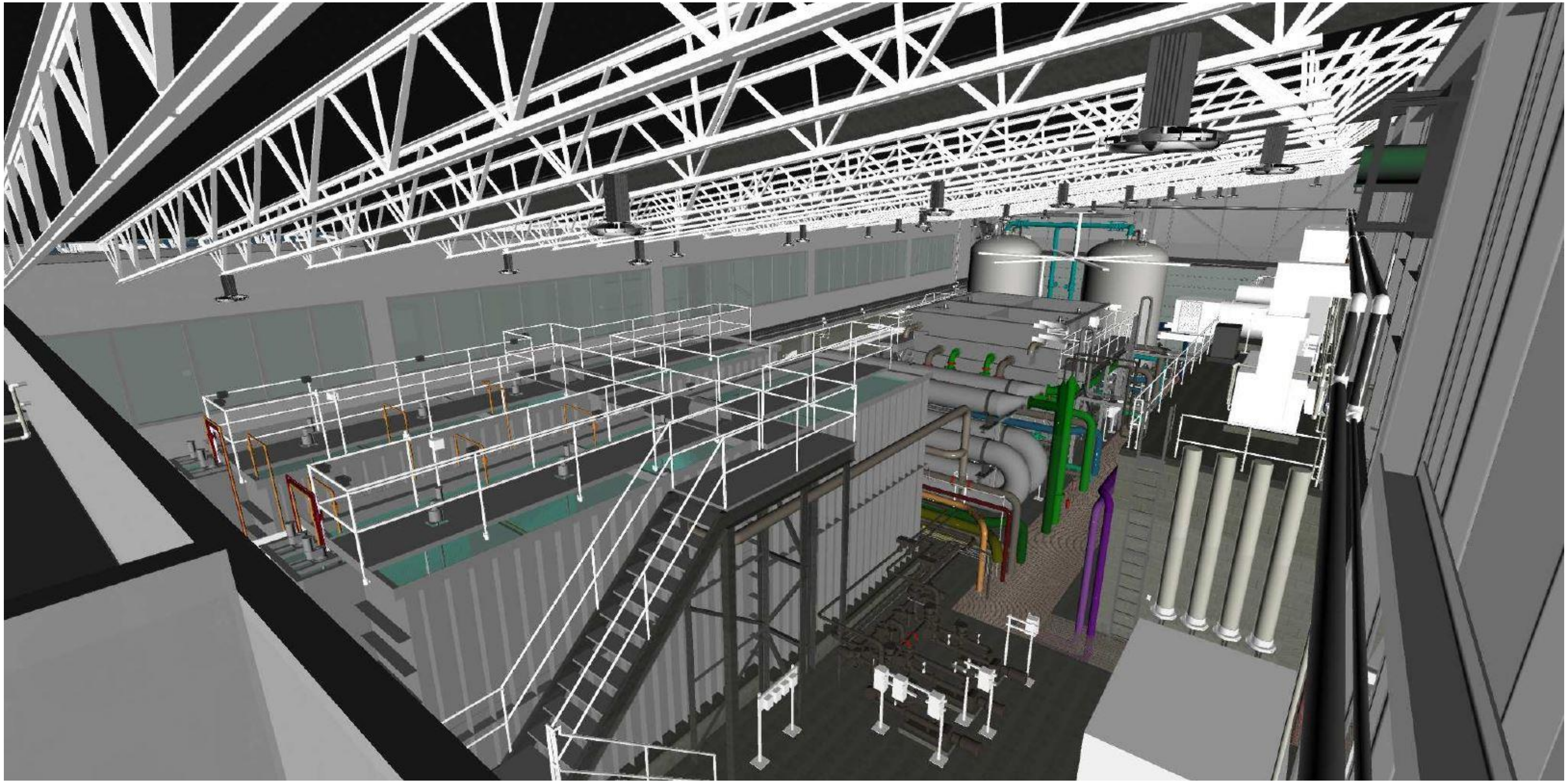
Recovery of Water

BIM Design Collaboration

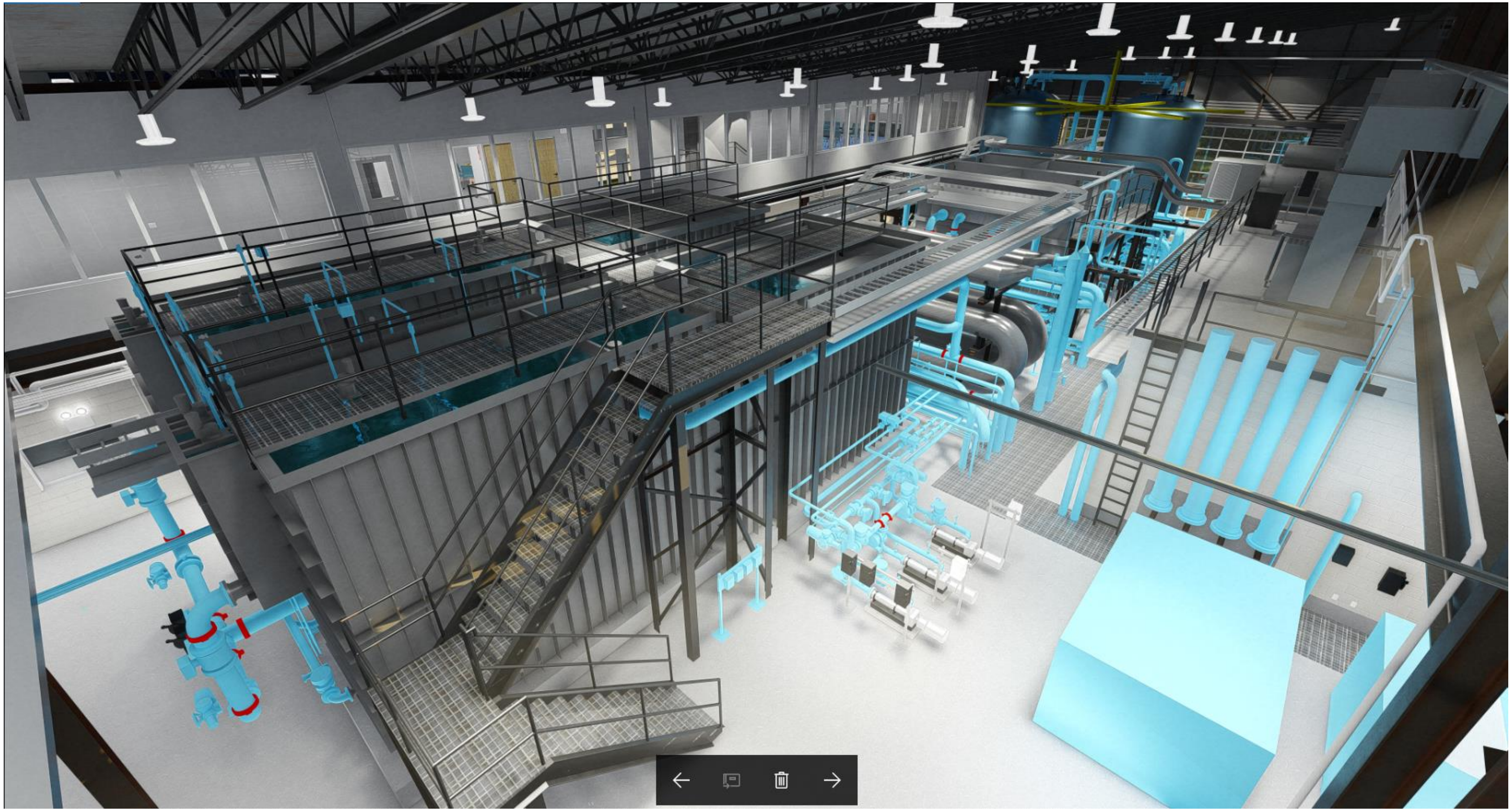


Recovery of Water

Rapid Model Development using Revit & BIM



Public Engagement



Virtual Reality

Augmented Reality APP

