Improving Water Reuse for a Much Healthier Potomac Watershed

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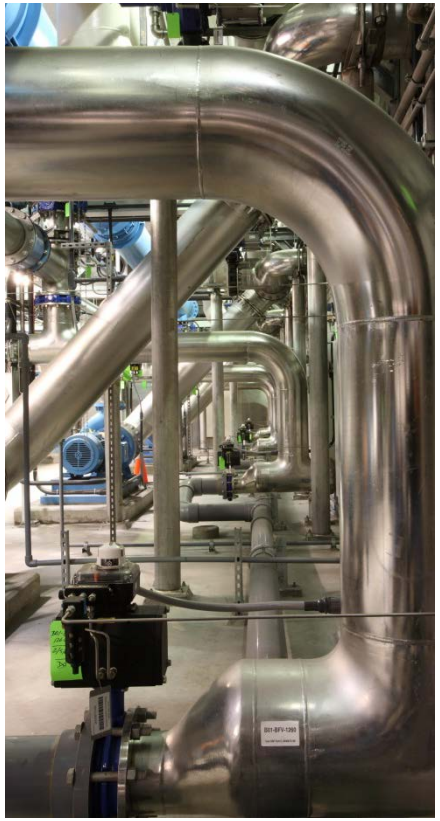


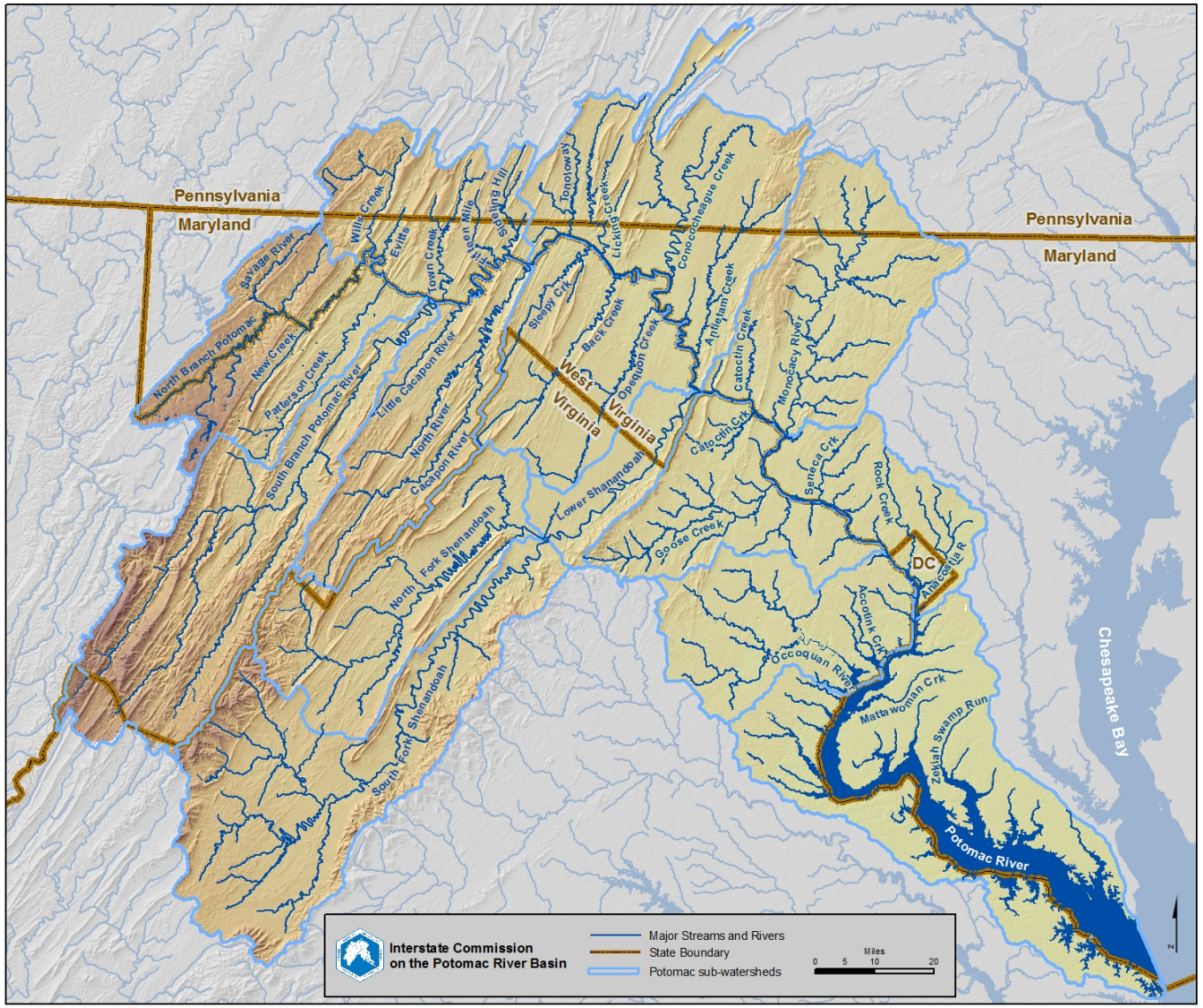
Project Team

- Dr. Sujay Kaushal – University of Maryland
- Dr. Shuiwang Duan – University of Maryland
- Dr. Diana Aga – University at Buffalo
- Dr. Adil Godrej – Virginia Tech
- Dr. Luke Iwanowicz – U.S. Geological Service
- Dr. Erik Rosenfeldt – Hazen and Sawyer
- Dr. Sudhir Murthy – DC Water

Project Advisory Committee (PAC)

