Impacts of Anthropogenic EDCS and the Role of Reuse and Conservation on the Quality of the Potomac River

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THE Water Research FOUNDATION

EPA United States Environmental Protection Agency

Agenda

- Project Drivers – Previous Research in the Potomac
- Review of DC DOE project
- Initial Results from EPA STAR Year 1 and Year 2
- Direction of research in 2019 and 2020
  - Beyond Preliminary Results
- Additional research needs

Project Driver: Intersex fish in Potomac Watersheds

The Washington Post

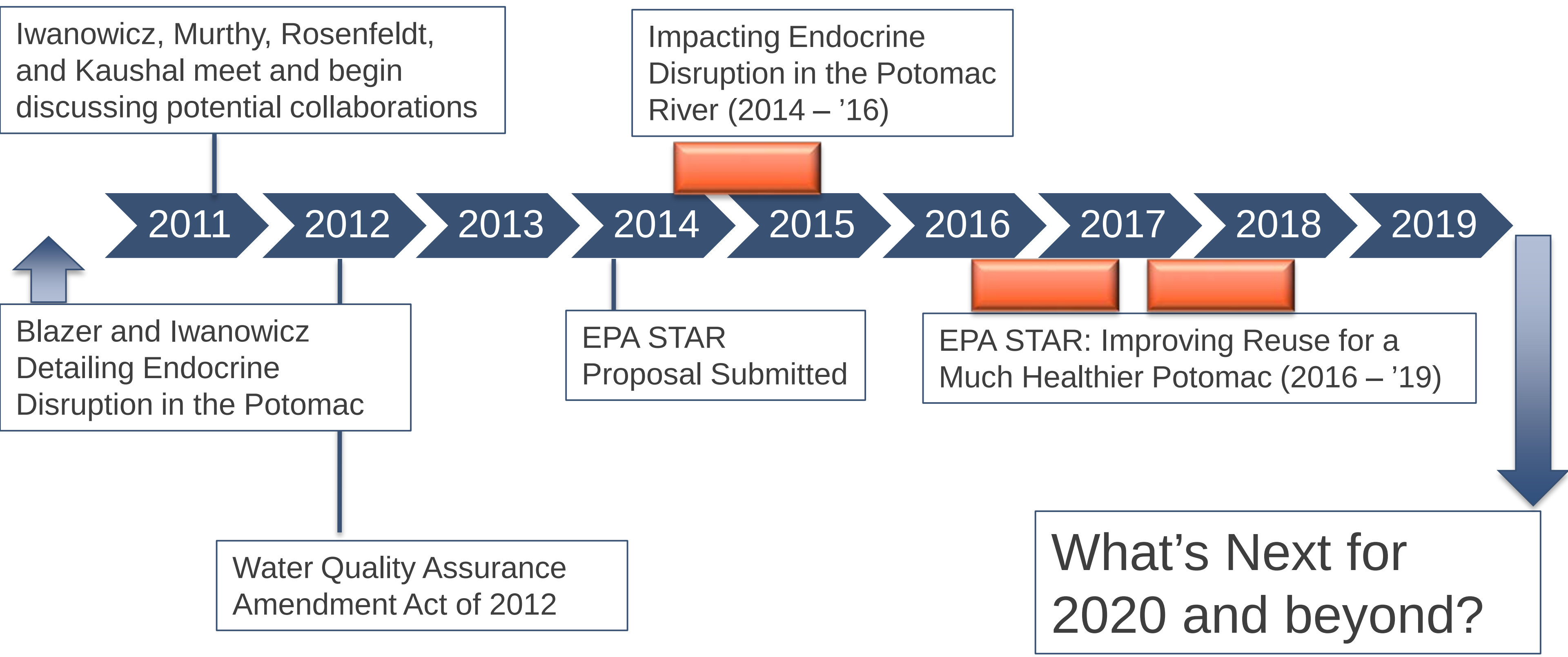
Health & Science

Bay's smallmouth bass under siege, report says

Chesapeake Bay News Aug 09 2012
Intersex fish widespread in Potomac River basin

Intersex Fish Now in Three Pennsylvania River Basins
Released: 6/30/2014 7:00:00 AM
http://www.usgs.gov/newsroom

Timeline of Potomac Research Projects

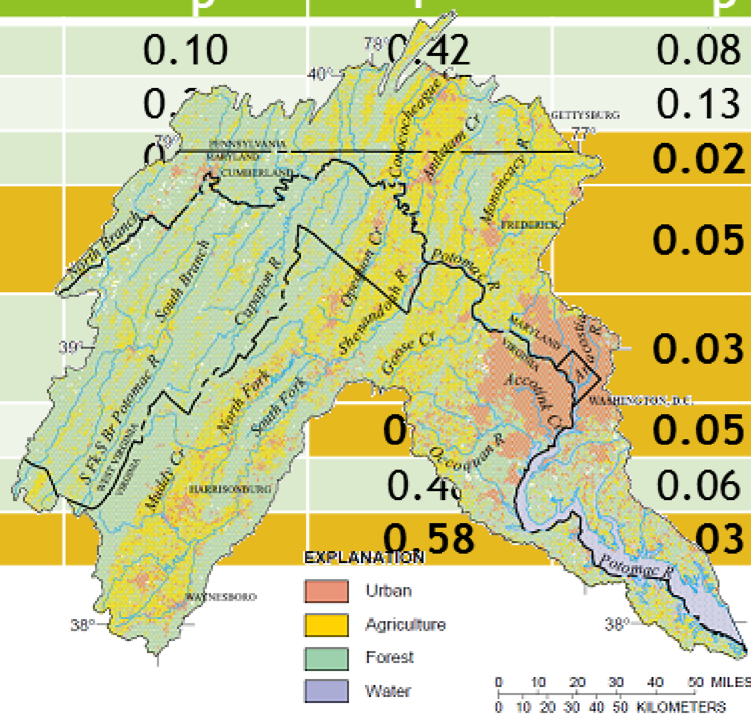


Previous Studies Paving the Way for this Research

Comparing Land Use and Observed Intersex Activity

Land-use	Intersex prevalence r^2	Intersex prevalence p	Intersex severity r^2	Intersex severity p
Human population density	0.39	0.10	0.42	0.08
Number of WWTPs	0.22	0.[illegible]	[illegible]	0.13
WWTP flow	0.32	[illegible]	[illegible]	**0.02**
Percent agricultural land use	**0.63**	[illegible]	[illegible]	**0.05**
Number of animal feeding operations	0.28	[illegible]	[illegible]	**0.03**
Number of poultry houses	0.27	[illegible]	[illegible]	**0.05**
Total number of animals	0.27	[illegible]	0.4[illegible]	0.06
Animal density	**0.49**	[illegible]	**0.58**	**[illegible]03**

Modified from Blazer et al., 2011



Land Use in the Potomac Watershed

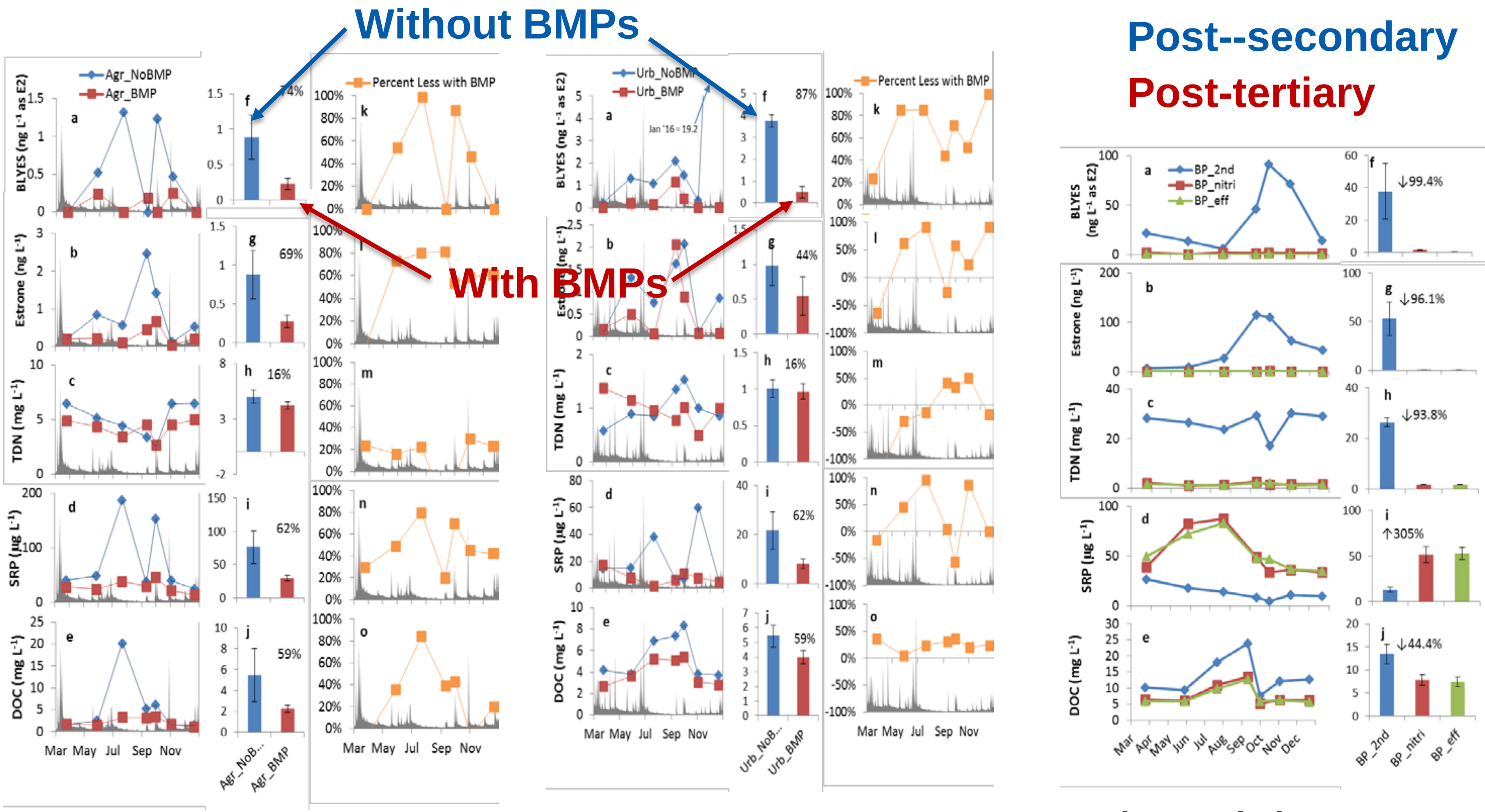
Water Quality Assurance Amendment Act of 2012: Impacting EEDCs in the Potomac Watershed

PROJECT OBJECTIVES

1. Assess the Performance of BMPs for comanaging EEDCs and nutrients
   - Agriculture, Urban Nonpoint sources
   - Point Sources (ie POTWs)

2. Assess the relative contribution of EDCs from WWTPs performing biological nutrient removal
   - Blue Plains WWTP
   - Other “Chesapeake Bay” WWTPs

