Cleaning wastewater every day for a better Bay.

Sustainable Water Recycling

Aquifer Replenishment System (ARS)

Director of Utilities
September 2, 2015

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Agenda

- Drivers
- Study Purpose
- Groundwater
- Advanced Water Treatment
- Conceptual Cost Estimates
- Conclusion & Next Steps
- Questions

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Drivers for water recycling

- Stricter wastewater regulations
- Land subsidence
- Groundwater depletion
- Saltwater contamination of the groundwater

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Stricter wastewater regulations

- Ever changing regulations
  - "Whack a mole" approach
    - Nutrients
      - How much is enough? – "Limit-of-Technology" (LOT) backstop threat with TMDL
    - Chlorophyll a
      - Will Water Quality Standards ultimately reflect the science?
    - Viruses
      - Already under discussion
    - Pharmaceuticals and Personal Care Products (PPCP)
    - ????
- POTW the only regulated contributor to a very complex water quality problem
- Not a sustainable approach

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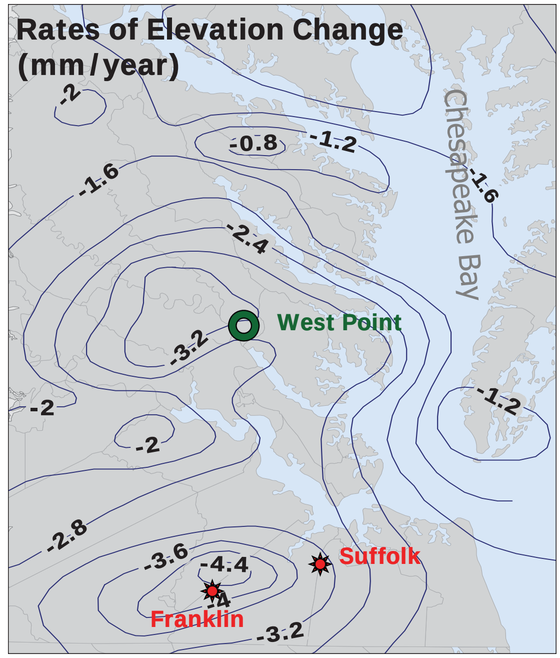
Land subsidence – *we are sinking*

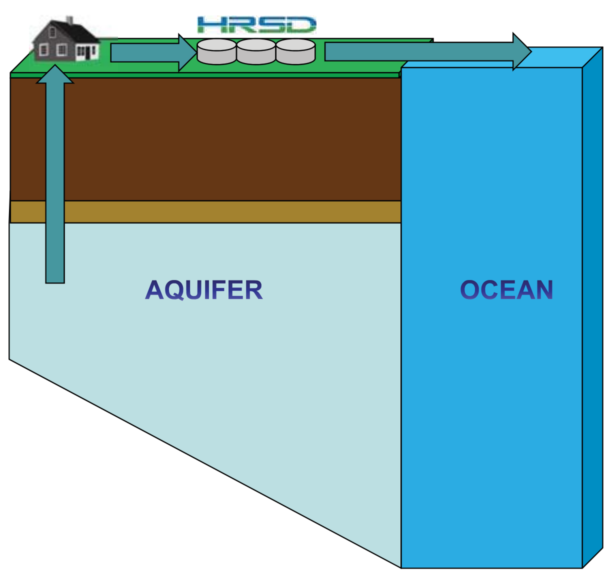
- From the USGS, Circular 1392
  - Issued Dec 2013
  - 50% of observed sea-level rise is due to land subsidence
  - Groundwater withdrawal estimated to account for as much as 50% of land subsidence



Groundwater depletion

Currently mining the aquifer

- Natural aquifer recharge is not keeping up with withdrawals
- Water is cleaned and discharged to local waterways, ultimately to the ocean with no downstream use – "one and done"



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Groundwater depletion

- Top priority by DEQ in current administration
- 177 permits = 147.3 MGD
  - Currently withdrawing approximately 115 mgd
- 200,000 unpermitted “domestic” wells
  - Estimated to be withdrawing approx. 40 mgd
- Economic development implications and stranded capital
- Eastern Virginia Groundwater Advisory Committee (EVGWAC) established

