Putting it all together: integrating monitoring, modeling, and research to inform restoration activities

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June 18, 2018

Contributions from: Jimmy Webber, Doug Moyer, Joel Blomquist, Jeni Keisman, John Wolf, Rebecca Murphy, Matt Johnston, Qian Zhang, Lindsey Gordon & more

A LOT of new and updated info available…

Monitoring & Trends

Nontidal water quality

Tidal water quality

Tidal attainment

Stream & tidal benthic

Submerged aquatic vegetation

Modeling Tools

CBP Watershed Model

Geographic load distribution

Geographic influence on Bay

BMP progress reports

Synthesis Analyses

USGS Non-tidal Syntheses

-Regional Nitrogen, Phosphorus and Sediment

-Groundwater

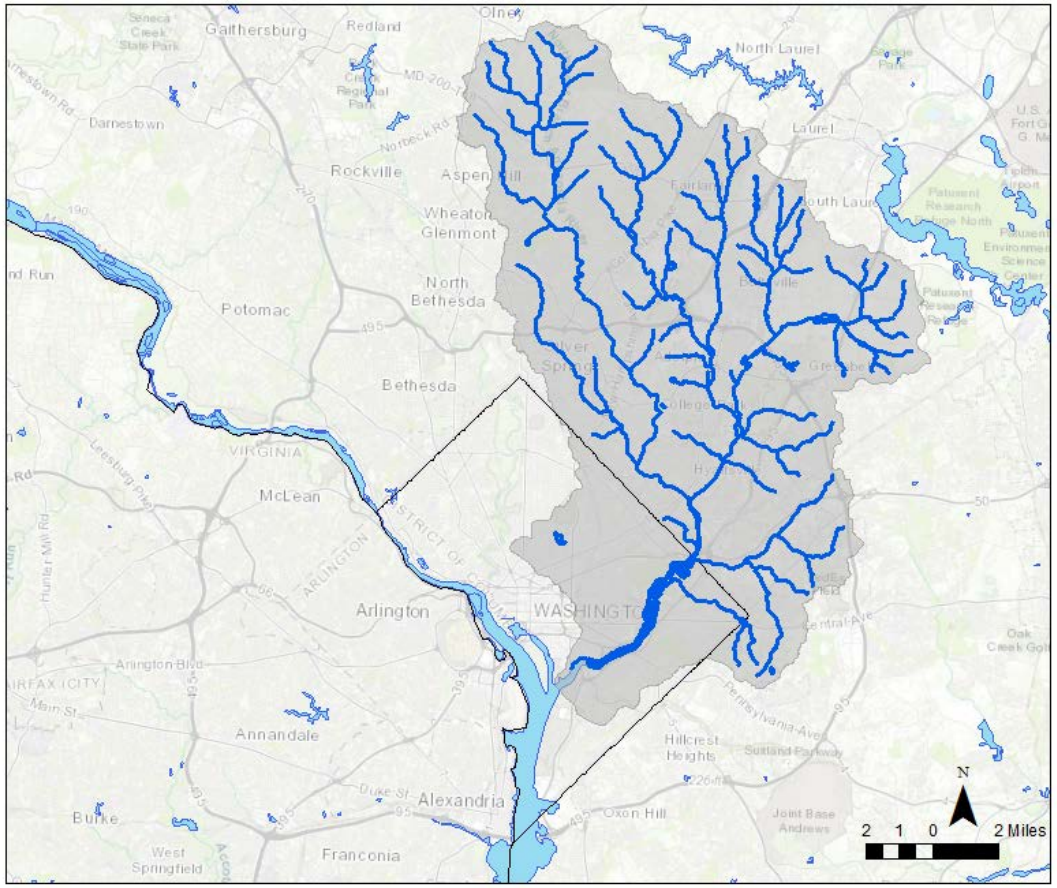
SAV Syntheses

Water Clarity Synthesis

Water Quality Synthesis

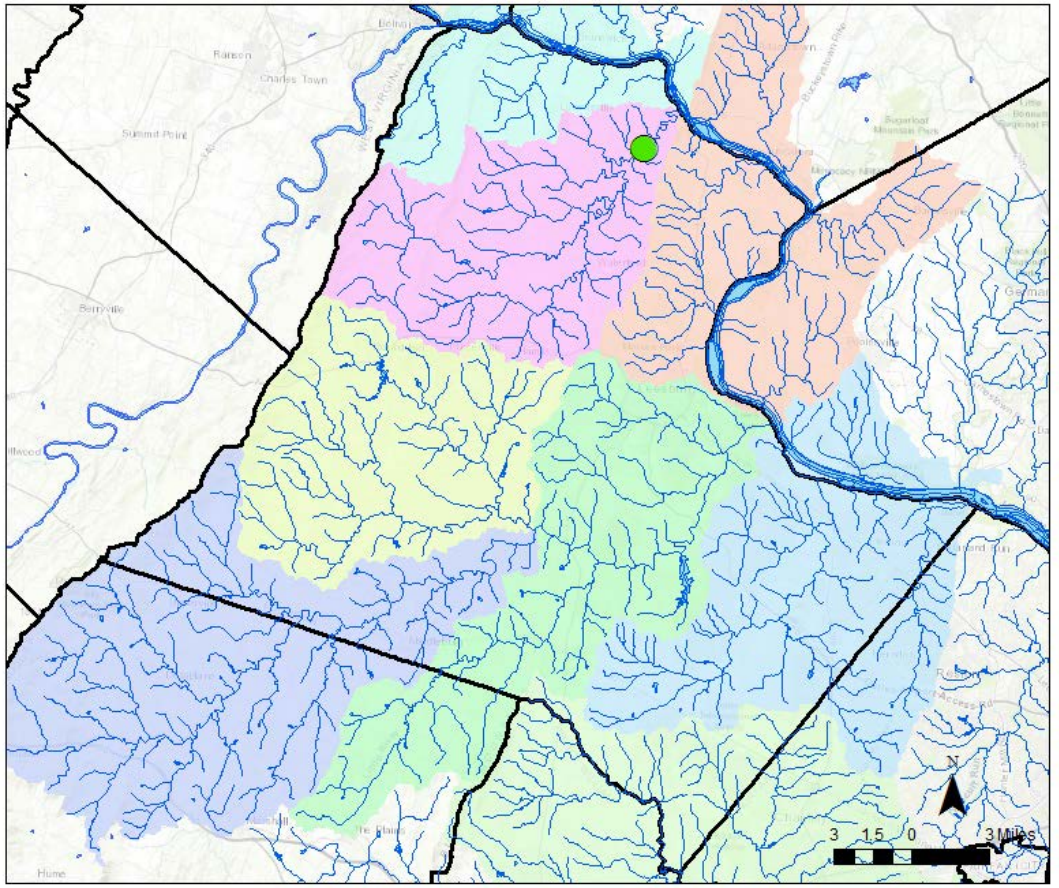
Utilizing the data to understand local stories