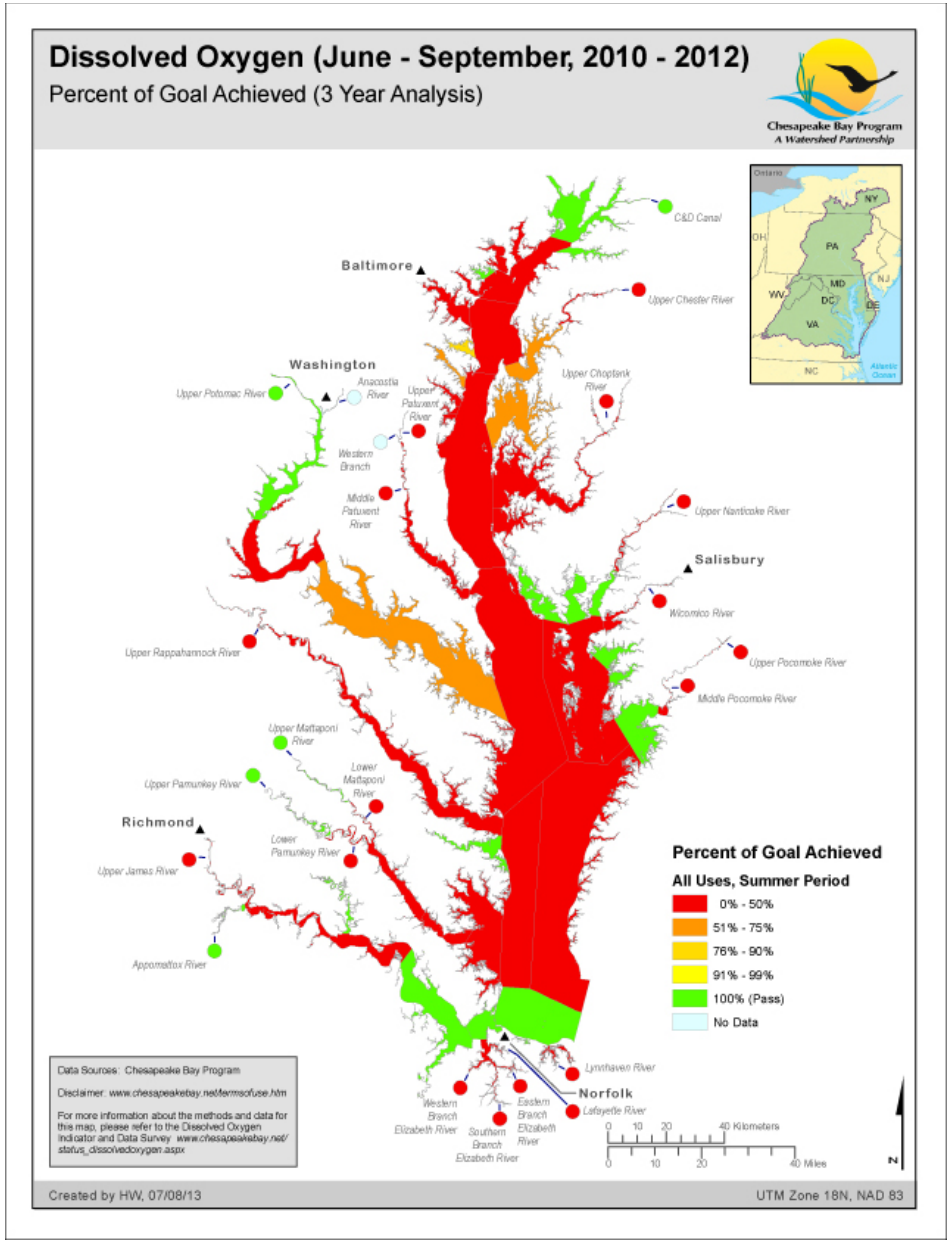
- Bob Angeliotti – Upper Occoquan Service Authority
- Dr. Rominder Suri – Temple University
- Leita Bennett – GHD
- Steven Bieber – Metropolitan Washington Council of Governments

Potomac River Watershed



Nutrients

- Wide variety of land uses in Potomac watershed
- TMDL established in 2010 for Chesapeake Bay
- Economic value in fisheries
  - $3.39 billion in sales
  - $890 million in income
  - Nearly 34,000 jobs to the local economy



Endocrine Disrupting Compounds

Speaking of Science

These fish started life as boys. Now scientists aren't sure what sex they are.

- Biogenic hormones

Sex-change chemicals in Potomac

Potential sources

- Municipal wastewater
- Stormwater

Intersex Fish Linked To Population And Agriculture In Potomac River Watershed

Health & Science

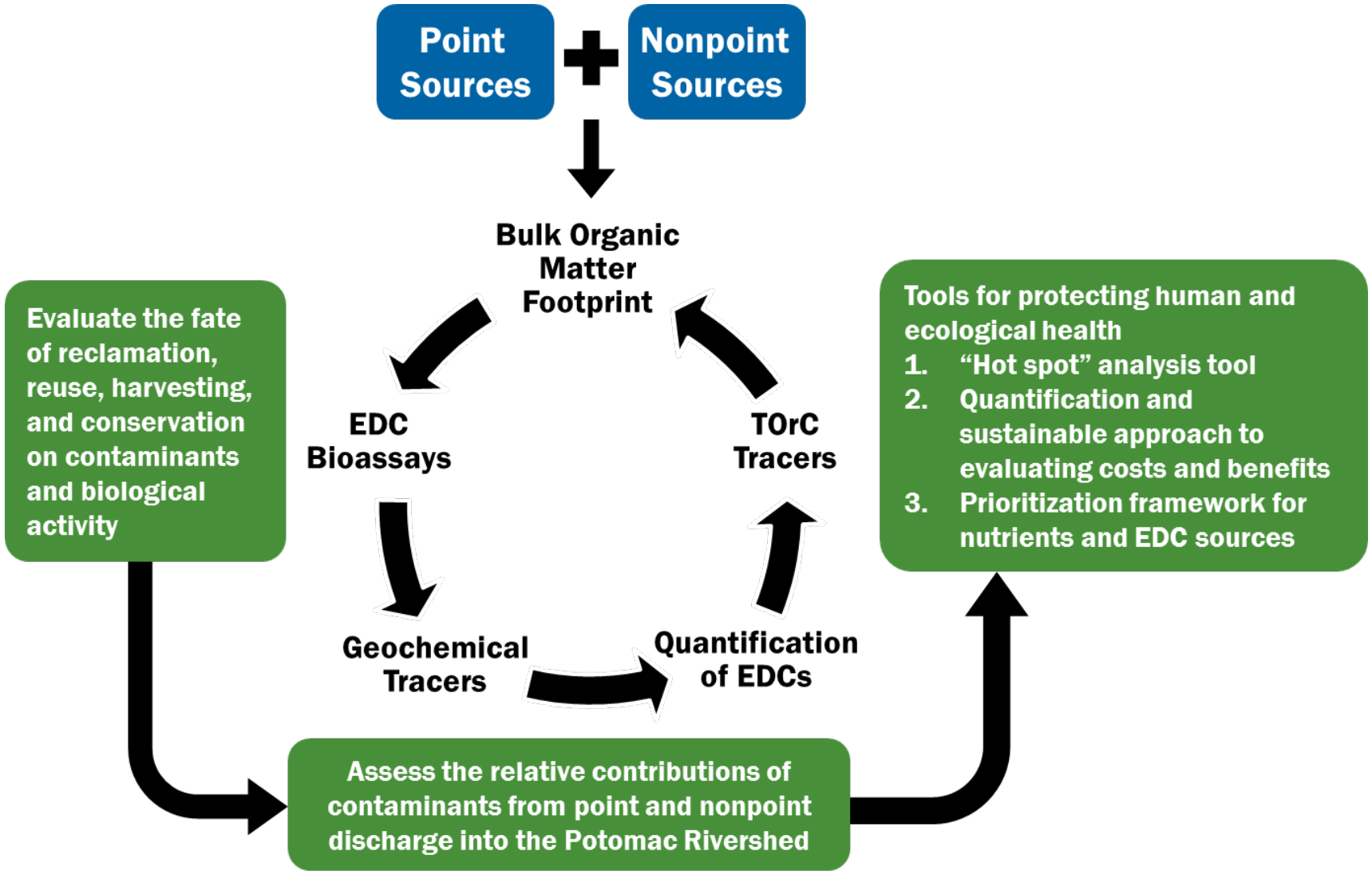
As more male bass switch sex, a strange fish story expands

Endocrine Disrupting Compounds

Land-Use	Intersex Prevalence		Intersex Severity	
	r^2	p	r^2	p
Human population density	0.39	0.10	0.42	0.08
Number of WWTPs	0.22	0.24	0.34	0.13
WWTP flow	0.32	0.15	0.63	0.02
Percent agricultural land use	0.63	0.02	0.50	0.05
Number of animal feeding operations	0.28	0.17	0.56	0.03
Number of poultry houses	0.27	0.18	0.50	0.05
Total number of animals	0.27	0.18	0.48	0.06
Animal density	0.49	0.05	0.58	0.03