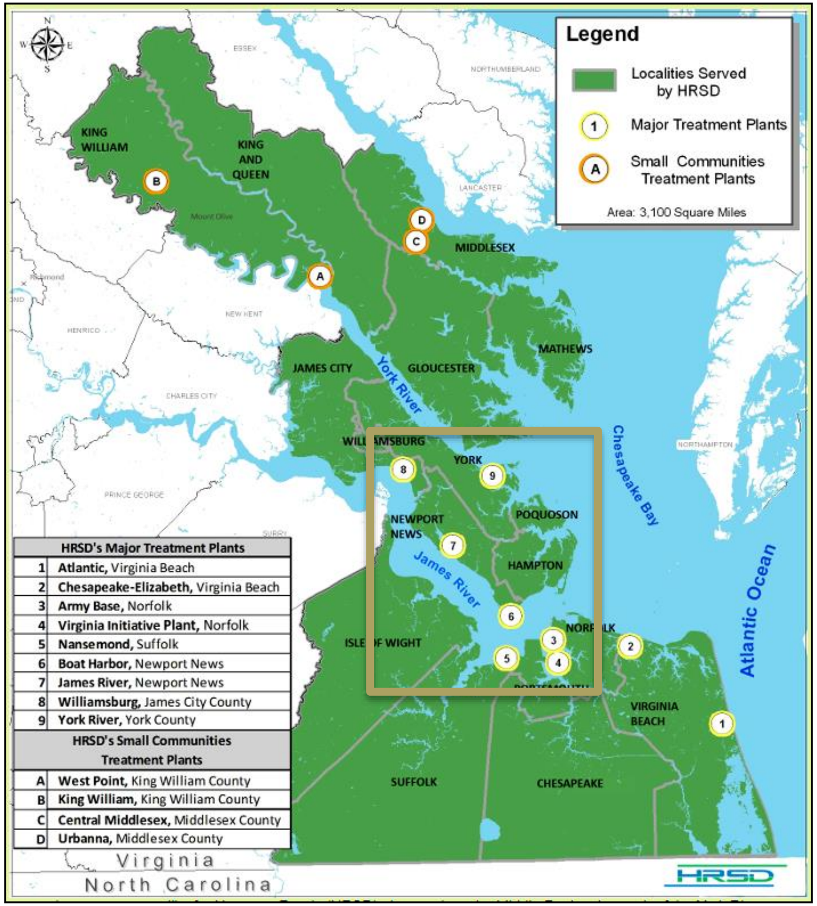
Recovery of Water

Construction

Recovery of Water

Where is SWIFT going?

- One MGD demonstration facility (Spring 2018)
- Seven Major WWTPs for a combined flow of 120MGD
- Full implementation planned by 2030



Recovery of Water

Phase 4 – Facility Plan Development