Anacostia River



- Very urban watershed, and has been developed for some time

Loudoun County

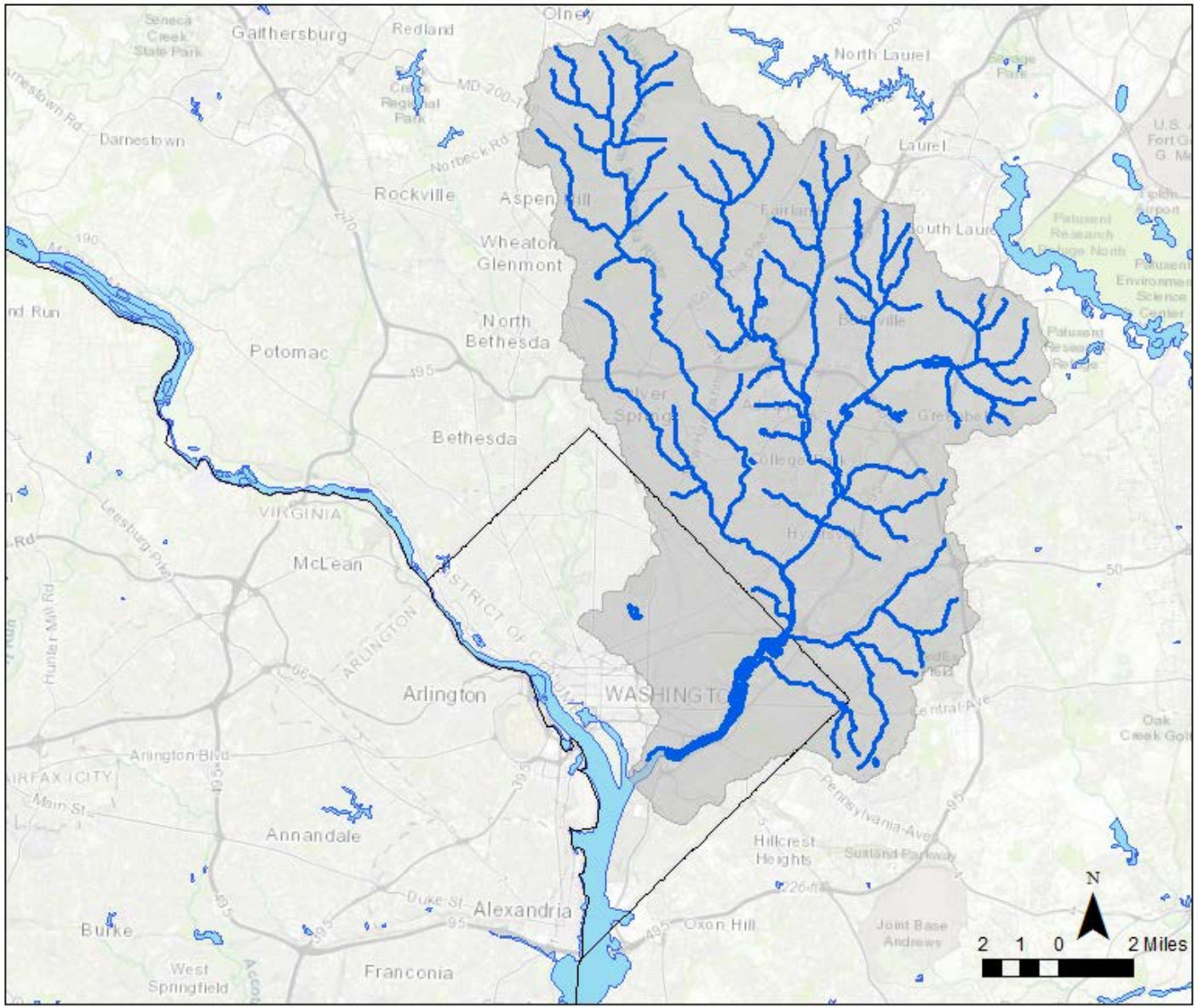


- Swiftly urbanizing area that, until recently, was mostly forest with agriculture

The Anacostia River has long been in focus for restoration

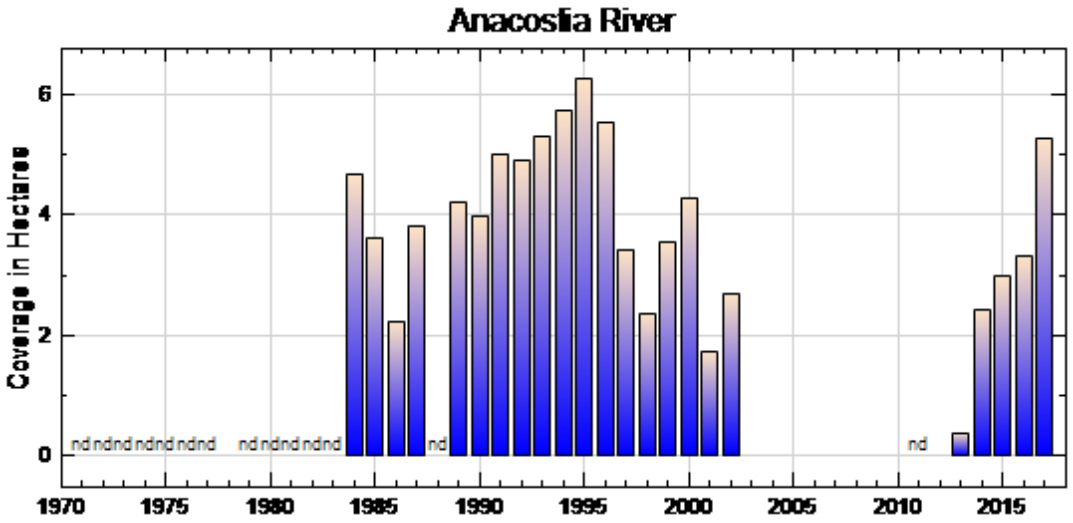
- Non-tidal and tidal portions of Anacostia River have traditionally had issues meeting designated uses for swimmable, fishable, and aquatic life
- Problems include fecal contamination from sewage and stormwater, sediment and low dissolved oxygen from algal blooms
- Many restoration efforts have been undertaken in the watershed including stormwater retrofits, green infrastructure and stream restoration

Anacostia River Watershed

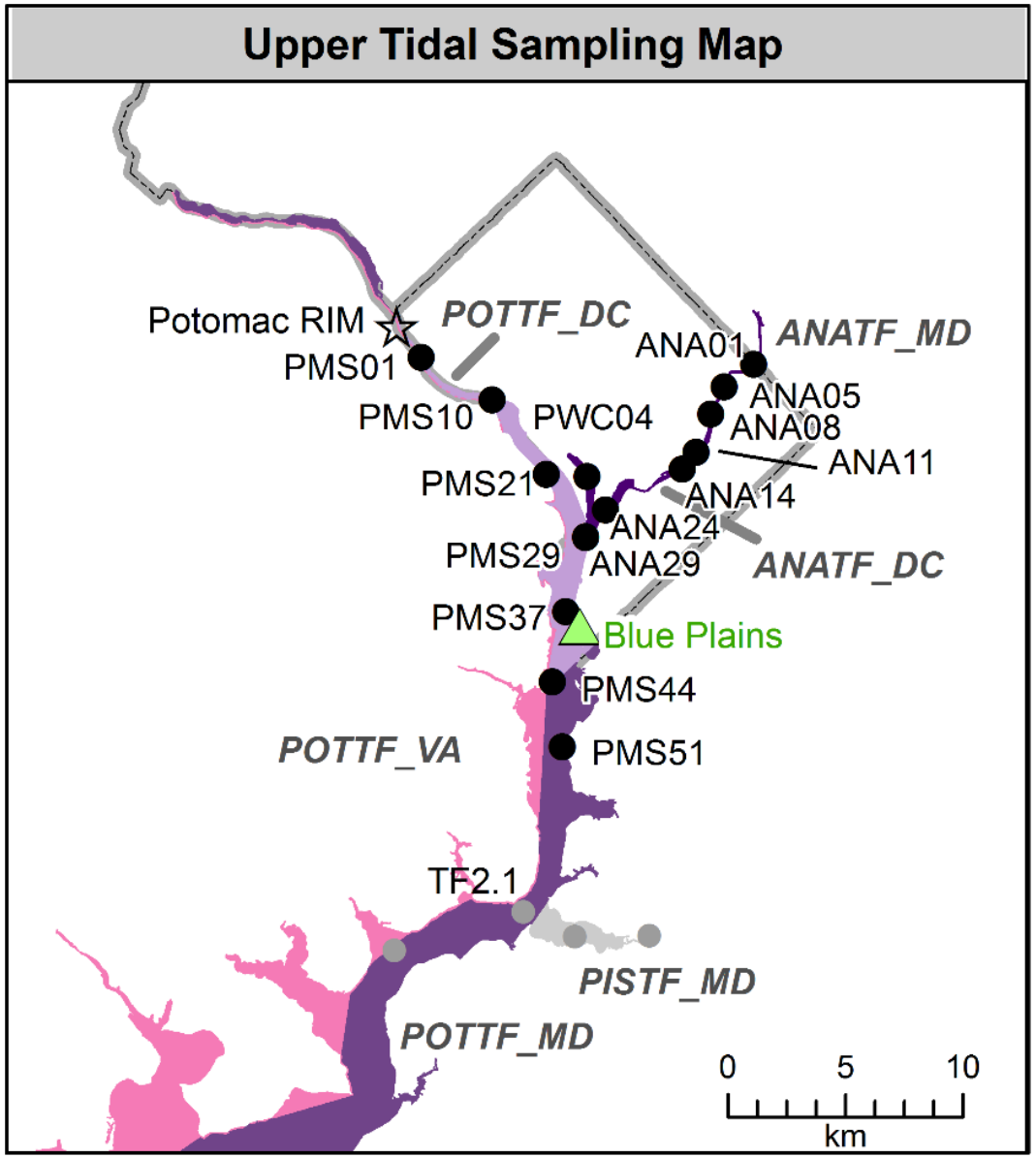


The tidal Anacostia River is showing some improvements

- Except for recent years, nitrogen had been decreasing and dissolved oxygen improving
- Water clarity has been improving
- Submerged aquatic vegetation (SAV) has been recovering and reached the goal for coverage in the most recent assessment



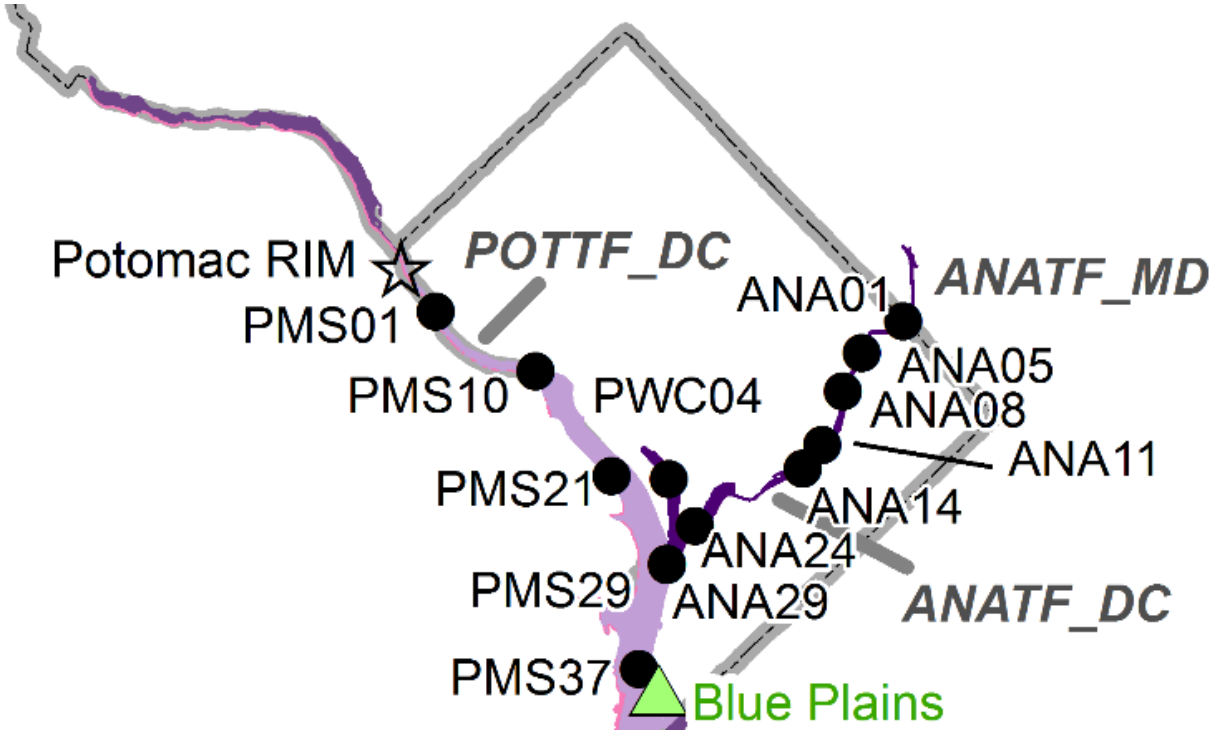
Virginia Institute of Marine Science.



