Overview of Ground Water on the Eastern Shore

Curt Smith
Director of Planning
Accomack-Northampton Planning District Commission
April 22, 2014
A-NPDC Overview and Purpose

• Commonwealth created 21 PDCs in 1970 to address regional issues by fostering cooperation amongst localities and cooperation between state & localities

• Accomack-Northampton District:
  • Members: 2 Counties and Town of Chincoteague
  • Also provides services to 18 other towns

• Affiliate Organizations:
  • A-N Regional Housing Authority → provides privately or authority-owned rental housing
  • ESV Housing Alliance → improving housing for homeowners
  • A-NPDC →
    • Community Development
    • Economic Development
    • Transportation Planning
    • Environmental Planning → Ground Water Committee; Climate Adaptation Working Group
Presentation Overview

1. Geologic/Hydrogeologic Framework Evolution
2. Ground Water Conditions
3. Ground Water Use
4. Threats to Ground Water Quality
5. Ground Water Management and Water Supply Planning
Geologic/Hydrogeologic Framework Evolution

• Timeline:
  i. Opening of Atlantic Ocean & Salisbury Embayment – ≈180 Million Years Ago (MYA)
  ii. Filling of Salisbury Embayment (Potomac Formation) – ≈180 to 35.5 MYA
  iii. Bolide impact & removal of pre-impact sediments – ≈35.5 MYA
  iv. Deposition of post-impact sediments – ≈35.5 MYA – Present
  v. Reworking of surficial sediments & progradation of peninsula – ≈200,000 YA – Present
  vi. Sea level reaches elevation of modern Chesapeake Bay transitioning system from riverine to estuarine - ≈8,000 YA
  vii. Sea level continues to rise and inundate the Chesapeake Bay watershed and the Chesapeake Bay begins to take its modern appearance we currently recognize - ≈3,000 YA
Development of Salisbury Embayment

Millions of Years Ago

- Basin feature in bedrock created by tectonic forces during the opening of Atlantic Ocean
- Bound by arches, or elevated regions, of bedrock
- Basin filled by intermittent marine overlap and sediment deposition

Ward and Powars, 1991
Opening of Atlantic Ocean

Millions of Years Ago

Appal. Plateau  Valley & Ridge  Blue Ridge  Piedmont  Coastal Plain

(not to scale)

Bailey and Johnson, 1999
In-Filling of Salisbury Embayment

Millions of Years Ago

- Sea level highstands =
  - Shoreline west of area
  - Shallow sea conditions here
  - Deposition of marine sediments
    - Fine sediments settle out during normal conditions
    - Punctuated by deposition of larger-grained sediments (silts/sands) during storm events

- Shoreline transgressions & regressions =
  - When ocean shoreline migrates over area
  - High energy = reworking of sediments, deposition of sands and “flushing” of fines

USGS PP#1688
Chesapeake Bay Impact Structure

180

Millions of Years Ago

35.5

Present


USGS
USGS Chesapeake Bay Evolution Animation

(Bratton et. al, 2009)
Development of Eastern Shore & Chesapeake Bay

Hobbs (2004)

Scott (2006)
Surficial Features: Relict Shorelines

Bailey (2009)

Cheriton Scarp

Cintos (2012)

Pungoteague Scarp

Ames Ridge

Mappsburg Scarp

Suffolk Scarp
South-Central Accomack County
(Melfa, Keller, & Painter)

2-D view of LiDAR data
ground elevation only

The Nature Conservancy (2011)
2-D view of LiDAR data ground elevation only
2-D view of LiDAR data ground elevation only
**Surficial Features: Carolina Bays**

- Over 700 shallow, elliptical depressions
  - Similar orientation (NW-SE)
  - Variable size (1 – 1,000 acres)
  - Some overlapping
  - Coarse-grained rims
  - Fine-grained floors

- Variable ages (100,000-<5,000 years)

- Debated origin
  - Wind & Water
  - Shock wave from bolide explosion

*NASA-WFF*

*Cintos (2012)*
Surficial Features: Carolina Bays

- Over 700 shallow, elliptical depressions
  - Similar orientation (NW-SE)
  - Variable size (1 – 1,000 acres)
  - Some overlapping
  - Coarse-grained rims
  - Fine-grained floors

- Variable ages (100,000-<5,000 years)

- Debated origin
  - Wind & Water
  - Shock wave from bolide explosion
Surficial Features: Carolina Bays

- Over 700 shallow, elliptical depressions
  - Similar orientation (NW-SE)
  - Variable size (1 – 1,000 acres)
  - Some overlapping
  - Coarse-grained rims
  - Fine-grained floors
- Variable ages (100,000-<5,000 years)
- Debated origin
  - Wind & Water
  - Shock wave from bolide explosion

Cintos (2012)
Ground Water Conditions on the Eastern Shore
Ground Water is not like an underground river!