Salt water contamination of groundwater

- Upconing of brackish water
- Lateral Intrusion of seawater

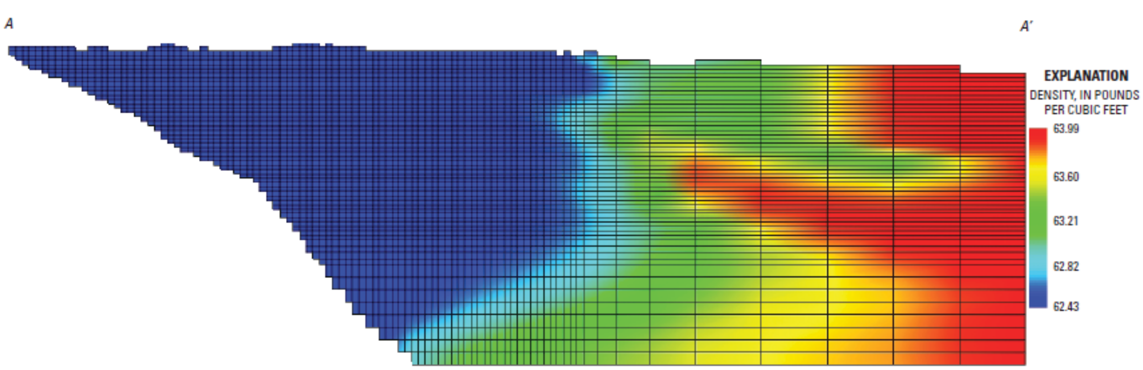


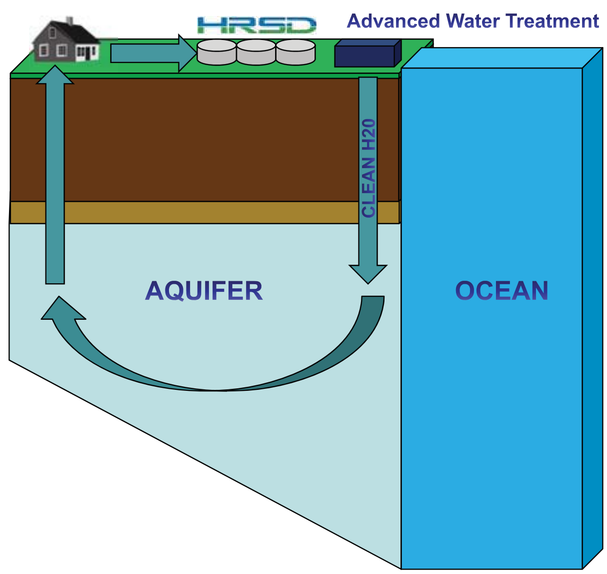
Figure A3. Simulated water density near the saltwater transition zone of the Virginia Coastal Plain. (Location of cross section shown in figure A2.)

Study purpose

- Can HRSD address any or all of these critical issues with a sustainable approach to water recycling?
  - Recognizing Hampton Roads is “water rich”
    - Significant capacity exists
    - Per capita consumption declining
    - No demand for direct reuse by industry or for irrigation
    - No desire to compete with our partner locality water providers

Sustainable water recycling

- HRSD’s concept - Inject clean water into the aquifer to:
  - Provide a sustainable supply of groundwater throughout Eastern Virginia
  - Jump forward to the advanced treatment ultimately needed to meet changing regulations
  - Reduce the rate of land subsidence
  - Protect the groundwater from saltwater contamination



Phase 1 - Scope of Work

- Analyze wastewater characteristics to determine the best advanced water treatment scheme
- Use DEQ's groundwater model for injection feasibility
  - Procured Aquaveo, through DEQ, to perform the modeling
- Evaluate soil compatibility
- Develop conceptual capital and lifecycle costs for a model facility

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Groundwater Recap

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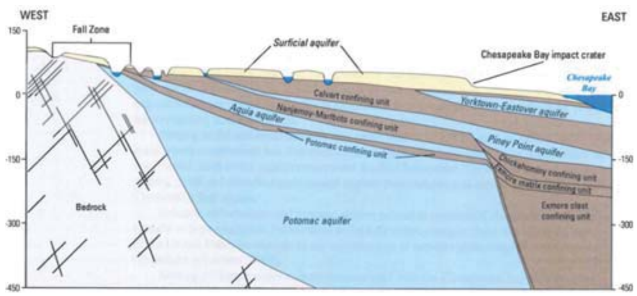
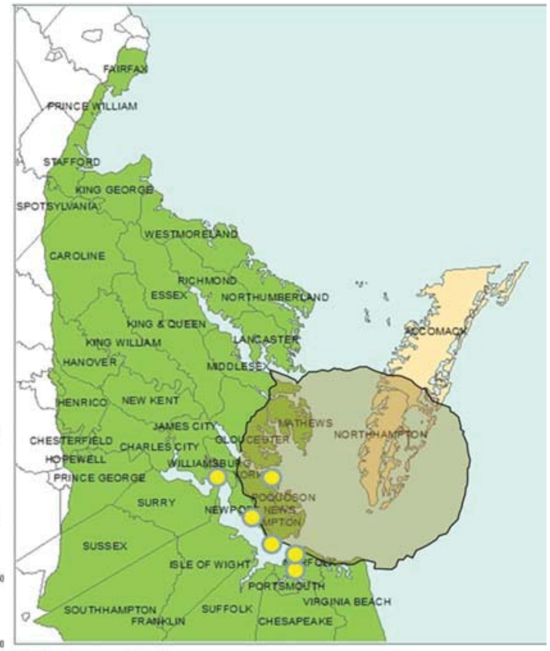
Hydrogeologic setting

