HRSD
Cleaning wastewater every day for a better Bay.

# Sustainable Water Recycling

## Aquifer Replenishment

# Why is HRSD interested?

- Discharges approaching limits of technology are expensive to build and costly to operate
- Nutrient loads are fully allocated in Bay watersheds
  - No room for growth beyond design capacity
  - Offsets will be required to support expansion of existing economy and any new economic development
- Regulatory uncertainty – what limits will HRSD ultimately be required to meet?



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# Phase I Feasibility Study goals

- Given changing discharge regulations, does it make sense to add advanced treatment to HRSD treatment plants and use that water beneficially?
- Is recharge feasible in the Eastern Virginia aquifer system?
- What are the key issues to consider?
- What will it cost?



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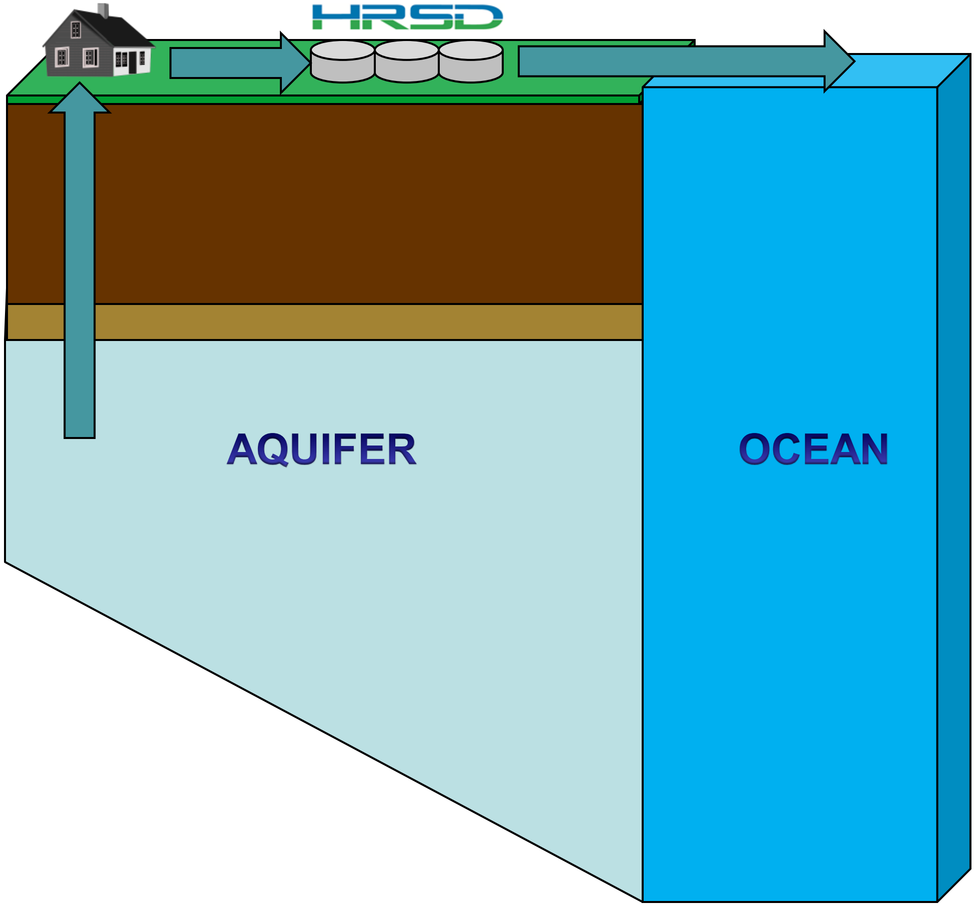
# Current state of groundwater in Eastern VA

**Currently mining but not replenishing 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
- Aggravating other problems including land subsidence and salt water intrusion



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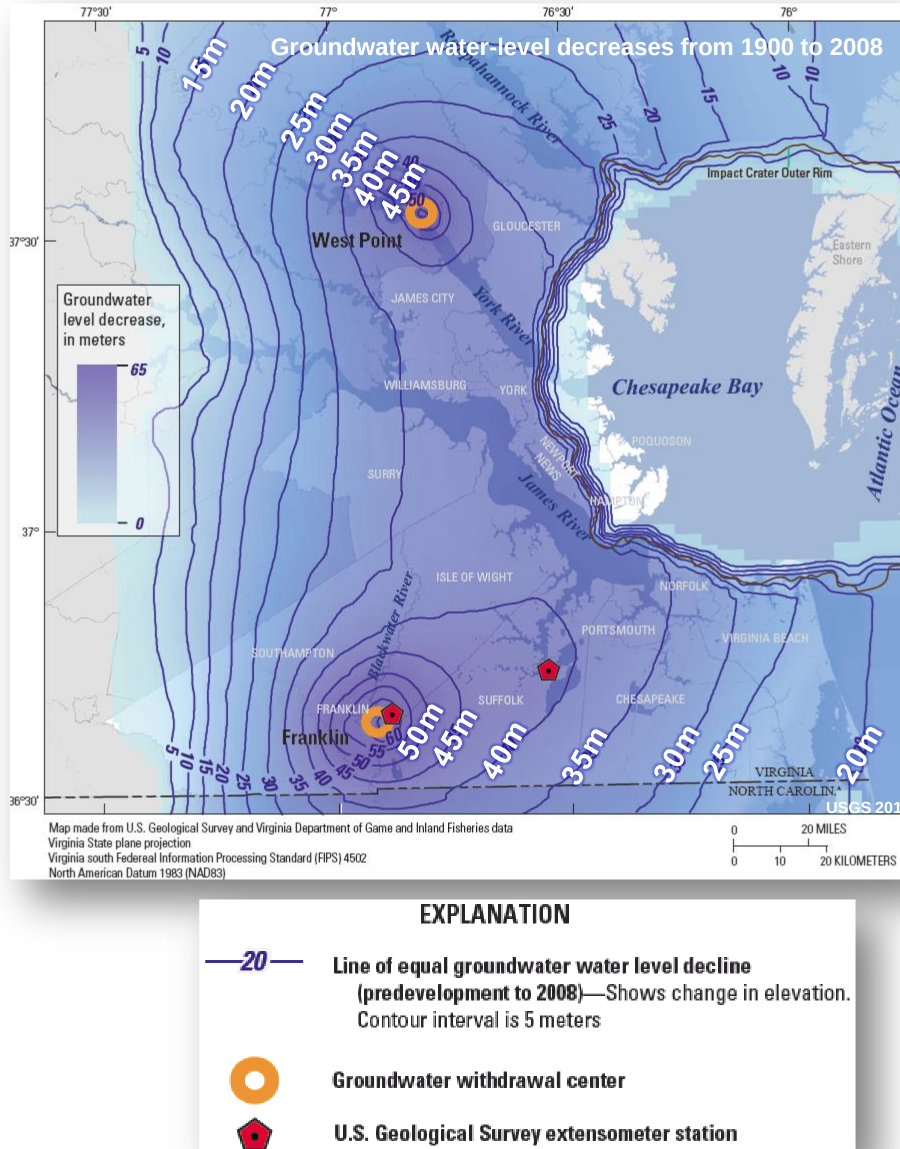
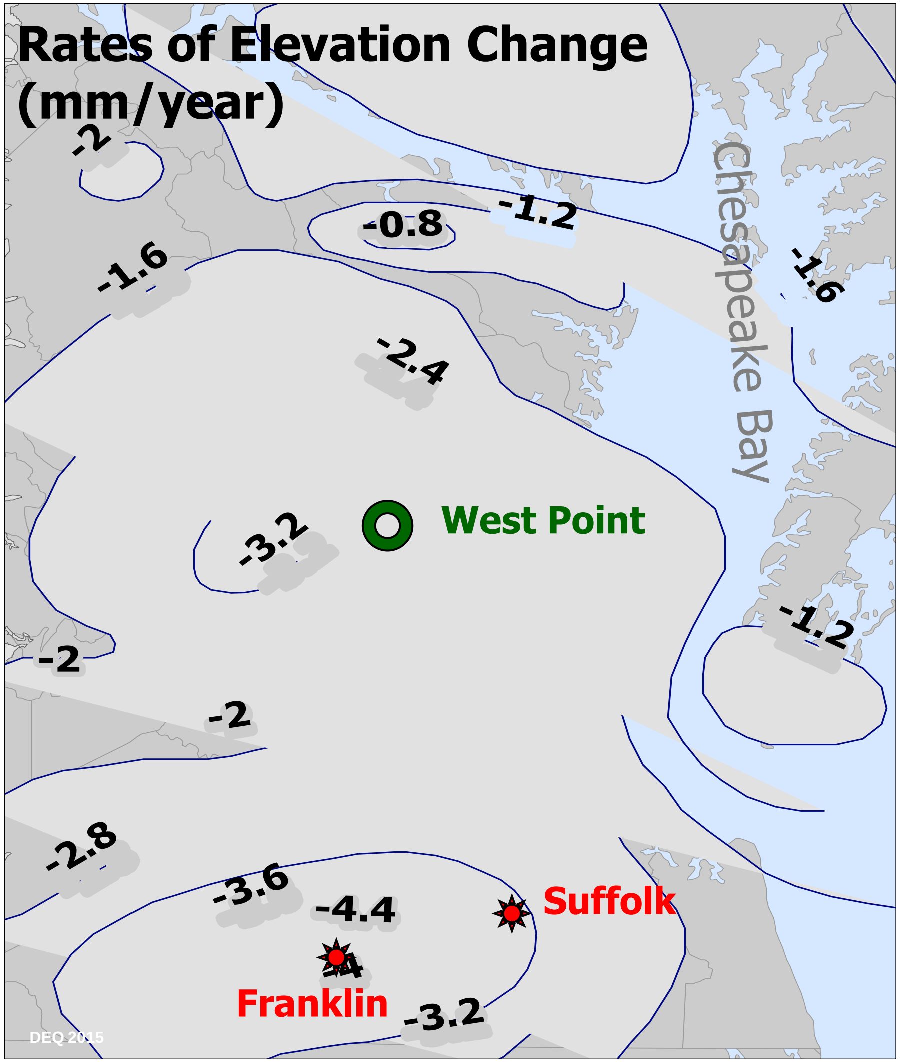
# Groundwater depletion