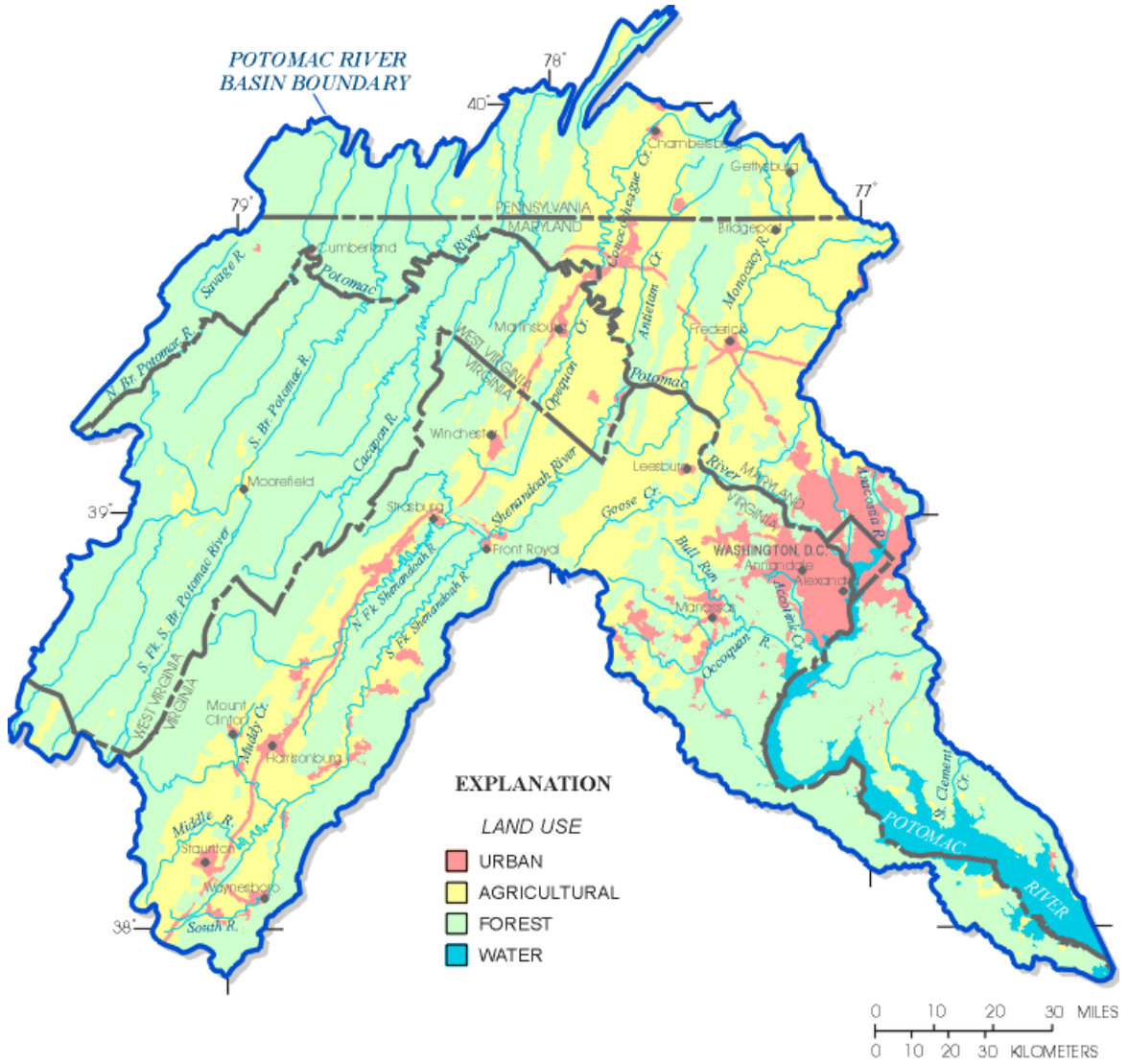
Modified from Blazer et al., 2011

Conceptual Model for Managing Pollutants



Year 1 – Hot Spot Analysis

- Identify and track spatial variations in "hot spots" of EDCs, biological activity, and nutrients
- USGS and Chesapeake Bay Program sites
- Includes sites impacted by treated wastewaters, mineral fertilizers, animal manure, and atmospheric deposition



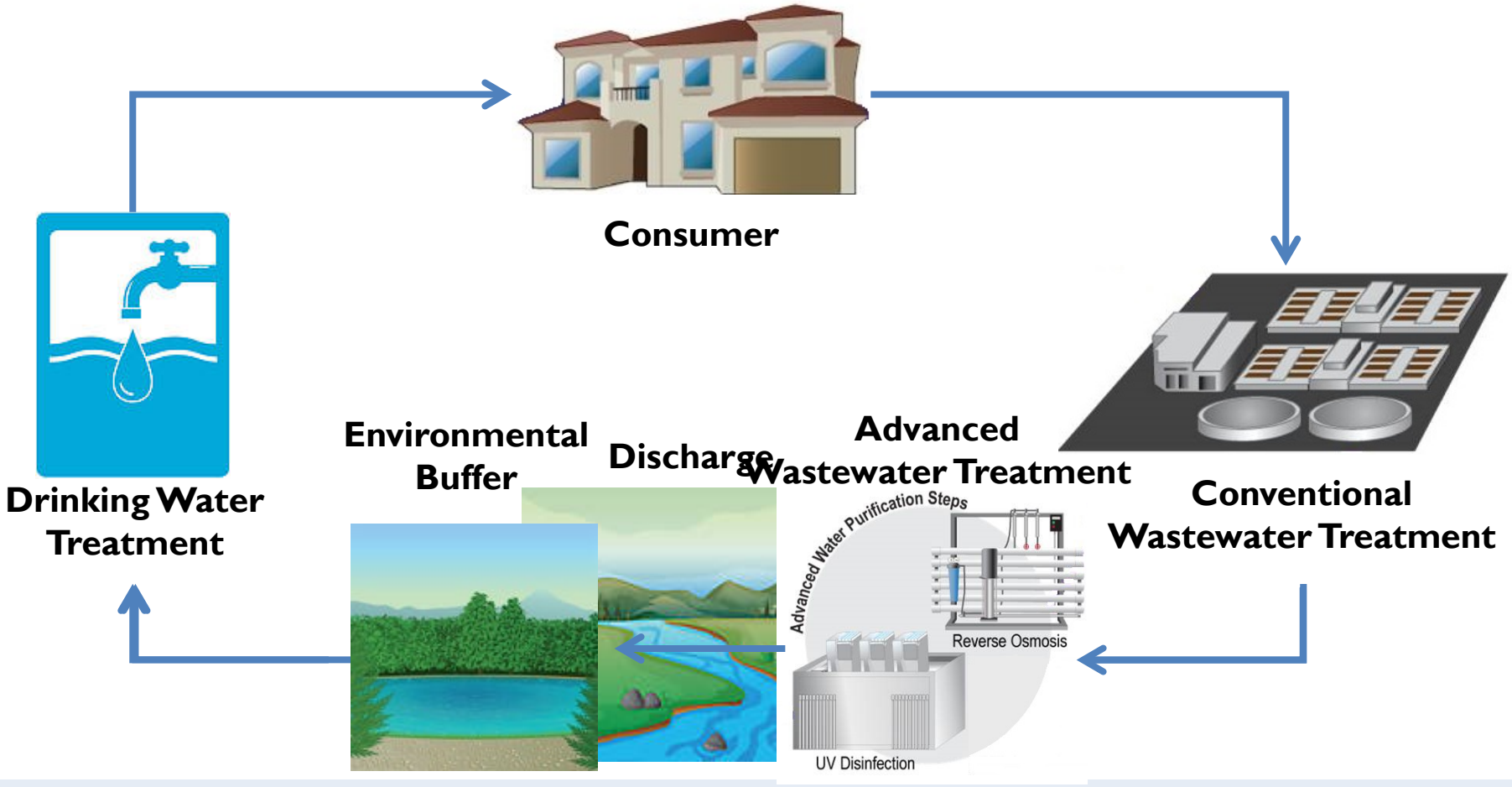
Year 2a – Impact of current management strategies

