Advances in Earth Science
Data for Decision Making

Mark Bennett
USGS Virginia and West Virginia Water Science Center
Consistent, long-term data is the foundation for our science and provides the basis for decision making by water resource managers.
- Understanding ecosystems and predicting ecosystem change

- Understanding climate variability and change

- Water availability and water use

- National hazards, risk, and resilience assessments
The Problem

High Rates of Relative Sea-Level Rise

- Portland: 1.82 mm/year
- Boston: 2.69 mm/year
- Providence: 1.99 mm/year
- Woods Hole: 2.61 mm/year
- Montauk: 2.73 mm/year
- Sandy Hook: 3.90 mm/year
- Baltimore: 3.68 mm/year
- Cape May: 4.06 mm/year
- Lewisetta: 4.97 mm/year
- Gloucester Point: 3.61 mm/year
- Sewells Point: 4.44 mm/year
- Duck: 4.59 mm/year
- Oregon Inlet Marina: 2.82 mm/year
- Beaufort: 2.57 mm/year
- Southport: 2.08 mm/year
- Charleston: 3.15 mm/year
- Fort Pulaski: 2.98 mm/year
- Mayport: 2.40 mm/year

NOAA Sea-Level Trend Data (Zervas, 2009)

Thieler and Hammar-Klose, 1999, USGS, OFR 99-593

Why it is Important

Very High Vulnerability to Sea-Level Rise

EXPLANATION
RISK RANKING
- Low
- Moderate
- High
- Very High

COASTAL VULNERABILITY INDEX

Data: NCEI, NOAA, U.S. Navy, NGA, NCEA, NCEC

Map: Google Earth

Thieler and Hammar-Klose, 1999, USGS, OFR 99-593
Infrastructure, Historic Sites, and Ecosystems Affected by Sea-Level Rise

1.7 Million people

Historic Resources

Military Bases

Coastal Marsh Ecosystems
Sea-Levels at Sewells Pt., Norfolk
NOAA# 8638610

- Sewell’s Point monthly mean sea level
- Average trend of Sewell’s Point monthly means
- Average global sea level
- Starting elevation in 1927

Elevation, in meters NAVD 88

Year
1900 1920 1940 1960 1980 2000 2020

4.4 mm/yr
1.8 mm/yr
Land Subsidence 1940-1970 (mm/yr)

Published by National Geodetic Survey

Holdahl and Morrison, 1974, Tectonophysics, 23(4), p. 373–390
Coastal Virginia Tide and Storm Monitoring

- USGS Surge-Wave-and-Tidal-Hydrodynamics
- Continuous sites expansion started as a result of USGS Hurricane Sandy Funding and local contacts
- 26 continuous sites (25 new)
- 13 Rapid deployment gages
- 14 storm-tide locations
- 2 wave transsects

Coordination and Funding
- Localities (10)
- NWS & NOAA CO-OPS
- NASA and COE
- USGS
Subsidence Monitoring Network (Re)-Establishment

Suffolk
58C 52

Franklin
55B 60

Legend
- NGS CORS
- USGS Extensometer
- USGS Tide Gage
- NOAA Tide Gage

New extensometer
Total Nitrogen per Acre Loads and Trends: 2005-2014

Improving Trends = 44 of 81 (54%)
Degrading Trends = 22 of 81 (27%)
No Trend = 15 of 81 (19%)

Of the 14 stations with the highest per acre loads for Total Nitrogen:
• 6 have improving trends
• 3 have degrading trends
• 4 have no trends
• 1 has insufficient data for trends
Changes in Nitrogen per Acre Loads: 2005-2014

Trend in load network is the first of its kind

Improving Trends = 44 of 81 (54%)
Degrading Trends = 22 of 81 (27%)
No Trend = 15 of 81 (19%)

Improving Stations
Range = -0.10 to -5.07 lbs/ac
Median = -0.68 lbs/ac (-10.0%)

Degrading Stations
Range = 0.04 to 1.21 lbs/ac
Median = 0.33 lbs/ac (7.84%)

Download figure: http://cbrim.er.usgs.gov/maps.html
Assessing Watershed Scale Responses to BMP Implementation in Fairfax County

1. Generate long-term monitoring data to describe:
   - Current water-quality conditions,
   - Trends in water-quality, nutrient and sediment loads and yields.

2. Evaluate relations between observed conditions/trends and BMP implementation.

3. Transfer the understanding gained to other less-intensively monitored watersheds.
Network

- Site selection optimized using statistical analyses and local knowledge
- All watersheds < 5 mi²
THE GREAT DISMAL SWAMP

Hydrologic Response to Increased Water Management Capability at the Great Dismal Swamp National Wildlife Refuge: Enhancing Resiliency for Wildlife and People

Collaborative effort among:

- U.S. Fish and Wildlife Service
- USGS Virginia Water Science Center
- The Nature Conservancy
- The City of Chesapeake
- Virginia Department of Conservation and Recreation, Division of Game and Inland Fisheries
- U.S. Army Corps of Engineers
THE GREAT DISMAL SWAMP

Hydrologic Response to Increased Water Management Capability at the Great Dismal Swamp National Wildlife Refuge: Enhancing Resiliency for Wildlife and People

Objective:

To assess the hydrologic response to increased water management and use the assessment to help design improved management strategies that (1) improve habitats by increasing the wetness and peat formation in the swamp, (2) reduce downstream flooding, and (3) reduce the risk of catastrophic fires.

Roots Exposed by Decomposing Peat

Burned Peat and Atlantic White Cedar Stumps– South One Fire, June 9-October 11, 2008
Hydrologic Response to Increased Water Management Capability at the Great Dismal Swamp National Wildlife Refuge: Enhancing Resiliency for Wildlife and People

**Approach:**

- Water-control structures are being installed and repaired on ditches to better manage the discharge of water from the peat.
- Water will be managed to enhance habitats, reduce downstream flooding, reduce the risk of catastrophic fire, and improve water quality.
- Groundwater and ditch levels, precipitation, soil-moisture, and water-quality will be monitored before structure installation.
- Developing model to simulate the impact of opening and closing water control structures
Objective:

To (1) characterize changes in potential carbon sequestration through the effects of groundwater levels and soil moisture on aboveground biomass, and peat thickness; (2) estimate the effects of refuge hydrologic management and restoration on carbon sequestration and maintaining resilient, target, plant communities; and (3) provide an assessment and valuation of select ecosystem services deemed important to FWS and other stakeholders.
Characterizing the response of stream low-flows to precipitation and climate.

A cooperative project with
Purpose.

- Build upon our low-flow analyses from 2010 to...

- **Extend the lead time for drought response.**

- Improve and extend DEQ’s drought response information and services throughout Virginia.

- Deepen our understandings of interactions among precipitation, low-flow, and other basin variables.
Concept: Effective recharge window.

We began to appreciate the idea that ...

- Rainfall during the N-D-J-F “recharge months” (before “leaf-out”), is linked to summer stream flow.

- Recharge during this critical time may drive water availability during summer low-flow months.
Drought probability using: Maximum likelihood logistic regressions.

Example maximum likelihood probability plots describing the chance that average monthly flow will exceed median August POR return flow as a function of the average of combined N-D-J-F mean monthly flows for station number 02039500, Appomattox River near Farmville, Virginia.

August as $F(\text{Ave. Combined N-D-J-F})$ Probability Plot

![Probability Plot](image)