- Top DEQ priority
- 177 permits = 147.3 MGD
  - Currently withdrawing approximately 115 mgd
- 200,000 unpermitted “domestic” wells
  - Estimated to be withdrawing approx. 40 mgd
- Significant pressure drop in excess of 50 meters since 1900



# Land subsidence – *we are sinking*

- According to USGS
  - Up to 50% of sea-level rise may be due to land subsidence
  - Up to 50% of land subsidence may be due to aquifer compaction
- Two potential solutions
  - Reduced withdrawal
  - Aquifer recharge




HAMPTON ROADS IS THE #2 LARGEST POPULATION CENTER AT RISK

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# Saltwater contamination of groundwater

- Potentially irreversible contamination

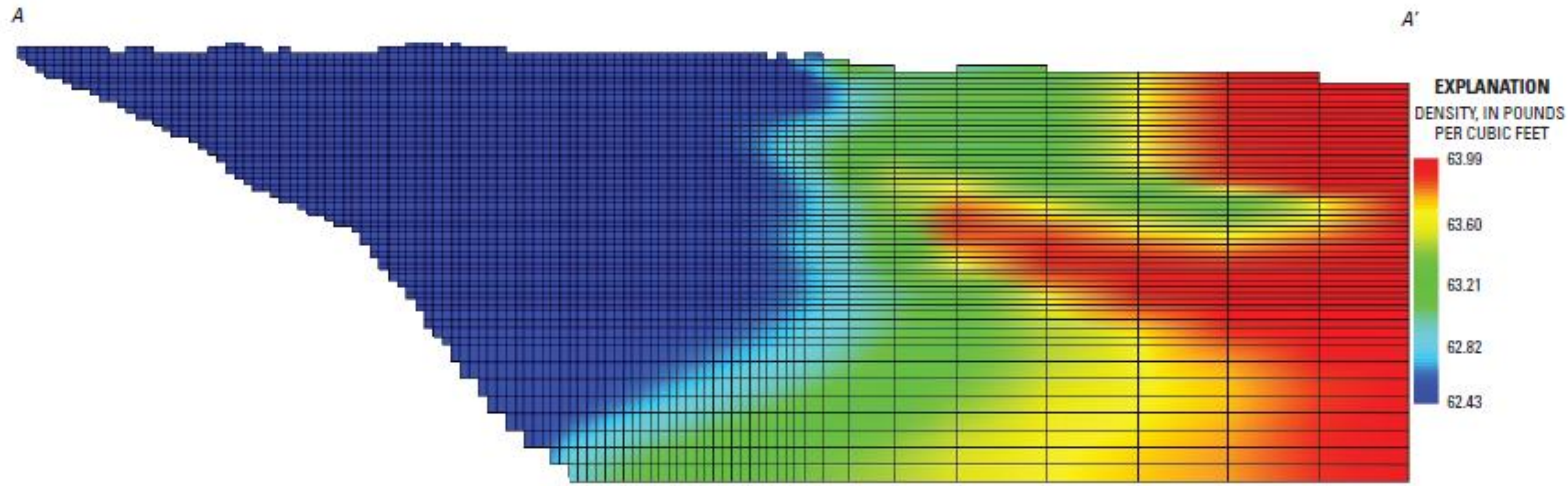
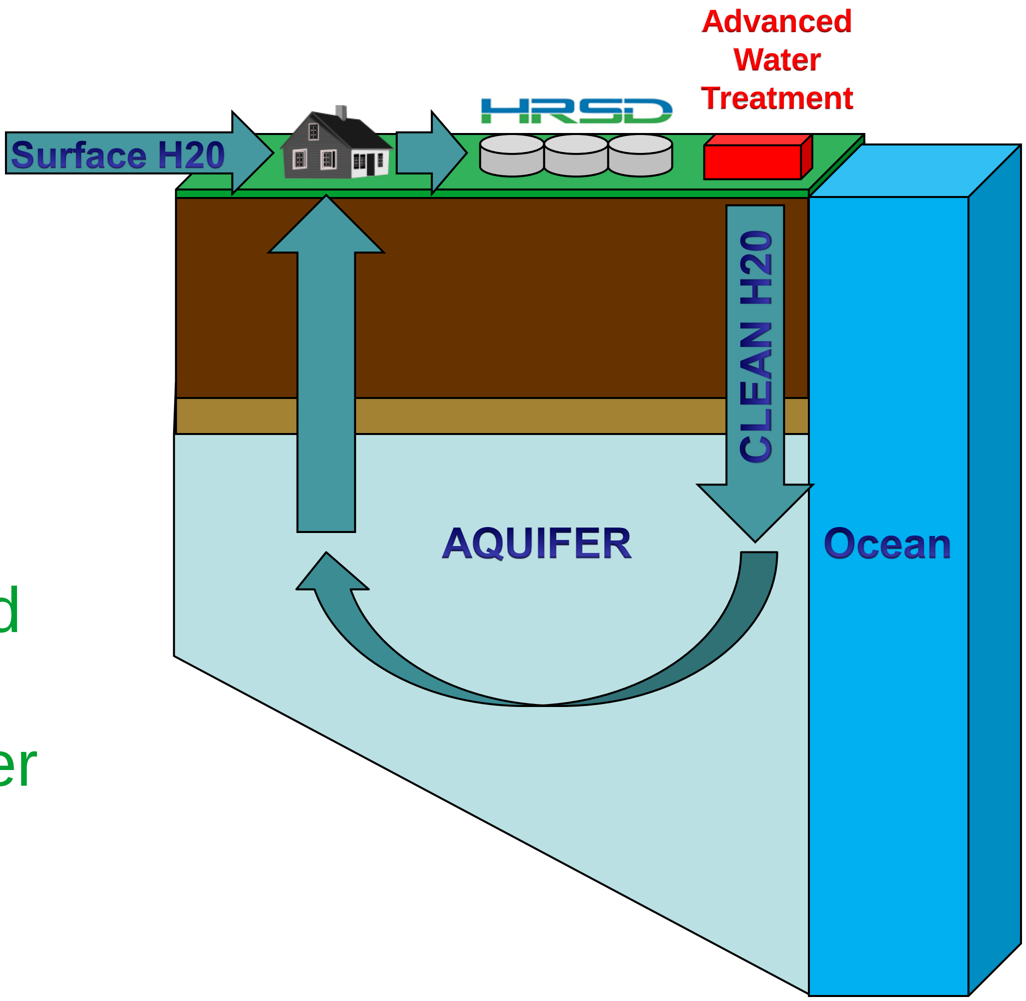



**Figure A3.** Simulated water density near the saltwater transition zone of the Virginia Coastal Plain. (Location of cross section shown in figure A2.)