- Effects of water reuse, stormwater harvesting, and management practices
- Sites to be chosen in coordination with PAC based on the results of Year 1

Advanced reclamation	Conventional reclamation
Stormwater reuse	Unmanaged stormwater
Managed agriculture (e.g. riparian buffers)	Unmanaged agriculture

Year 2b – Impact of planned potable reuse

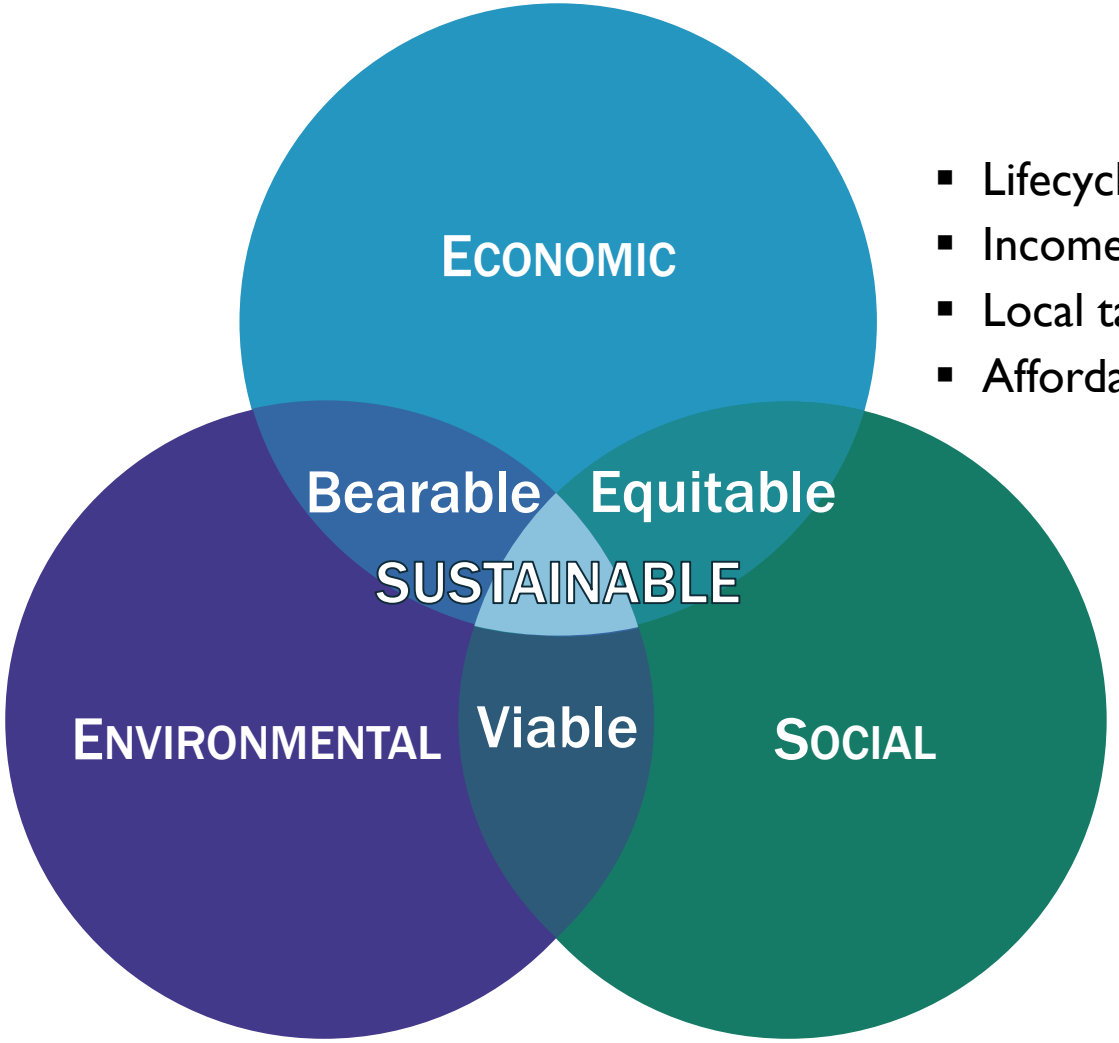
Pilot-level studies on the impact of planned and unplanned water reuse



Year 3 – Cost-benefit analysis

- Incorporate economic and societal factors
- Framework with three components
  1. EDC and nutrient sources – seasonal and spatial variability
  2. Proportion of EDC and nutrient sources along 10 sections of the Potomac
  3. Effectiveness of management strategies
- Output of potential EDC and nutrient reduction in the Potomac River watershed