** Estimated Timeline*

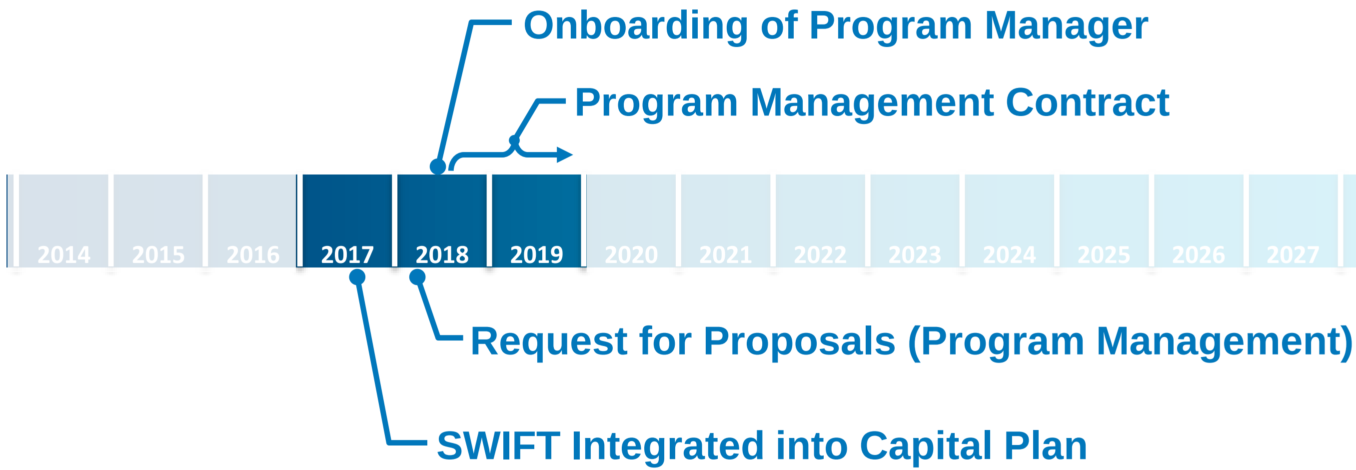
<u>Facility Planning Elements</u>:

- **Right size SWIFT treatment**
- **Evaluate exiting treatment upgrades**
- **Pursue real estate needs**
- **Understand capital and operational costs**