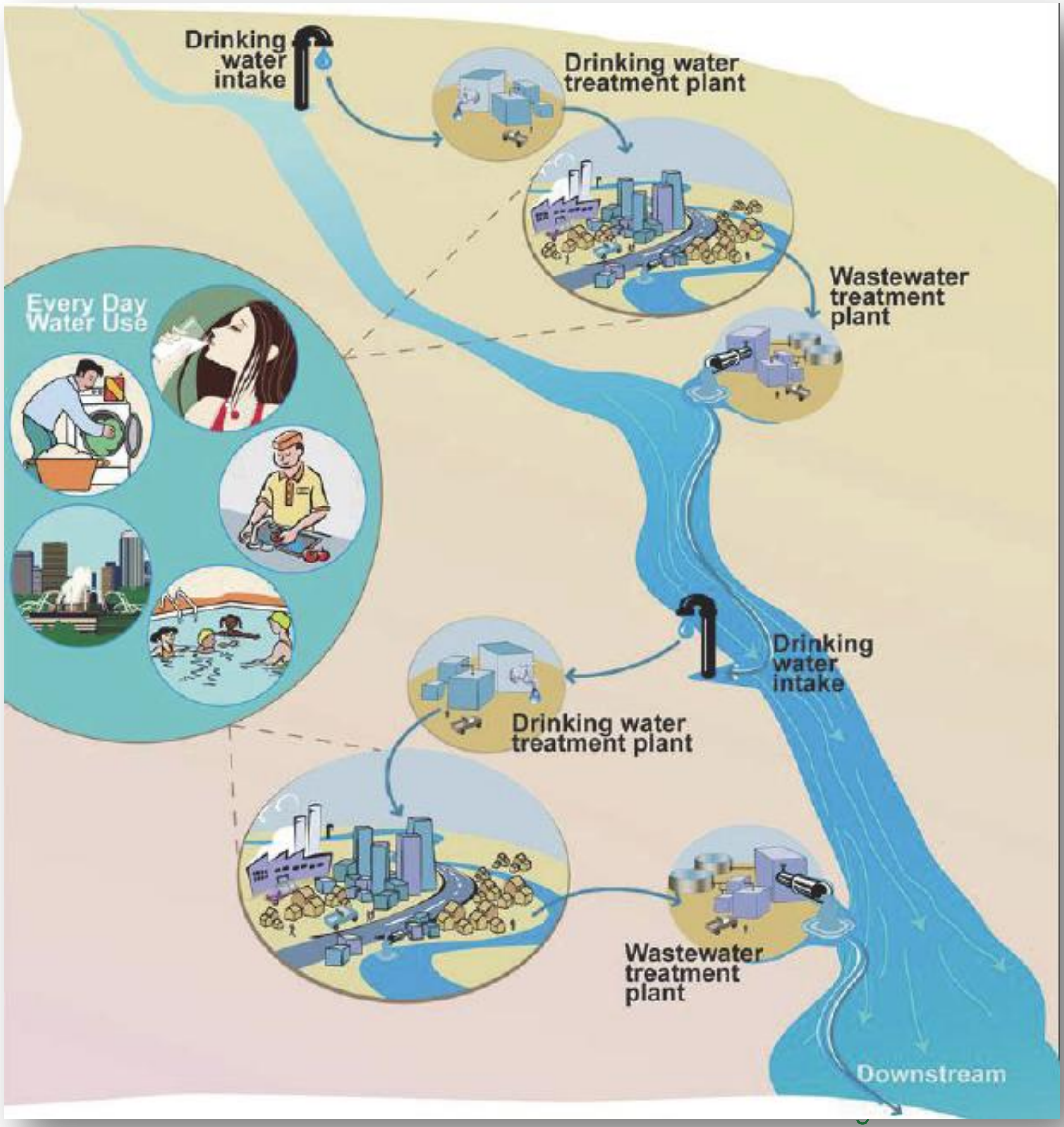
# Proposed cycle of sustainable water recycling

- HRSD's concept - replenish the aquifer with clean water to:
  - Reduce nutrient discharges to the Bay
  - Provide a sustainable supply of groundwater
  - Reduce the rate of land subsidence
  - Protect the groundwater from saltwater contamination

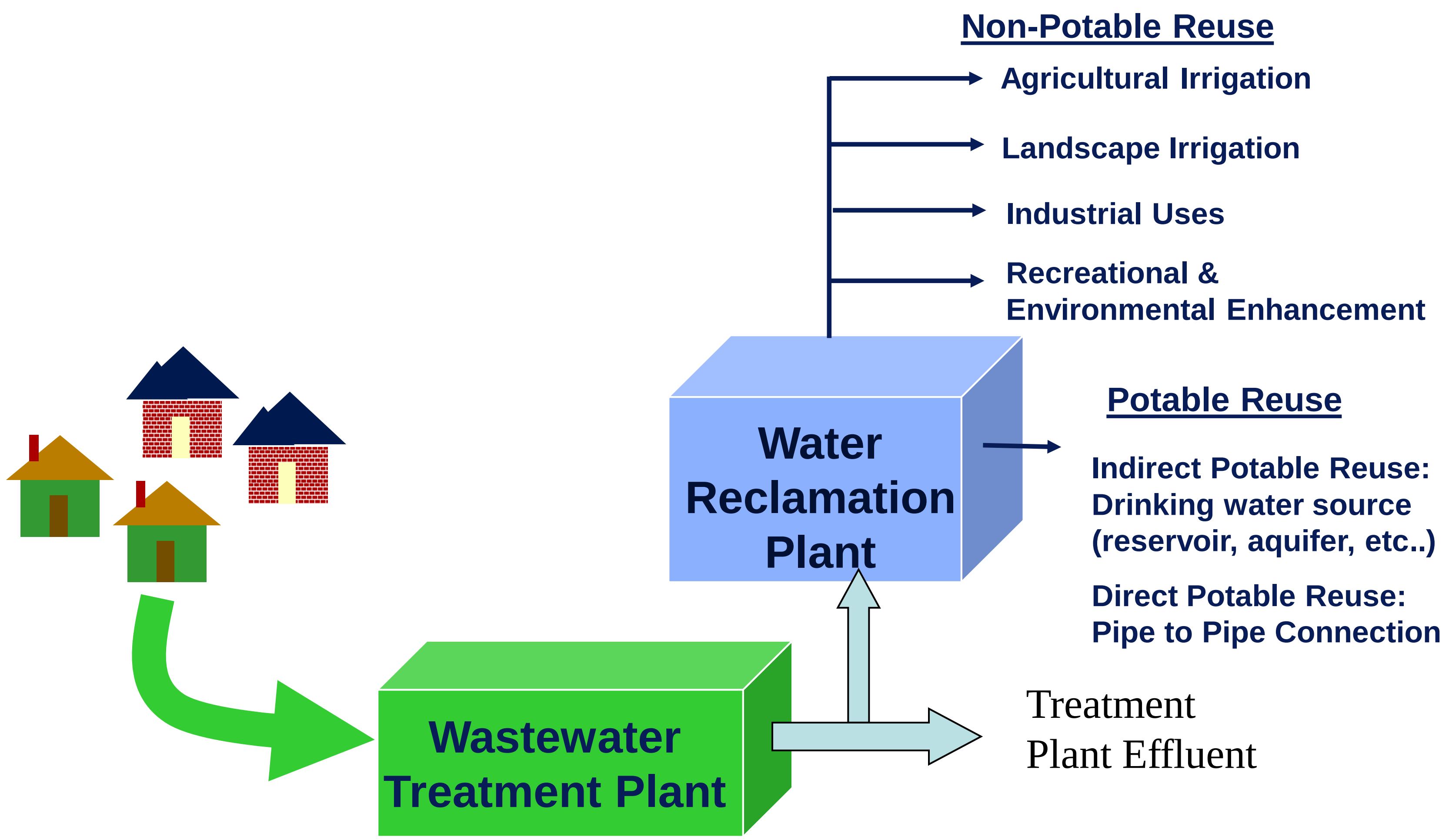


# De Facto water recycling

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



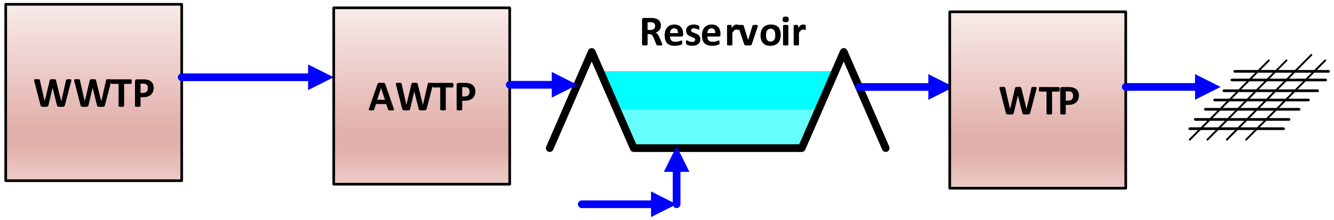
# Water recycling opportunities



# 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 – Northern VA
  - Gwinnett County (Georgia)
  - Singapore NEWater



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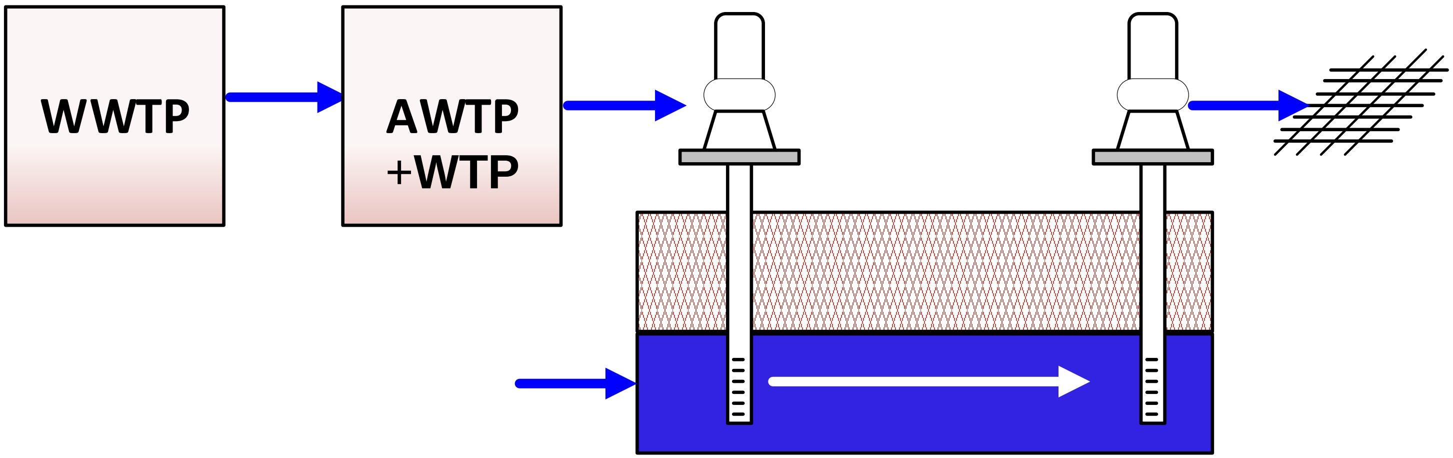
# Water recycling - Groundwater recharge via direct injection




