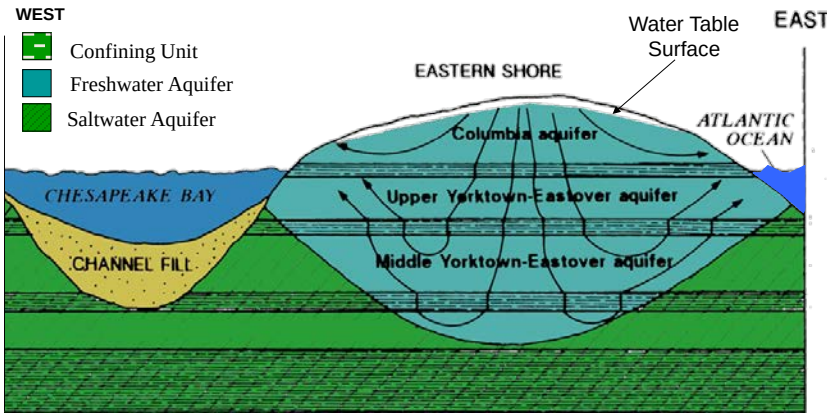
POTENTIAL FOR SALTWATER INTRUSION SUMMARY

Eastern Shore of Virginia

Fresh groundwater on the Eastern Shore of Virginia occurs as a lens that "*floats*" overtop denser saltwater in a manner similar to less dense ice floating on top of water (see ***Ghyben-Herzberg relation*** for reference). The lens is replenished by direct precipitation that falls on the Shore, infiltrates the soil and reaches the Columbia aquifer, the uppermost fresh groundwater body. The USGS estimated that about 12% of the precipitation falling on the Shore reaches the Columbia aquifer, or about 625 million gallons per day (MGD) on average in a normal year. Clays restrict water movement to the underlying Yorktown aquifers, the principal source of water on the Eastern Shore, and ***the USGS estimates only about 0.1% (about 9 MGD on average) of the precipitation falling on the Shore replenishes the Yorktown aquifers.***

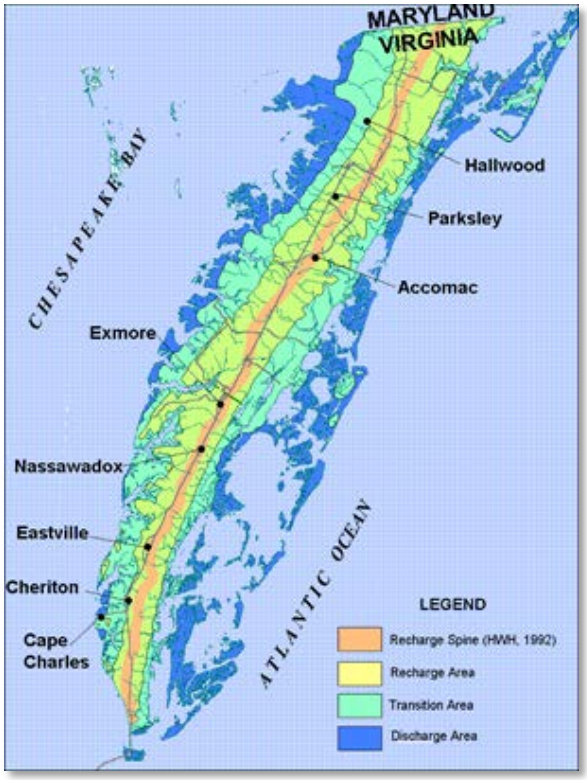


Above: Conceptual figure illustrating freshwater lens floating over saltwater, maintained by recharge from precipitation at the surface.

Freshwater lens size is controlled by the height of the groundwater above sea level, which in turn is determined by 1) the recharge rates; 2) aquifer permeability (rate that groundwater flows through the aquifer); 3) distance to a discharge area; and 4) rate of groundwater withdrawals. The lens is thickest near the center of the Shore near Route 13 and decreases in thickness toward the Seaside and Bay. Near the center spine the freshwater lens can be as great as 300-feet thick. Along the coast, thickness is typically less than 100 feet.

The low recharge rate to the Yorktown-Eastover aquifer and the surrounding ocean water make the Shore far more vulnerable to saltwater intrusion than the Coastal Plain west of the Chesapeake Bay. However, the extent saltwater intrusion can occur is uncertain, there has never been research dedicated to understanding the 1) vertical and lateral extent; 2) movement and stability; 3) response to groundwater use; and 4) sustainability of the freshwater lens. Available information is from local studies; limited water qualtiy monitoring data; and numeric models. Local studies and water quality monitoring data are limited in both spatial and temporal extent. For instance, much of the water qulaity monitoring on the Eastern Shore was obtained in the 1980's, with comparatively little more recent information. Additonally, while the model currently used to predict regional impacts from groundwater use is capable of simulating saltwater intrusion, the model has not been calibrated for this use, and the model predictions can only be used as "*indicators*" for saltwater intrusion potential.

The following summarizes information currently avaiable and recommendations for future research on saltwater intrusion on the Shore.



Above: Map illustrating general areas the freshwater lens is recharged, and areas where the freshwater discharges to the Bay and ocean.