Phase 5 – Implementation Plan

Recovery of Water

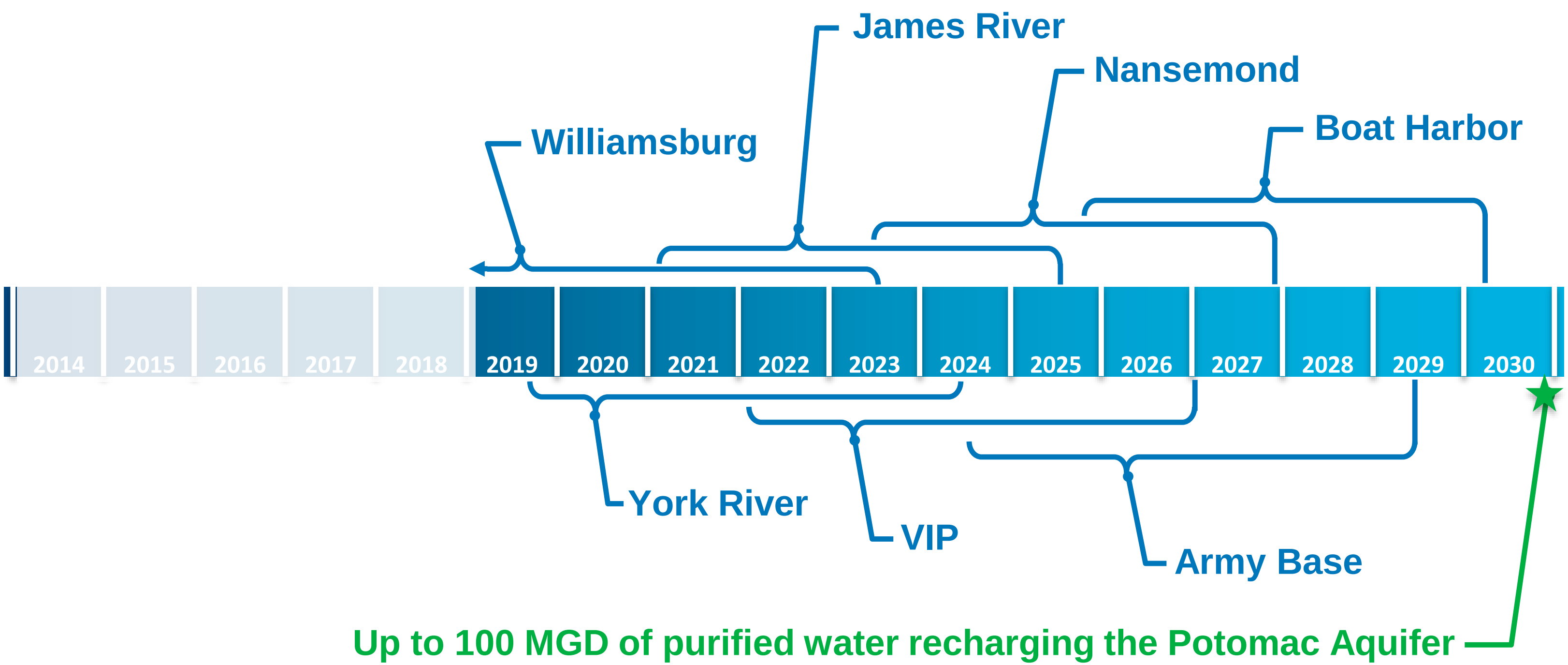
** Estimated Timeline*



Phase 6 – Full Scale Facility Implementation

Recovery of Water

** Estimated Timeline*



← *Each project includes procurement, design, construction, and start-up phases.*

Questions?

Neco Bio-Bus is powered by your waste for a sustainable f
Tell us wh
you think

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Recovery of Water

Recovery of the Future

WRRF TODAY

WRRF TOMORROW

Biosolids
In-Plant Carbon

Phosphorus

Nitrogen

High-Value Carbon

Rare Earth Elements

Plasmids

Recovery of Digester Gas

- Easily recovered and utilized
- Multiple utilization technologies
- Renewable energy source


Pipeline Injection

Vehicle Fuel


Boilers


CHP

How much RNG can we make?

Recovery of Energy

Rule of Thumb:

15,000 - 20,000 gasoline gallon equivalents / year / MGD

Lots of Energy!!!!!!

10MGD - 150,000 -200,000 GGE/yr

- *15-20 Refuse Trucks*
- *50-70 Police Cruisers*
- *10-20 City Transit Busses*
- *300-400 Personal Vehicles*

RNG Pathways: There are Challenges