Impact of BMPs on Nutrients and EDCs



Agriculture Non-point

Urban Non-point

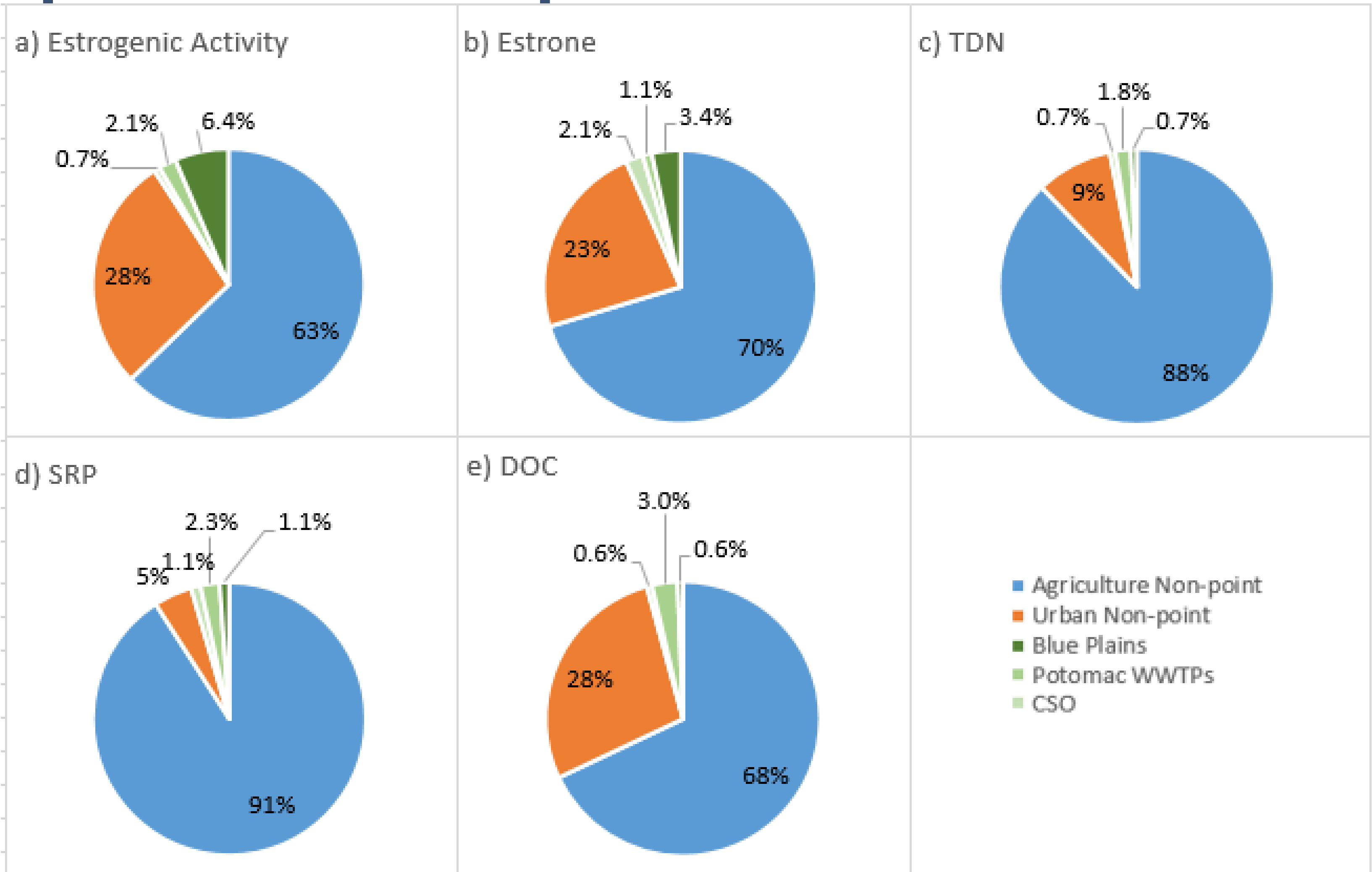
Blue Plains

Comparing Discharges with Background Levels and Other Sources

		E1 (ng/L)							
		Background Potomac	Blue Plains	WWTP 2	CSO	Agr. (No BMPs)	Agr. (BMPs)	Urb. (No BMPs)	Urb. (BMPs)
Estrogenic Activity (ng/L as E2)	Background Potomac		0.304	0.387	0.033	0.004	0.177	0.0005	0.181
	Blue Plains	0.246		0.411	0.211	0.055	0.314	0.022	0.231
	WWTP 2	0.430	0.024		0.219	0.067	0.264	0.029	0.266
	CSO	0.121	0.187	0.241		0.401	0.197	0.438	0.219
	Agr. (No BMPs)	0.494	0.087	0.348	0.267		0.042	0.408	0.219
	Agr. (BMPs)	0.191	0.158	0.001	0.169	0.038		0.017	0.183
	Urb. (No BMPs)	0.004	0.107	0.121	0.207	0.128	0.102		0.147
	Urb. (BMPs)	0.495	0.309	0.205	0.208	0.193	0.144	0.112	

p-values < 0.05 indicates strong differences between observed values

Estimated Loads to the Potomac from point and non-point sources



Conclusions: Objective 1

Upstream and Downstream Impacts on EEDCs from "best-in-class" nutrient management strategies

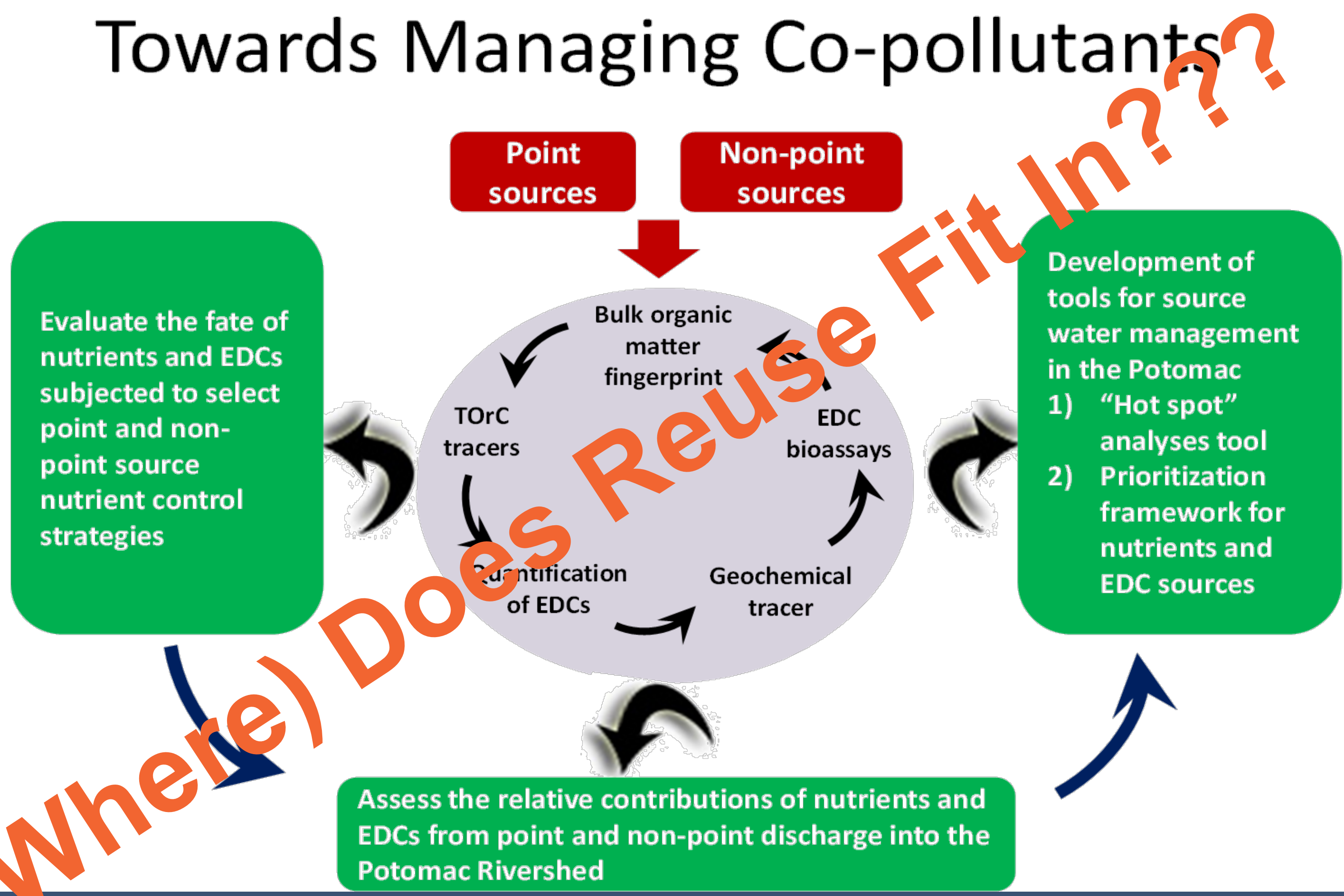
- BMPs showed significant reductions in EEDC inputs to the Potomac Aquifer from agriculture and urban runoff.
  - Agriculture: restricting livestock access to streams, planting grasses for stream shading and improving streambank stability.
  - Urban: maintaining shaded habitat, reducing impervious area, restoring stream habitat and riparian, and creating wetlands.
- Reductions in EEDCs with BMPs for non-point source BMPs → effective co-management of EDCs with phosphorous control methods.
- Blue Plains profile sampling revealed large reductions in EEDCs with advanced nitrogen control.

Conclusions: Objective 2

Assess relative contribution of EDCs from WWTPs performing biological nutrient removal

- Annual load analysis indicated non-point sources accounted for over 80% of EDC load to the Potomac
  - Blue Plains contributing less than 3%.
- Results from two, 30-day, passive sampling campaigns indicated:
  - Higher EEDCs were observed in the spring of 2016 deployment
  - Input of Blue Plains effluent correlated with reductions in observed EEDC mass.
- Nutrient and NOM fingerprinting analysis qualitatively suggests that:
  - WWTPs affected the nutrient fingerprint of the receiving stream, while non-point sources significantly affected NOM but did not affect nutrient enrichment.
  - Changes in nutrient fingerprint associated with Blue Plains Effluent correlated with a reduction in EDC concentration in the Potomac River below the outfall.

Extending the Approach



(Where) Does Reuse Fit In???

EPA Science to Achieve Results: Improving Reuse for a Much Healthier Potomac Watershed

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University at Buffalo

Adil Godrej, Amelia Flannery – Virginia Tech

Erik Rosenfeldt – Hazen and Sawyer

Sudhir Murthy – DC Water

Luke Iwanowicz – U.S. Geological Service

Study Objectives

1) *Use multiple analytical, biological activity, isotopic, and fluorescence tracers to identify and track spatial and temporal variability hot spots of EDC and nutrient sources at a large watershed scale,*
2) *Use case studies to examine impacts of advanced wastewater reclamation, stormwater reuse, and agricultural best management practices on source controls of nutrient and co-pollutants,*
3) *Utilize a sustainable approach to quantitatively analyze the costs, impact, and benefits of the reuse and management strategies for achieving human and ecological health improvement.*

Project Timeline

Year 1 (July 2016 – June 2017)

- Identify and track spatial and temporal variations in “hot spots”

Year 2 (September 2017 – August 2018)