- Groundwater flows through porous soils and sediment that includes gravels, sands, silts, and clay.
Soil/Sediment type determines if it can be used as a source of water

An Aquifer is a Source for Groundwater and is:

Any coarse grained material (sand, gravel) that can supply sufficient water for a beneficial use

A Confining Unit Impedes Movement of Groundwater and is:

Any fine grained material (silt, clay) that can significantly restrict vertical movement of groundwater such that the resulting groundwater is under pressure.
Aquifers are defined by where they appear relative to a confining layer

- **Water Table**
  - Water is not “under pressure”
  - Well yield is lower than comparable confined aquifers
  - Replenished (recharged) directly by precipitation
  - More vulnerable to contamination from surface activities

- **Confined aquifer**
  - Water is under pressure, confined by an overlying layer(s) of silt and clay
  - Replenished from vertical flow through the confining unit (recharge is much lower than a water table aquifer)
  - More vulnerable to saltwater intrusion
All Groundwater Aquifers on the Eastern Shore

- Fresh Groundwater is restricted to the Columbia (Water Table) aquifer and significant portions of the Yorktown-Eastover aquifer
- Brackish groundwater is found in portions of the Yorktown-Eastover, all of the St. Marys Aquifer, Piney Point, and Potomac aquifers
- The Columbia, Yorktown-Eastover, and Piney Point aquifers are found throughout the Eastern Shore
- St. Marys and Potomac Aquifers are absent in the southern portion of the Shore

Source: McFarland and Bruce, 2006
Water Table and Fresh Water Confined Aquifers on the Eastern Shore

Fresh ground water is restricted to depths less than 350 feet

Estimated Recharge to Water Table Aquifer = 625 MGD approx
Estimated Recharge to Yorktown-Eastover Aquifer = 9 MGD approx
(based on USGS Eastern Shore Model)
Movement through the Groundwater System

- Horizontal flow typically toward a surface water body. Gradient is often low and the actual flow rate is low.
- Vertical flow typically downward and very low.
Hydraulic Gradient Under Confined Pumping Conditions

- Horizontal flow may be re-oriented toward well. Gradient (flow rate) is often significantly increased.
- Vertical flow remains downward but rate often significantly increased.
Groundwater Levels under no Pumping

The pressure in the aquifer changes with distance from the well.
Pumping from a confined aquifer with little leakance through the confining layer

The pressure in the aquifer changes with distance from the well.
Pumping from a confined aquifer with significant leakance through the confining layer

The pressure in the aquifer changes with distance from the well.
Multiple Wells Additively Increase Water Level Declines

Static Water Level

Drawdown in the Pumping Well

Cone of Depression (Single Well)

Drawdown in Adjacent (Non-Pumping) Well

Drawdown Due to Pumping Adds to Existing Drawdown

Cone of Depression is Superimposed on the Existing Cone of Depression

The Cone of Depression is the Sum of Each Well’s Cone of Depression

Aquifer
How Much Water Recharges the Aquifers?

- All fresh water comes from precipitation falling directly on the Shore
- About 88% of the precipitation never infiltrates to the groundwater
How Much Water Recharges the Aquifers?

• Most of the rainfall never infiltrates to the groundwater and is lost through:
  • Evaporation
  • Interception (on plants and trees)
  • Direct runoff
  • Evapotranspiration
Of the water infiltrating to the water table, only a small amount reaches the Yorktown aquifer.

- **Limited Recharge:**
  - Of the 44-inches of annual precipitation only 5 to 6 inches infiltrate to the water table (625 MGD)
  - And only about 0.05 in/year make it to the confined aquifer (9 MGD)

**Total Estimated Recharge to Water Table Aquifer = 625 MGD**
Recharge amounts vary across the Shore

Recharge to Surficial Aq

Location of Paleochannels

Recharge to Y-E Aq
Recharge to the water table is a function of soil type, slope, and location.