Map by Rebecca Murphy.

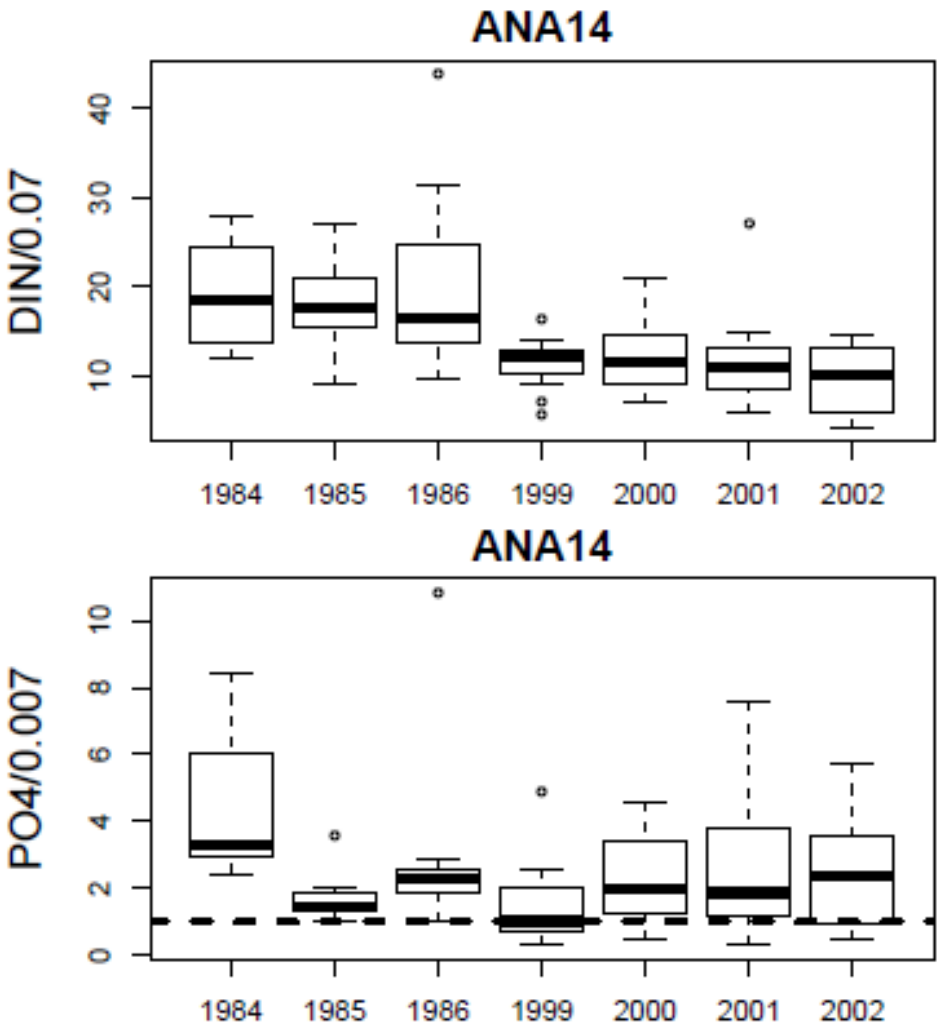
The tidal Anacostia River is showing some improvements

- The Anacostia has consistently had excess nitrogen, though the nitrogen levels have been decreasing
- Phosphorus has reached levels low enough to be limiting at times



Map by Rebecca Murphy.

Saturation limits

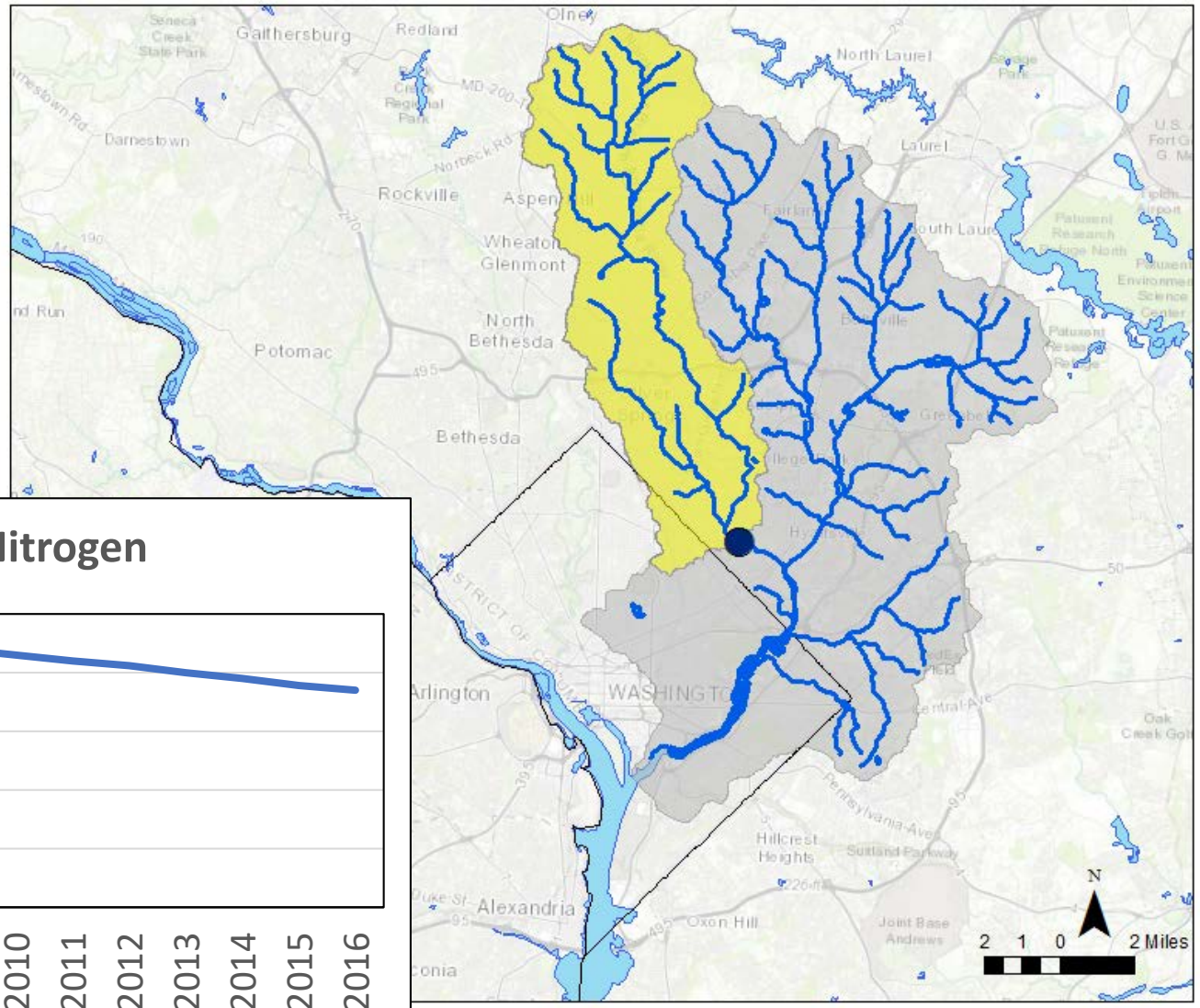


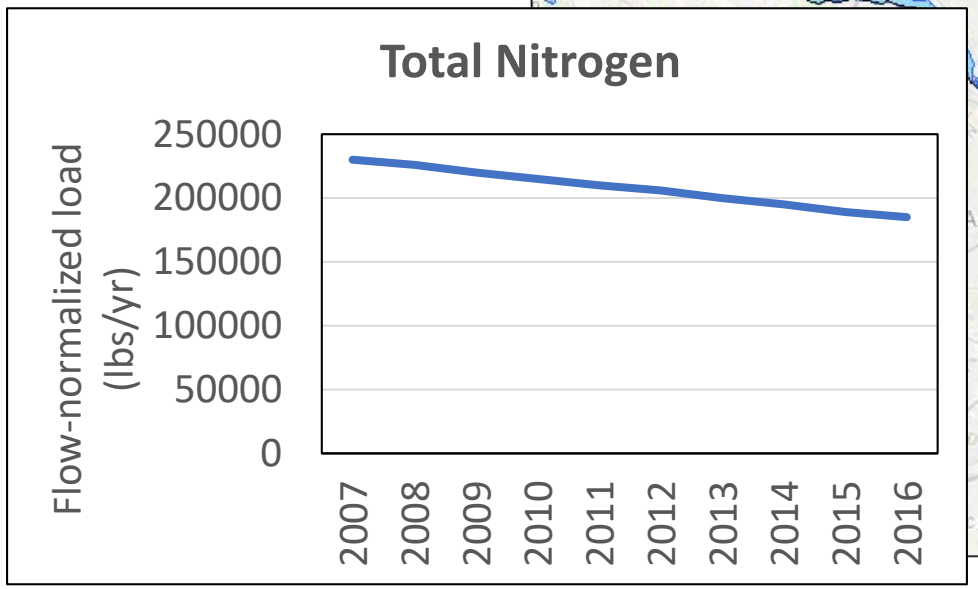
Preliminary data by Cuiyin Wu, CBPO.