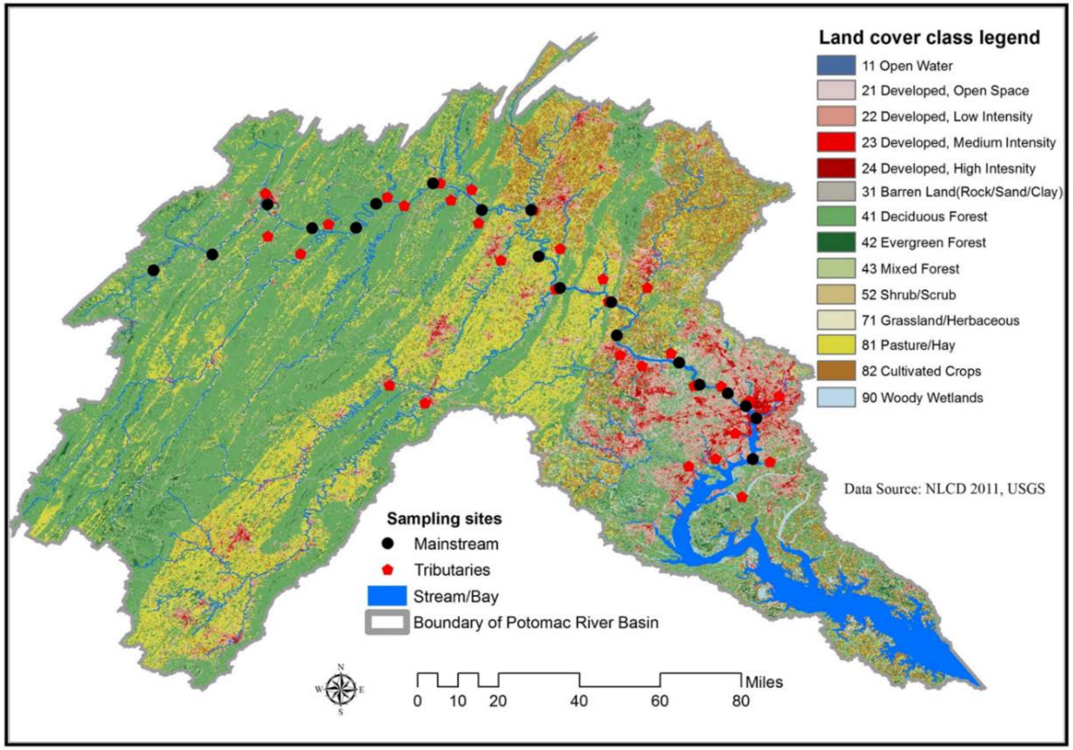
- Focused study on impact and outcomes of reclamation, reuse, harvesting, and management strategies on sources of pollutants

Year 3 (July 2018 – June 2019)

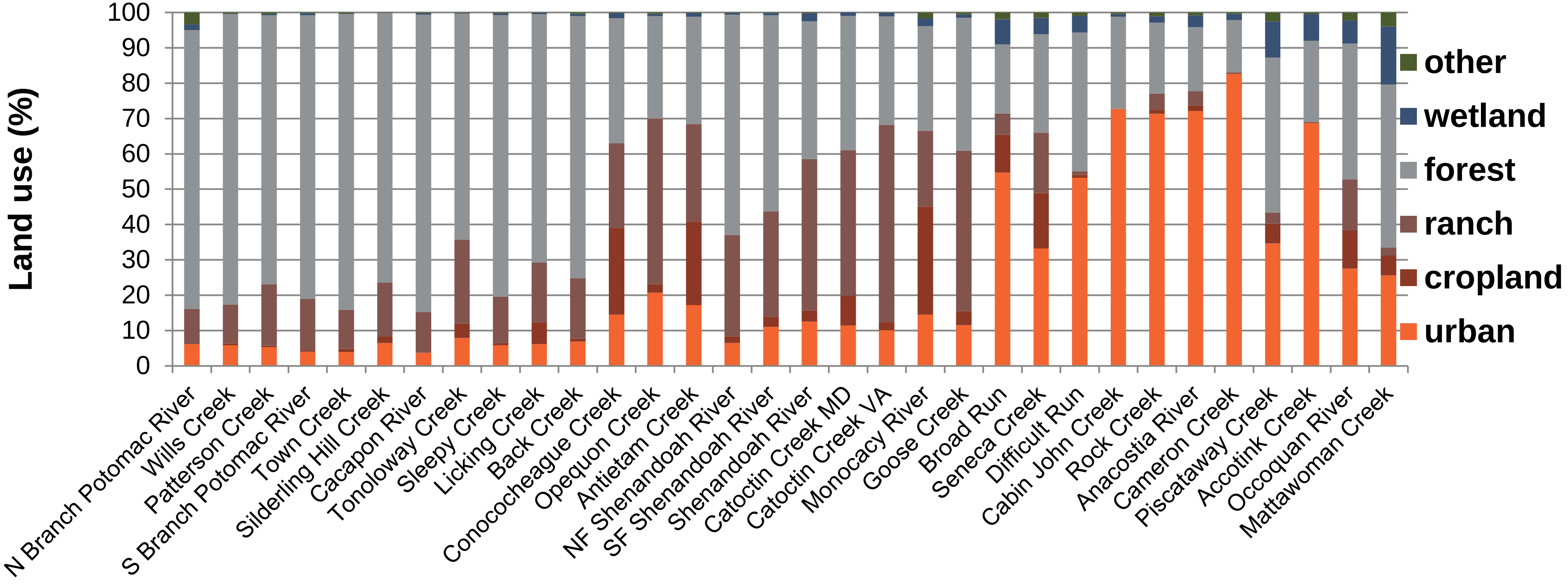
- Quantitative assessment of costs, benefits, and impact of advanced reclamation, reuse, harvesting, and management practices on human and ecological health in the Potomac

Year 1 – Hot Spot Analysis

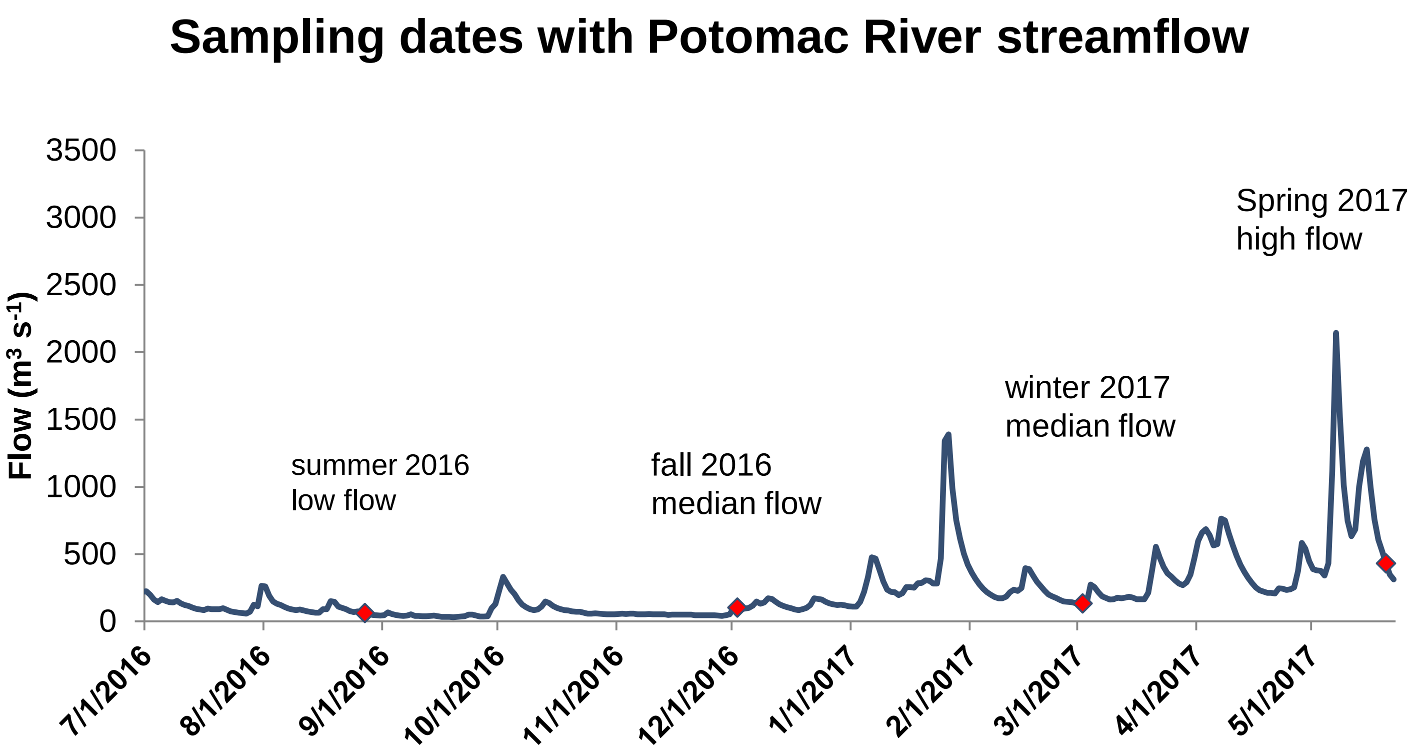
- Identify and track spatial variations in “hot spots” of **EDCs**, biological activity, and **nutrients**
- USGS and Chesapeake Bay Program sites
- Includes sites impacted by treated wastewaters, mineral fertilizers, animal manure, and atmospheric deposition



Land use of 31 primary sub-watershed



Quarterly Sampling At Base Flow



Some of the analyses

EDCs

- Estrogen chemicals (U. of Buffalo)
- Other EDC chemicals (U. of Buffalo)
- EDC biological activity (enzyme method) (USGS)

Nutrients (UMCP)

- Soluble reactive P
- Nitrate plus nitrite
- Nitrate isotopic tracers – N-15 and O-18
- Total dissolved nitrogen (TDN)

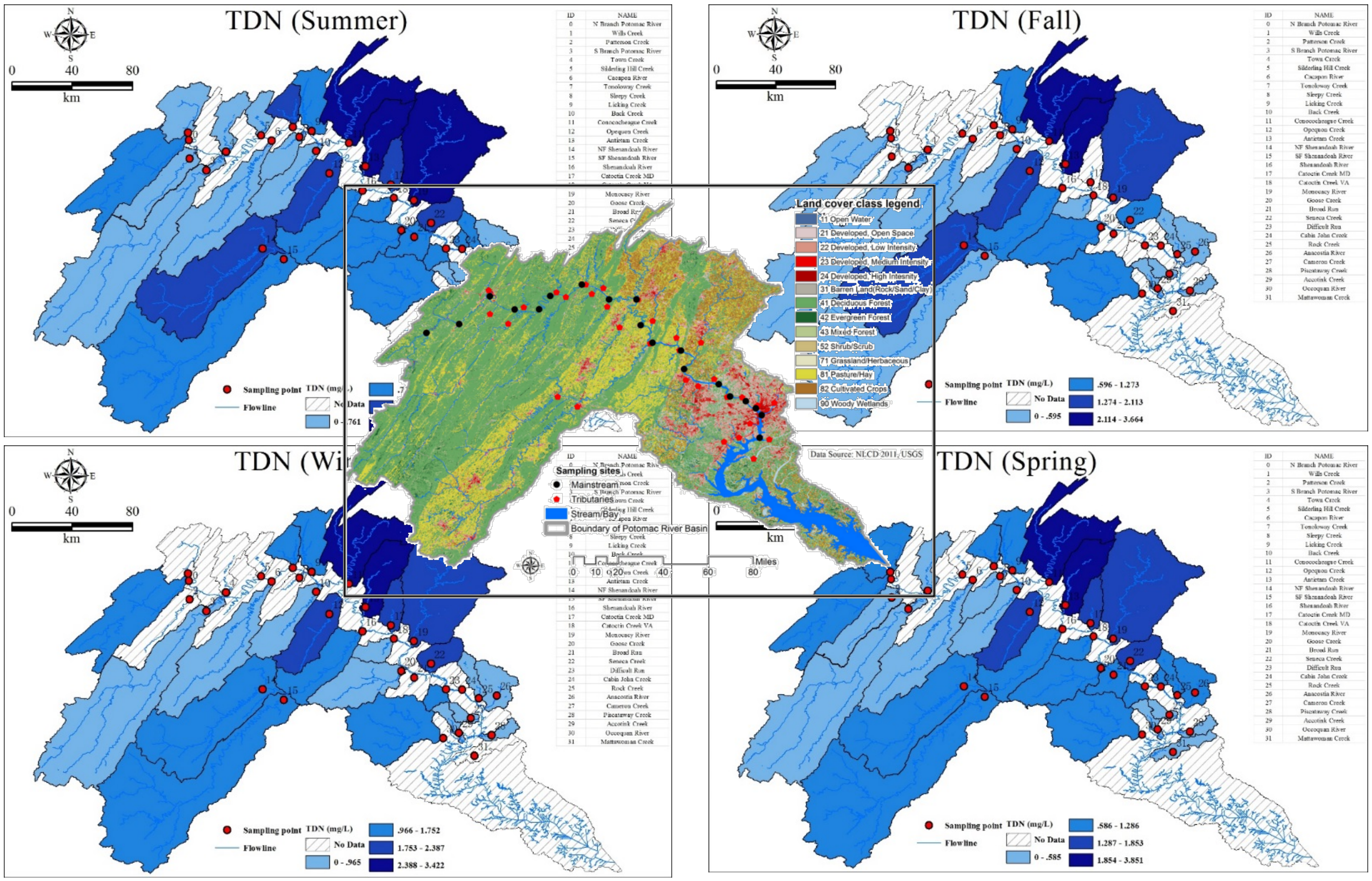
In situ measurements (UMCP)