Triple-Bottom Line Approach

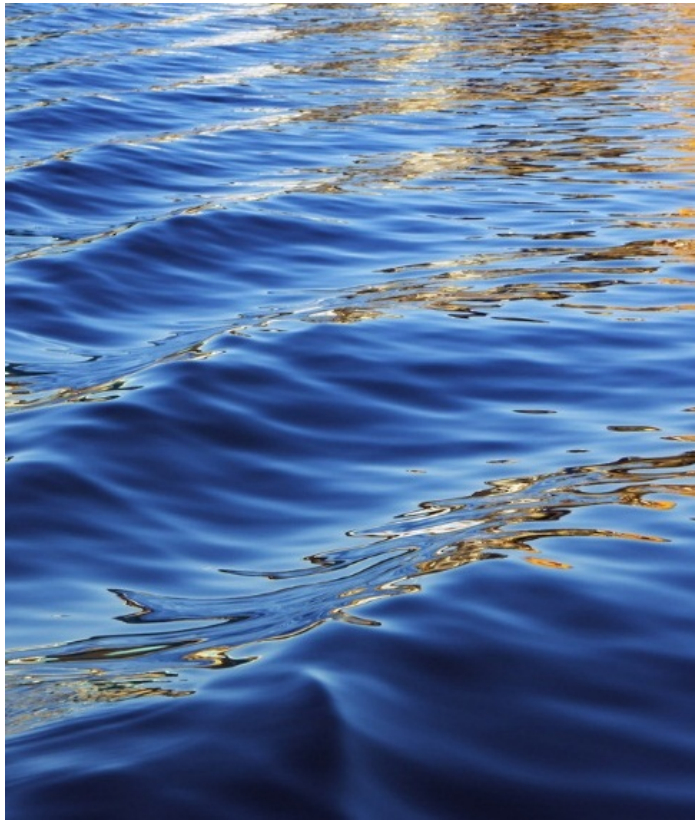


- Lifecycle cost
- Income
- Local tax revenue
- Affordability

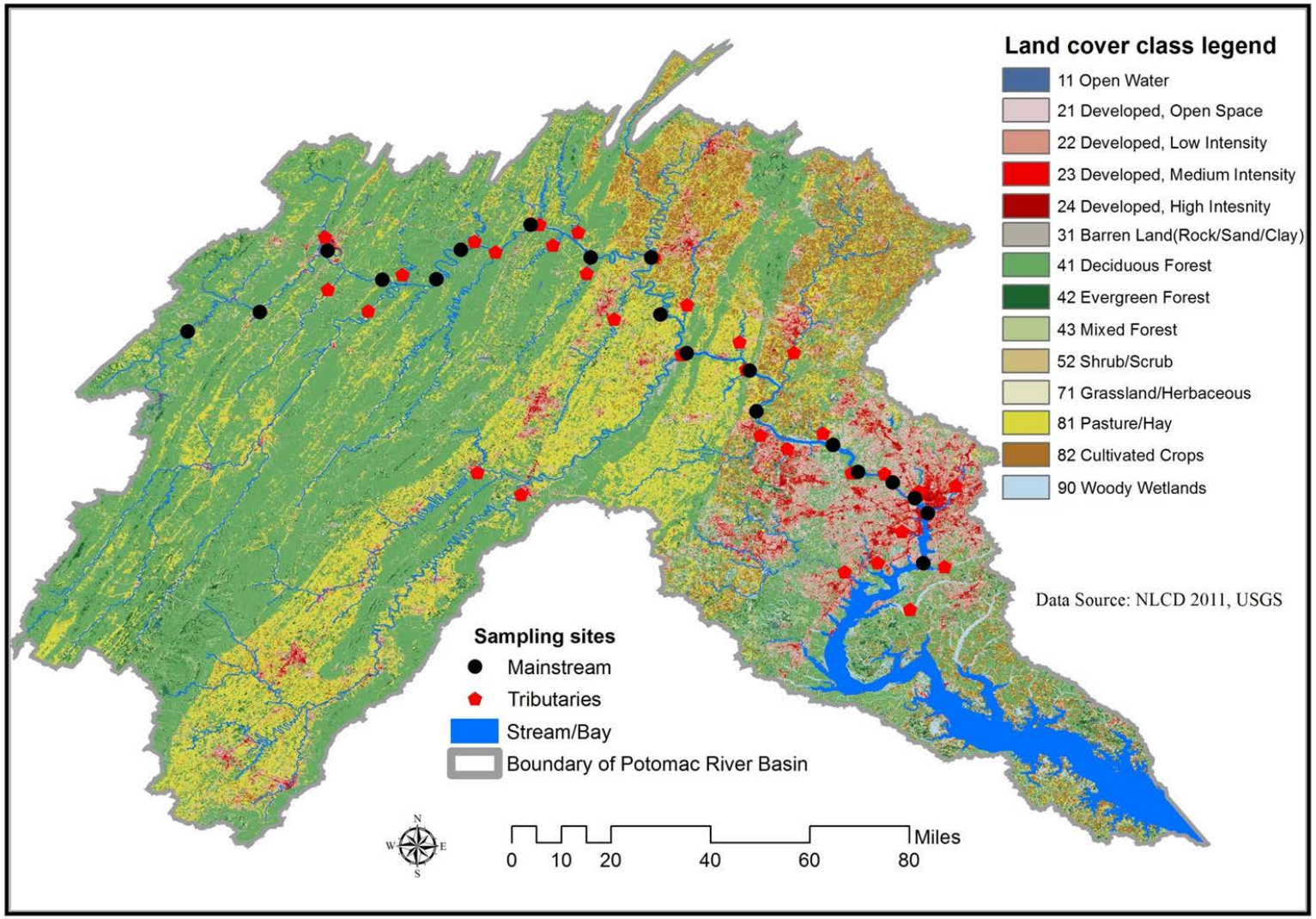
- Water quality
- Air quality
- Carbon footprint
- Land footprint
- Eutrophication and ecosystem impact

- Recreation
- Property Values
- Job growth
- Public health
- Water shortage impact
- Public perception

Sampling Sites and Preliminary Results



Sampling sites in August 2016 (19 main stem site and 31 headwater sub-watershed sites)



