2-22-2018

Climate Impacts On Infrastructure

Mark Bennett

Climate Impacts On Infrastructure

Mark Bennett, USGS
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Climate Related Impacts to Infrastructure

Obvious vulnerabilities

- Flooding
- Storm Runoff
- Extreme precipitation
- Storm surge
- Wind-driven tides

Not so obvious vulnerabilities

- Estuarine salinity
- Groundwater inundation
  - Sewage infrastructure
  - Onsite waste-water treatment
- Water quality and water availability
- BMP efficacy

Estuarine Salinity –

Chickahominy River

- Primary source of fresh water to the region
- Limited source during droughts due to low flows and salinity
- Tidal barrier dam designed/installed in 1940’s

Estuarine Salinity –

Scenarios Modeled

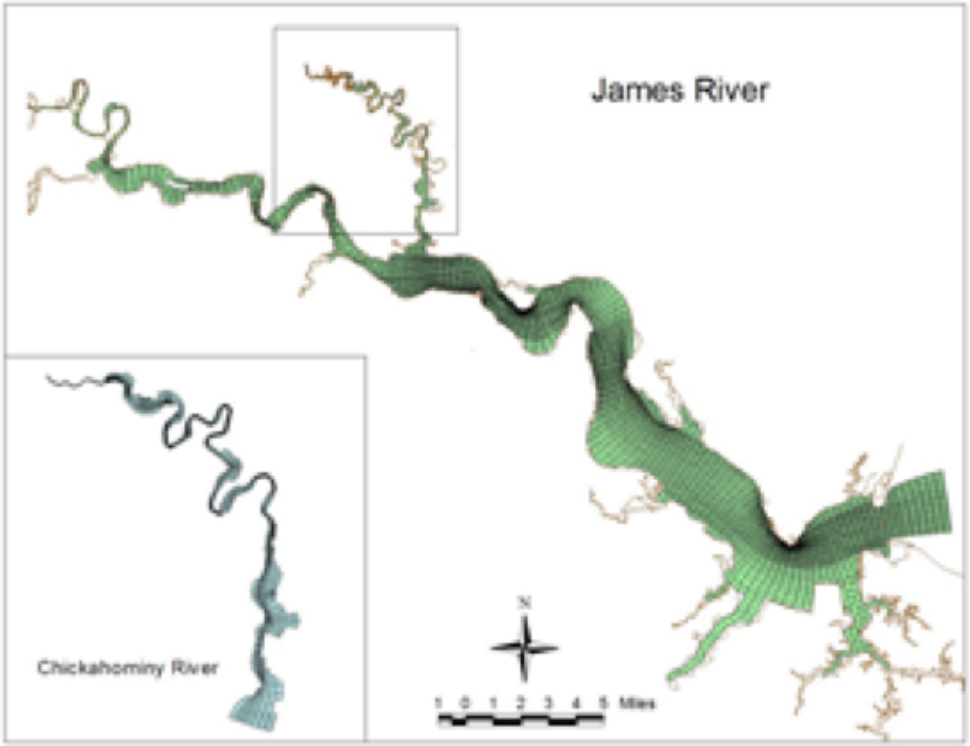
- ✓ Normal and drought flow conditions in Chickahominy River
- ✓ Low, Median, and High Sea-level Rise Scenarios
  1. 20th Century rate = 3-4 mm/year; 30-40 cm by 2100
  2. 20th Century rate + 2 mm/year acceleration; up to 50 cm by 2100
  3. 20th Century rate + 7 mm/year acceleration; up to 100 cm by 2100