- Water temperature
- Conductivity
- pH

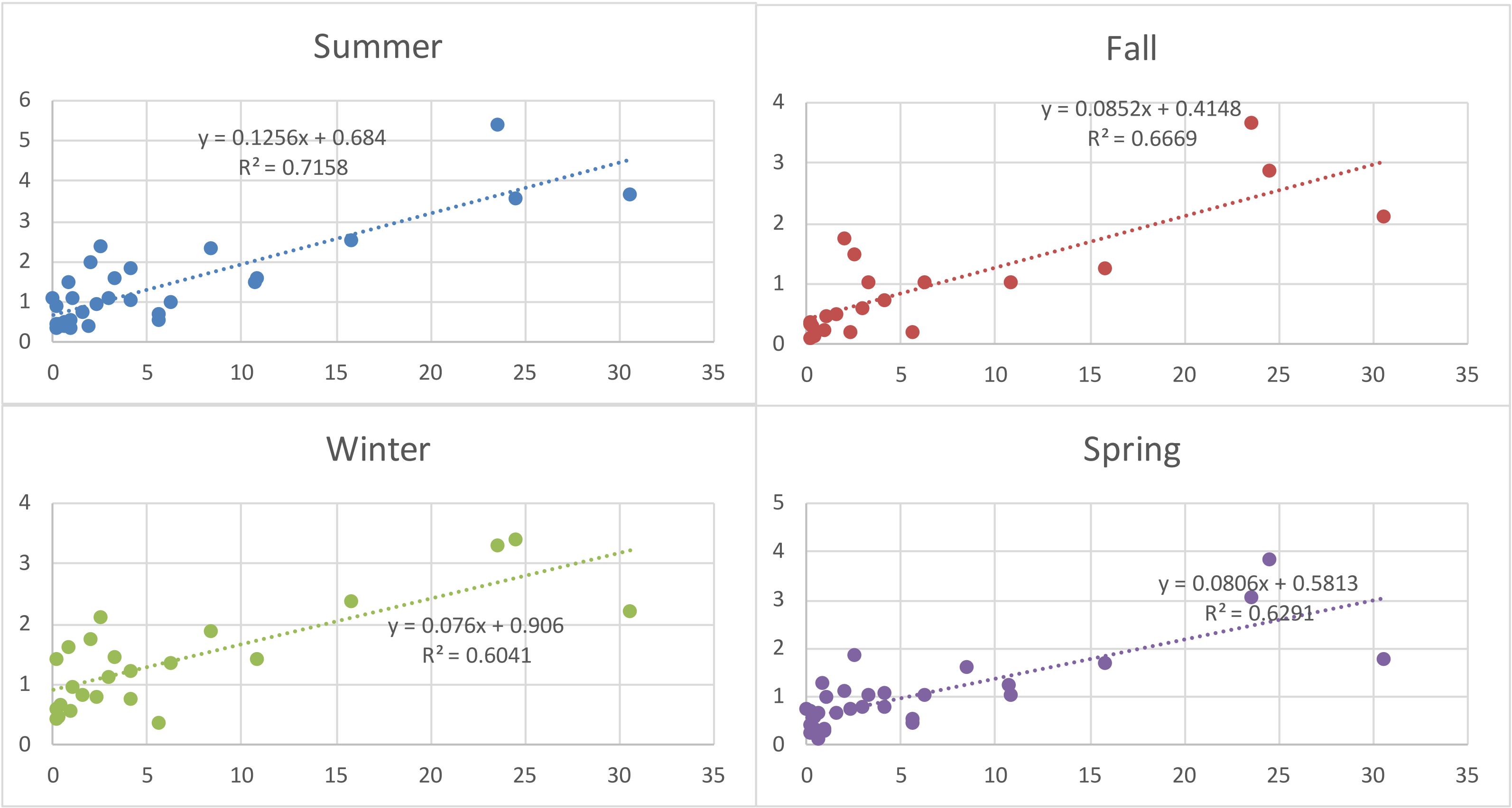
Organic and inorganic carbon (UMCP)

- Dissolved inorganic carbon (DIC)
- Dissolved organic carbon (DOC)
- UV/Vis light absorbance
- Fluorescence scans – Fluorescence index, biological index, humification index

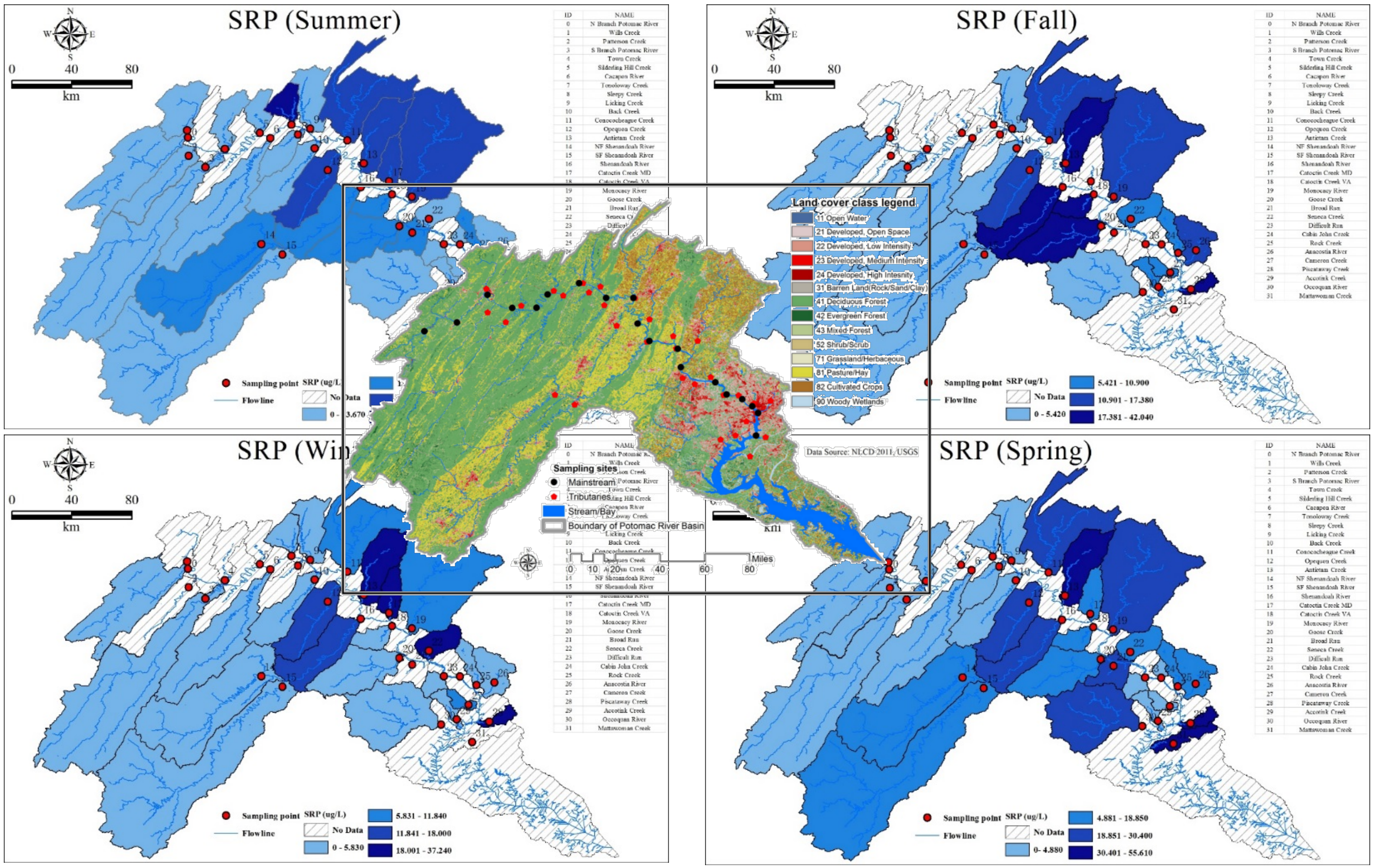
Results – Total Dissolved Nitrogen (TDN)



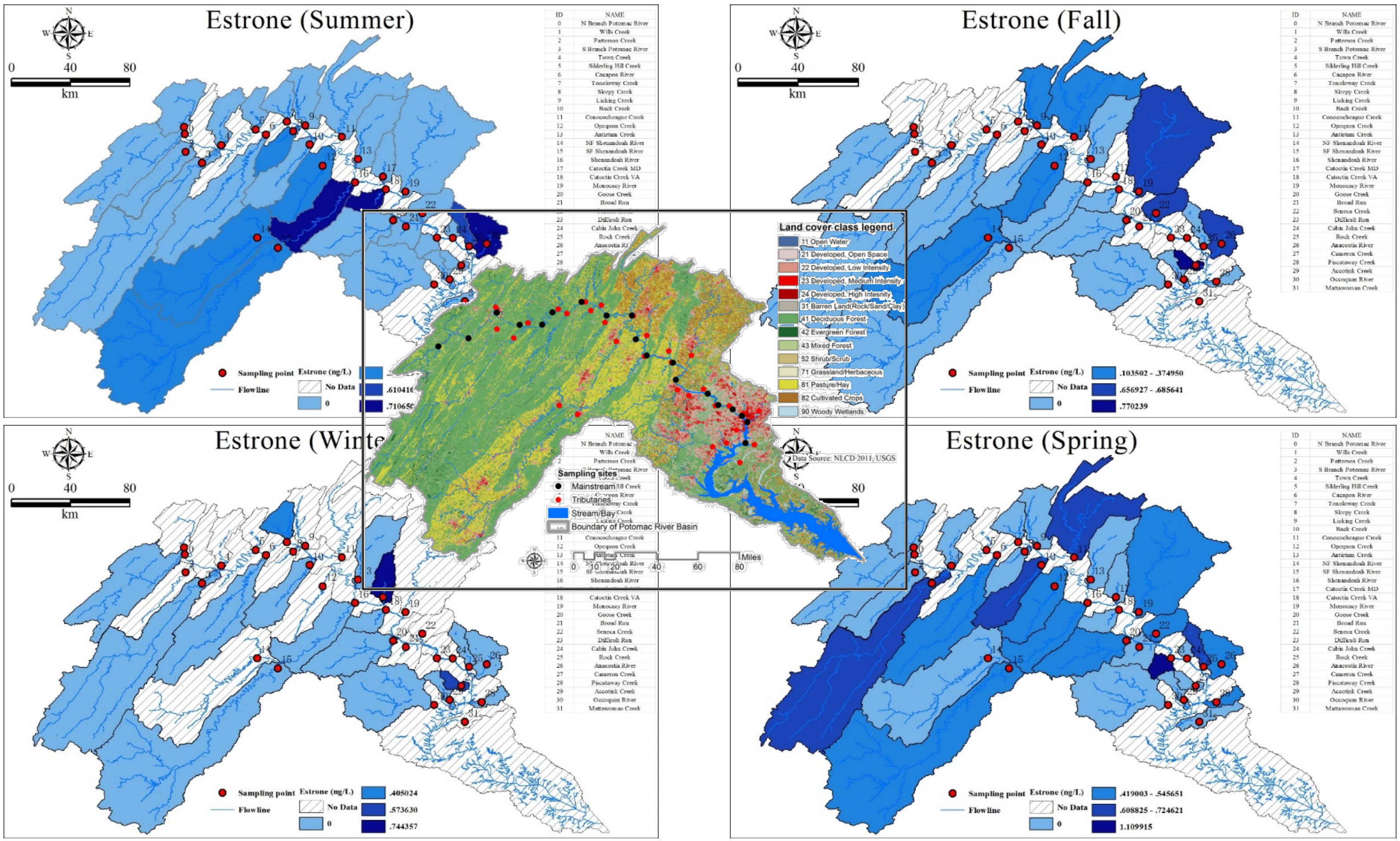
TDN concentration vs %cropland



Results – Soluble Reactive Phosphorus(SRP)