- 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)

# Recycled water quality - Functional targets

## Two major water quality aspects to consider:

- 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
  - Water quality based on regulatory definitions:
    - Drinking water standards (MCLs)
    - Water Reuse standards (no VA injection standard yet)

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# Geochemistry and Aquifer Compatibility

- Water put into aquifer 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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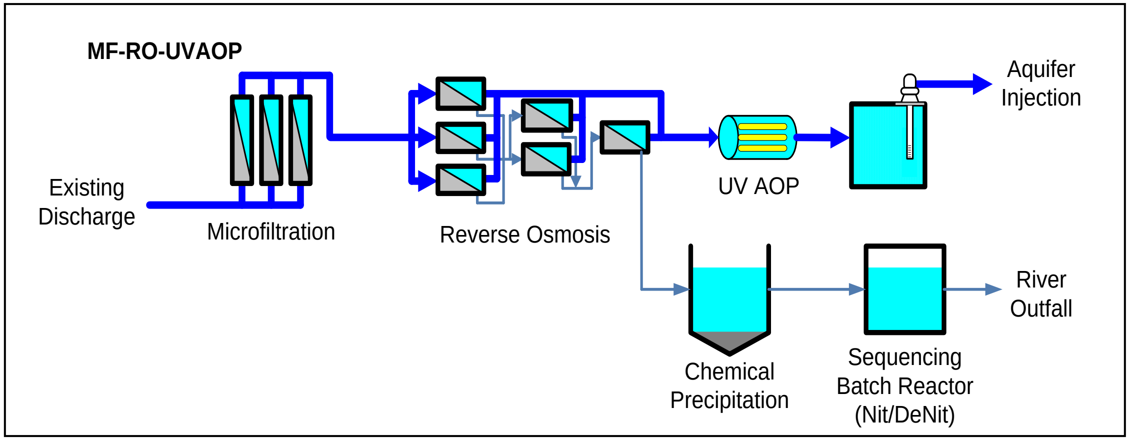
# Geochemical evaluation

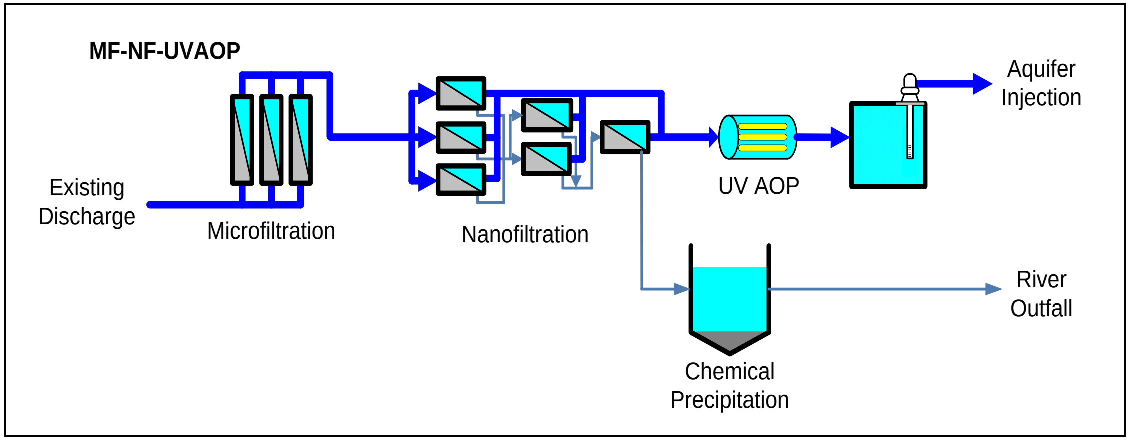
- Evaluate reactions between treated water and aquifer mineralogy
  - 99% inert material (quartz, feldspars, etc).
  - Remaining material can be problematic (clays)
- Lessons learned from Chesapeake's injection well
  - Injected 28 billion gallons since 1987

# Advanced water treatment alternatives

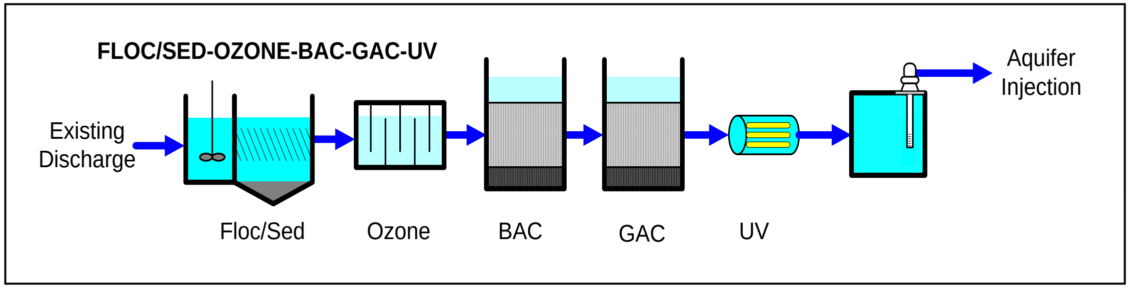
## Reverse Osmosis (RO)