Estuarine Salinity –

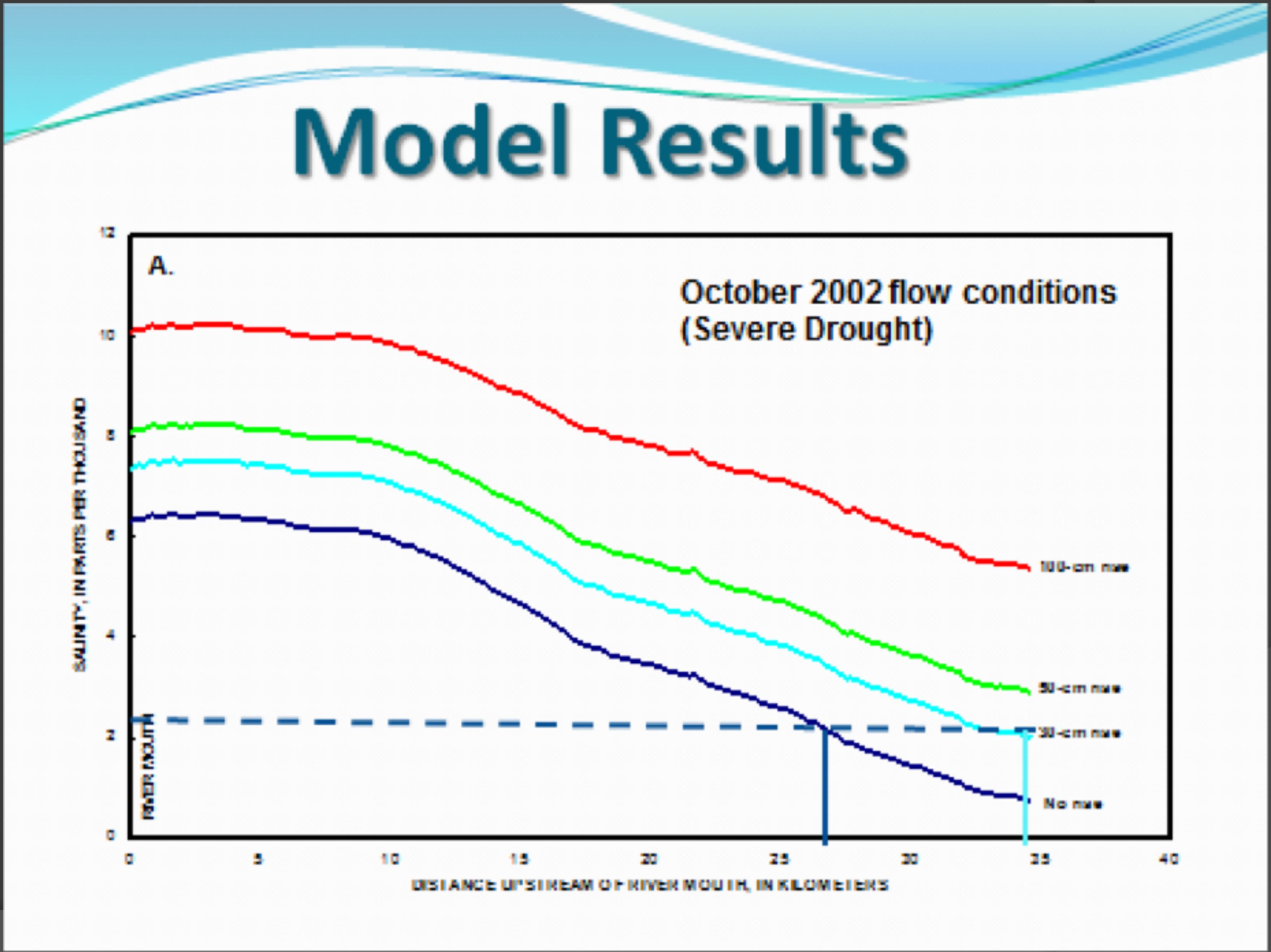
Model Results

Model development, testing and calibration by VIMS and USGS

Adapted Chesapeake Bay model and river models



Estuarine Salinity –



Estuarine Salinity –

Model Results

Number of Days high tide overtops current tidal barrier

Model scenario	Dry year 2002	Wet year 2003	Typical year 2005
No rise	1	22	17
30-cm rise	44	133	120
50-cm rise	138	190	195
100-cm rise	214	214	214