The non-tidal portion of the Anacostia River is also showing some improvements

- The non-tidal Northern Branch and Sligo Creek watersheds are monitored with a USGS water quality monitoring station
- Like the tidal water quality stations, it shows decreasing total nitrogen
- Increasing dissolved nutrient trends need more exploring

USGS water quality monitoring station

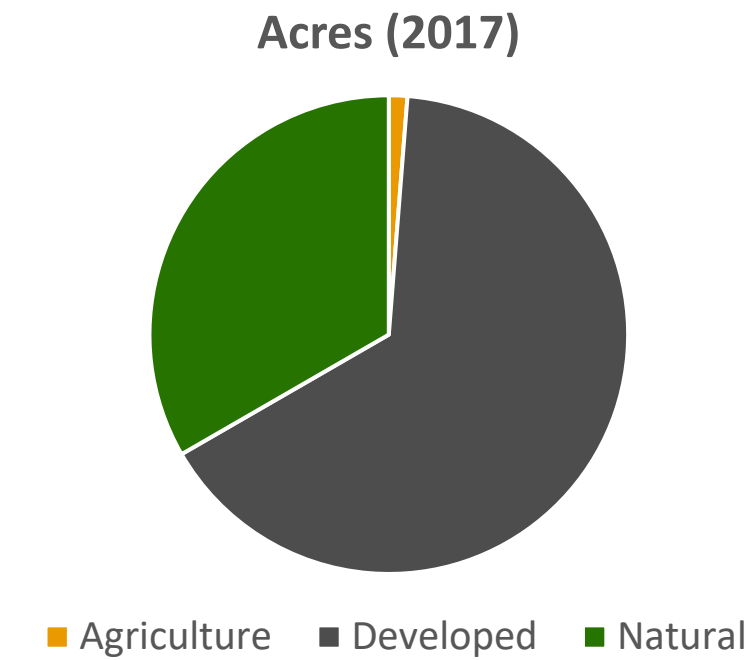




https://cbrim.er.usgs.gov

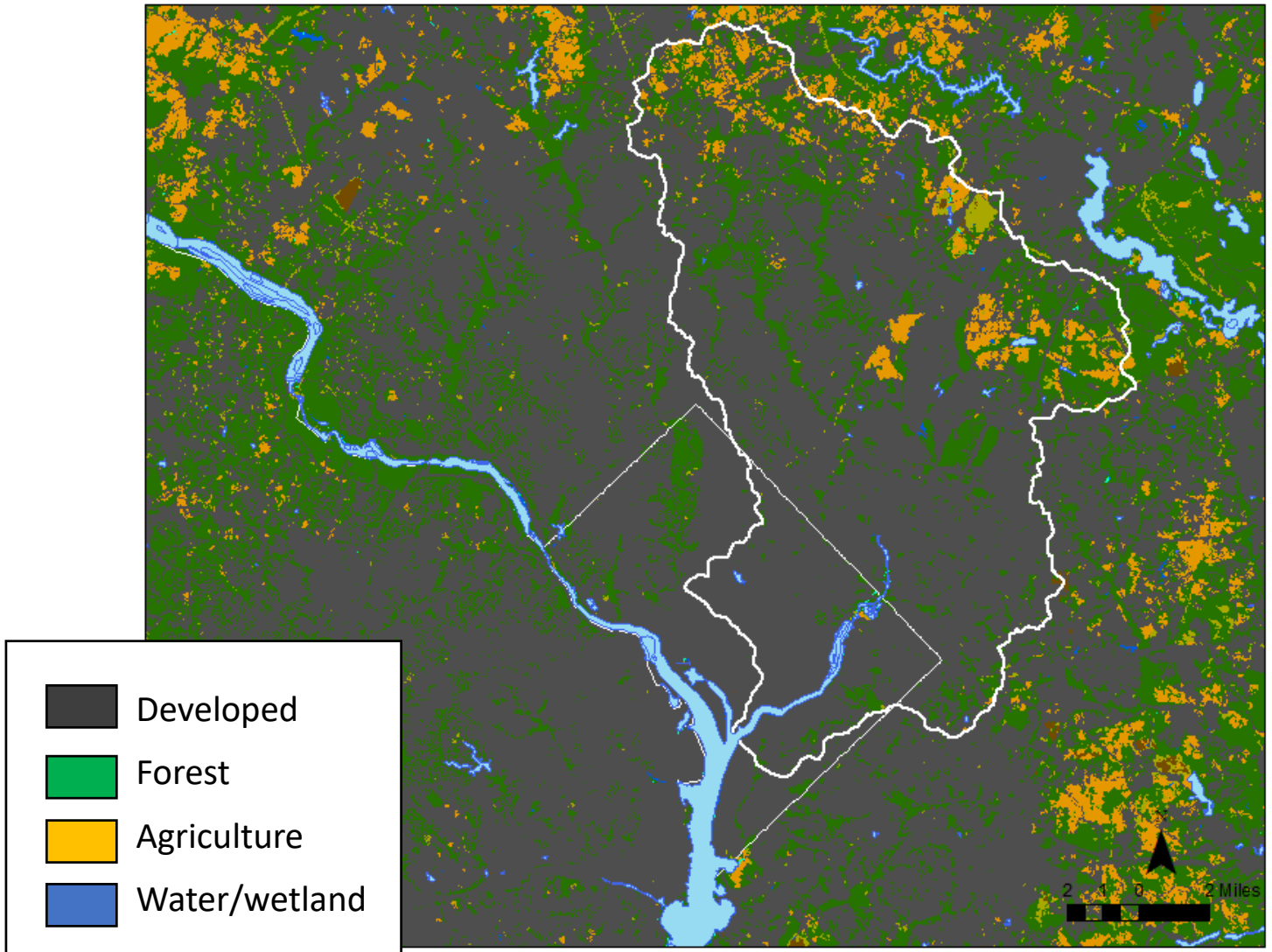
Drivers of water quality in the Anacostia River

The Anacostia River watershed is primarily urban and has been for some time



Phase 6 Watershed Model, http://cast.chesapeakebay.net

Land use (2013)



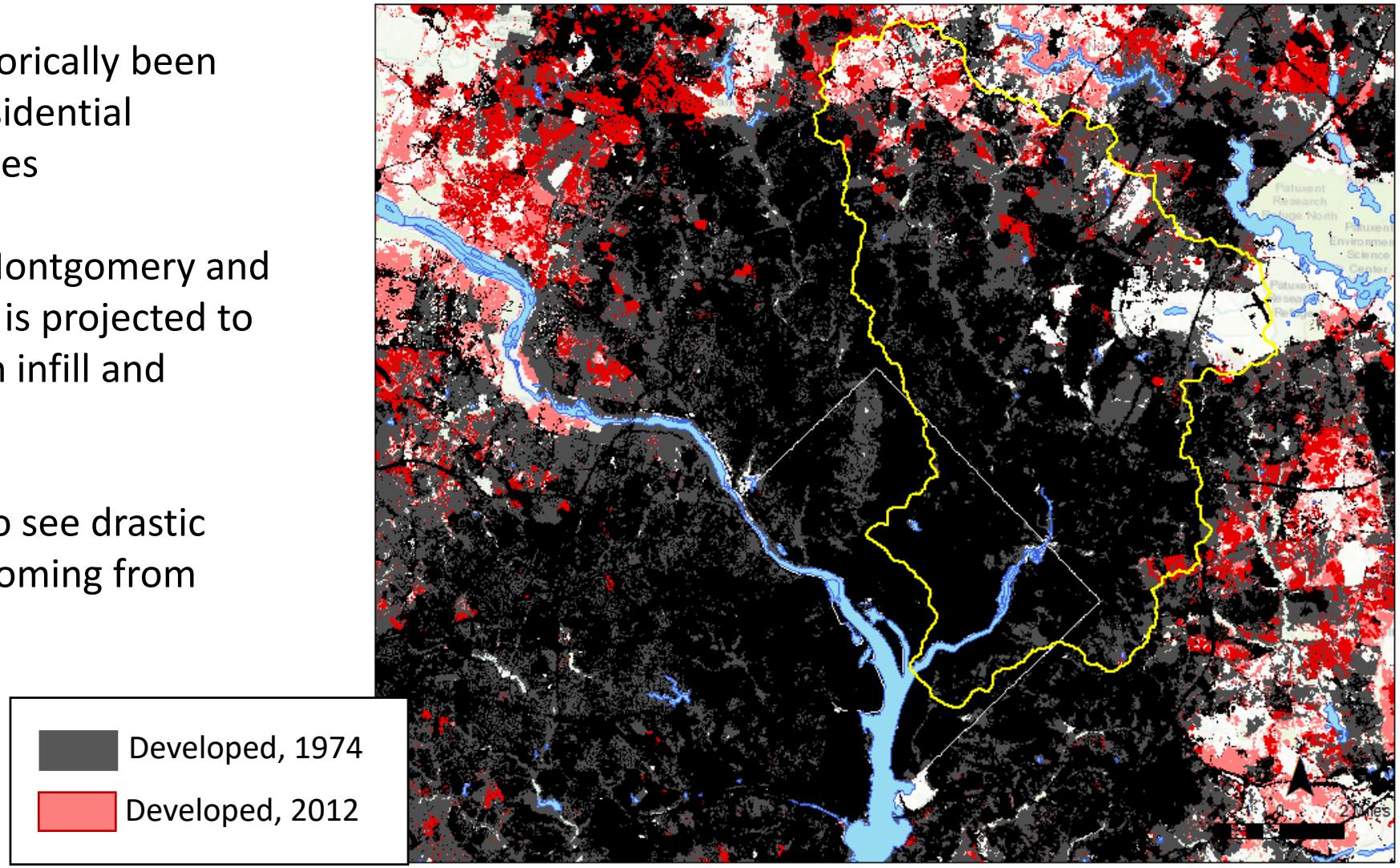
Phase 6 Land Use Viewer, https://chesapeake.usgs.gov/phase6/

