HRSD's Vision for Advanced Water Treatment and Managed Aquifer Recharge in Eastern Virginia, USA: Sustainable Water Initiative for Tomorrow (SWIFT)

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Declining aquifer levels, land subsidence, and saltwater intrusion are occurring in the Potomac Aquifer System in Eastern Virginia. HRSD has developed an innovative program called the Sustainable Water Initiative for Tomorrow (SWIFT) that will address these challenges and provide additional benefits to the region, including nutrient credits for urban stormwater and other needs. SWIFT will add advanced water treatment (AWT) to seven of HRSD's existing treatment plants to produce more than 100 MGD of finished water that meets drinking water standards and is compatible with the receiving aquifer. Finished water will be pumped into the Potomac Aquifer System (PAS) as part of a groundwater replenishment program to counter the documented aquifer challenges. The SWIFT program enhances the sustainability of the region's long-term groundwater supply, and it also decreases the existing, permitted nutrient load currently entering the sensitive Chesapeake Bay, allowing the offset of MS4 urban stormwater nutrient management, for which several formal trading agreements with localities have already been executed. This presentation will review the SWIFT program from concept development, including aquifer modeling and feasibility investigations, to AWT pilot testing, construction of a 1.0 MGD demonstration facility, incorporation of SWIFT as an integrated planning element, public outreach efforts, and finally to the plans for full-scale build-out.

At the initiation of the SWIFT program, a regional groundwater modeling study was completed to evaluate and demonstrate the benefit of pumping water into the PAS. Results of that work suggest significant improvement in hydrostatic pressures throughout eastern Virginia, and near complete elimination of groundwater extraction concerns, specifically aquifer dewatering in the locations of most intense pumping. Test wells have been installed at two treatment plants and monitoring wells are now being installed as part of the demonstration facility construction. In addition, HRSD partnered with USGS to install at the Nansemond Treatment Plant the third extensometer, which is an instrument used to monitor land subsidence, in the coastal plain of Virginia. There is good circumstantial evidence that SWIFT could slow the rate of or perhaps reverse land subsidence which is a significant portion of the observed sea level rise in the Hampton Roads area.

An initial evaluation examined historical treatment plant effluent water quality data to determine feasibility of AWT for HRSD. An industry review was also conducted to determine the treatment processes used at other similar managed aquifer recharge (indirect potable reuse) facilities in the U.S. and to identify the current landscape of regional potable reuse regulations in the absence of federal regulations. Two such AWT trains were identified as viable candidates: (1) coagulation/flocculation/sedimentation, ozone oxidation, biologically active carbon filtration, granular activated carbon adsorption, ultraviolet disinfection, and chlorine disinfection (Carbon-based approach); and (2) ultrafiltration, reverse osmosis, ultraviolet advanced oxidation, and chlorine disinfection (Membrane-based approach). Both of these treatment processes provide a multi-barrier approach for pathogens and organics, which is critical for potable reuse.

HRSD conducted side-by-side pilot testing at the York River Treatment Plant of these two AWT approaches and eventually selected a carbon-based process scheme for further testing and demonstration. Pilot testing of the carbon-based approach is continuing with a focus on documenting virus removal, evaluating emerging contaminant removal, avoiding the formation of bromate, enhancing the removal of problematic compounds including 1,4-dioxane and N-nitrosodimethylamine, refining the estimate of GAC reactivation interval, and evaluating the benefit of soil aquifer treatment for the removal of pathogens, organics and disinfection byproducts.

Pilot results demonstrated excellent performance of both the carbon-based and membrane-based AWT trains. Extensive sampling was conducted daily, weekly, and monthly for an extensive suite of parameters that included all Safe Drinking Water Act (SDWA) parameters, a wide variety of contaminants of emerging concern (CECs), and additional contaminants not yet regulated by drinking water standards. In addition to normal operation, a series of special studies were conducted with the pilot that included a virus challenge test, disinfection byproduct (DBP) formation potential, and WWTP excursion simulations. The pilot testing resulted in confidence that both treatment trains would meet the water quality goals that were developed for the SWIFT program through discussions with an independent advisory panel and regulatory agencies.