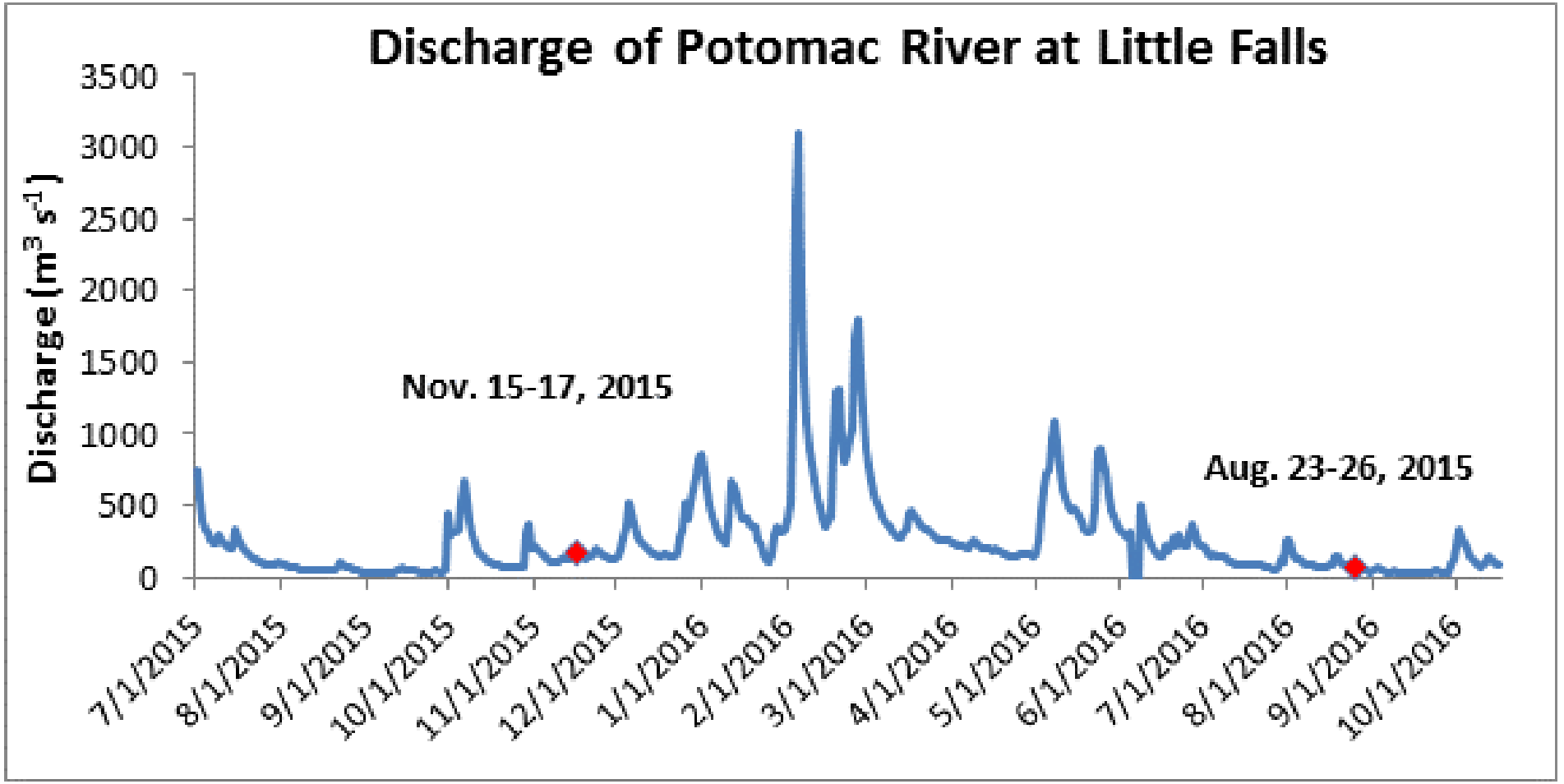
Sampling the Land Use Gradient

Upper Potomac: **Forest**

Middle Potomac: **Agriculture**

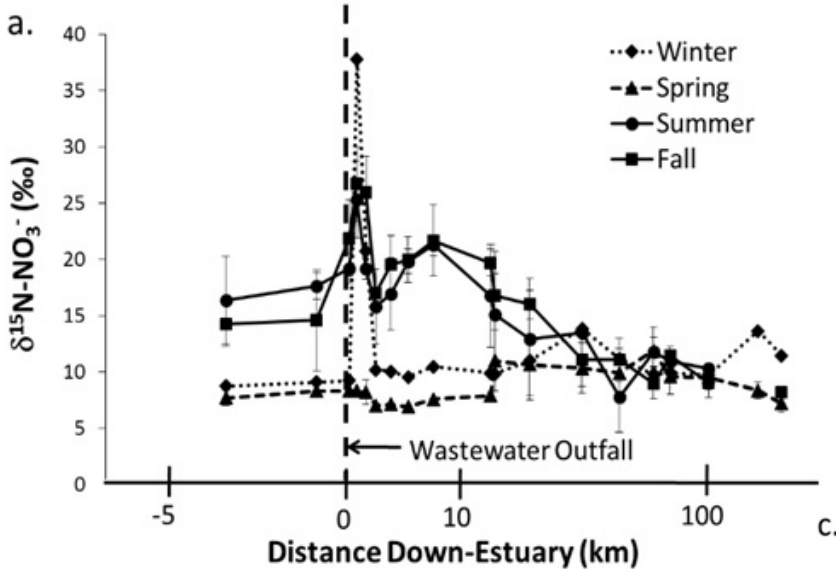
Lower Potomac: **Urban**

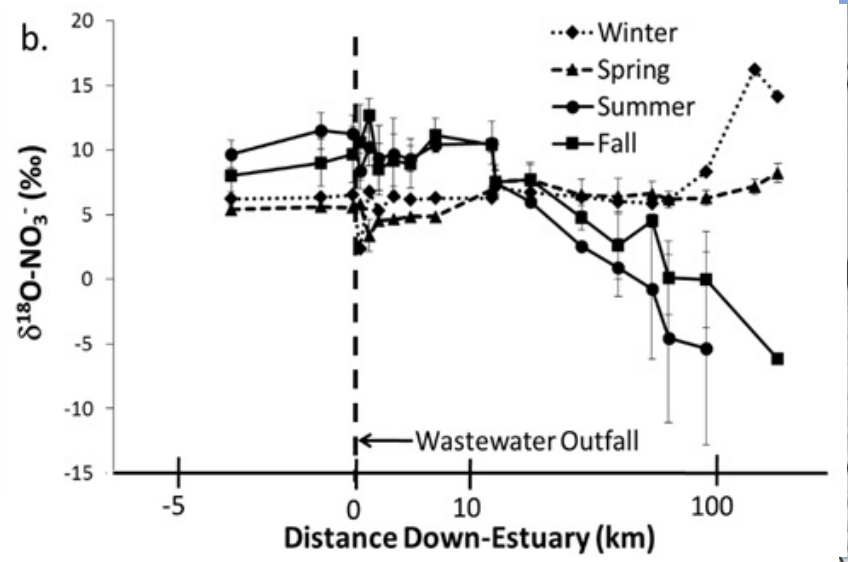
Hot Spot Sampling at Baseflow

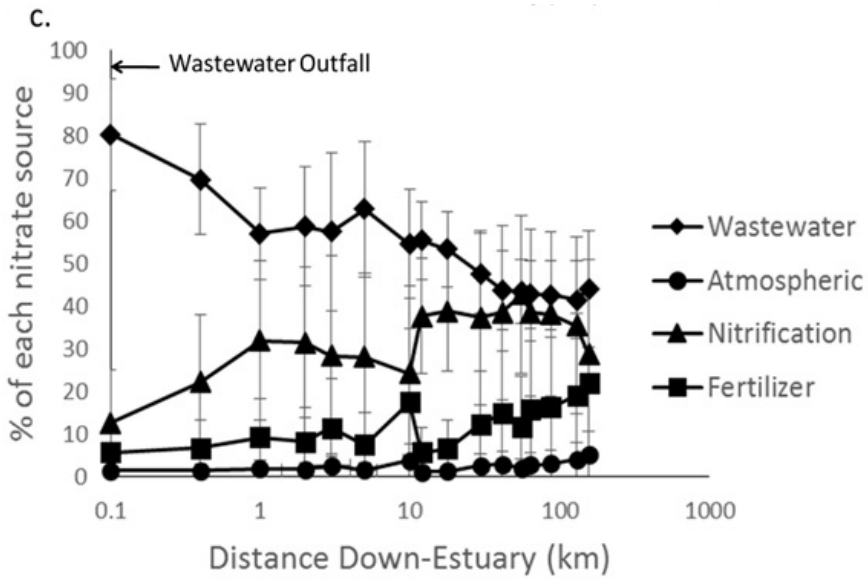


Fall 2015 (middle flow) and Summer 2016 (base flow)

Tracking Nitrogen Sources Along the Potomac River







Pennino, Kaushal, Murthy et al. (2016)