Potential Recharge areas (based on soil type and slope)

Estimated Recharge Rates

Source: USGS
Recharge to the Yorktown depends more on where pumping from the aquifer is occurring

Estimated in 1900 (pre-pumping)

Estimated in 2003 (Effects of pumping)
Recharge rate to the Yorktown has increased over time due to pumping

- Current Yorktown-Eastover Aquifer use exceeds recharge by approximately 1 MGD
- Recharge will increase as use increases – but will NOT keep pace with pumping

Source: USGS Eastern Shore Model
Estimated Water Ages Reflect Recharge Rates

Water Table

Upper Yorktown

Middle Yorktown

Lower Yorktown

Accomack-Northampton Planning District Commission
Water Table / Yorktown Dilemma

- **WATER TABLE AQUIFER**
  - Little Storage
  - Little Use
  - High Inflow

- **DEEP AQUIFER**
  - Large Storage
  - Low Inflow
  - High Use

Accomack-Northampton Planning District Commission
Ultimately the Balance of Recharge to Use Dictates Stability of the Fresh Water Lens

Fresh ground water is restricted to depths less than 350 feet.

Estimated Recharge to Water Table Aquifer = 625 MGD approx
Estimated Recharge to Yorktown-Eastover Aquifer = 9 MGD approx
(based on USGS Eastern Shore Model)
Groundwater Use on the Eastern Shore

DEQ Permitted Wells
- Public Water Supply
- Commercial
- Industrial
- Irrigation

Accomack-Northampton Planning District Commission
Ground Water Use and Ground Water Level Measurements

• Ground Water Use for permitted wells (wells pumping greater than 300,000 gallons-per-month) are submitted to VDEQ

• Ground Water Levels are routinely measured in Observation Wells by the USGS
Non-Agricultural Ground Water Use Trends

Accomac County
Northampton County

Accomack-Northampton Planning District Commission
All Permitted Ground Water Use

Northampton Agricultural
Accomack Agricultural
Northampton Public/Commercial/Industrial
Accomack Public/Commercial/Industrial

Accomack-Northampton Planning District Commission
Types of Groundwater Use

- Irrigation: 20%
- Commercial/Industrial: 18%
- Municipal: 62%

Groundwater Use Distribution From Calendar Year 2002
Why Measure Ground Water Levels?

• Ground water use:
  • Lowers ground water levels, reducing available water to other ground water users
  • Reduces the size of the freshwater lens

• Impact of ground water use can be evaluated:
  • Indirectly using models
  • Measured directly from pumping wells and observation wells
Water Level Change and Monthly Use

Depth Below Ground Surface (ft)

Monthly Water Use (GPD average)


67M 13 SOW 115D - Screen Depth = 239-249 ft

Chincoteague Water Use

Accomack-Northampton Planning District Commission
Water Level Change and Annual Use Near Perdue Farms

Annual Groundwater Use (GPD average)

Depth Below Ground Surface (ft)

Year

65K 27 SOW 114A - Screen Depth = 150-160 ft

Perdue Farms Water Use
Effect of Irrigation Use

Observation Wells SOW 113 West of Wardtown

Depth Below Ground Surface (ft)

Legend
# Agricultural
# Industrial/Commercial
! Municipal
@A USGS Observation Well

- 63J 1 SOW 113A - Screen Depth = 110-120 ft
- 63J 2 SOW 113B - Screen Depth = 215-225 ft
- 63J 3 SOW 113C - Screen Depth = 280-290 ft
Long Term Decline from Irrigation Use

Observation Wells SOW 113 West of Wardtown

Legend
- Agricultural
- Industrial/Commercial
- Municipal
- USGS Observation Well

Screen Depth = 110-120 ft

Accomack-Northampton Planning District Commission
Amount of water level decline in the Lower Yorktown Aquifer
Threats to Ground Water Quality & Quantity on the Eastern Shore

• Water Table Aq.
  • Quality $\rightarrow$ Surface Activities
  • Quantity $\rightarrow$ Drought

• Confined Aq.
  • Quality $\rightarrow$ Over-pumping
  • Quantity $\rightarrow$ Over-pumping
Potential Threats To Water Table
Water Quality

Sources:
Agriculture / Livestock
- Nutrients (Fertilizers)
- Pesticides / Herbicides
- On-site waste disposal
Waste Units
- Septic Systems / Drain Fields
- Public Sewers
- Underground Storage Tanks (USTs)
Residential
- Nutrients / Pesticides - Herbicides
- Petroleum and solvents

Function of amount (loading) and area of application
Potential Threats to Yorktown-Eastover Aquifer Water Quality

- Freshwater aquifer
- Confining unit
- Salt water aquifer

Sea level

Water Table

Yorktown Aquifers

Freshwater

Salt water

Land Surface

Freshwater aquifer

Confining unit

Salt water aquifer

Accomack-Northampton Planning District Commission
Over a vertical distance of only 150 feet the chloride concentrations increase by almost 5,000 percent.