- VA Coastal Plain aquifer system
- Eastern Virginia Groundwater Management Area
- Vast majority of the withdrawal from Potomac Aquifer
- Truncated by Chesapeake Bay Impact Crater

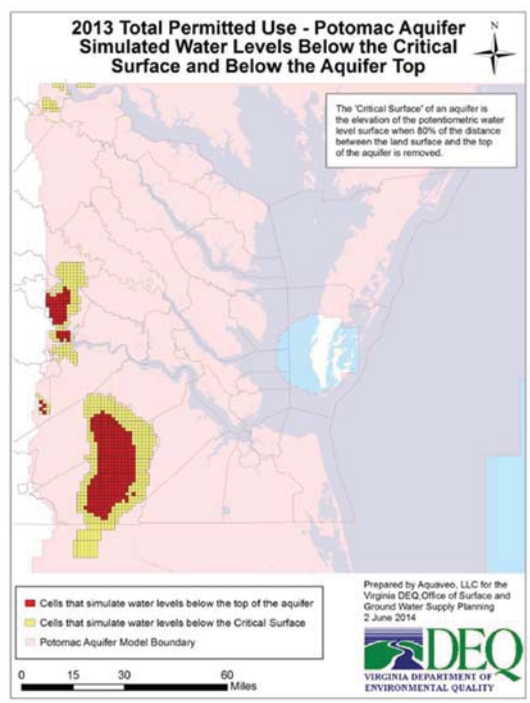




Effective: January 1, 2014
Prepared By: Virginia Department of Environmental Quality
Groundwater Withdrawal Permitting Program

Hydraulic issues

- Over-allocated withdrawal
  - Water levels falling several feet/yr
  - Some water levels below the aquifer tops in western Coastal Plain
- Model simulations predict the total permitted withdrawals are unsustainable
  - Areas below regulatory criteria
  - Areas experience aquifer dewatering



Groundwater Modeling and Geochemistry

Groundwater modeling

- Modeling quantifies the impact of groundwater injection
  - Is there a measurable benefit to the aquifer system (DEQ criteria)?
  - What pressures are required and what does well field look like?

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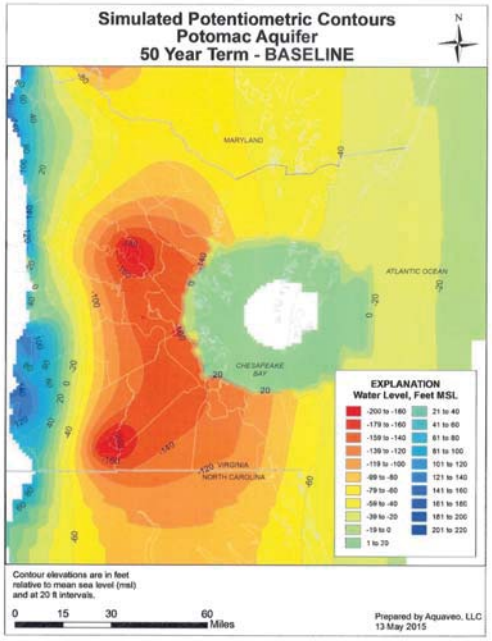
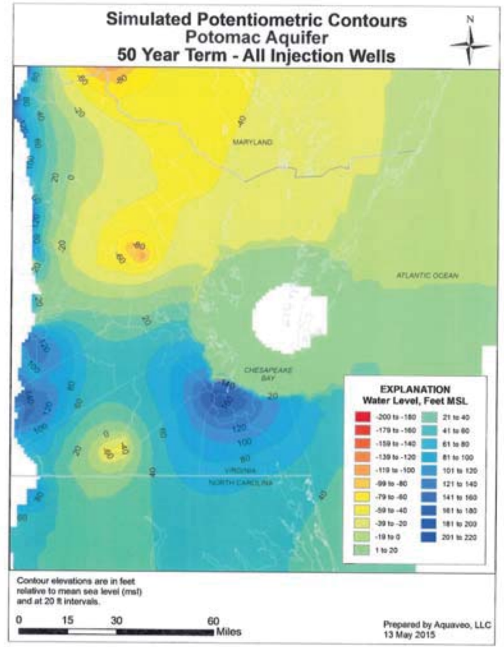
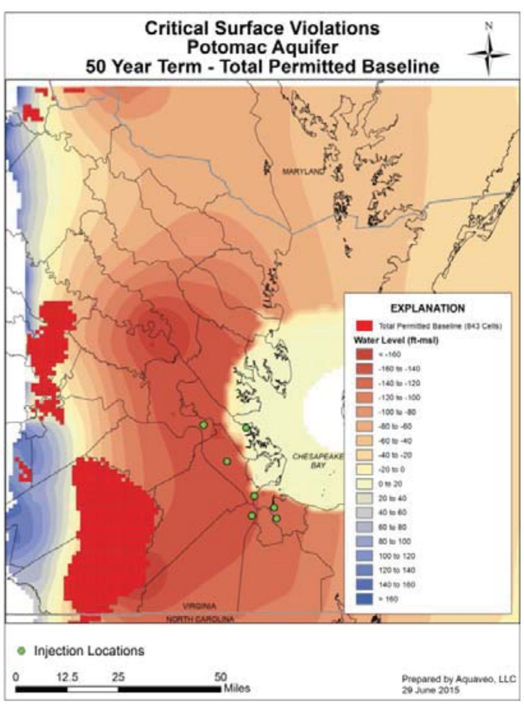
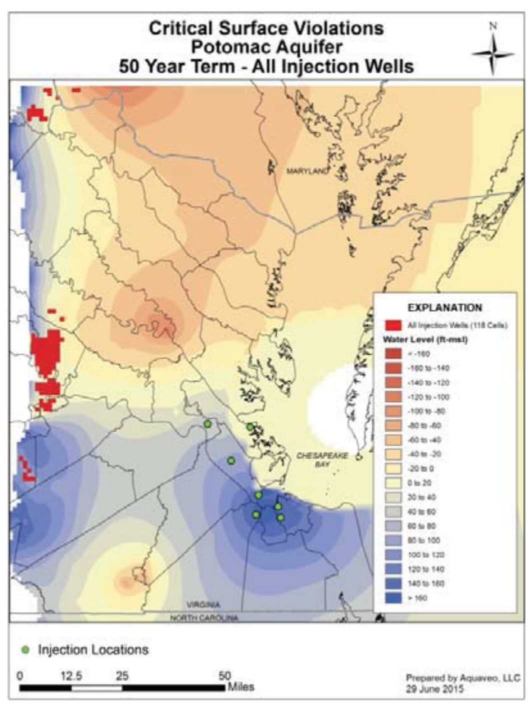
Potomac Aquifer water levels before and after injection