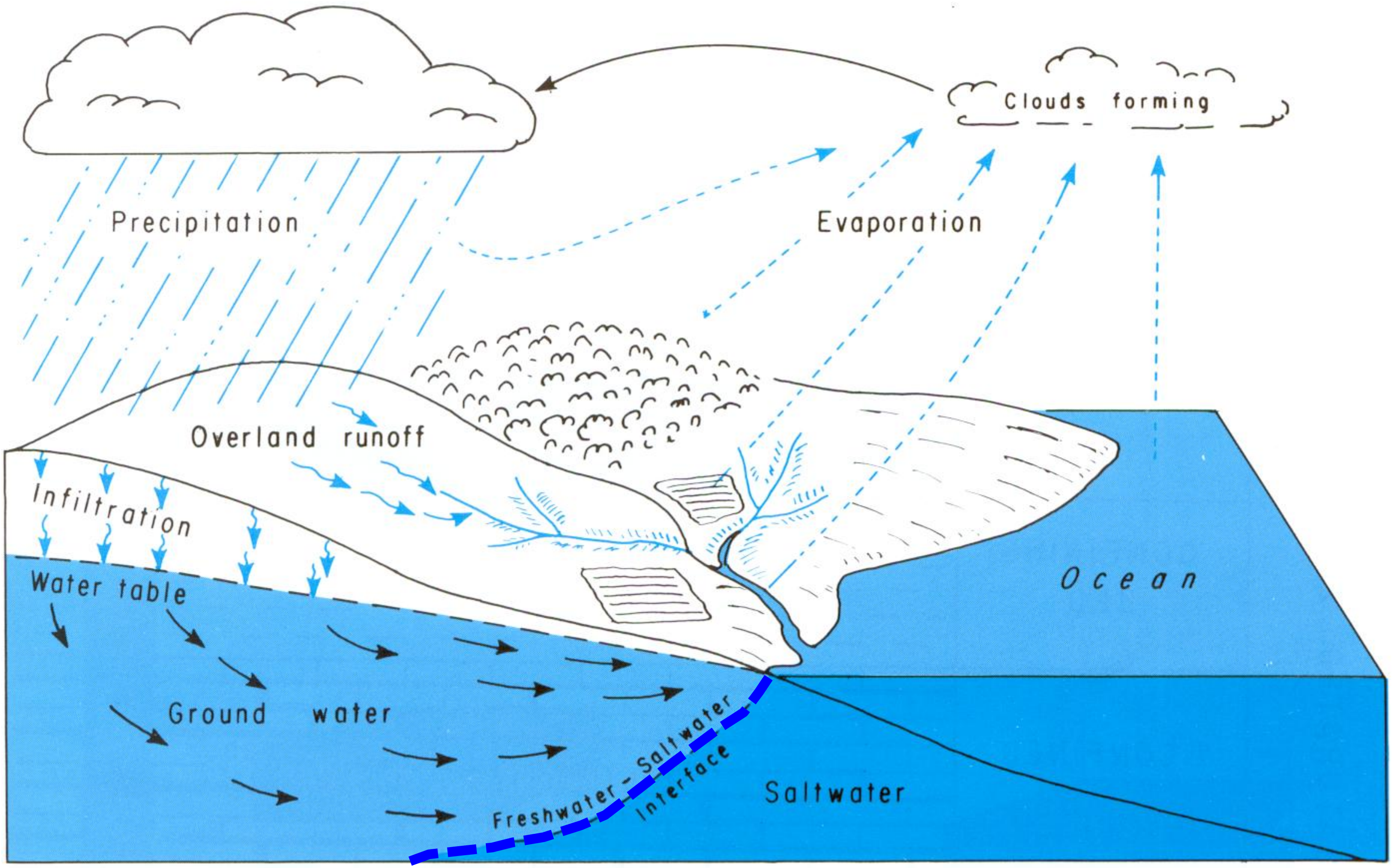

## Nanofiltration (NF)




## Biologically-Active Granular Activated Carbon (BAC)/ Granular Activated Carbon (GAC)

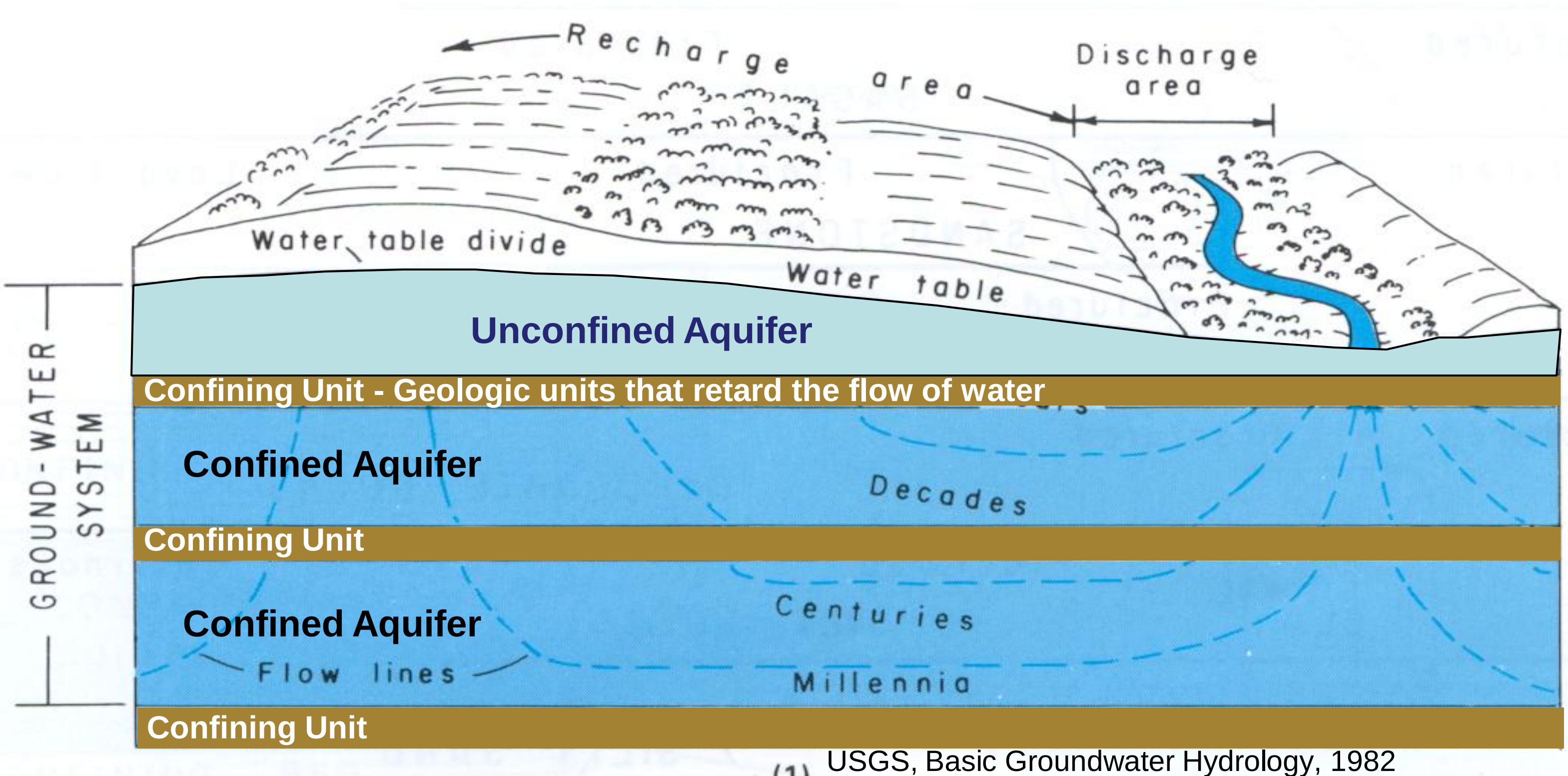


## HYDROLOGIC CYCLE



# Hydrogeologic framework

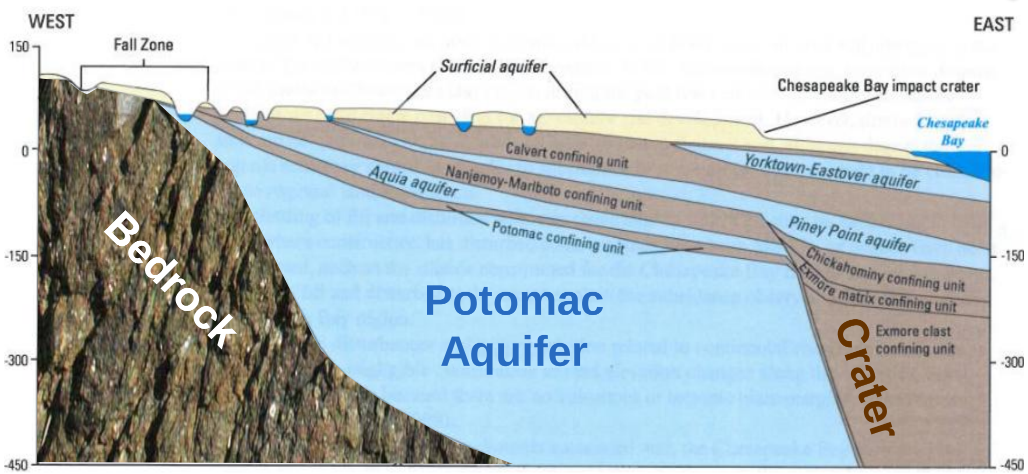
- Subsurface Geology - sediments (sands, silts, clays, shells, bedrock way down there)
- Aquifers - geologic units that easily store and transmit water
  - Unconfined
  - Confined - pressurized




USGS, Basic Groundwater Hydrology, 1982

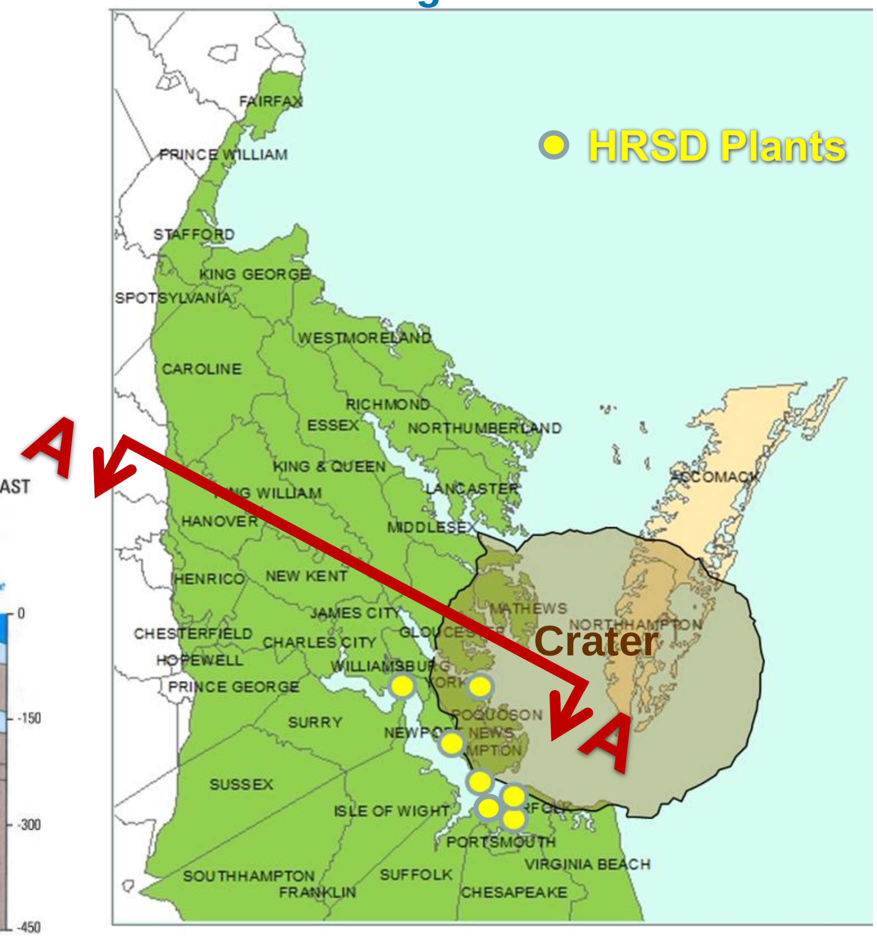
# Hydrogeologic setting in the Coastal Plain of Virginia

- Fall Line (around I-95 corridor) to the Ocean
- Truncated by Chesapeake Bay Impact Crater (Bolide/Meteor)
- Essentially no natural recharge
  - Aquifer water is 40,000 years old