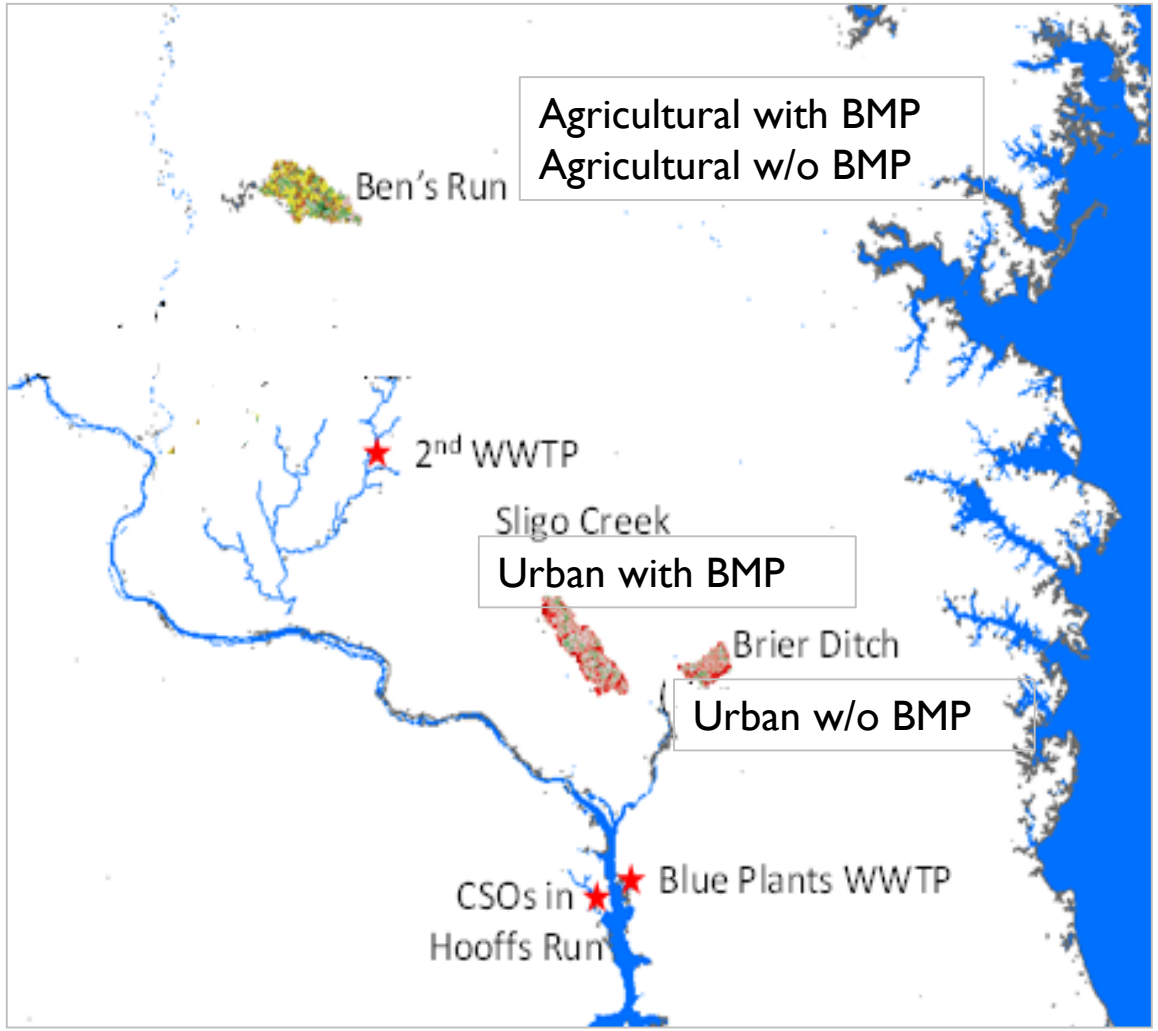
Evaluating Sources and Management of Nitrogen and EDC's

- **Paired streams**

↕ **Agricultural w/o BMP**
↕ **Agricultural with BMP**

↕ **Urban w/o BMP**
↕ **Urban with BMP**

Efficiencies of stormwater BMPs = w/o BMP - with BMP



Rosenfeldt et al. DC Council Project

Agricultural BMPs

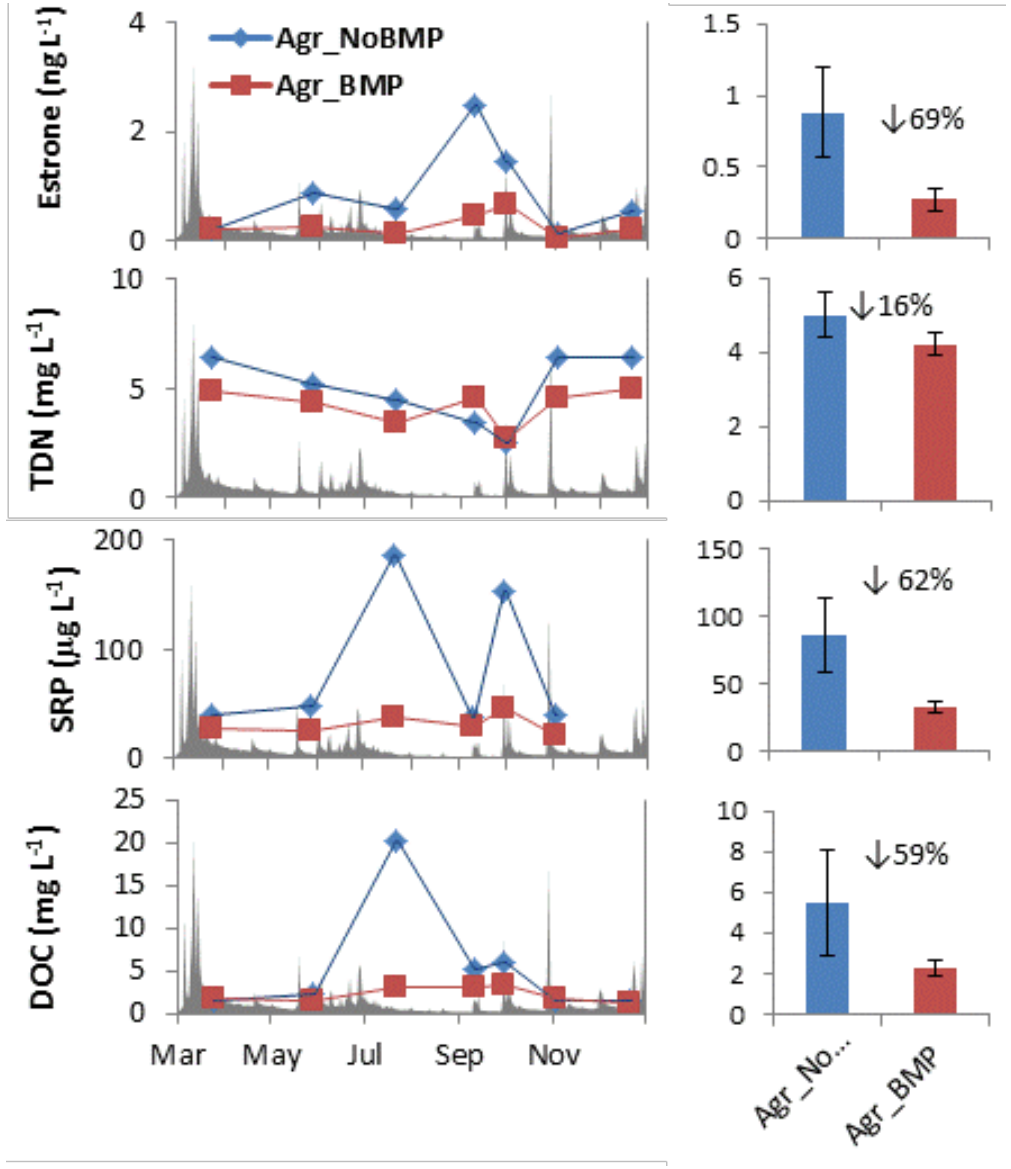
- Fencing
- Spring to replace in-stream cattle watering
- Stream crossings
- Plantings of cool season grasses