Rising Groundwater Levels –
Hidden Response to Sea Level Rise

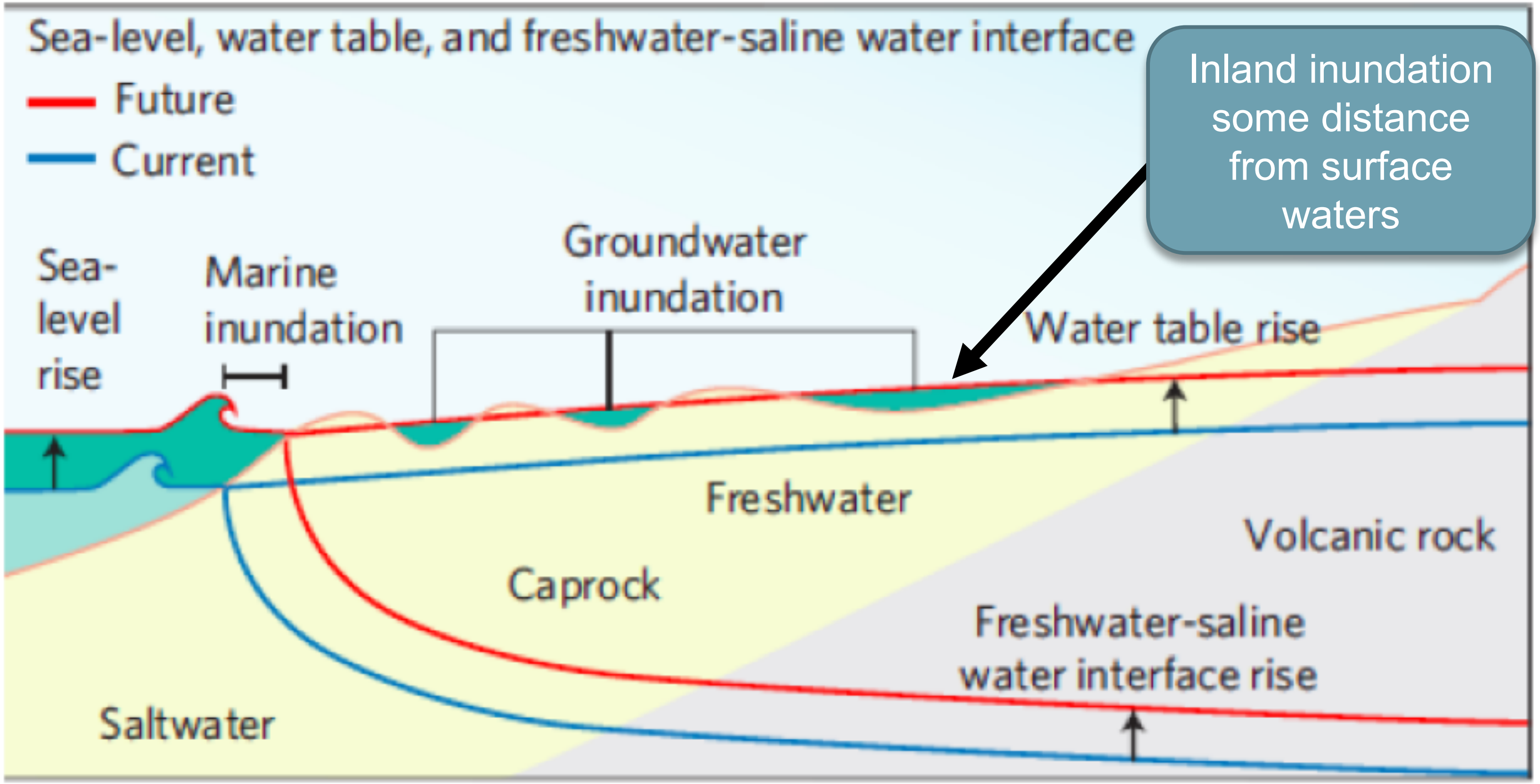
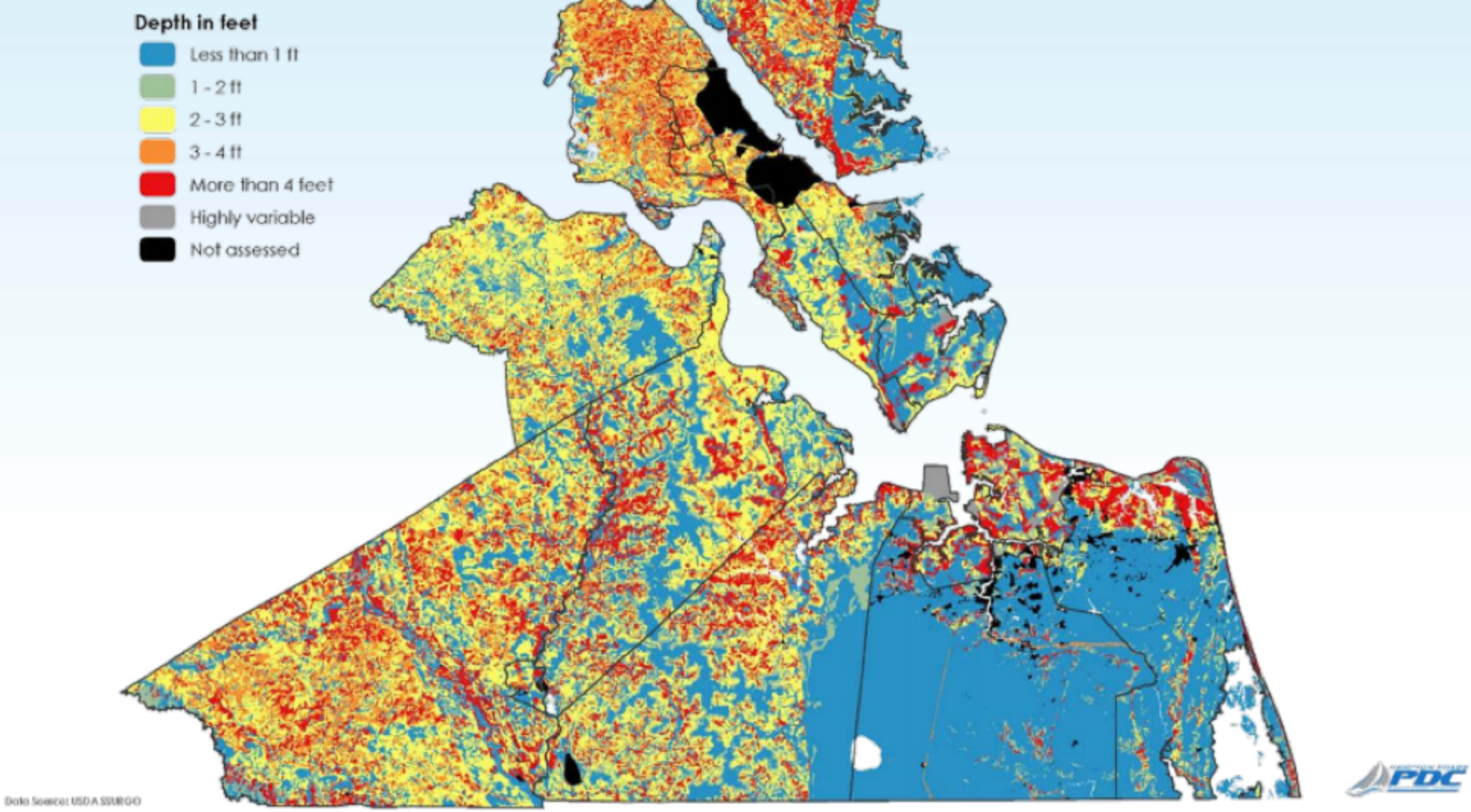


Figure 1: Conceptual diagram of marine and groundwater inundation, obtained from Rotzoll and Fletcher (2012).