Section A-A

Eastern Va Groundwater Management Area

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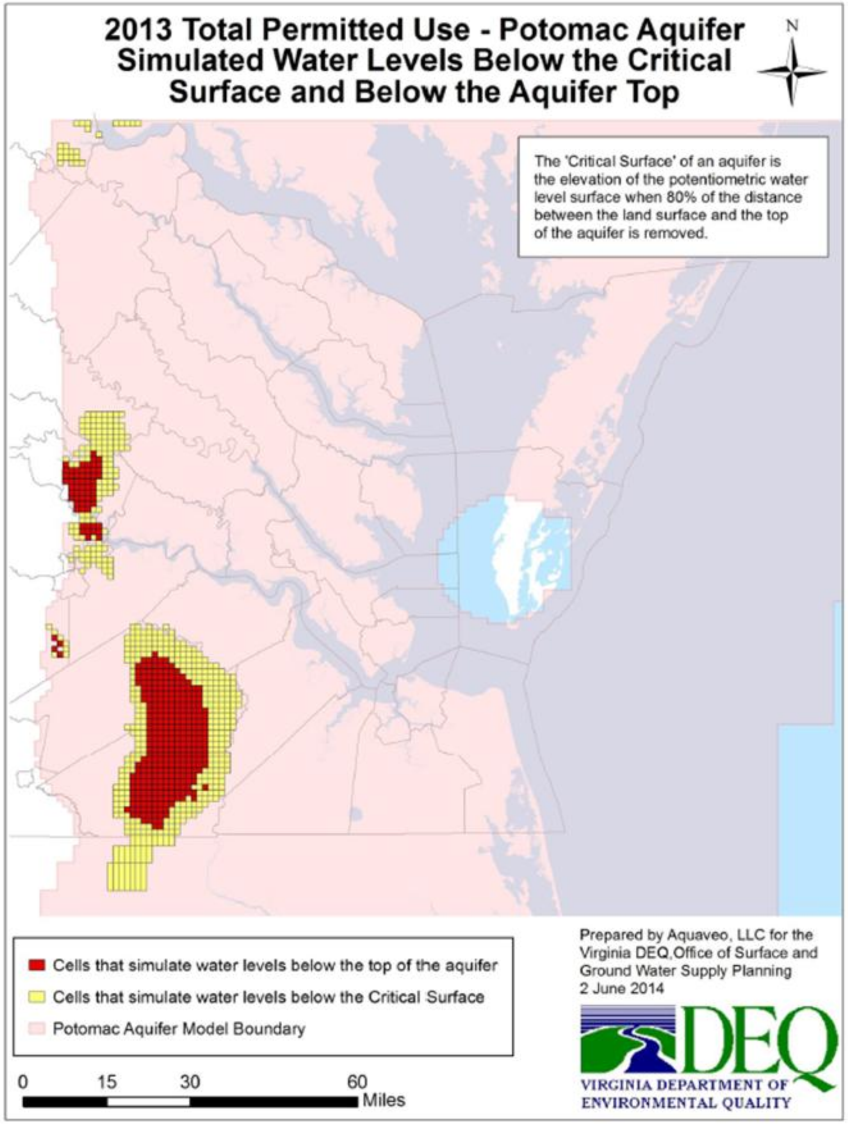
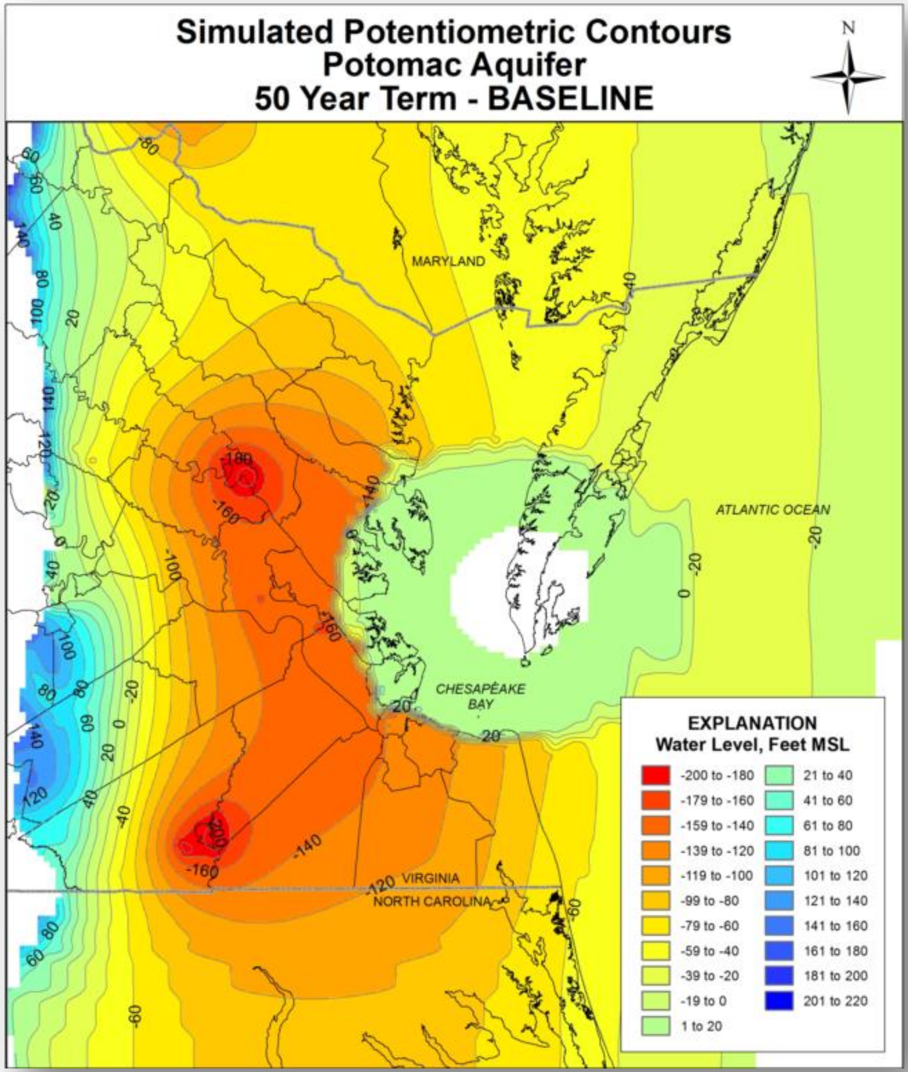
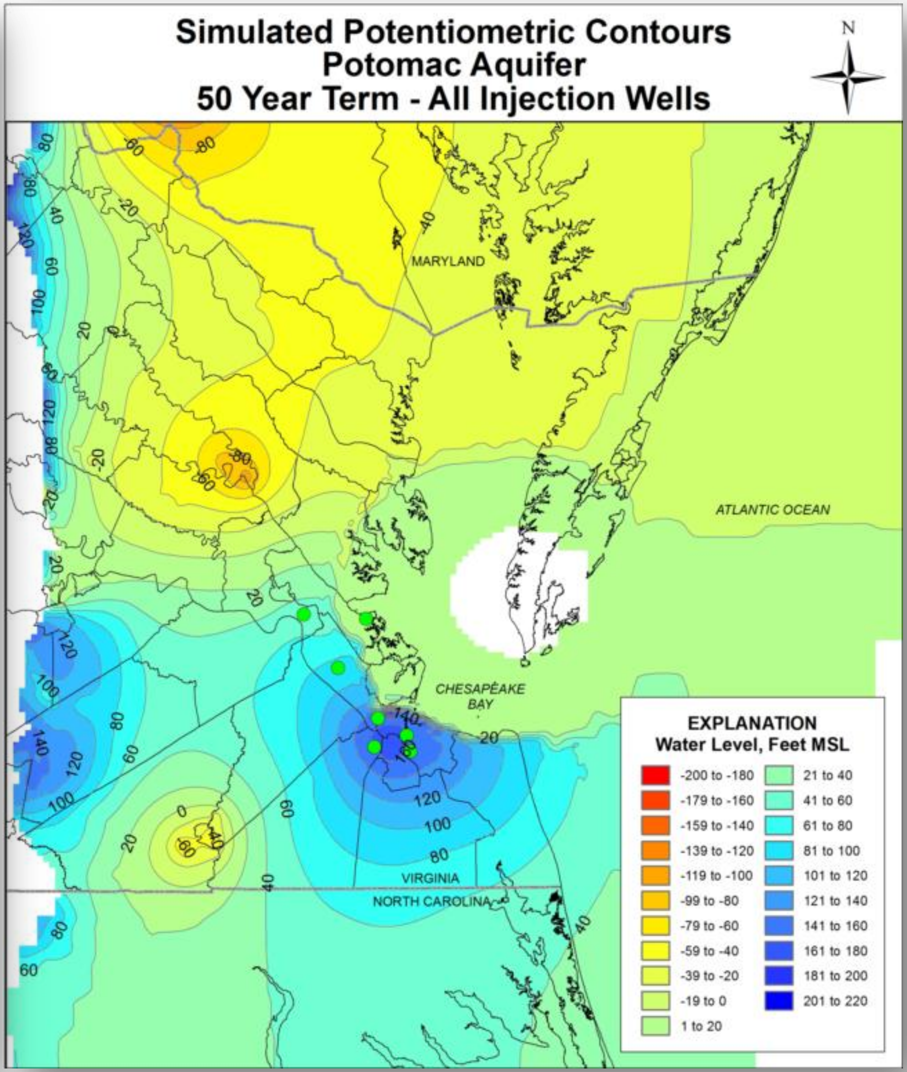
# Unsustainable Aquifer Withdrawals