Drivers of water quality in the Anacostia River

The Anacostia River watershed is primarily urban and has been for some time

- The watershed has historically been primarily urban and residential development for decades
- New development in Montgomery and Prince George's county is projected to occur primarily through infill and redevelopment
- We would not expect to see drastic increases in pollution coming from developed land

Change in Land-use

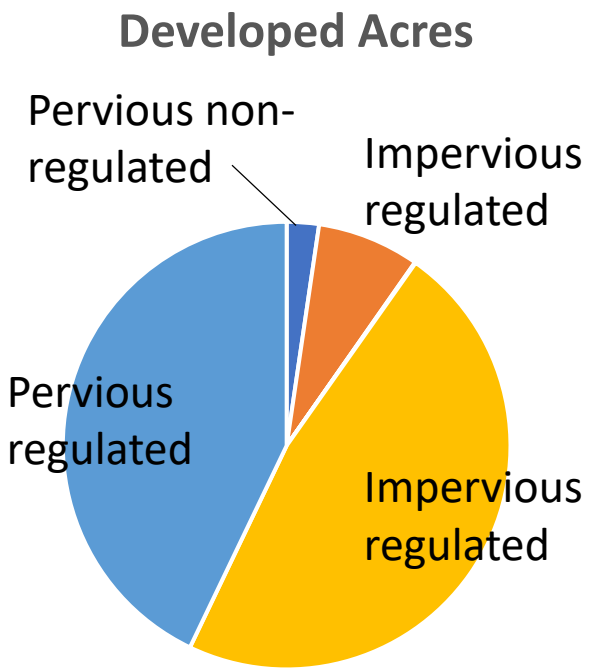


Falcone, J. et al., 2015.

Drivers of water quality in the Anacostia River

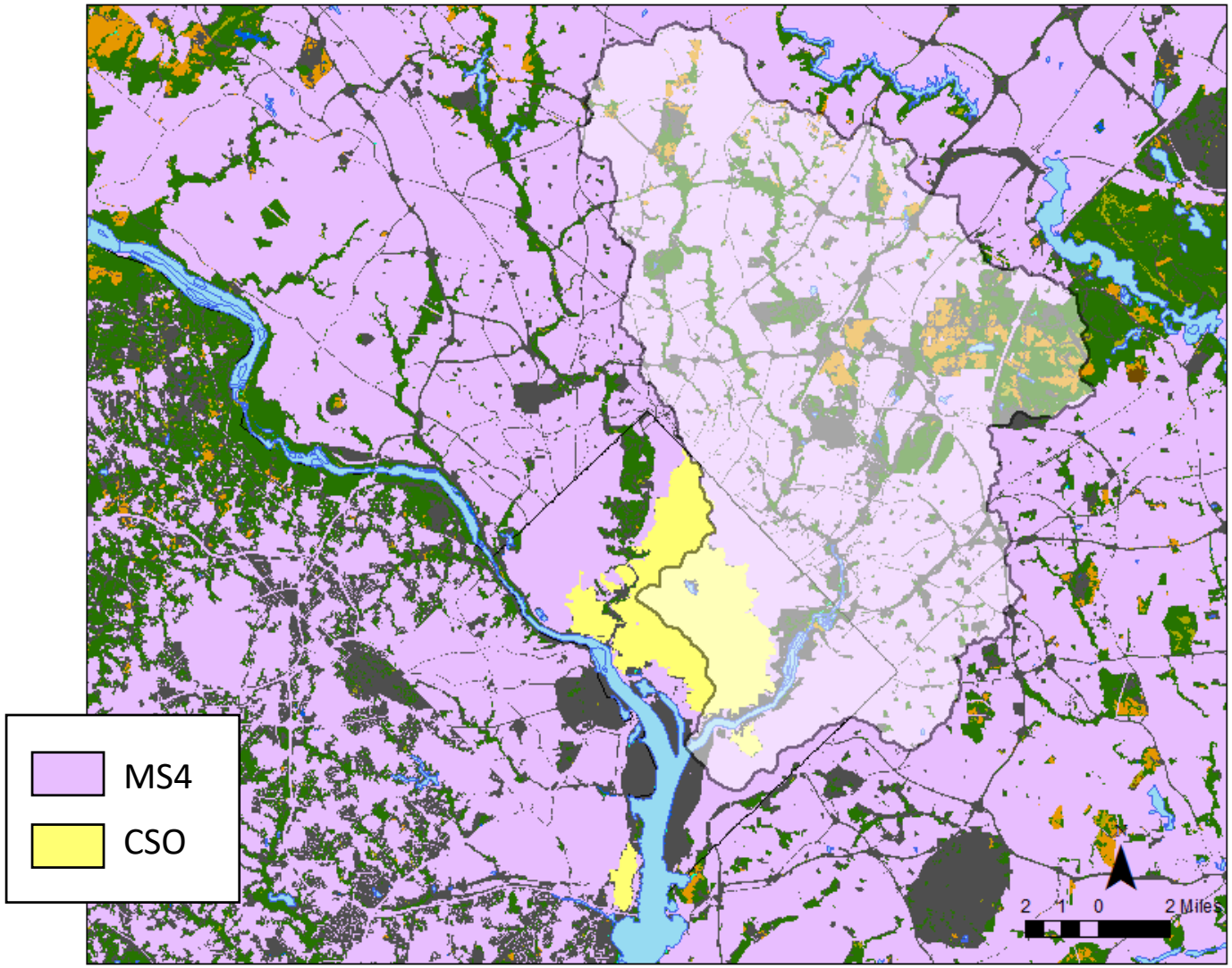
The Anacostia River watershed is primarily urban and has been for some time

- The majority of the watershed's developed land is regulated in MS4 or CSO areas