Image from Moss, 2016

Figure 3

Depth to Water Table

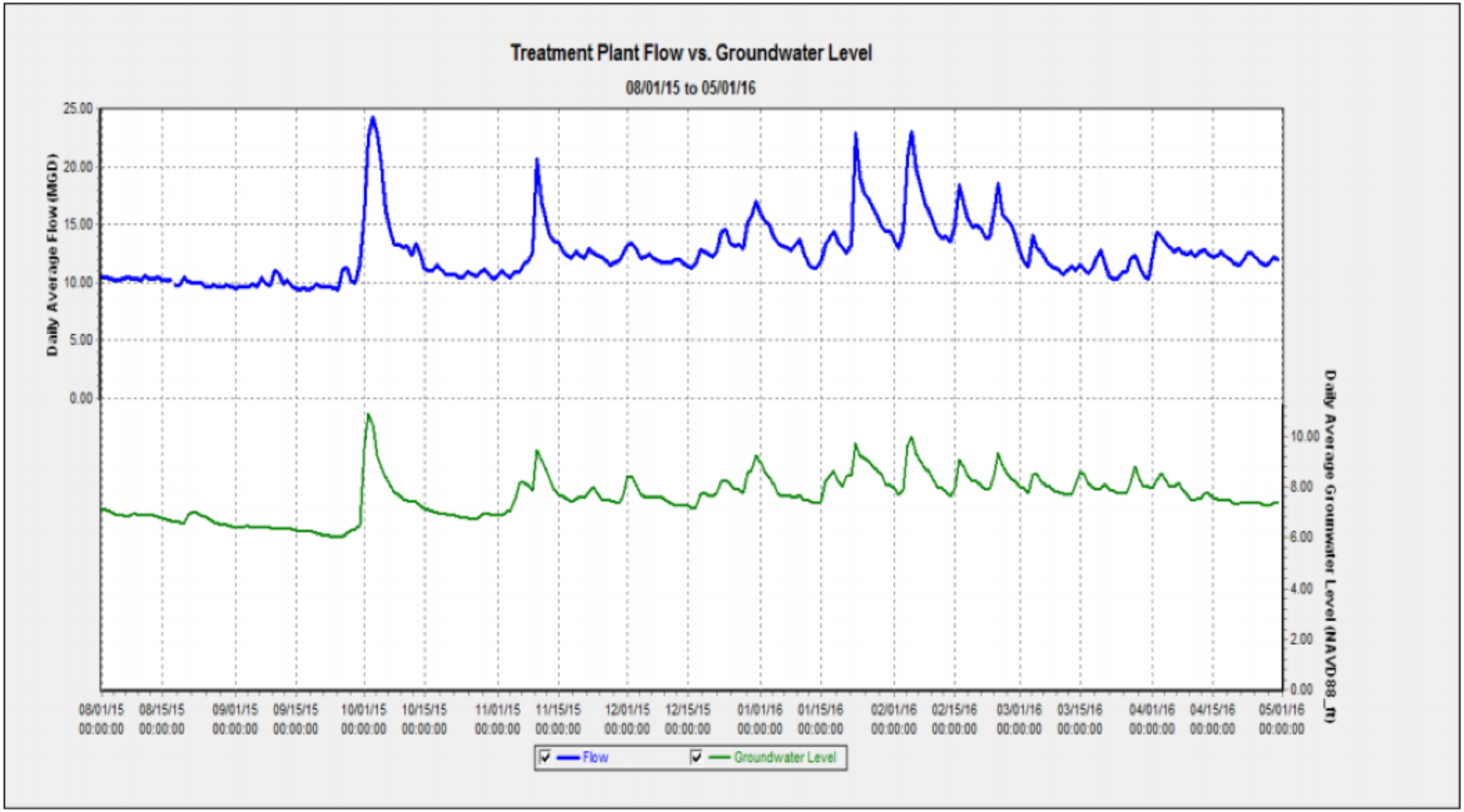


Sea Level Wise
A vibrant future for Virginia Beach

From G. Johnson, City of Virginia Beach, 2016 Hampton Roads Water Symposium

From K. Peterson-HRSD, 2016 Hampton Roads Water Symposium

Groundwater in the Wastewater System

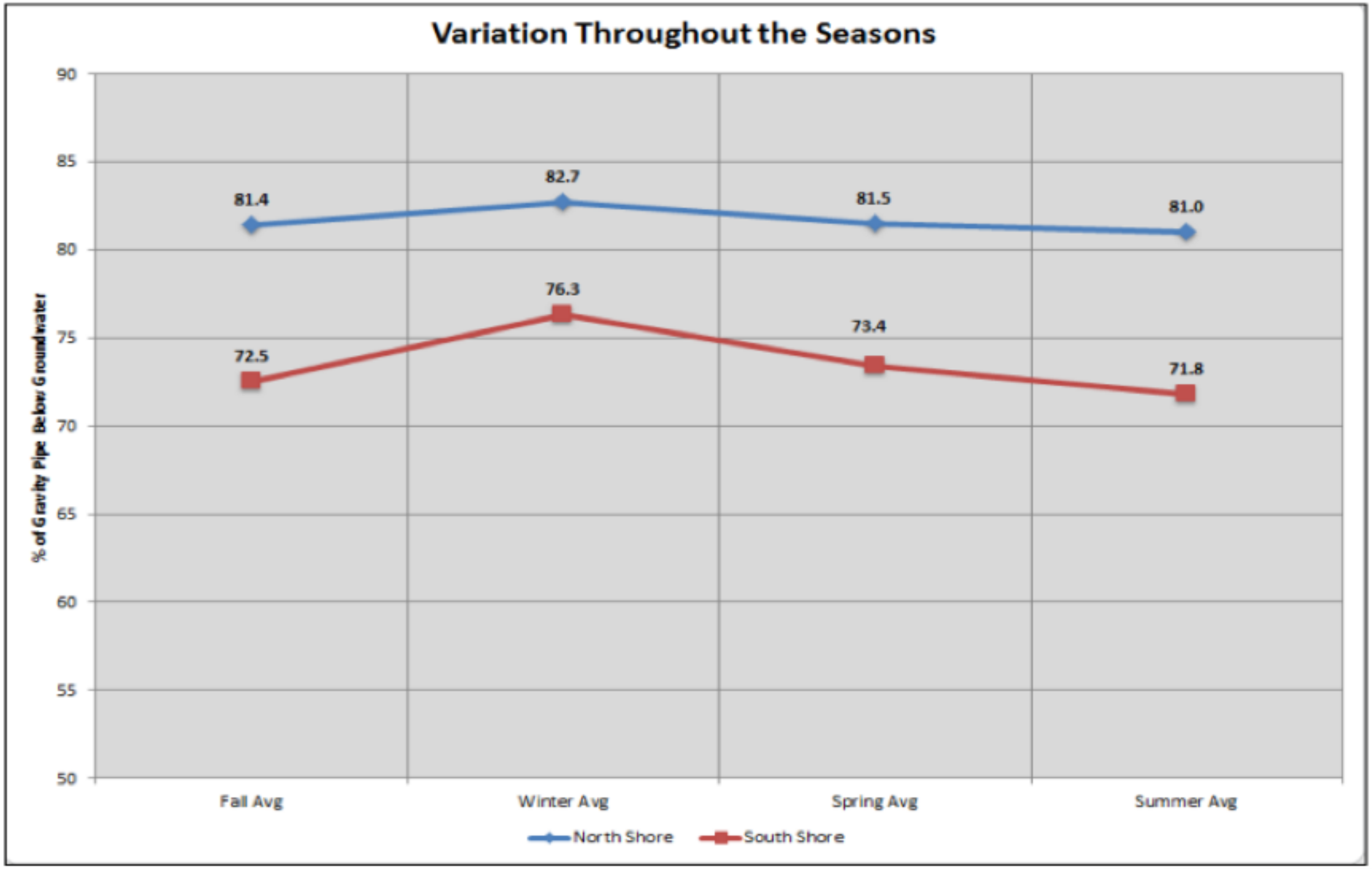


HRSD

From K. Peterson-HRSD, 2016 Hampton Roads Water Symposium

Infrastructure vs. Seasonal Groundwater Levels

- What percent of the gravity system is "potentially" below the groundwater?