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

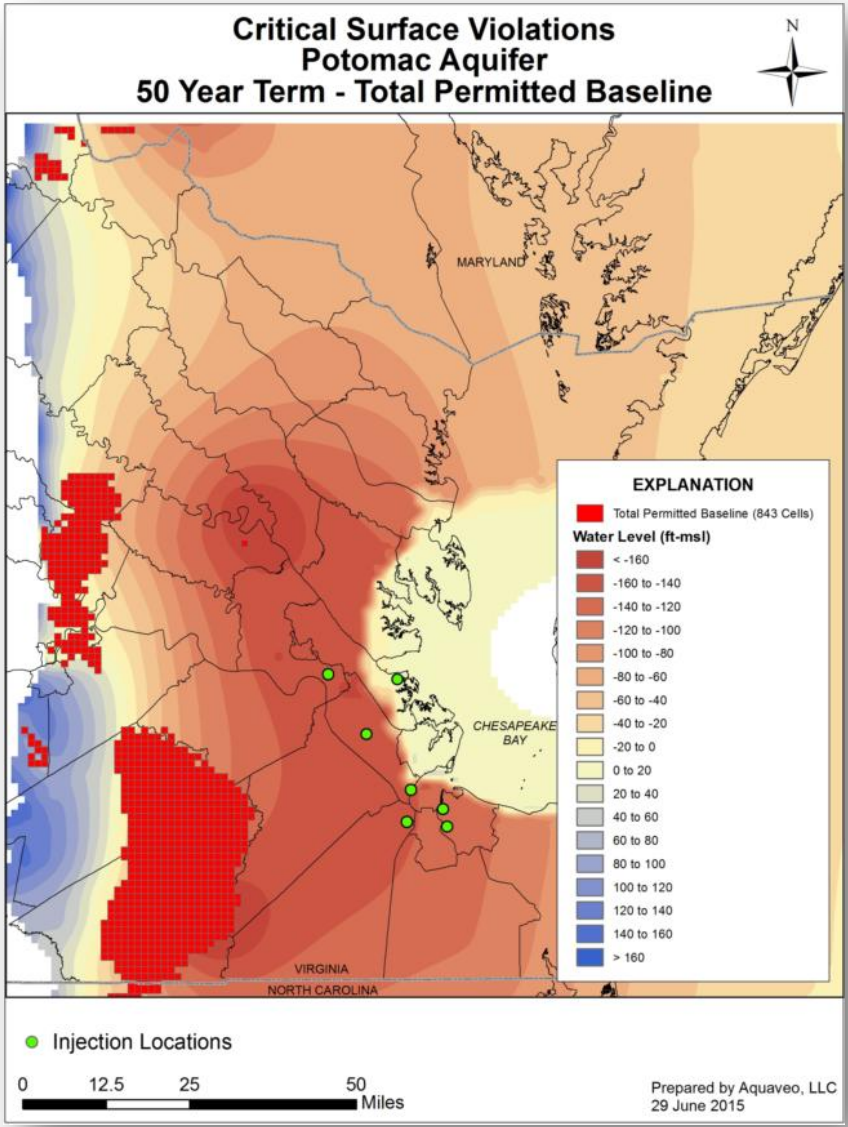


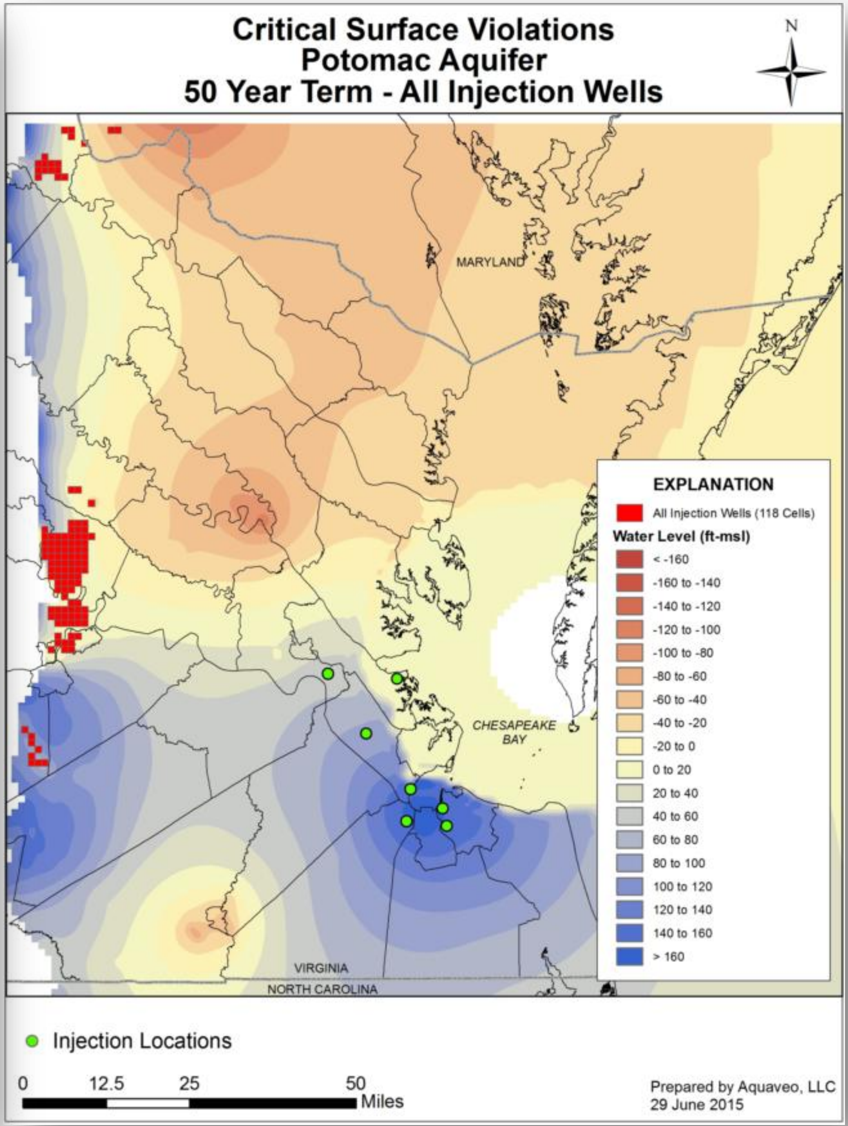
# Potomac Aquifer water levels before and after injection