Phase 6 Watershed Model, http://cast.chesapeakebay.net

MS4 & CSO areas



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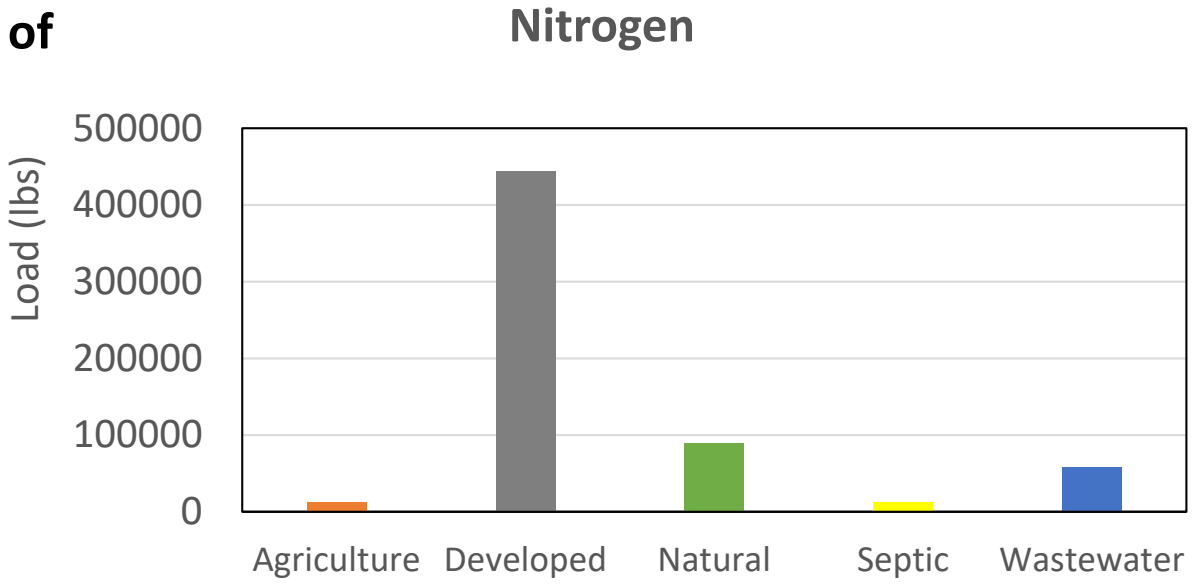
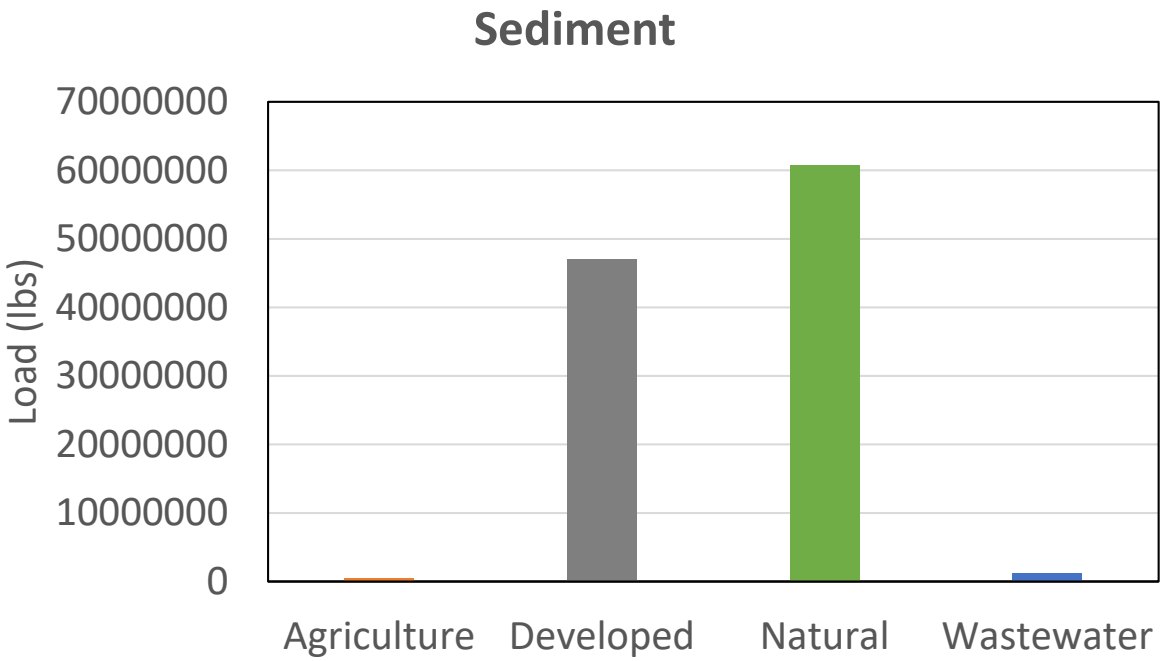
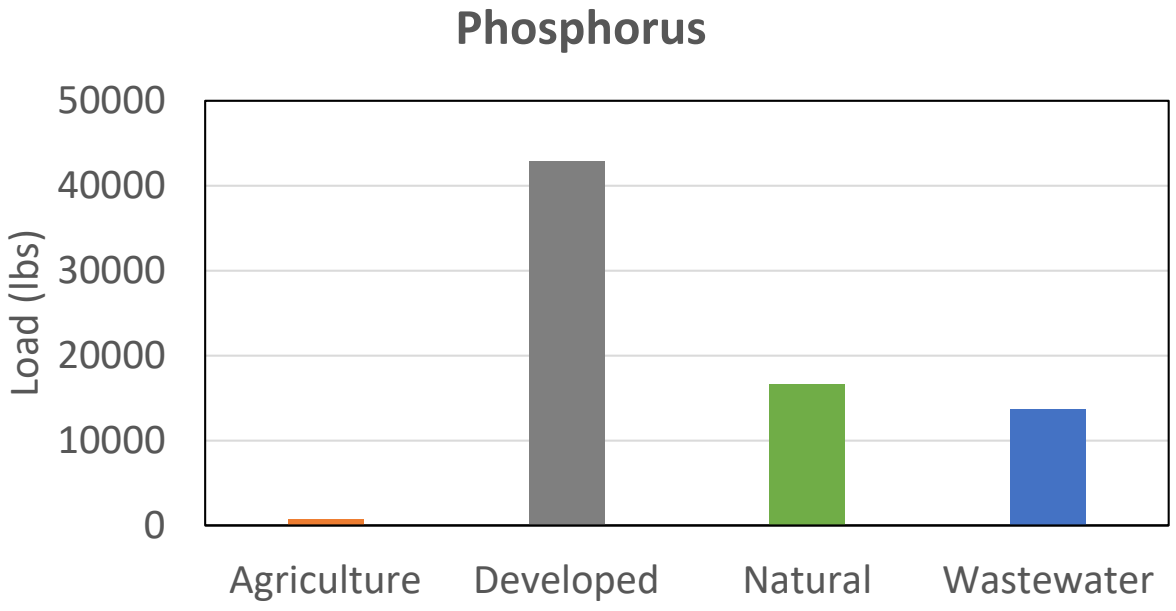
Sources of nutrient and sediment pollution

Stormwater from developed land is the largest source of both nutrients and sediment

- Runoff is directly or indirectly responsible for the majority of nutrient and sediment loads
- Wastewater is a relatively minor contributor compared to stormwater







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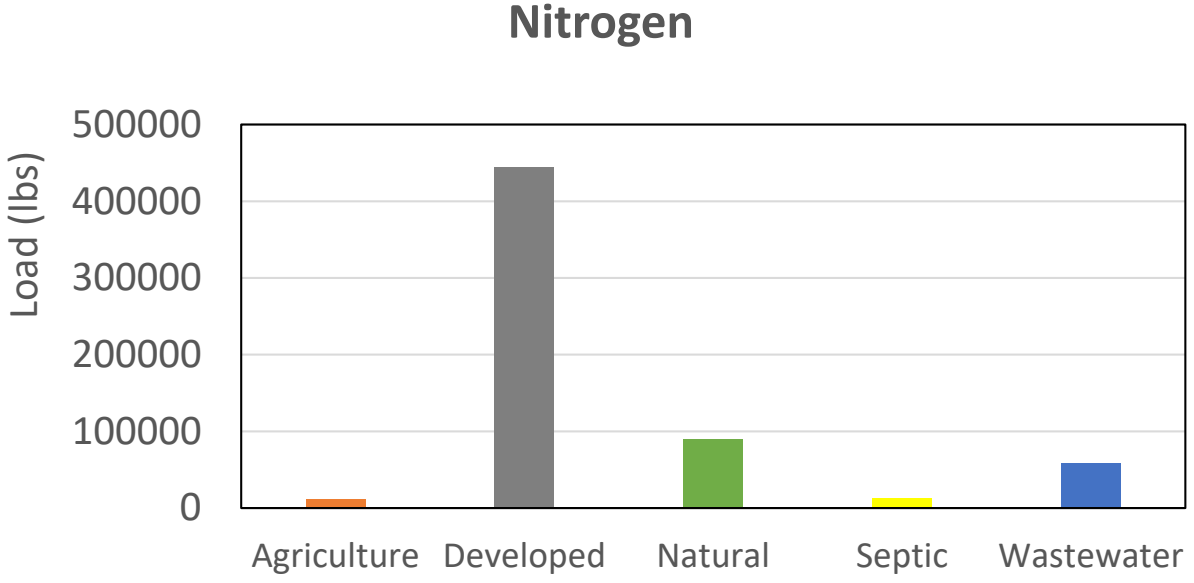