While pilot testing was occurring, extensive sampling and modeling was being performed to characterize the quality of the existing water in the PAS and determine the fate of the future finished AWT water in the PAS. The signature result of the aquifer compatibility study was the high level of total dissolved solids (TDS) in the PAS ranging from 1,000 milligram per Liter (mg/L) to 5,000 mg/L. A key outcome of the groundwater modeling was the determination that recharge water will require more than 100 years to travel one mile due to the size of the PAS. Additional modeling and sampling was performed in order to quantify the magnitude of benefit that the SWIFT program will provide to the PAS.

Important to the success of the SWIFT program is the advancement of HRSD's pretreatment control program so that the program reflects a potable reuse system. This included analysis of HRSD's existing industrial and commercial users to identify problematic waste streams that could be entering each WWTP and providing additional treatment barriers for specific users. HRSD also considered relevant outreach strategies for residential and commercial users.

The next phase of the SWIFT program is construction and operation of a 1 MGD demonstration facility, the SWIFT Research Center, that will demonstrate at a meaningful scale that advanced treatment will produce finished water that meets primary drinking water standards and is compatible with the PAS. The intent of the facility is to provide at least 12 months of operational data to inform and optimize the design and construction of full-scale facilities. The SWIFT Research Center is located at HRSD's Nansemond Treatment Plant and has been in operation since March 2018.

The successful operation of the Research Center will lead to full-scale implementation of the SWIFT program, yielding over 100 MGD of AWT water by 2030 and becoming one of the largest potable reuse and managed aquifer recharge programs in the world. Up to seven AWT facilities will be co-located with existing HRSD WWTPs. Modeling was performed to determine the sizing of the full-scale AWT facilities that best meets HRSD's goal of reducing WWTP secondary effluent load to the Chesapeake Bay while still being cost efficient and effectively utilized.

Figure 1. Results of regional groundwater modeling suggesting that the SWIFT program will have a meaningful impact on the PAS in Virginia.

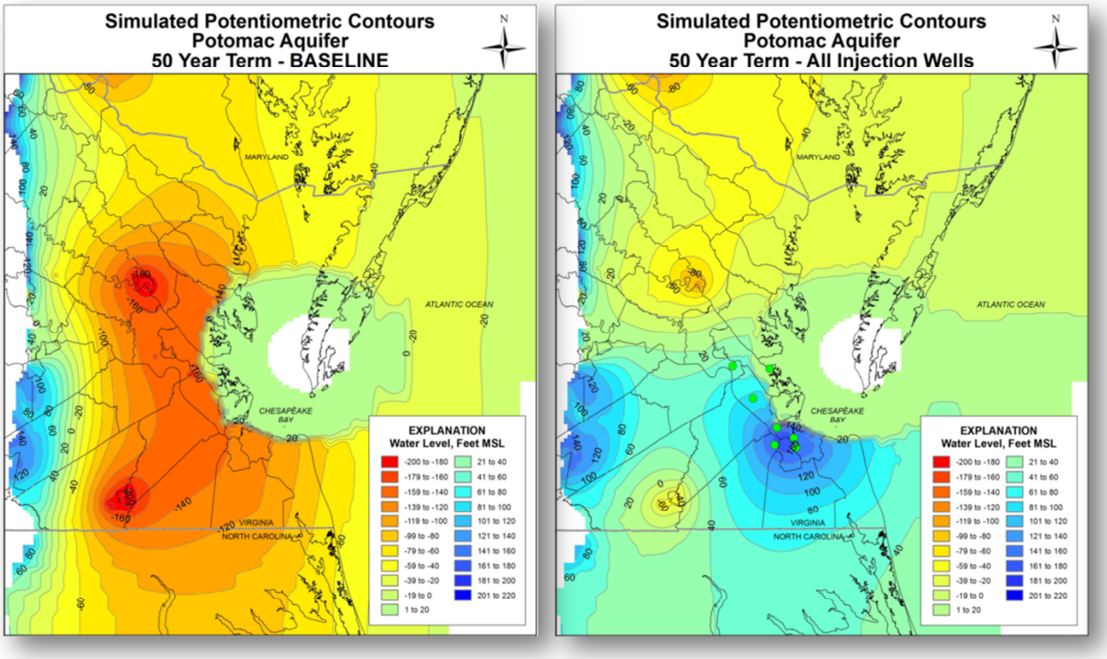

Figure 2. Rendering of the SWIFT Research Center, which includes a 1 MGD AWT demonstration process, recharge well, monitoring well network, public outreach facilities, research and operating laboratories, a control room, a pilot AWT research facility, and offices and training facilities.