The aquifer recovers! - Critical cells: Potomac Aquifer





Groundwater modeling results summary

- Injecting clean water eliminates Critical Cells
- Injection benefits the entire Eastern Virginia Groundwater Management Area
- Dispersed location of plants is beneficial for injection – required pressures are reasonable
- Confirmed "wireless" water distribution concept – entire aquifer benefits
- York River injection well site will need to be outside of the crater limits

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Geochemistry

- Injectate must be compatible with the native groundwater and the aquifer material.
  - Operational issues
  - Regulatory issues
- Physical plugging
  - Disrupting clay particles
  - Precipitating minerals
  - Can clog the screen, filterpack and aquifer immediately around the well
- Dissolution/mobilization of metals

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Geochemical evaluation

- Determine injection water chemistry based on potential water treatment processes:
  - RO/UVAOP
  - NF/UVAOP
  - BAC/GAC
- Compare the clean water from those 3 processes to the to native groundwater (data from NWIS)
  - each individual Potomac aquifer zone (Upper, Middle and Lower)
  - mixing between treated water and native groundwater
- Evaluate reactions between treated water and aquifer mineralogy (using Chesapeake core data)
  - 99% inert material (quartz, feldspars, etc).
  - Remaining material can be problematic (clays)

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Geochemical compatibility

- Treatment processes produce water with varying aquifer and groundwater compatibility
- GAC/BAC and Nanofiltration (NF) - compatible
- RO – requires adding salts to increase total dissolved solids and ionic strength to be compatible

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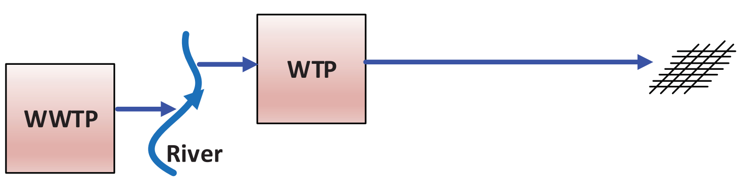
Advanced Water Treatment for Recycling Water

De Facto water recycling



- Common throughout the world and in Virginia
  - James River
  - Roanoke River Basin (Lake Gaston)