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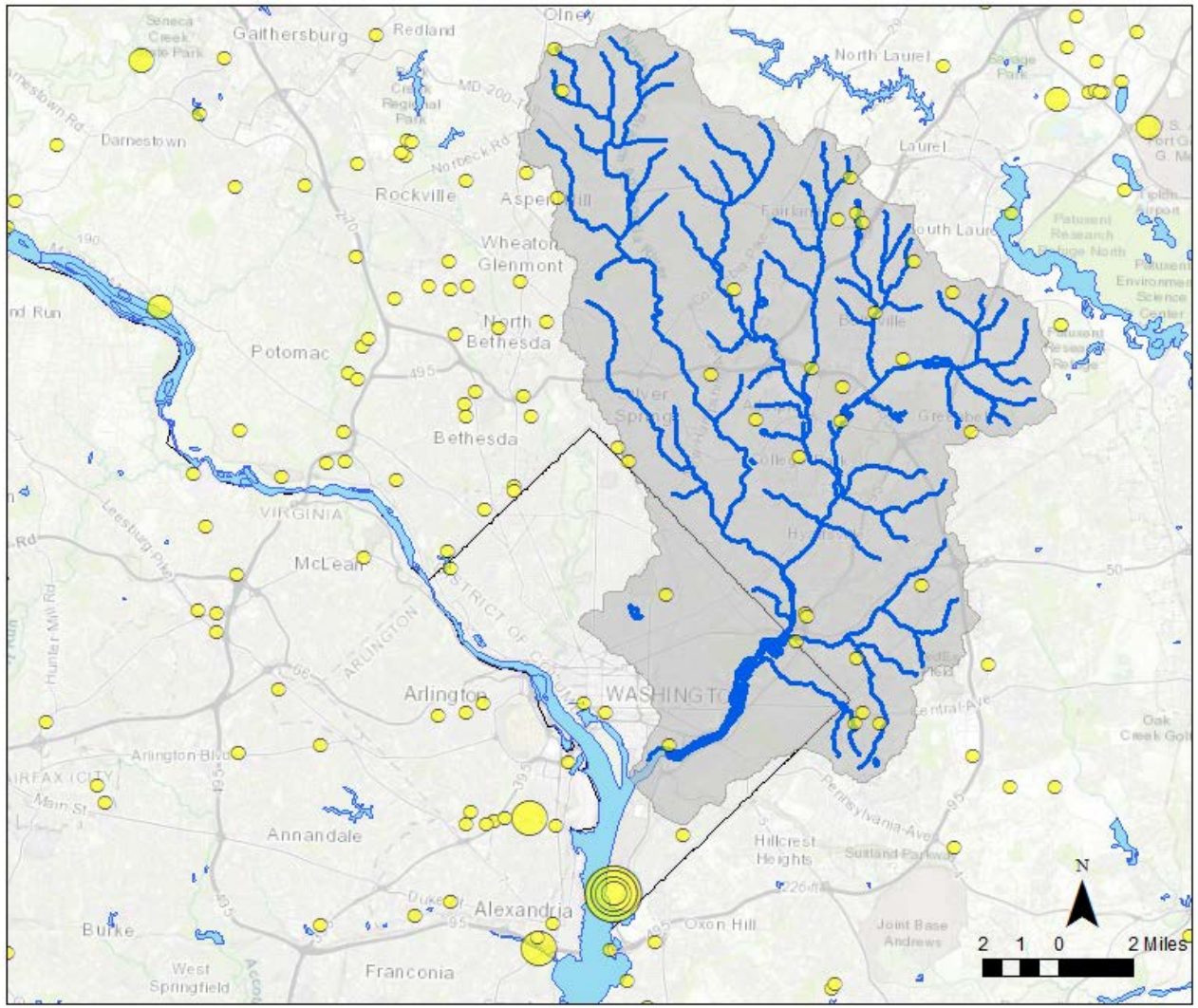
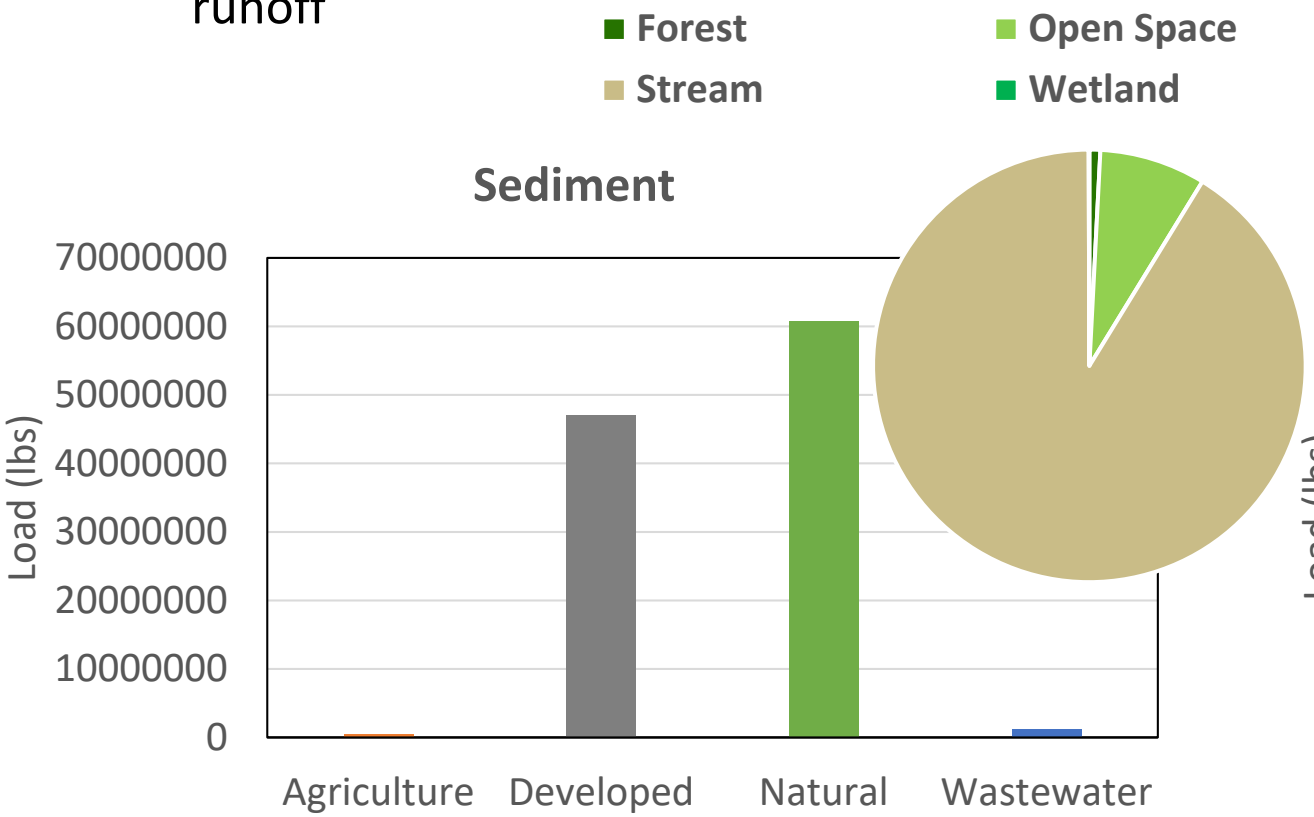
Wastewater treatment plants and nitrogen load

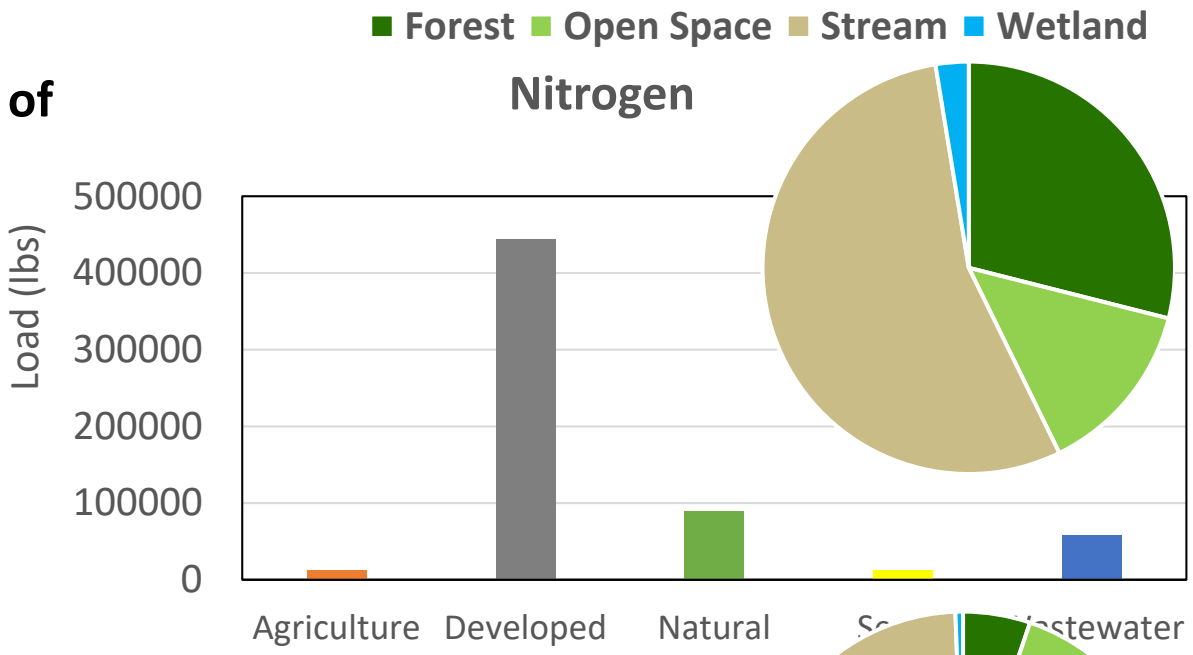


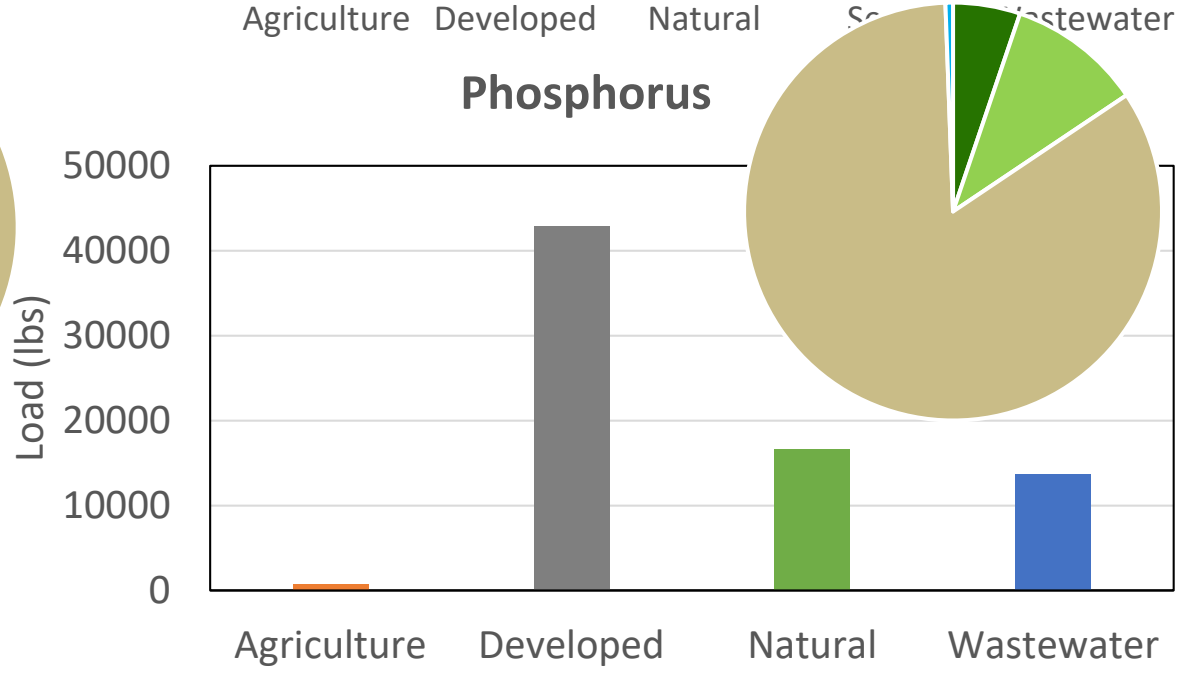
Sources of nutrient & sediment pollution