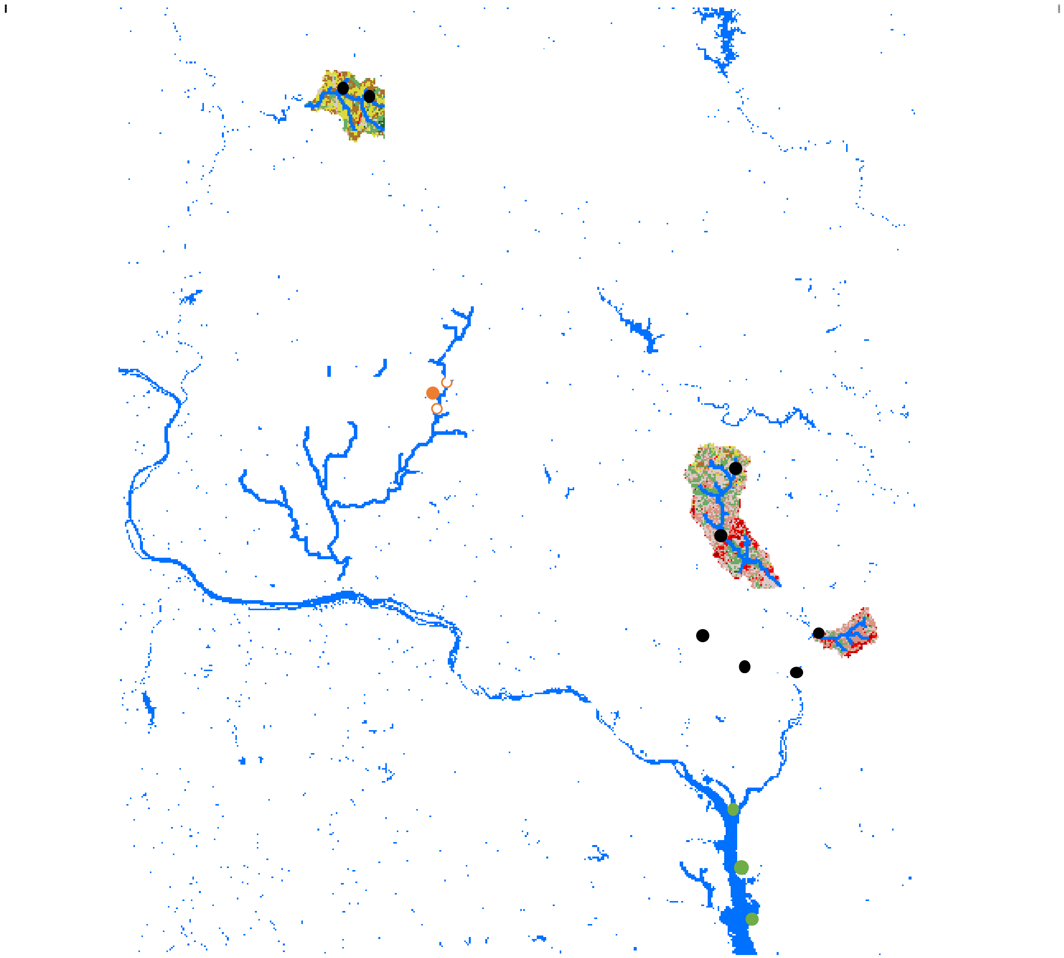
Results – Estrogen (mainly Estrone)



Work plans for Year 2

- Year 1 – Hot Spot Analysis
  - Identify and track spatial and temporal variations in "hot spots"
- **Year 2a – Impact of current management strategies (University of Maryland)**
  - Use paired watershed studies to evaluate impacts and outcomes of current reclamation, reuse, harvesting, and management strategies on source controls of pollutants.
- **Year 2b – Impact of planned potable reuse (Virginia Tech)**
  - Focused study on the comparative impact of planned potable reuse.
- Year 3 – Cost-benefit analysis of EDC/Nutrient Co-management strategies
  - Will the control framework change with inclusion of EDCs?

Year 2 Sampling Plan: Sites in Maryland



Agricultural runoff

1. Ben's Run tributary with BMP
2. 1. Ben's Run tributary without BMP

Urban runoff

1. Paint Branch: with BMP
2. Brier Ditch: without BMP
3. Rock creek: with forested park
4. Sligo Creek:
5. NE Branch Anacostia
6. Paint Branch headwater

Point Sources:

Blue Plains WWTP

1. Upriver Potomac
2. Downriver Potomac
3. WWTP effluent

Seneca WWTP

1. Upstream Seneca
2. Downstream Seneca
3. WWTP effluent

Year 2 Sampling Plan: sites in Virginia

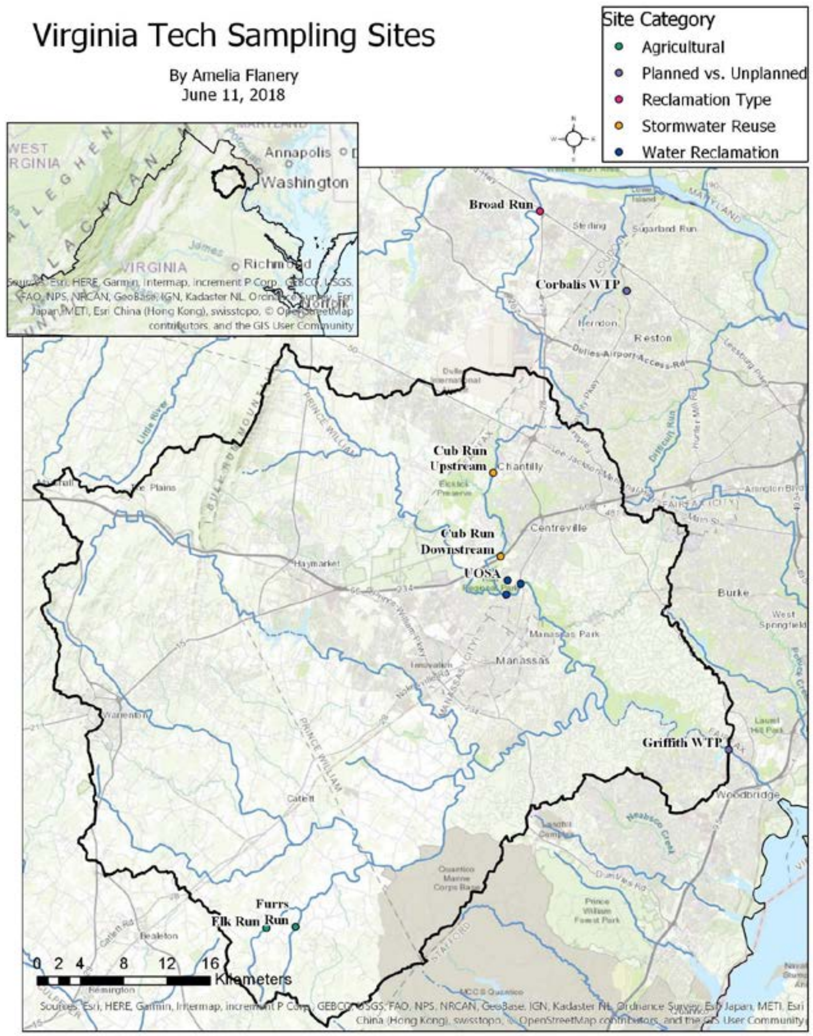
Agricultural runoff:
1. With BMP: Furrs Run
2. Without BMP: Elk Run

Urban runoff
1. With BMP: Cub Run above BMP
2. Without BMP: Cub Run below BMP

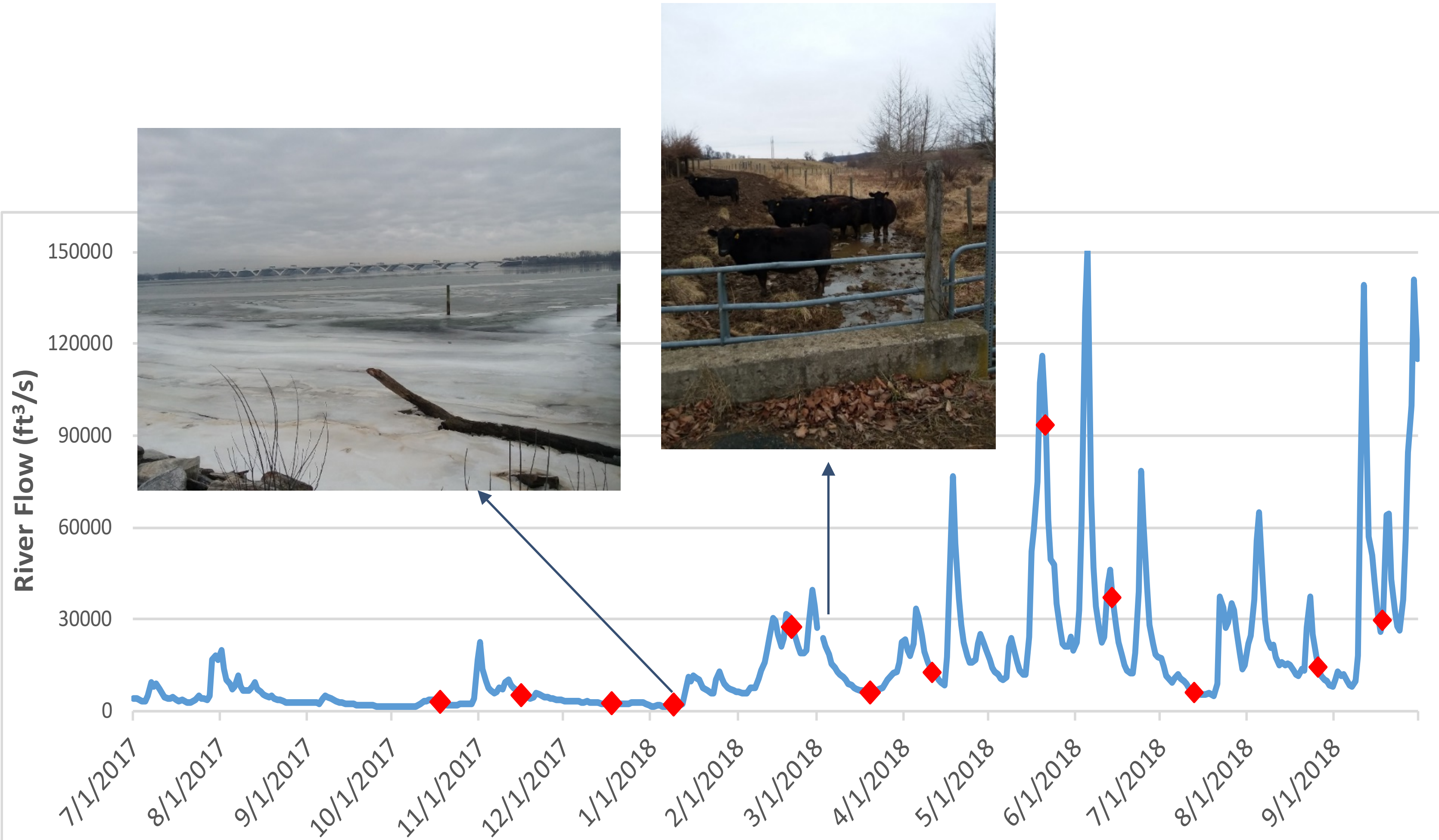
Point Sources:
UOSA WWTP
1. Upriver Bull Run
2. Downriver Bull Run
3. UOSA WWTP effluent