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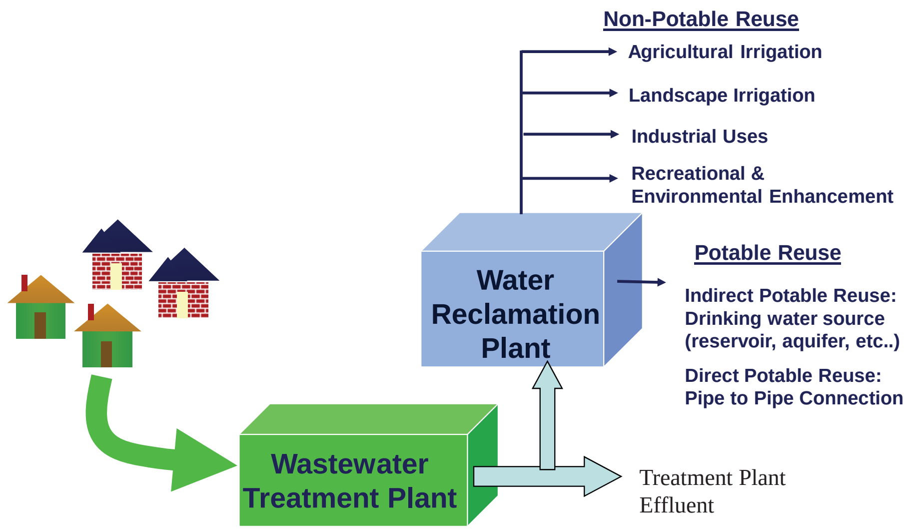
Water recycling opportunities



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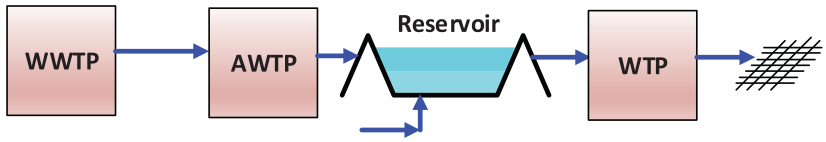
Operational water recycling projects

Project	Location	Type of Potable Reuse	Year	Capacity	Current Advanced Treatment Process
Montebello Forebay, CA	Coastal	GW recharge via spreading basins	1962	44 mgd	GMF + Cl_2 + SAT (spreading basins)
Windhoek, Namibia	Inland	Direct potable reuse	1968	5.5 mgd	O_3 + Coag + DAF + GMF + O_3/H_2O_2 + BAC + GAC + UF + Cl_2 (process as of 2002)
UOSA, VA	Inland	Surface water augmentation	1978	54 mgd	Lime + GMF + GAC + Cl_2
Hueco Bolson, El Paso, TX	Inland	GW recharge via direct injection and spreading basins	1985	10 mgd	Lime + GMF + Ozone + GAC + Cl_2
Clayton County, GA	Inland	Surface water augmentation	1985	18 mgd	Cl_2 + UV disinfection + SAT (wetlands)
West Basin, El Segundo, CA	Coastal	GW recharge via direct injection	1993	12.5 mgd	MF + RO + UVAOP
Scottsdale, AZ	Inland	GW recharge via direct injection	1999	20 mgd	MF + RO + Cl_2
Gwinnett County, GA	Inland	Surface water augmentation	2000	60 mgd	Coag/floc/sed + UF + Ozone + GAC + Ozone
NEWater, Singapore	Coastal	Surface water augmentation	2000	146 mgd (5 plants)	MF + RO + UV disinfection
Los Alamitos, CA	Coastal	GW recharge via direct injection	2006	3.0 mgd	MF + RO + UV disinfection
Chino GW Recharge, CA	Inland	GW recharge via spreading basins	2007	18 mgd	GMF + Cl_2 + SAT (spreading basins)
GWRS, Orange County, CA	Coastal	GW recharge via direct injection and spreading basins	2008	70 mgd	MF + RO + UVAOP + SAT (spreading basins for a portion of the flow)
Queensland, Australia	Coastal	Surface water augmentation	2009	66 mgd via three plants	MF + RO + UVAOP
Arapahoe County, CO	Inland	GW recharge via spreading	2009	9 mgd	SAT (via RBF) + RO + UVAOP
Loudoun County, VA	Inland	Surface water augmentation	2009	11 mgd	MBR + GAC + UV
Big Spring (Wichita Falls), TX	Inland	Direct potable reuse through raw water blending	2013	1.8 mgd	MF + RO + UVAOP

Water recycling - Surface water augmentation



- Examples:
  - Upper Occoquan Service Authority
    Leader in Water Reclamation and Reuse
    - (Northern Virginia)
  - Gwinnett County (Georgia)
  - Singapore NEWater