HRSD

Rising Groundwater Levels –

- **Sewage infrastructure** - HRSD documented inflows from groundwater system. Additional water increases costs of treatment operation.

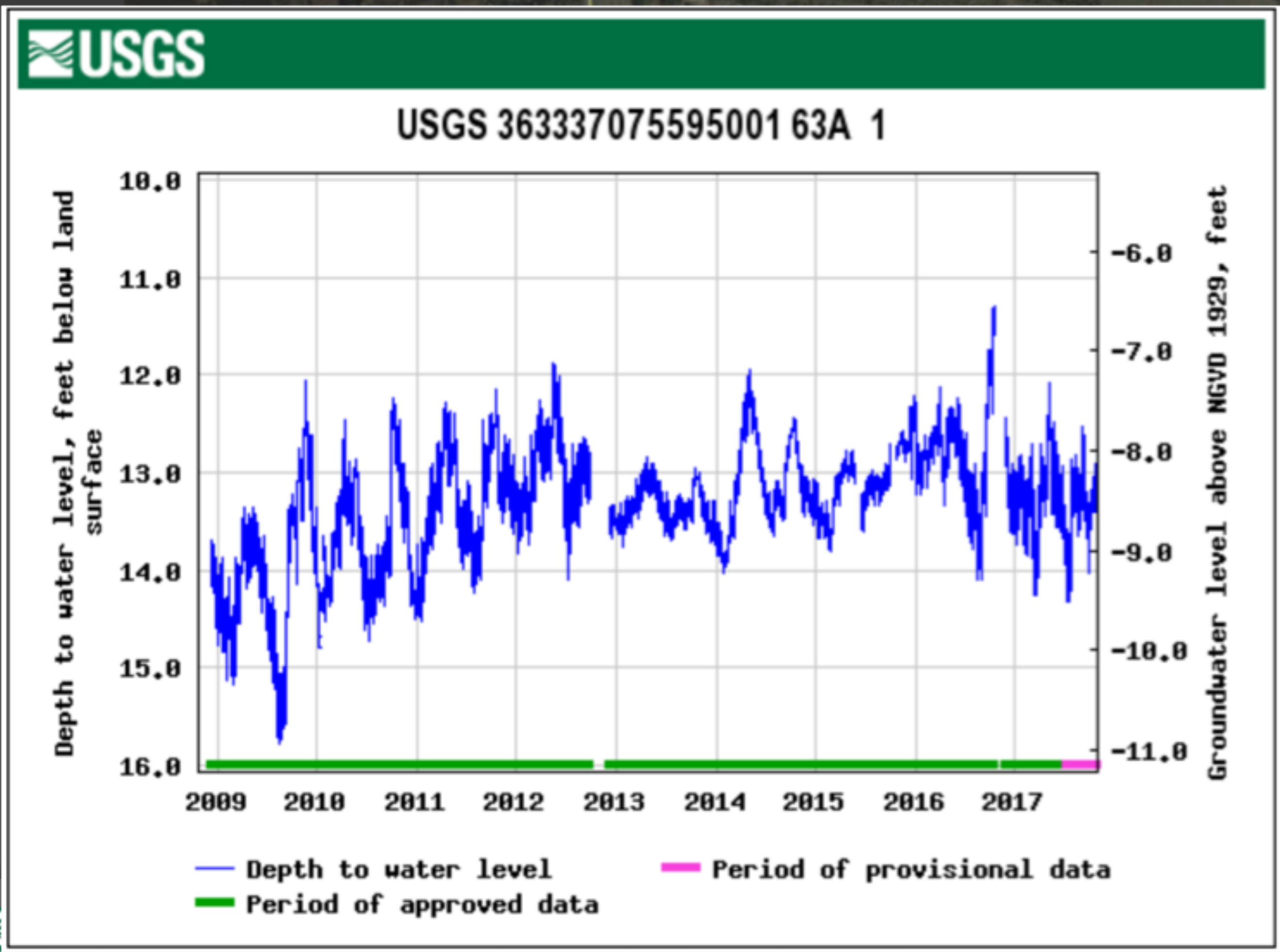
- **Onsite waste-water treatment** – Large scale applications are problematic where water tables are shallow.