Planned Potable Reuse
1. Unplanned IPR Water Plant
2. Planned IPR Water Plant

Broad Run: comparison with Seneca Creek of Maryland



Sampling Dates with changing Potomac flow



Year 2 Preliminary Results – Effect of BMPs on nonpoint sources

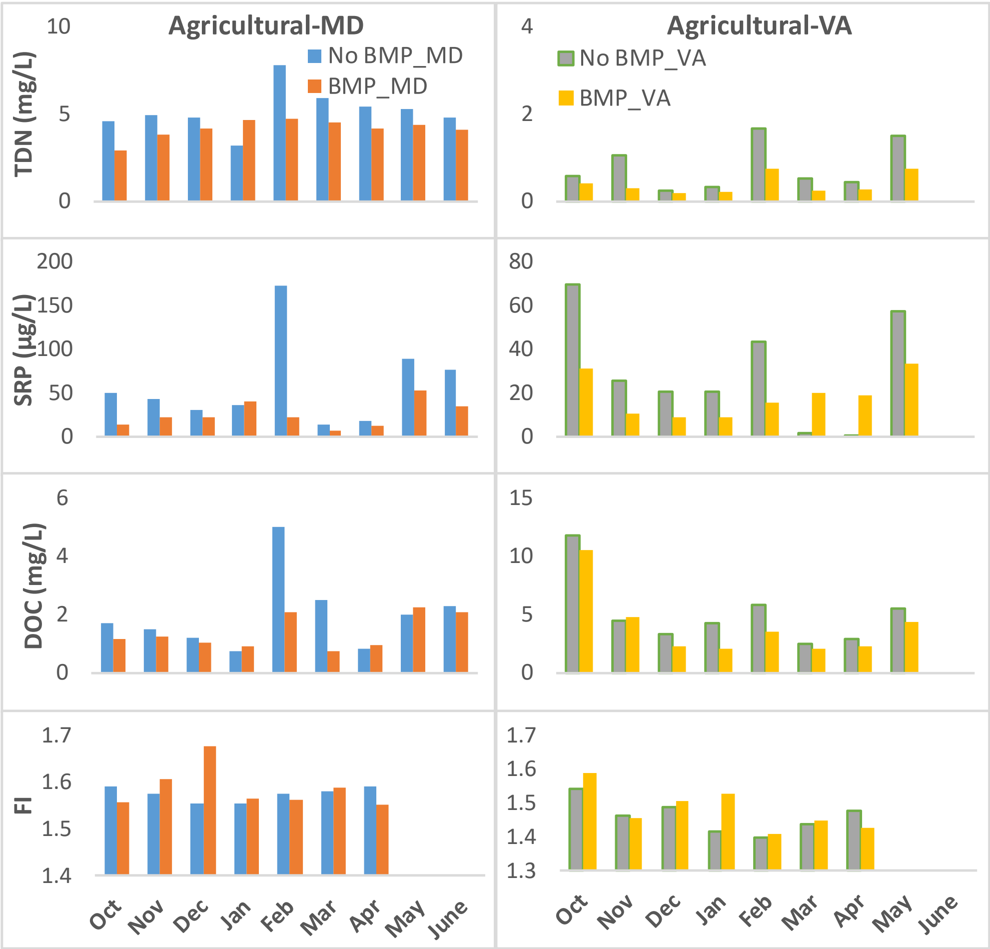
1. Agricultural BMPs

2. Urban BMPs

3. Point Source Impacts

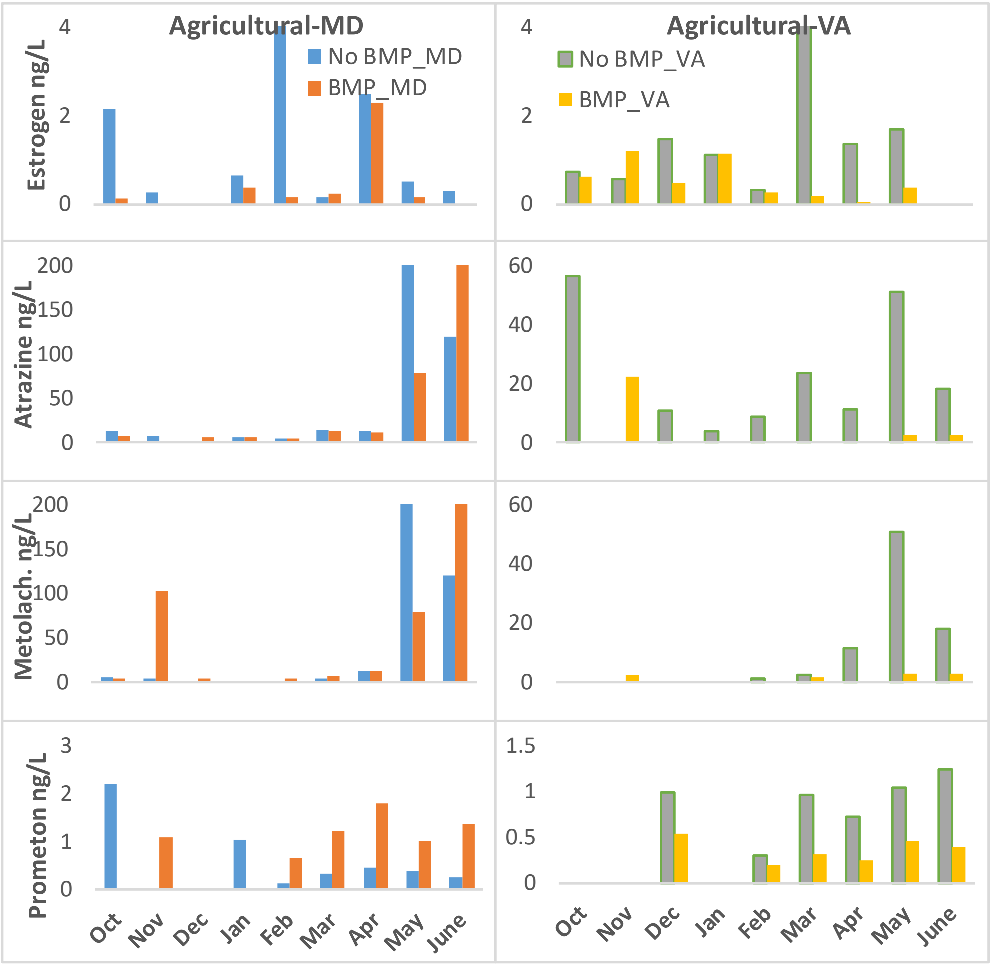
4. Focus on Planned vs. Unplanned IPR

Year 2 Preliminary Results – Agricultural nutrients and DOC



In general, lower total dissolved nitrogen (TDN), soluble reactive phosphorus (SRP) and dissolved organic carbon (DOC) occurred in agricultural sites with BMPs.

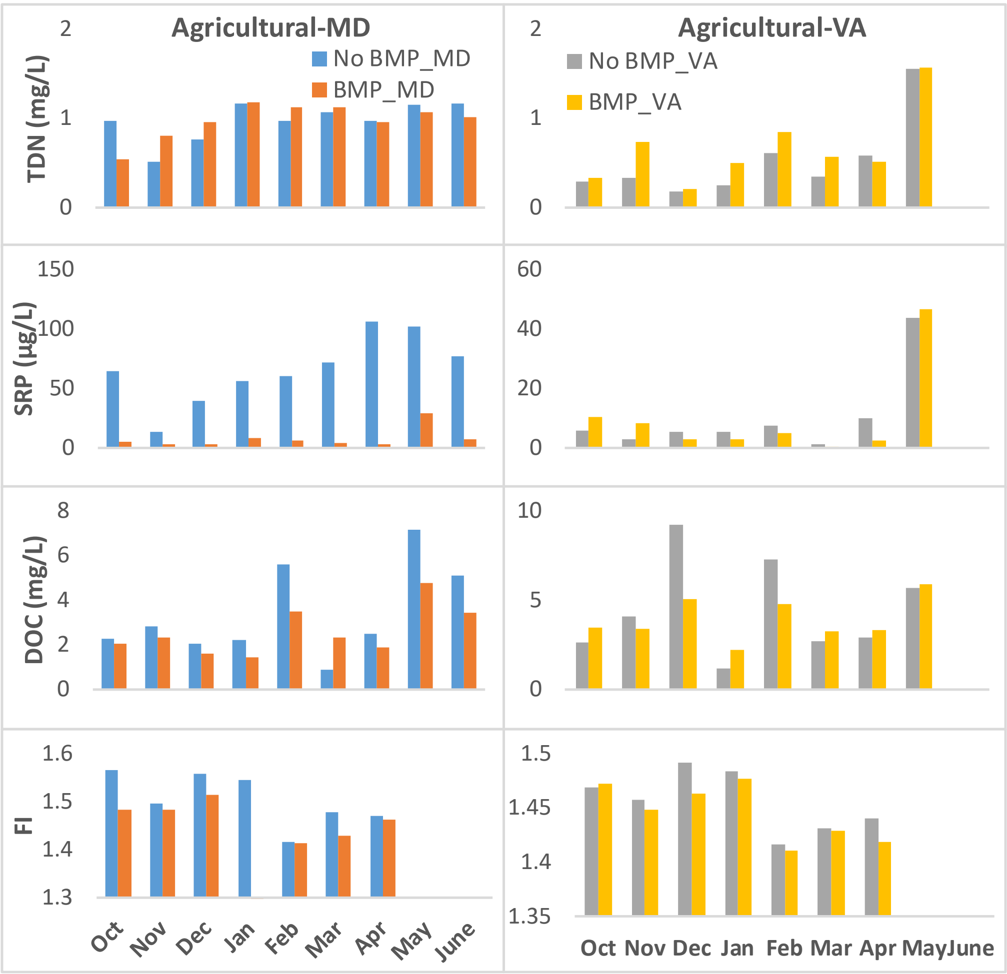
Year 2 Preliminary Results – Agricultural TOrCs



In general, the BMP sites had lower estrogen (1-2 exception) than the site without.

Only the Virginia BMPs had lower atrazine (one exception), metolachlor (one exception) and prometon than the site without.