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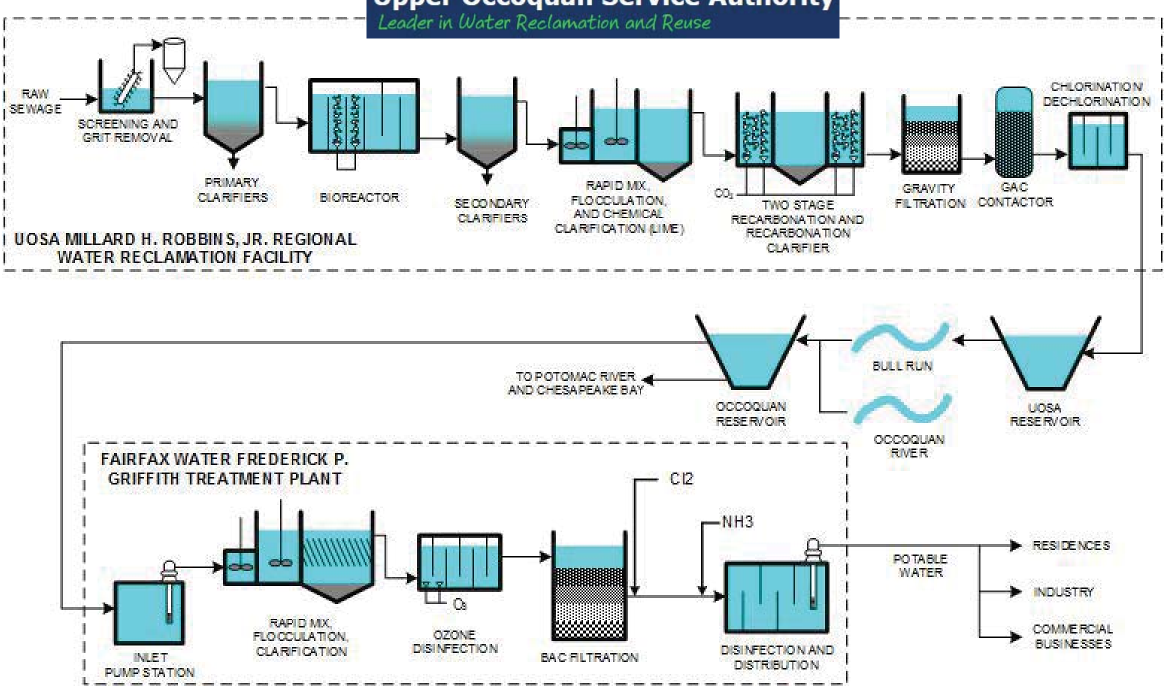
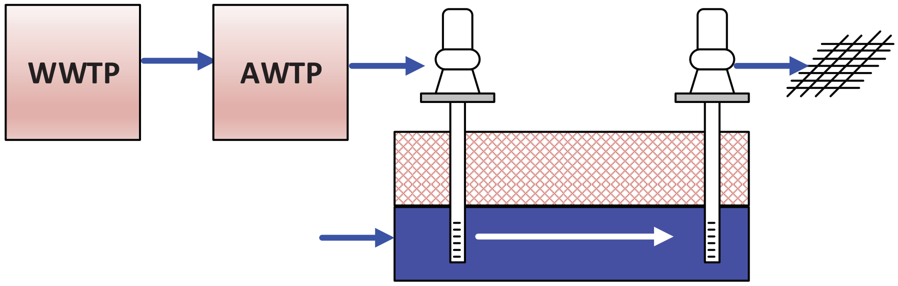
Water recycling in Virginia (since 1978)

Upper Occoquan Service Authority
Leader in Water Reclamation and Reuse



Water recycling - Groundwater recharge via direct injection

This is a form of Indirect Potable Reuse



- Examples:
  - Groundwater Replenishment System (Orange County, CA)
  - West Basin (El Segundo, CA)
  - Los Alamitos (Long Beach, CA)
  - Scottsdale Water Campus (AZ)
  - Hueco Bolson (El Paso, TX)

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Recycled water quality - Functional targets

Two major water quality aspects to consider:

- Receiver (or Aquifer) "centric" issues
  - Anti-degradation criterion – determined by others (DEQ, stakeholders, EPA)
  - Aquifer compatibility – water chemistry interactions (pH, alkalinity, etc.)
- User (human-health) "centric" issues
  - Injectate water quality based on regulatory definitions:
    - Drinking water standards (MCLs)
    - Water Reuse standards (no VA injection standard yet)
  - Occoquan Reservoir and Dulles Corridor Standards?

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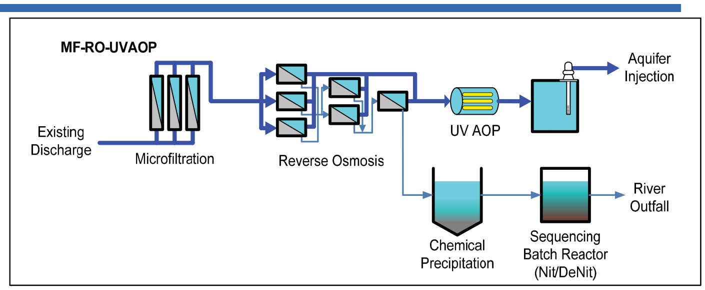
Existing recycled water quality targets