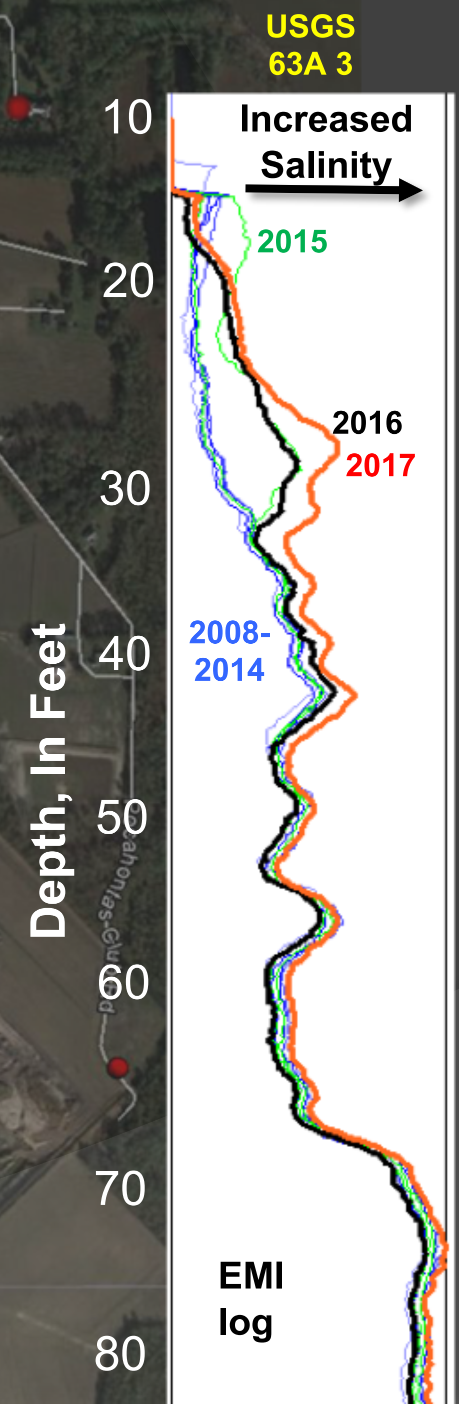
USGS
science for a changing world

Rising Groundwater Levels –

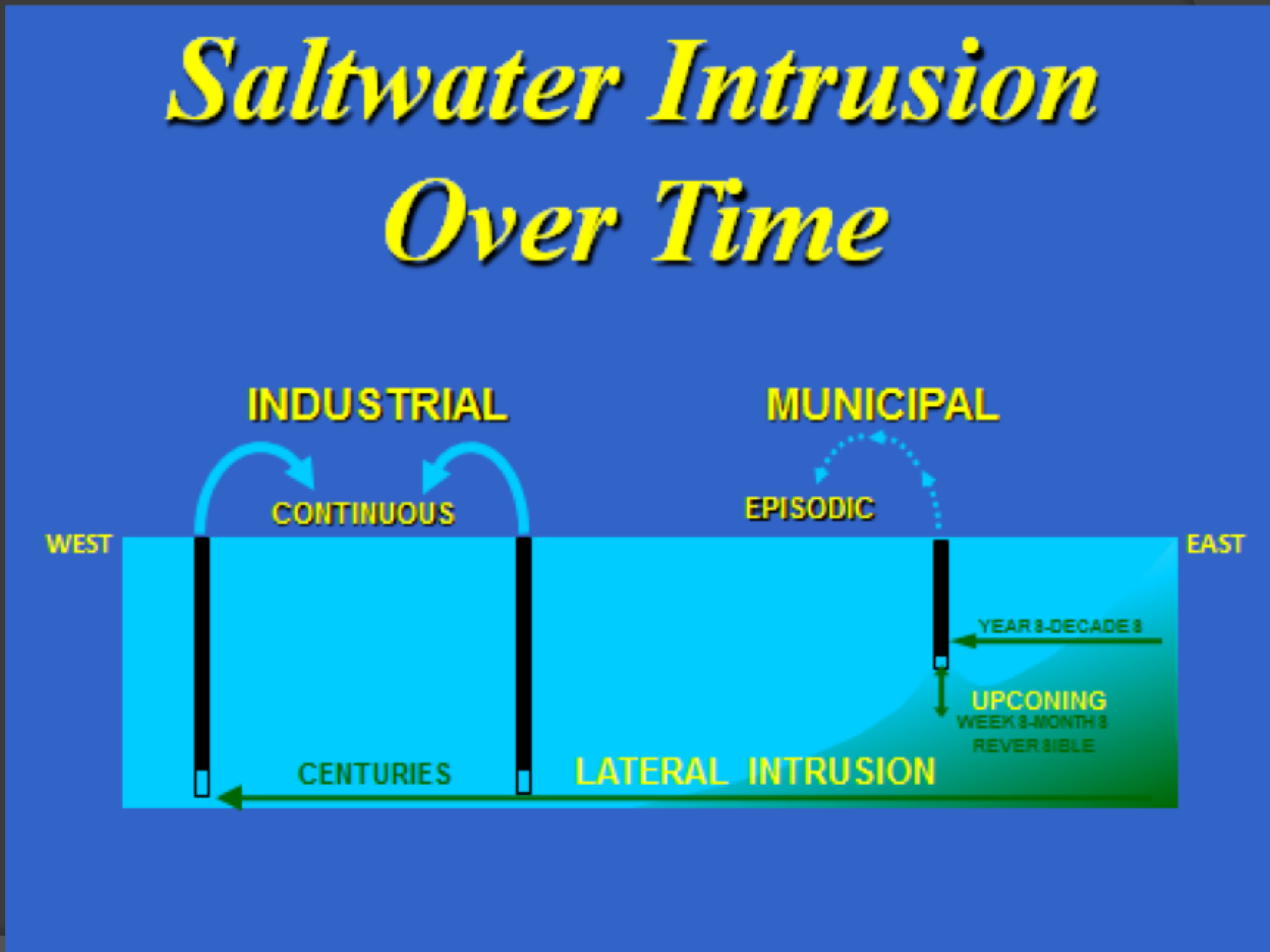
Water Quality Limitations on Water Availability