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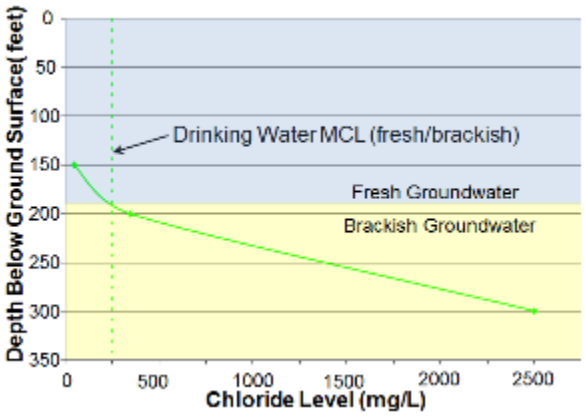
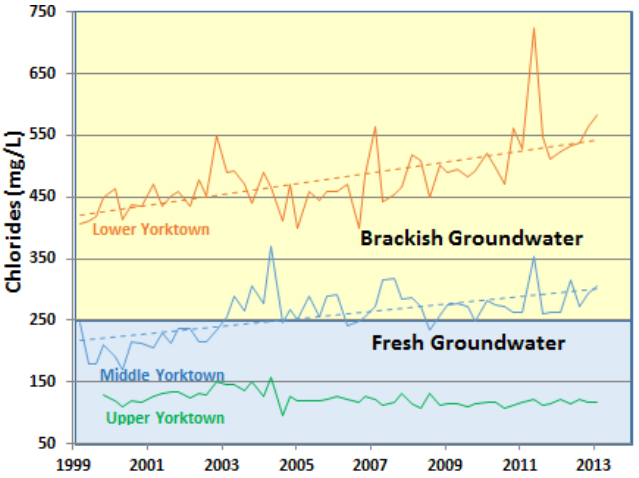
Freshwater Lens Extent: Principal method for determining vertical and lateral extent of the fresh groundwater is through direct measurement of water quality from observation wells. The USGS and State Water Control Board established State Observation Wells (SOW) in the 1980's for the purpose of monitoring groundwater levels and quality in the aquifers. The water quality monitoring ceased near the end of the 1980's and no consistent water quality measurements have been obtained from these observation wells since this time. One use of this information is defining the vertical transition between fresh and salty (brackish) water through clustered observation wells (observation wells that are constructed near each other but with screened openings at different depths. ***A SOW cluster at Upshur Neck on the Seaside shows the transition from fresh to brackish groundwater over a vertical interval of only 150 feet.*** Unfortunately most of the SOW clusters on the Shore are located near the spine, where the freshwater lens is thickest and do not show this transition from fresh to brackish.

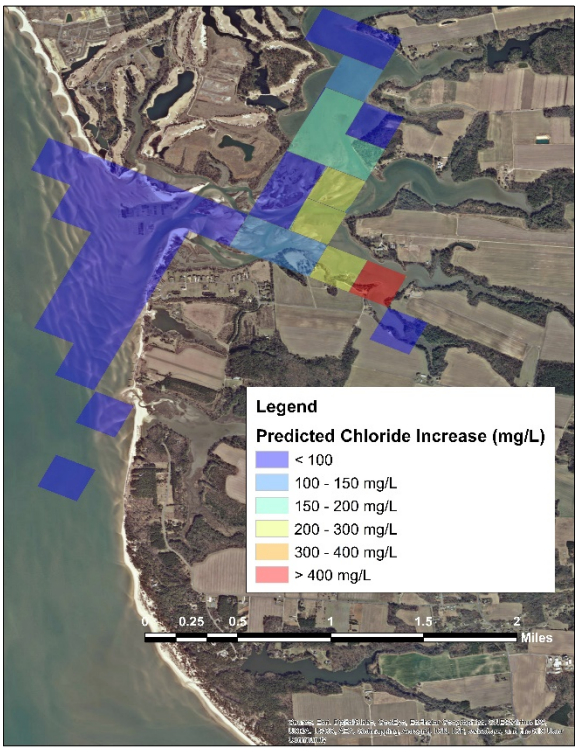


Above: Water quality from 1980's from SOWs at Upshur Neck.

Saltwater Intrusion: Occurs from lateral movement from the Bay or Seaside or upward movement (upconing) from underlying brackish groundwater as the size of the freshwater lens decreases due to groundwater withdrawals. ***The degree that saltwater intrusion occurs is a function of the amount and location of groundwater use; proximity to the Bay or Seaside; and depth*** (the deep lower Yorktown-Eastover aquifer receives the least recharge and is closest to underlying brackish groundwater and is therefore more susceptible to saltwater intrusion. The shallow Columbia aquifer receives the greatest recharge and has the most separation from brackish groundwater and is less susceptible to saltwater intrusion. As illustrated from wells near the Bay, saltwater intrusion has been measured at a number of locations on the Shore. There is, however, no SOW framework established to monitor saltwater intrusion. Current monitoring is directed locally and does not provide regional information on the Shore.



Above: Saltwater intrusion occurring in the middle and lower Yorktown-Eastover aquifers. No saltwater intrusion occurring in the upper Yorktown-Eastover aquifer.



Above: Current regional groundwater model is not calibrated to simulate for saltwater intrusion. Results can only be used to "indicate" potential saltwater intrusion.

A regional model developed by the USGS can simulate saltwater intrusion, however, there is insufficient information on the freshwater – saltwater interaction on the Shore to calibrate this model. Until the necessary data is collected, the model cannot be calibrated, and results from the model can only be used as "*indicators*" of potential saltwater intrusion.

Recommendations: Relatively little information is known about the freshwater/saltwater interface for the Yorktown-Eastover aquifer, specifically: 1) vertical and lateral distribution; 2) thickness / transition from brackish to fresh groundwater; and 3) response to groundwater use. A systematic groundwater monitoring program for the Shore, similar to the program outlined by the USGS in the recent ***Scientific Investigations report 2015-5117*** for the Virginia Coastal Plain west of the Chesapeake Bay is necessary to address these significant data gaps. A systematic program would provide the information necessary to develop a calibrated regional model capable of predicting potential for saltwater intrusion from groundwater withdrawals. This is a critical tool necessary to maintain a sustainable groundwater resource on the Eastern Shore of Virginia.

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