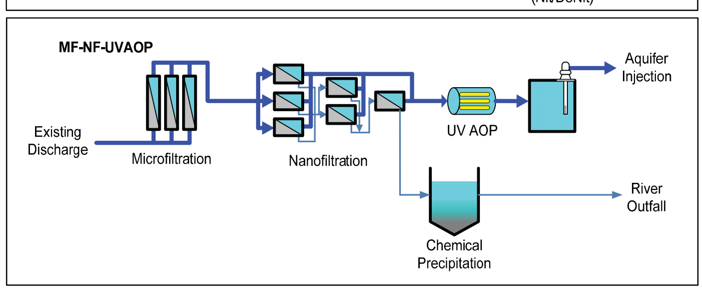
Parameter	Pertinent Regulatory Requirements for Indirect Potable Reuse				
	Occoquan and Dulles Policies	El Paso (TX) – Direct Injection	FL – Direct Injection	CA – Direct Injection	EPA – Direct Injection
TOC	COD = 10 mg/L (~ 3mg/L TOC)	None	3 mg/L; TOX < 0.2 mg/L	0.5 mg/L	2 mg/L (of WW origin)
Enteric Viruses	Multiple barriers required (E. coli < 2 / 100 mL)	None, but multiple barriers required	Multiple barriers required (Total Coliform < 4 / 100 mL)	12-log LRV	Multiple barriers required (Total Coliform BDL)
Crypto				10-log LRV	
Giardia				10-log LRV	
Nitrogen	TKN < 1 mg/L; TN < 4 mg/L (Broad Run WRF only)	NOx – N < 10 mg/L	TN < 10 mg/L	TN < 10 mg/L	None
TDS	None	1,000 mg/L	None	RO required	None
Misc	Drinking water MCLs; TSS < 1 mg/L; Turb < 0.5 ntu; TP < 0.1 mg/L	Drinking water MCLs; Turbidity < 1 NTU	Drinking water MCLs; Turbidity < 2-2.5 NTU	RO and AOP treatment req'd; Drinking water MCLs;	Drinking water MCLs; Turbidity < 2 NTU