- **Saltwater intrusion**





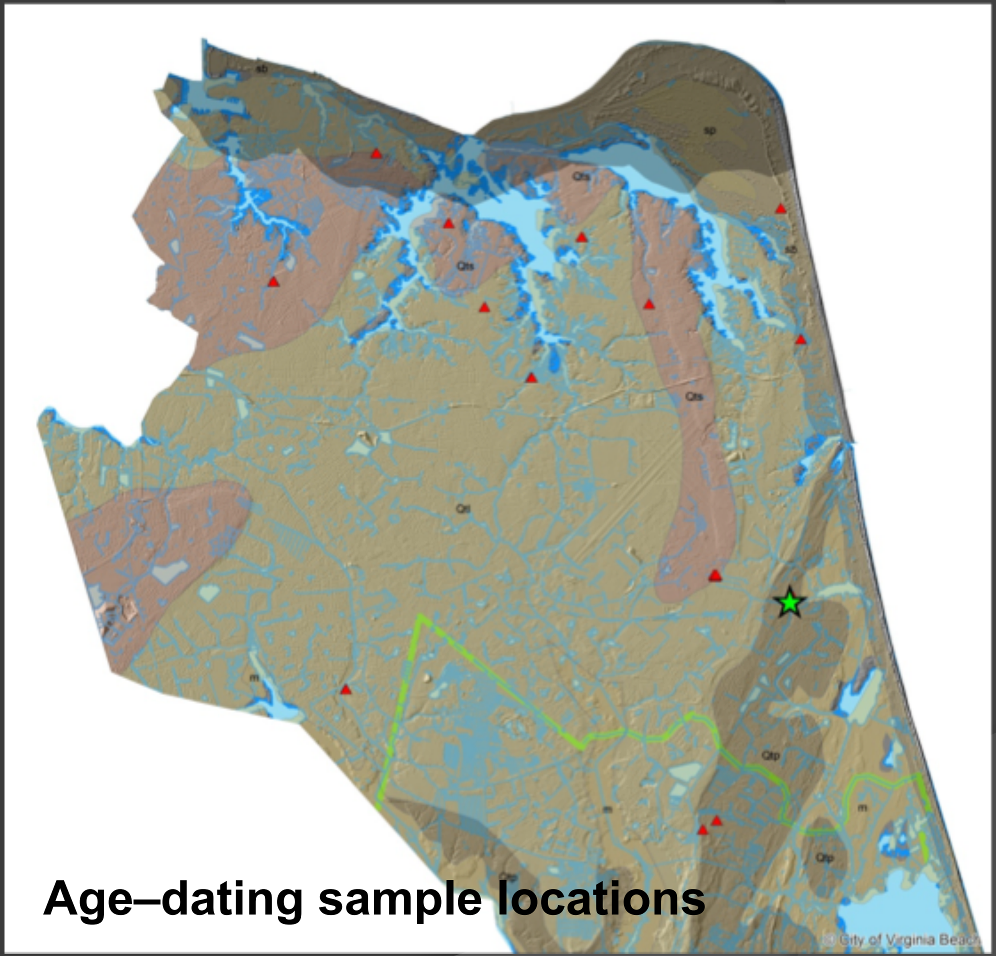
Rising Groundwater Levels –
Water Quality Limitations on Water Availability