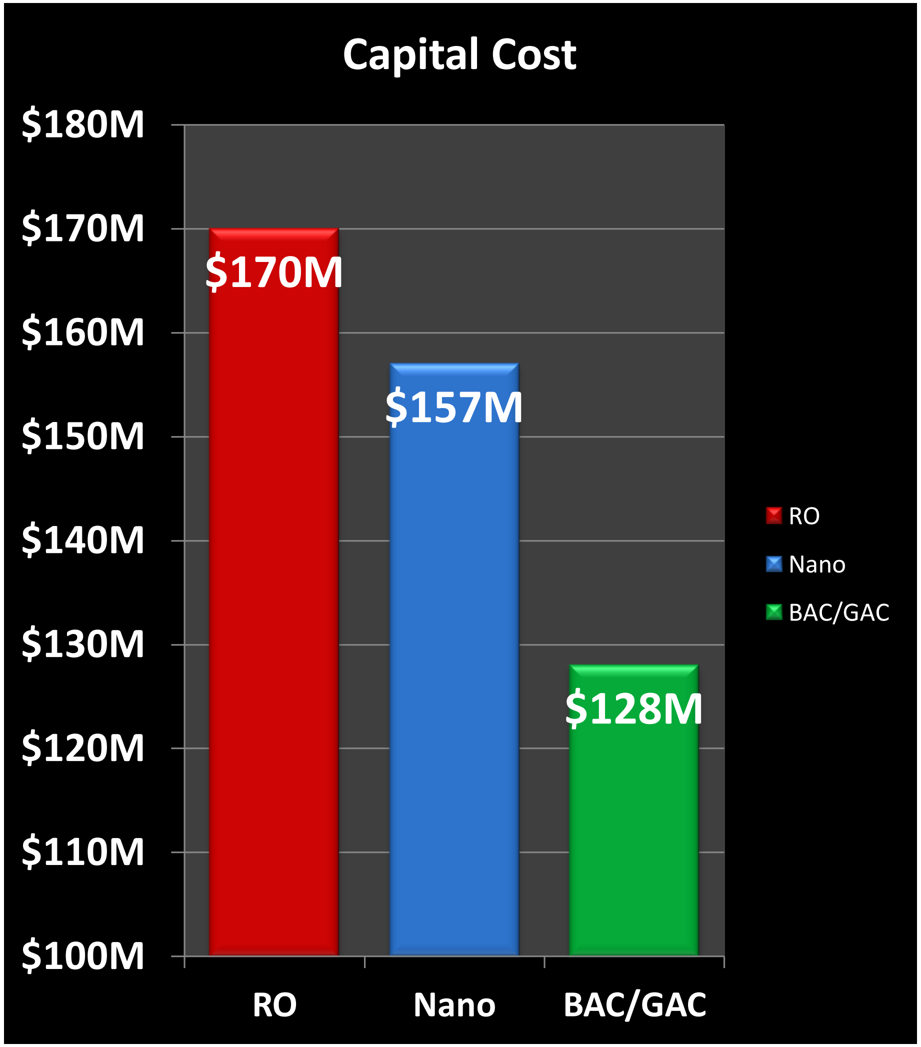



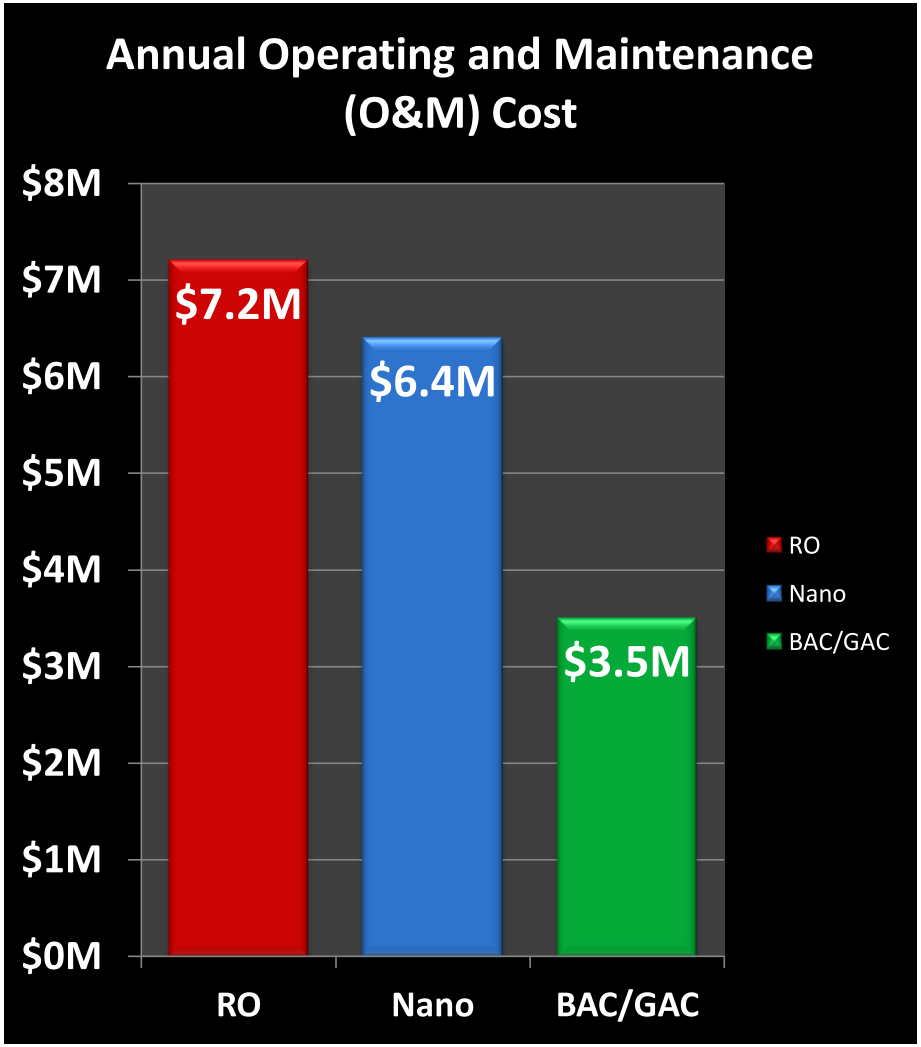
# The aquifer recovers! - Critical cells: Potomac Aquifer



# Cost for 20 MGD

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# Cost Summary

- Total project in the $1 billion range (120 mgd)
  - For 6 or 7 plants (not CE or Atlantic)
  - York needs additional study to locate injection site
- Annual operating costs $21 - $43 M
- Operating costs could be recovered with reasonable permitted withdrawal fee
  - Provides incentive for permits without significant reserves for potential future needs – right sized
  - Encourages conservation



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# Conclusion – Summary of Benefits

- Significantly reduced discharge into the Chesapeake Bay (only during wet weather)
  - Creates source of nutrient allocation to support other needs
  - Increases available oyster grounds
- Regulatory stability for treatment processes
- Sustainable source for groundwater replenishment
  - Supports water needs throughout Eastern Virginia without piping to specific locations (wireless solution)
- Potential reduction in the rate of land subsidence
- Protection of groundwater from saltwater contamination



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## HRSD Uniquely positioned

- No downstream low-flow issues from HRSD plants
- Daily capacity to make an impact on aquifer
- Large regional political subdivision
- Governor appointed Commissioners
  - Commission has committed resources to continue to move toward implementation
- 20-year CIP forecast in excess of $4B
  - Can re-prioritize to include this project



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# Next steps

- Engage stakeholders – get input on next phase of study
- Model and quantify
  - Impact on saltwater intrusion
  - Impact on land subsidence
  - Safe yield
  - Spatial analysis and travel time to existing withdrawals
- Additional water treatment technology analysis and evaluation – pilot-scale
- Scope demonstration-scale project (1 MGD) – advanced treatment & aquifer injection
- Further evaluation of geochemistry
- Develop more detailed costs for each plant

# Timeline

- Finalize Phase 2 scope – Dec 1, 2015
- Complete Phase 2 by end of 2016
- Room scale pilot projects – evaluation early 2017
- 2017
  - Endorsement from DEQ/VDH to move forward
  - EVGWAC recommends recharge project
  - EPA agrees to integrated plan to meet CD requirements
  - Phase 3 WIP includes this project to achieve TMDL goals
- 2018
  - Demonstration pilot – well developed, monitored
- 2020
  - EPA/DEQ/VDH formally approves CTC for SWR
- 2020 to 2030 (accelerated to 2025 based on Phase 3 WIP needs)
  - Construction through phased implementation
- 2030 Fully operational
  - 120 MGD of clean water put into the aquifer



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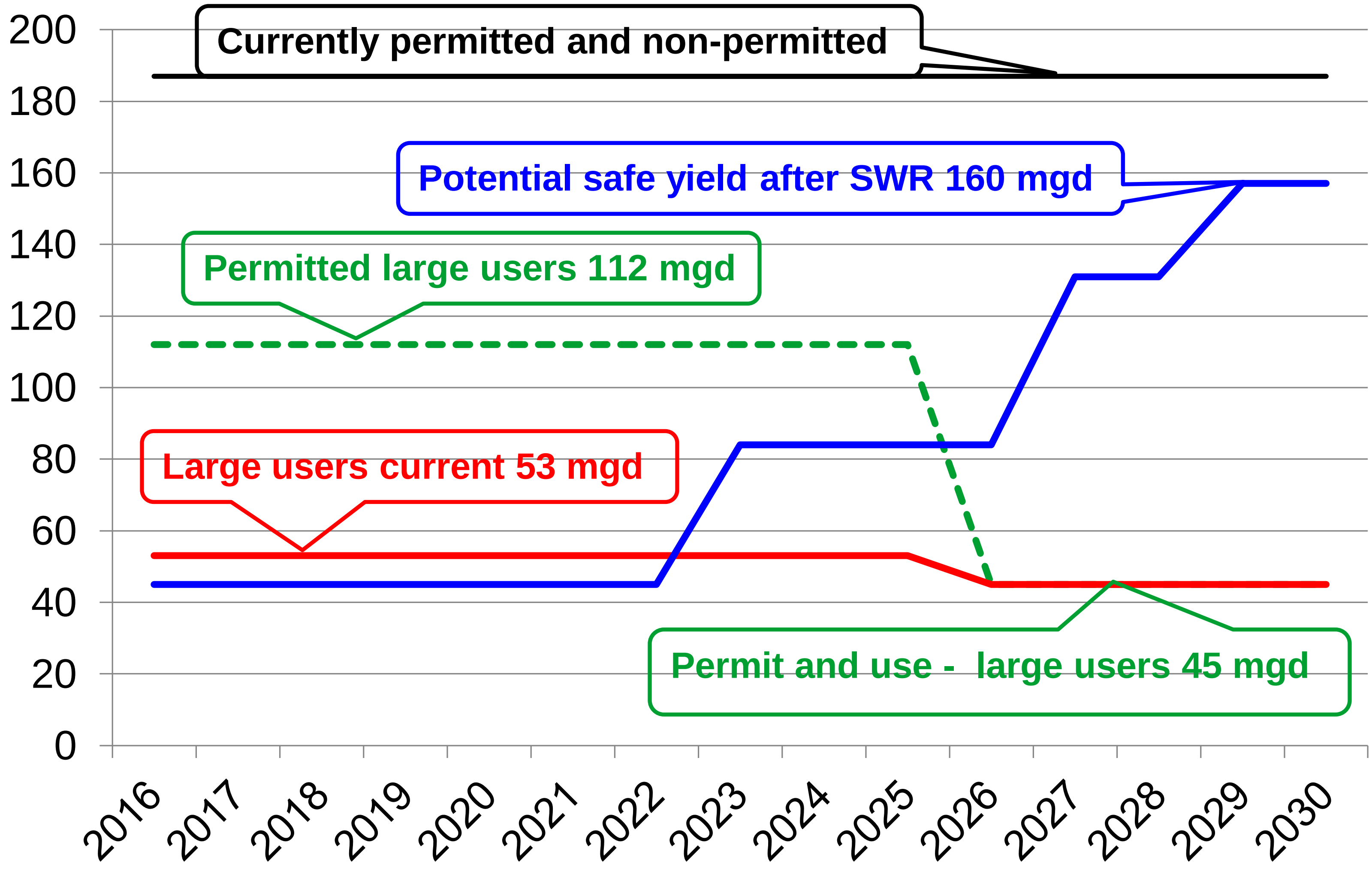
# Time Line



Currently permitted and non-permitted
Potential safe yield after SWR 160 mgd
Permitted large users 112 mgd
Large users current 53 mgd
Permit and use - large users 45 mgd
200
180
160
140
120
100
80
60
40
20
0
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030

## Specific ask of Stakeholders

- Maintain openness to concept of Sustainable Water Recycling through aquifer replenishment
  - Additional study, pilot testing, modeling and analysis needed
- Reach out directly to HRSD with concerns
  - Next phase can be modified to include additional areas of concern

# Questions?

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