Advanced water treatment alternatives

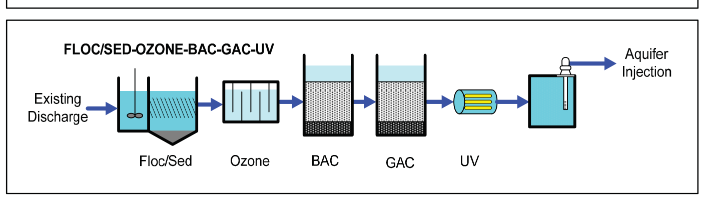
Reverse Osmosis (RO)-Based



Nanofiltration (NF)-Based

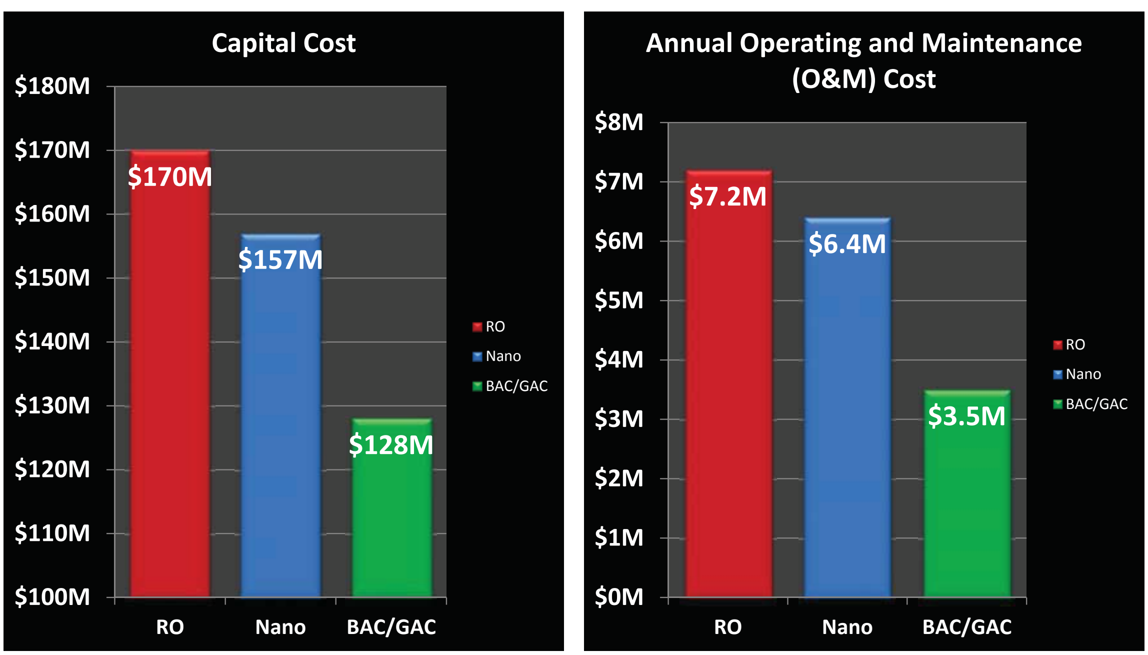


Biological Activated Carbon (BAC)/ Granular Activated Carbon (GAC)-Based



Conceptual Costs Estimates

Cost for 20 MGD



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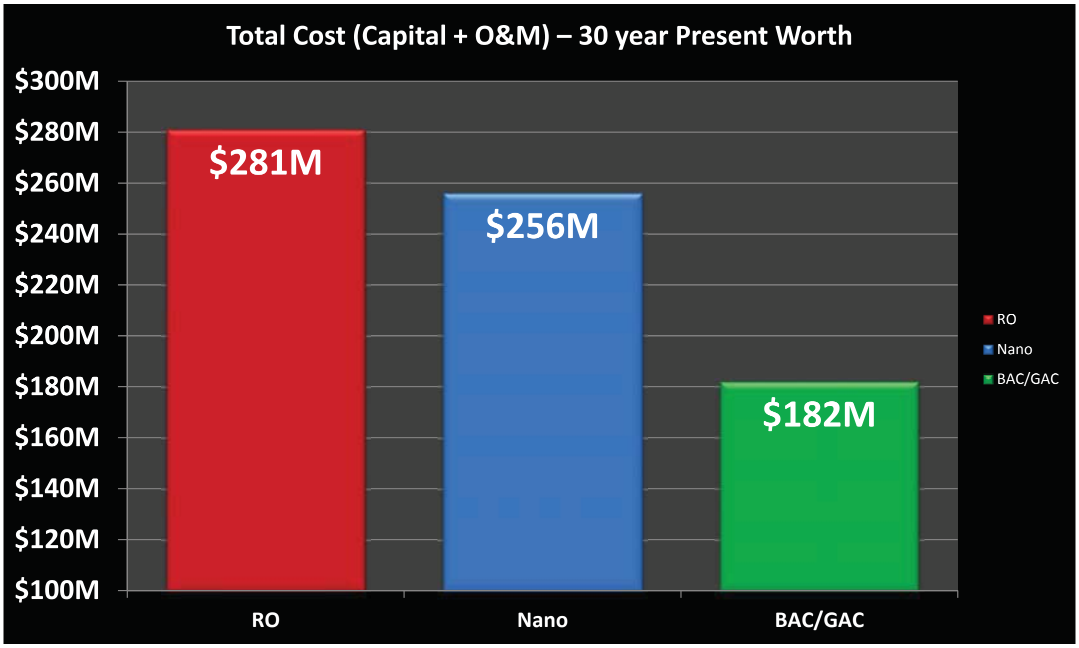
30-year Present Worth – 20 MGD



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Cost Summary

- Total project in the $1 billion range (120 mgd)
  - For 7 plants (not CE or Atlantic)
  - York needs additional study to locate injection site
- Annual operating costs $21 - $43 M
- Sets stage for integrated planning discussion
- Operating costs (low end) could be recovered with very reasonable permitted withdrawal fee

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Conclusion and Next Steps

Conclusion – Summary of Benefits

- Regulatory stability for treatment processes
- Reduction in the rate of land subsidence
- Sustainable source for groundwater replenishment
- Protection of groundwater from saltwater contamination
- Eliminates need to pipe recycled water to specific users – “wireless” solution
- Significantly reduced discharge into the Chesapeake Bay (only during wet weather)
  - Increases available oyster grounds
  - Creates source of nutrient allocation to support other needs

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Conclusion

- High level modeling and analysis indicate aquifer recharge may be a feasible method of sustainable water recycling for HRSD
- Concept has potential to provide many environmental benefits
- Cost is not out of reach – already planning on over $2B for RWWMP
  - TMDL backstop over a $1B threat
- Timing may be right for a project of this complexity, impact and controversy to succeed

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Conclusion

New panel looks at why underground water is disappearing east of Interstate 95

By REX SPRINGSTON Richmond Times-Dispatch | Posted: Tuesday, August 18, 2015 11:45 pm

Underground water is disappearing east of Interstate 95, and problems could start showing up in a few years in parts of the Richmond area, an expert said Tuesday.

Details about the decades-old groundwater decline emerged at the first meeting of a new panel that's looking for ways to address the problem.

The General Assembly created the panel, the Eastern Virginia Groundwater Management Advisory Committee, this past winter. The group will meet well into 2017 and will present recommendations to the 2018 General Assembly.

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Next steps

- Model and quantify
  - Impact on saltwater intrusion
  - Impact on land subsidence
- Develop treatment train pilots and scope for full scale injection pilot (1 MGD)
- Additional water treatment technology analysis and evaluation – "Room" scale pilot
- Further evaluation of geochemistry
- Develop more detailed costs for each plant
- Engage stakeholders

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Questions?

*Future generations will inherit clean waterways and **be able to keep them clean**.*

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