Chloride Increase With Depth
Upshur Neck Seaside Example

Drinking Water MCL (fresh/brackish)

Fresh Ground Water

Brackish Ground Water
Why the Eastern Shore of Virginia?

Most likely cause for a loss of fresh ground water is salt water intrusion due to over pumping.
Ground Water Management and Water Supply Planning

- ESVA Ground Water Committee
- ESVA Ground Water Resource Protection and Preservation Plan
ESVA Ground Water Committee

• Formed in 1990 by Accomack & Northampton to study and plan for ground water protection and management
• 11-member Committee meets monthly
  • 2 County Administrators, 4 County Supervisors, 4 County-appointed members, A-NPDC Executive Director
• Coordinated by A-NPDC with funding from Counties & VA Coastal Zone Management Program
• Contracts consulting hydrogeologist to advise Committee
• Activities:
  • Develop protection and management plans
  • Ground Water Research: USGS, VA Tech, Randolph-Macon
  • Public Workshops & Educational Materials
  • Review/comment on state withdrawal permit applications and federal environmental assessments
  • Coordinate with state/federal governments on ground water-related regulations
  • ESVA Ground Water Model
  • ESVA Ground Water Award Program
  • Household Hazardous Waste Collection
ESVA Ground Water Resource Protection and Preservation Plan

• Originally adopted in 1992 and Updated in 2013

• Purpose:
  • Ensure that adequate and safe drinking water is available to all citizens of the commonwealth
  • Encourage, promote, and protect all other beneficial uses
  • Encourage, promote, and develop incentives for alternative water sources, included but not limited to desalinization

• Components of Plan
  • Water Resources: Current understanding of water resources. Will periodically update as new research is available.
  • Land and Water Resource Use: Water use will be updated annually.
  • Resource Vulnerability:
  • Saltwater Intrusion: Water quality trends updated annually. Modeling and other research updated periodically.
  • Water Level Declines: Updated annually.
  • Land Use Activities: Updated periodically based on research.
  • Sustainability Plan
Component Summary

• Institutional Controls: Federal / State / Local

• Research:
  • Hydraulic Characteristics: Paleochannels; Confining Units; Deeper Aquifers
  • Water Quality: Freshwater/Saltwater Transition; Agricultural Nutrients; On-Site Systems; Emerging Contaminants
  • Climate Change

• Monitoring: Water Use; Groundwater Levels; Water Quality

• Alternate Source Development: Columbia (Water Table); Membrane Treatment; Reuse; ARS

• Conservation and Reduction
Highlights

• Relevant components of the 1992 plan have been retained.
• Sections of the plan will be updated, some as frequently as annually to maintain current. Plan and various components such as monitoring data and research publications will be linked on the internet to improve accessibility.
Highlights

• Better understanding of the groundwater resource: Columbia aquifer is replenished at much higher rates than the Yorktown-Eastover. With lower withdrawals, the Columbia is an underused resource.
Highlights

• Better understating of the vulnerability: Improved models for the Shore provide greater insight on flow dynamics. Yorktown-Eastover more vulnerable near the Bayside and Seaside, less vulnerable near the spine than previously thought.
Highlights

- Research needs are more focused and will be periodically revised.
Accomack County Water Supply Plan

• Regulations: 9 VAC 25-780
  • Adopted in 2011
  • Required to be reviewed every 5 years and rewritten every 10 years

• Purpose:
  • Ensure that adequate and safe drinking water is available to all citizens of the commonwealth
  • Encourage, promote, and protect all other beneficial uses
  • Encourage, promote, and develop incentives for alternative water sources, included but not limited to desalinization

• Components of Plan
  • Existing Water Sources (Description of water systems)
  • Existing Water Use (Description of current and historical use)
  • Existing Water Resource Conditions (Groundwater Resource, Natural Resources)
  • Projected Water Demand (Future water use)
  • Water Demand Management (Water Conservation and Management)
  • Drought Response and Contingency Plan
  • Statement of Need and Alternatives (Use / Resource Constraints; alternate sources / technologies)
Thank You!

Curt Smith
Director of Planning
Accomack-Northampton Planning District Commission
csmith@a-npdc.org
757-787-2936