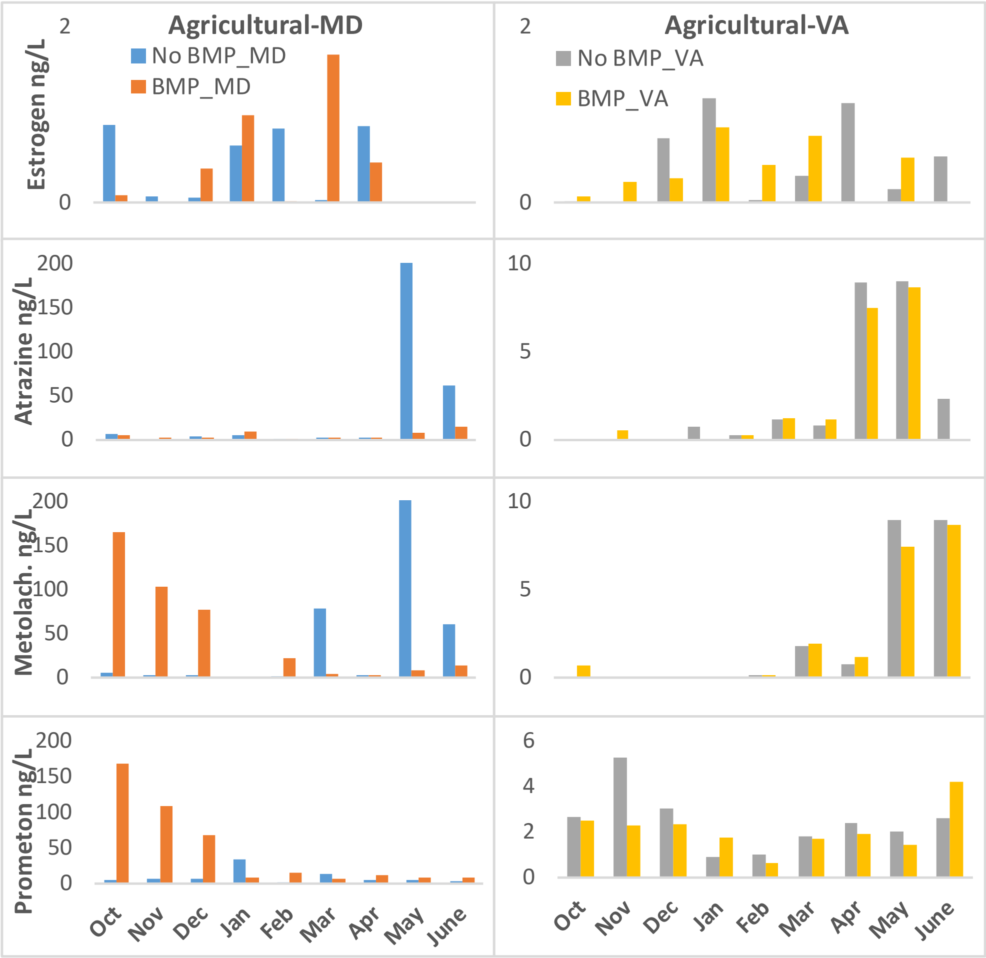
Year 2 Preliminary Results – Urban nutrients and DOC



The Maryland BMP site had lower SRP, DOC (one exception), and fluorescence index (FI for DOC quality) than the site without.

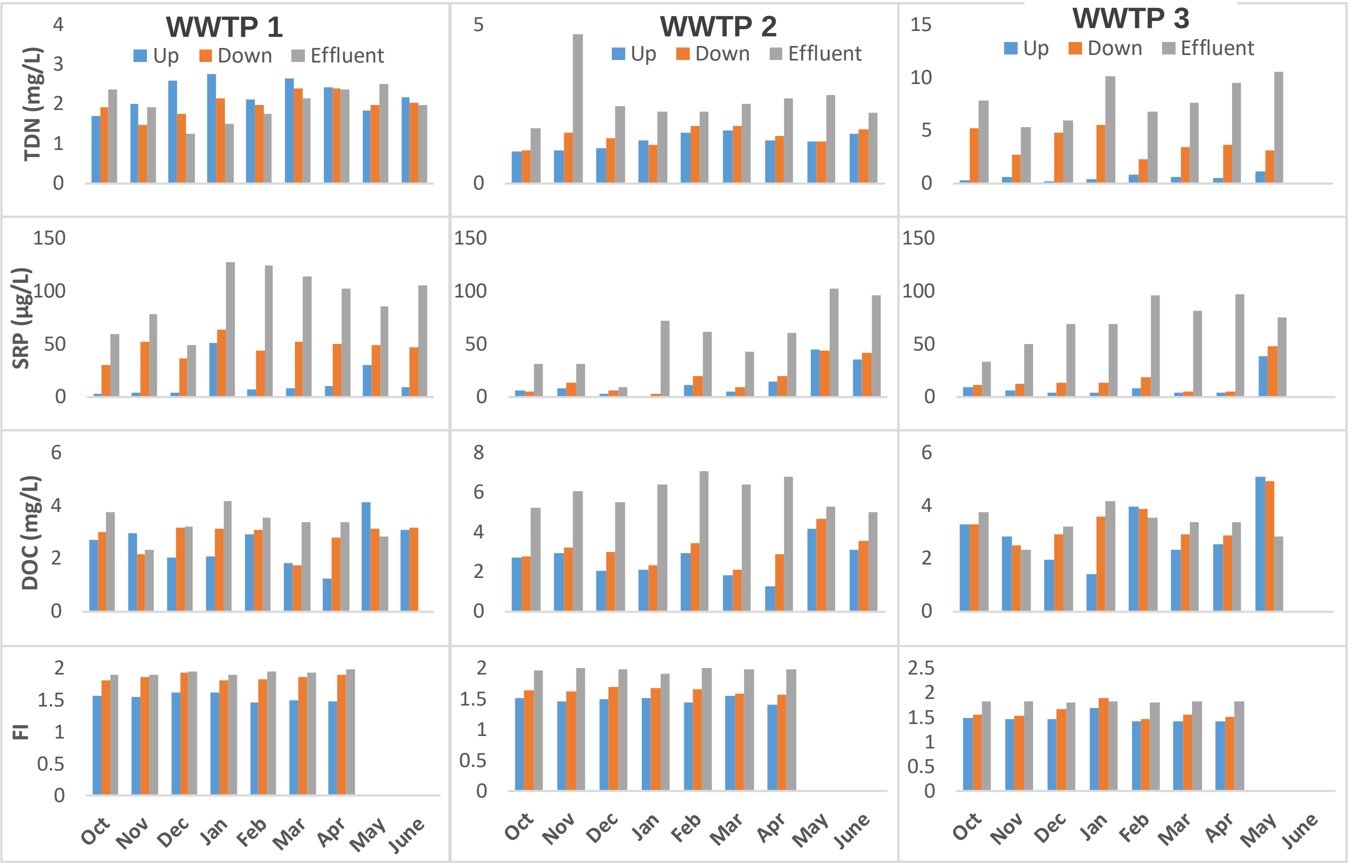
The Virginia BMP site had lower FI than the site without. Otherwise, there was no significant difference.

Year 2 Preliminary Results – Urban TOrCs



No consistent difference in estrogen, atrazine, metolachlor or prometon between streams with and without BMPs.

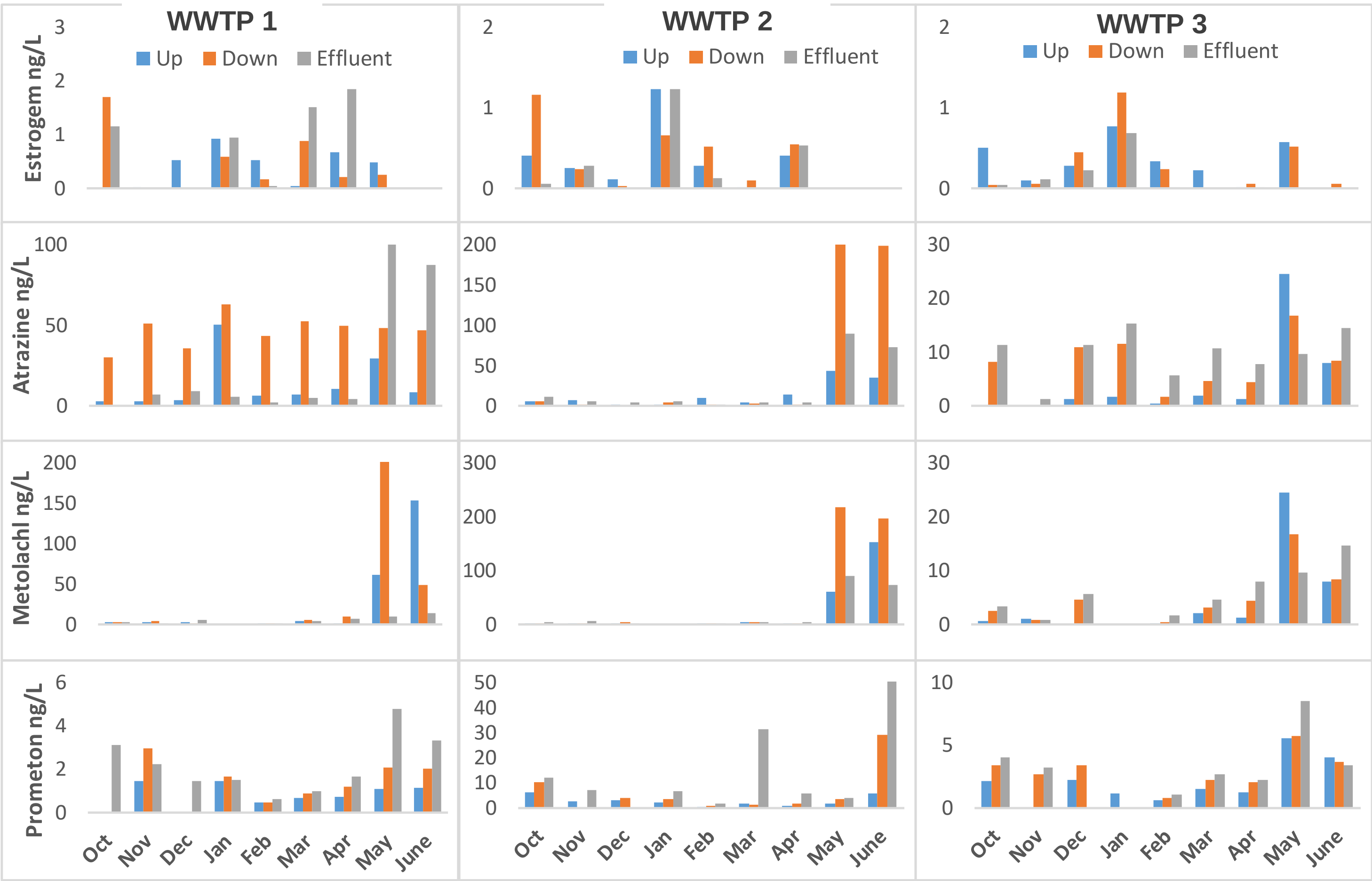
Year 2 Preliminary Results – Point source nutrients and DOC



WWTP effluent discharge caused downstream increases in SRP and fluorescence index (FI).