Saline intrusion – Reversible? Not likely

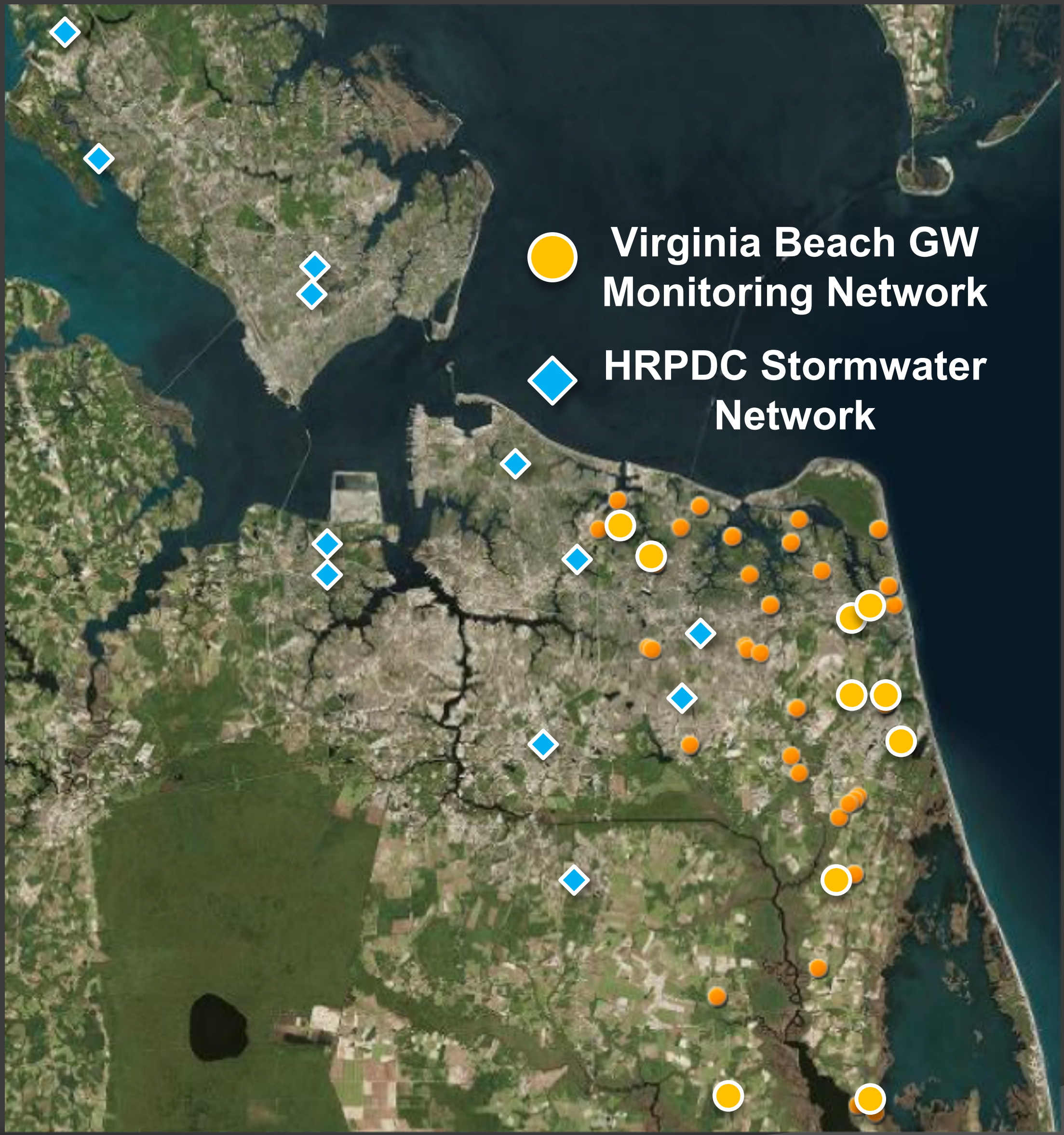
Inverse carbon-14 age dating models

- Shallow aquifers have been exposed to **freshwater flushing for 30,000 years**
- Relatively **thin freshwater lense** – 200 ft max. Majority of area <150 ft.
- **22% of shallow aquifer water contains residual seawater**
- Indicates **salt-water intrusion may be irreversible** on reasonable time-scales



Age–dating sample locations

Rising Groundwater Levels –
Water Quality Limitations on Water Availability



TMDLs/Rising GW

VA Tech/USGS Collaboration

1. **Shallow groundwater tables –** *Johnson, Sample, and McCoy (in press- JIDE)*

USGS 2013-2015 Sampling

1. **10 QW samples/yr**

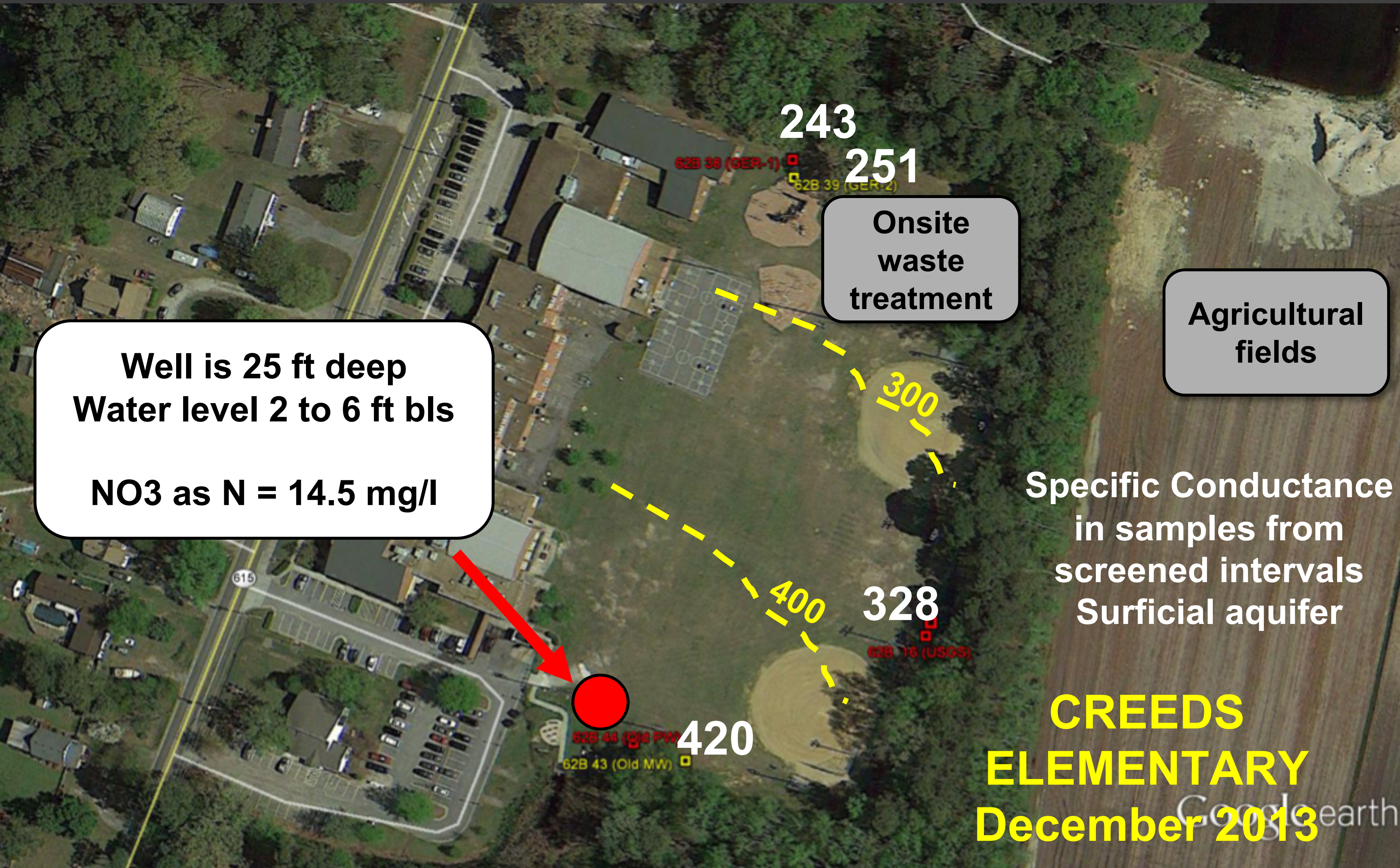
1. **Ecoli –** *Rapid transport of nutrients and coliphage in rural areas near onsite waste water infrastructure*

1. **Focus on <40 ft deep wells -** *Locally elevated nutrients in urban areas*

USGS

Rising Groundwater Levels –

Water Quality Limitations on Water Availability



BMP Efficacy –

A Chesapeake Bay Program STAC Workshop:
Monitoring and Assessing Impacts of Changes in Weather Patterns and Extreme Events on BMP Siting and Design

- **How anticipated changes in weather patterns and extreme events may affect the integrity of a subset of urban stormwater, agriculture, and stream restoration Best Management Practices (BMPs) over time**

- **Updated design storm curves that account for future climate change.**