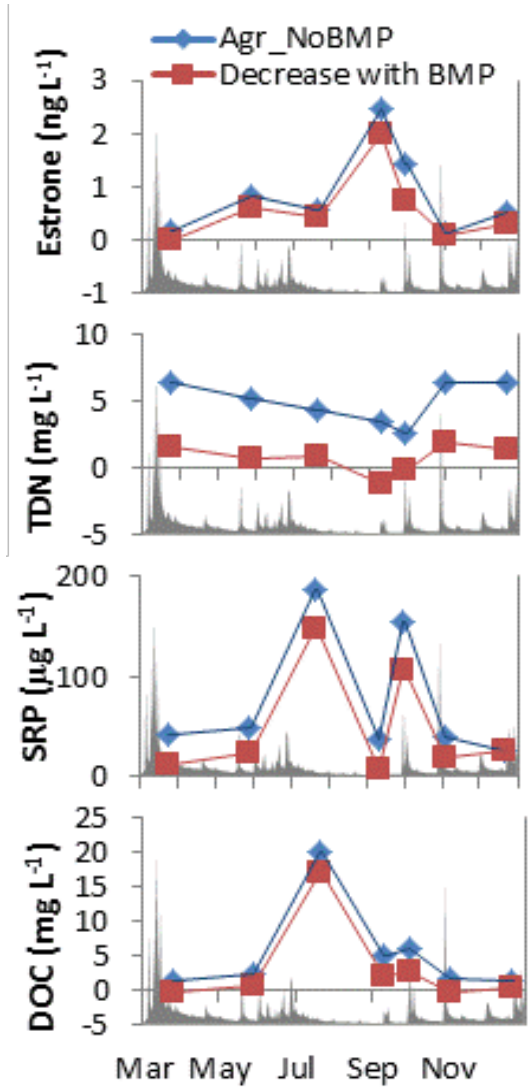
Decreases in TP concentrations

2006 – Fencing installation began (visible erosion)

Autumn 2007 – Fencing in place, and the riparian area is reverting back to its natural state.

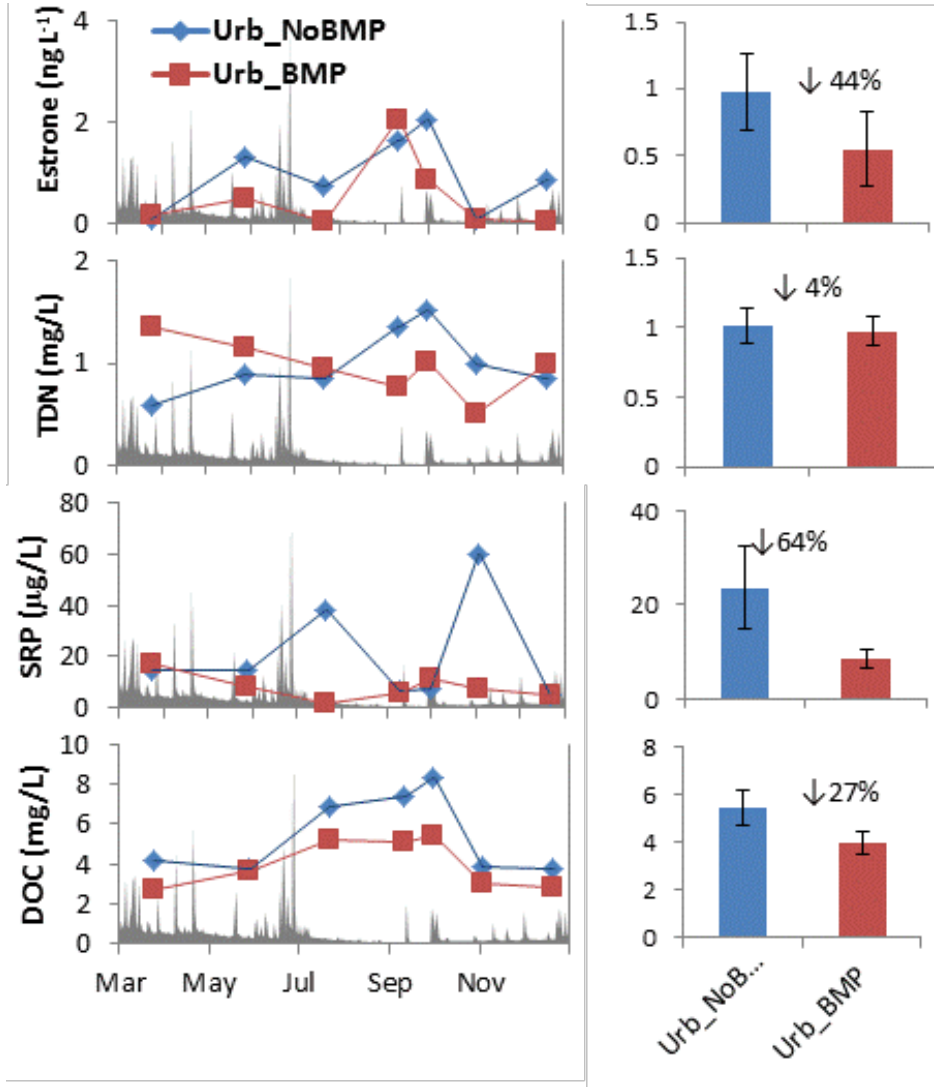
Agricultural BMPs reduce Estrogen, N, P, or C inputs

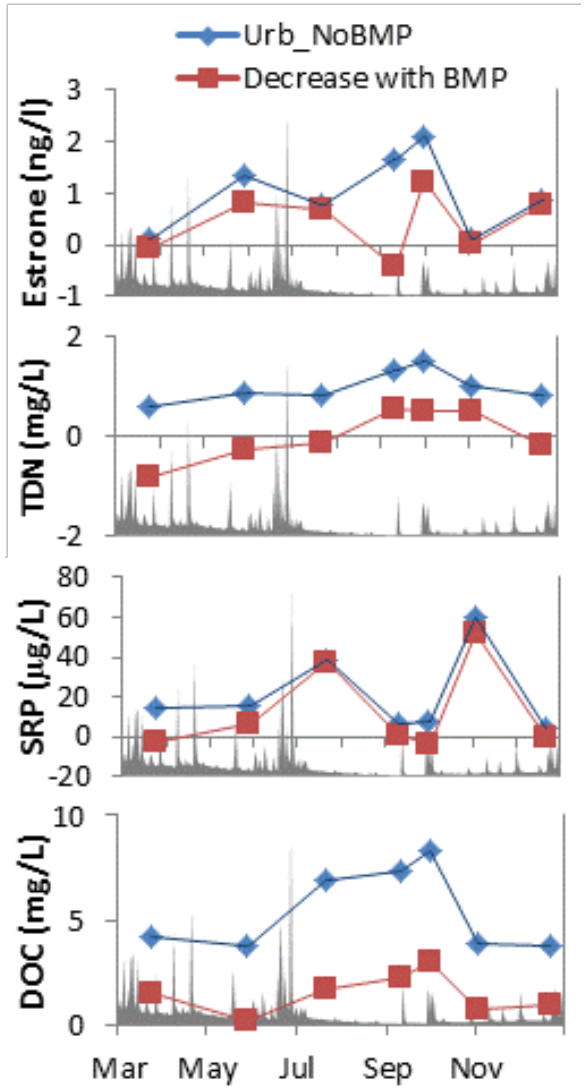




Duan et al. In Prep. w/ Rosenfeldt, Aga, Iwanowicz, Kaushal

Urban BMPs reduce Estrogen, P or C inputs





Duan et al. In Prep. w/ Rosenfeldt, Aga, Iwanowicz, Kaushal

Next Steps

Continuing Isotopic analyses

- Nitrate isotopes for N source
- Fluorescence scan for carbon source
- Carbon and nitrogen data for particulate sources

Analyzing EDC chemicals and reactivity

Continue seasonal sampling of hot spots