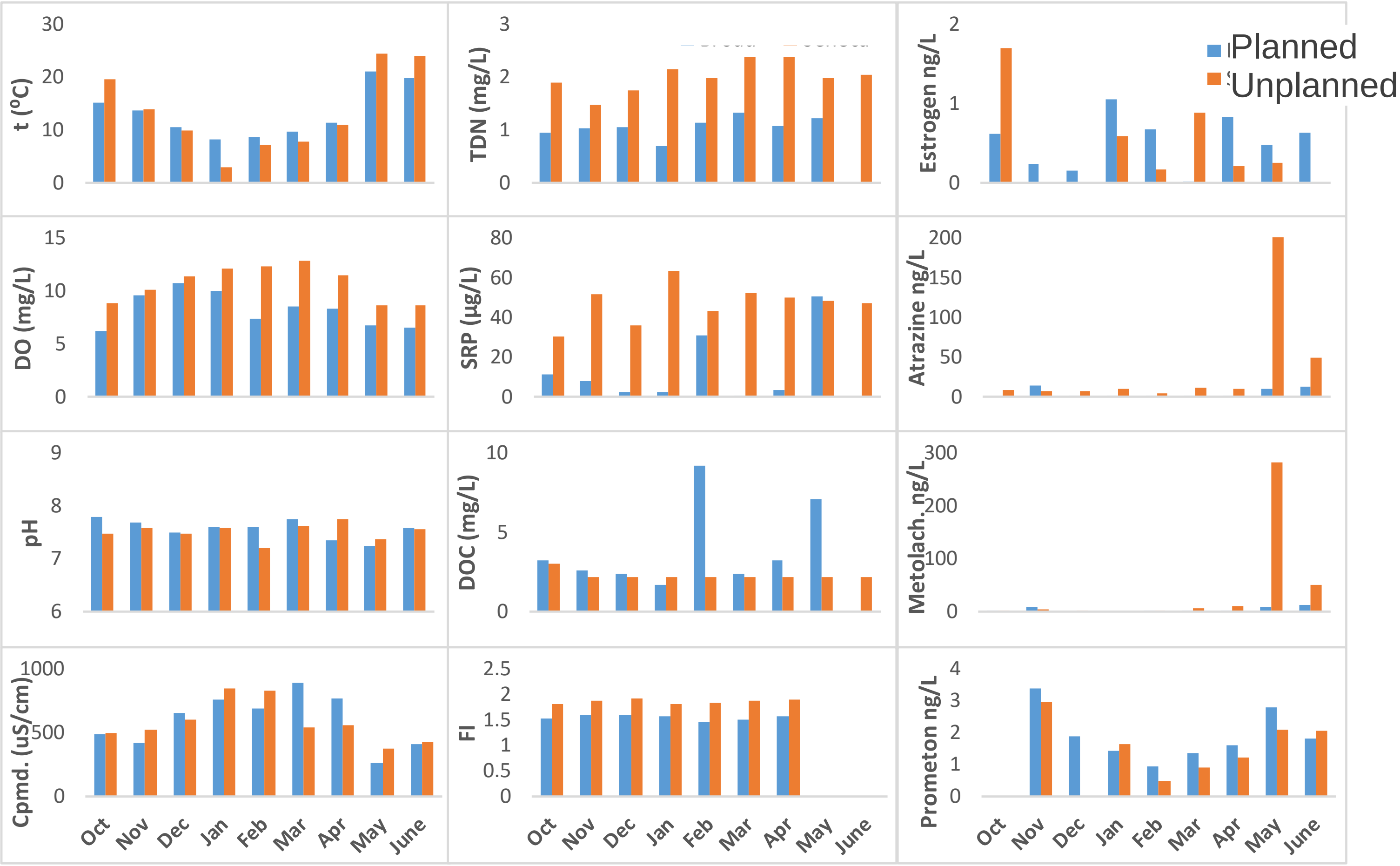
WWTP effluent discharge can lead to downstream increases or decreases in TDN or DOC, dependent on difference between stream and WWTP effluent.

Year 2 Preliminary Results – Point Source TOrCs



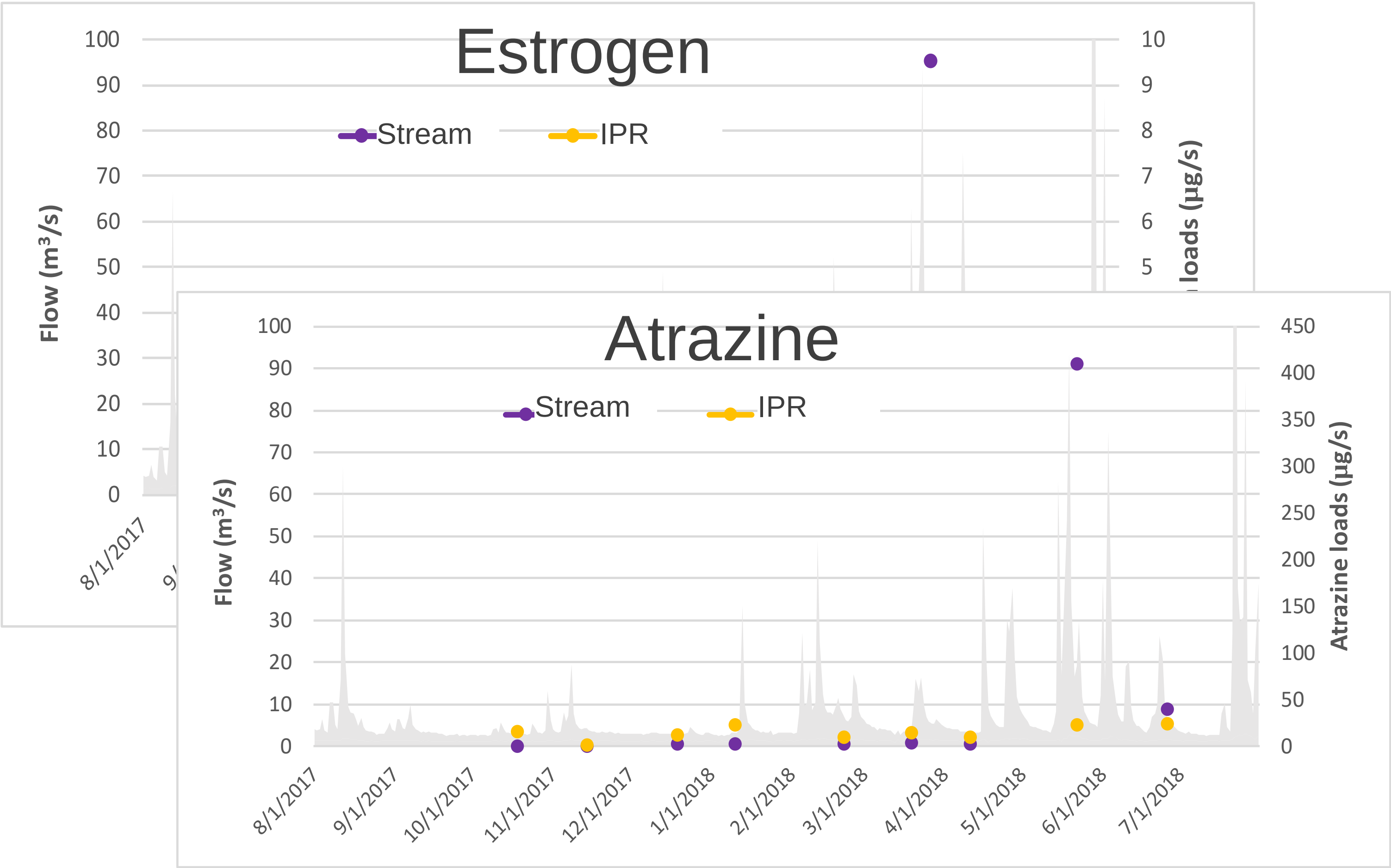
Point Source discharge sometimes caused downstream increases in pesticides (atrazine, metolachlor, or prometon).

Impact of planned potable reuse



The stream representing with "planned" potable use had lower concentrations of SRP, DOC, atrazine and metolachlor than the stream representing "unplanned" potable use.

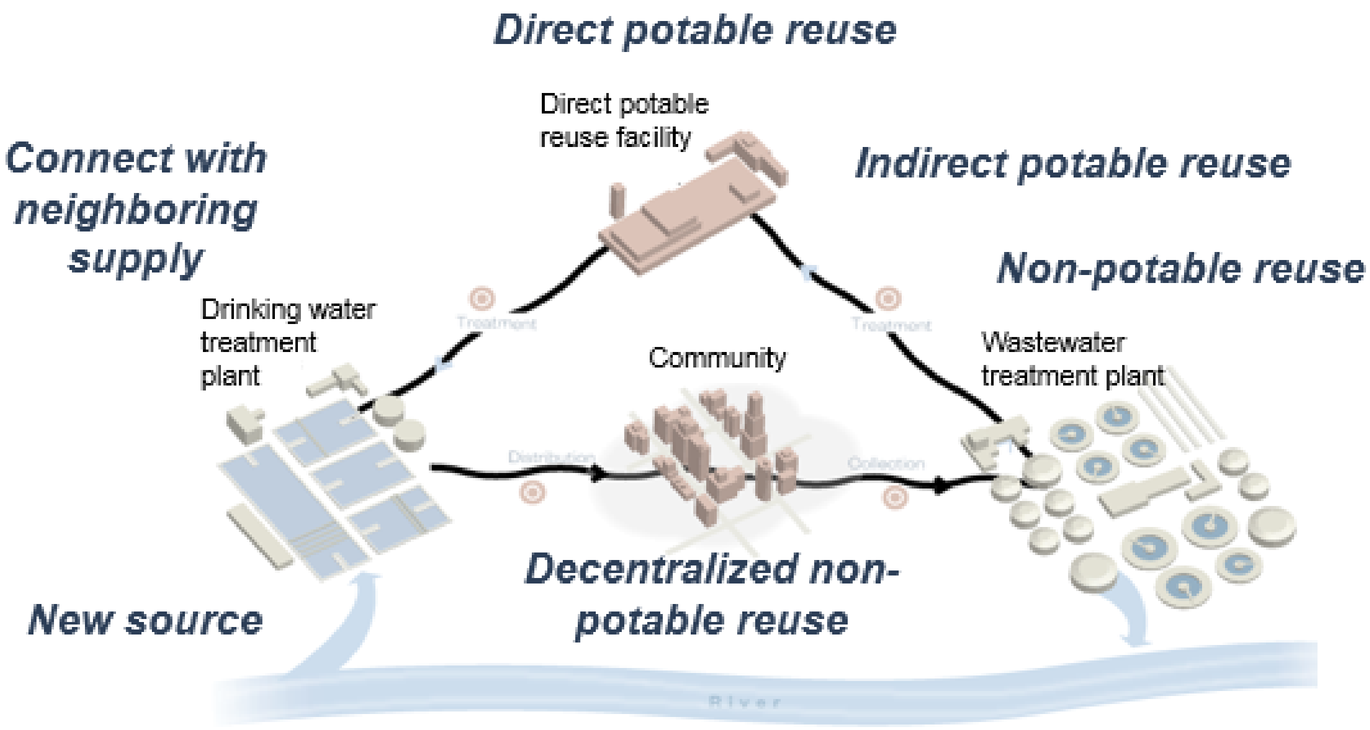
Load Analysis



Year 3: CBA for co-managing EDCs and Nutrients

Multi-Criteria Decision Analysis Framework, based on TBL

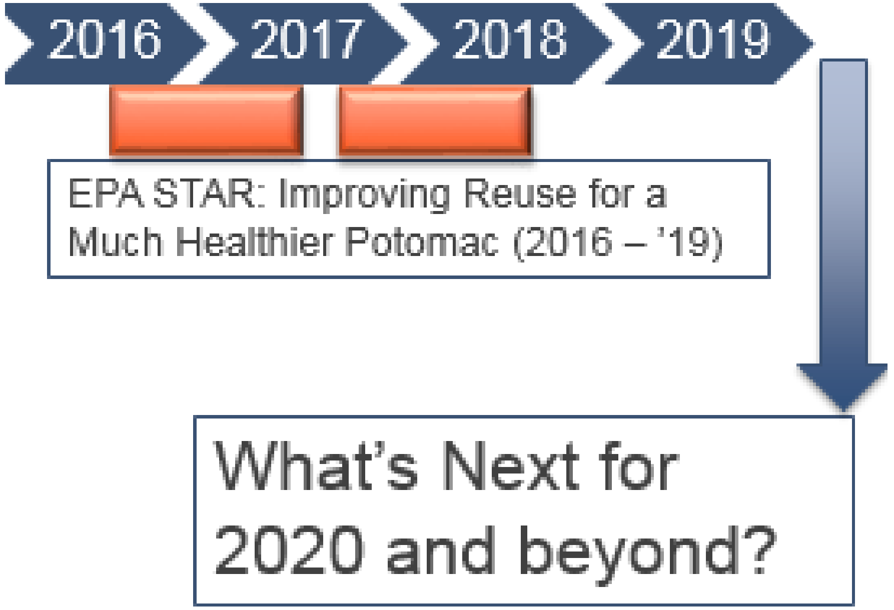
- Leveraging: “A Framework and Tool for Triple Bottom Line Water Supply Planning” (WRF Reuse 14-03)



Research Gaps for the Future

1. *Integrating Remote Sensing into Potomac Water Quality Monitoring*

2. *Integrated management of Potomac Water Quality Risks:* ***Pathogens****, Nutrients, and Trace Organics*



Questions?

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