Stormwater from developed land is the largest source of both nutrients and sediment

- Streambank erosion is the major contributor of sediment
- Stream erosion is still tied to stormwater runoff







Choosing practices that address the Anacostia's sources

The most cost-effective practices differ slightly depending on geography, but common practices emerge

- Some of the most cost-effective practices are highly implemented in the Anacostia river watershed
- Other effective stormwater management practices are not as highly implemented, and signify opportunities for future restoration efforts

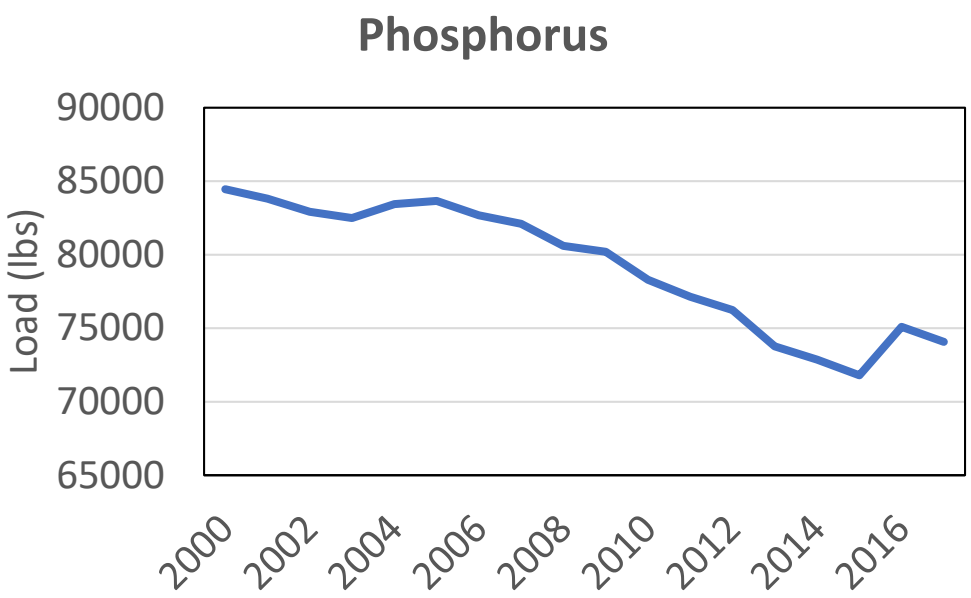
		$/lbs reduced/year		
Management Practice	**2017 Progress**	**Nitrogen**	**Phosphorus**	**Sediment**
Erosion and Sediment Control	74.5%	0	0	0.23
Nutrient Management Plan	67.9%	0	0	0
Dirt & Gravel Road E & S Control	27.0%	0	0	0.73
Forest Buffer	0.1%	14.52	66.8	0.1
Forest Planting	1.0%	18.54	91.61	0.19
Bioswale	0.1%	187.18	1330.21	0.92
Infiltration Practices w/o Sand, Veg	1.0%	206.8	1482.24	0.98
Wet Ponds and Wetlands	13.0%	250.04	846.02	0.47
Dry Extended Detention Ponds	1.0%	259.25	1971.83	0.49
Vegetated Open Channels	0.0%	275.32	2096.31	1
Tree Planting	0.2%	296.81	900.97	1.32
Storm Drain Cleaning	0.0%	299.72	1348.72	0.81
Stormwater Performance Treatment	3.9%	629.61	3397.18	1.86
Bioretention/raingardens	0.7%	641.14	2712.28	1.64
Runoff Reduction	0.8%	711.01	5157.82	3.34
Filtering Practices	1.2%	879.43	4464.22	2.47
Grey Infrastructure Nutrient Discovery Program (IDDE)	0.0%	913.13	3652.51	0
Dry Detention Ponds	7.3%	2301.59	8725.8	6.47
Urban Stream Restoration	7.0%	2528.99	3051.01	1.53
Filter Strip Runoff Reduction	0.0%	3396.18	9578	6.82
Impervious Disconnection	0.0%	14875.3	95314.22	65.93
Permeable Pavement	0.0%	21537.63	81937.93	22.02

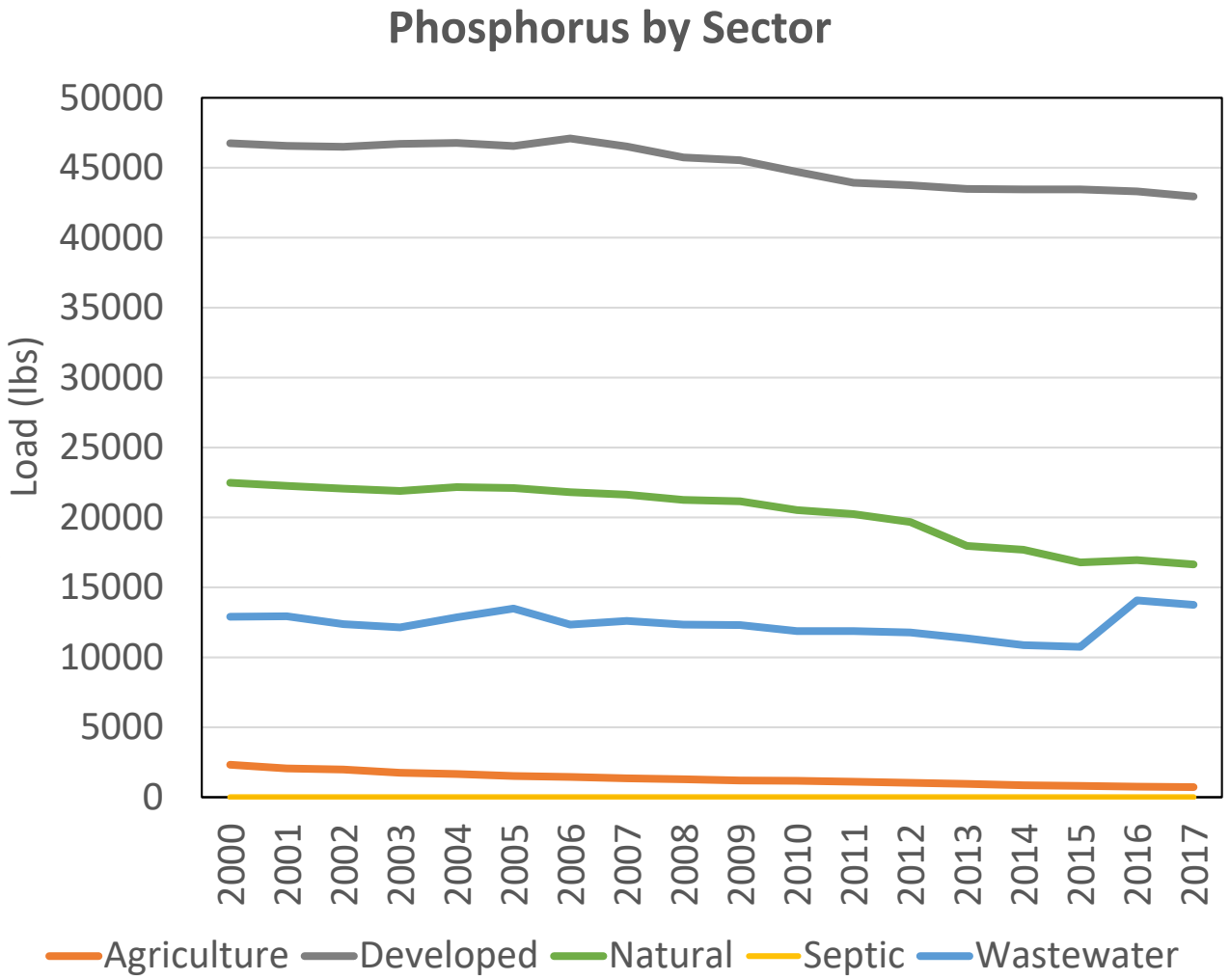
Phase 6 Watershed Model, http://cast.chesapeakebay.net

Addressing the Anacostia's sources of pollution

We may be seeing impacts from management practices in the Anacostia River watershed

- Phosphorus and sediment are estimated to have been decreasing in recent years, potentially in response to stream restoration efforts, urban nutrient management, and CSO improvements



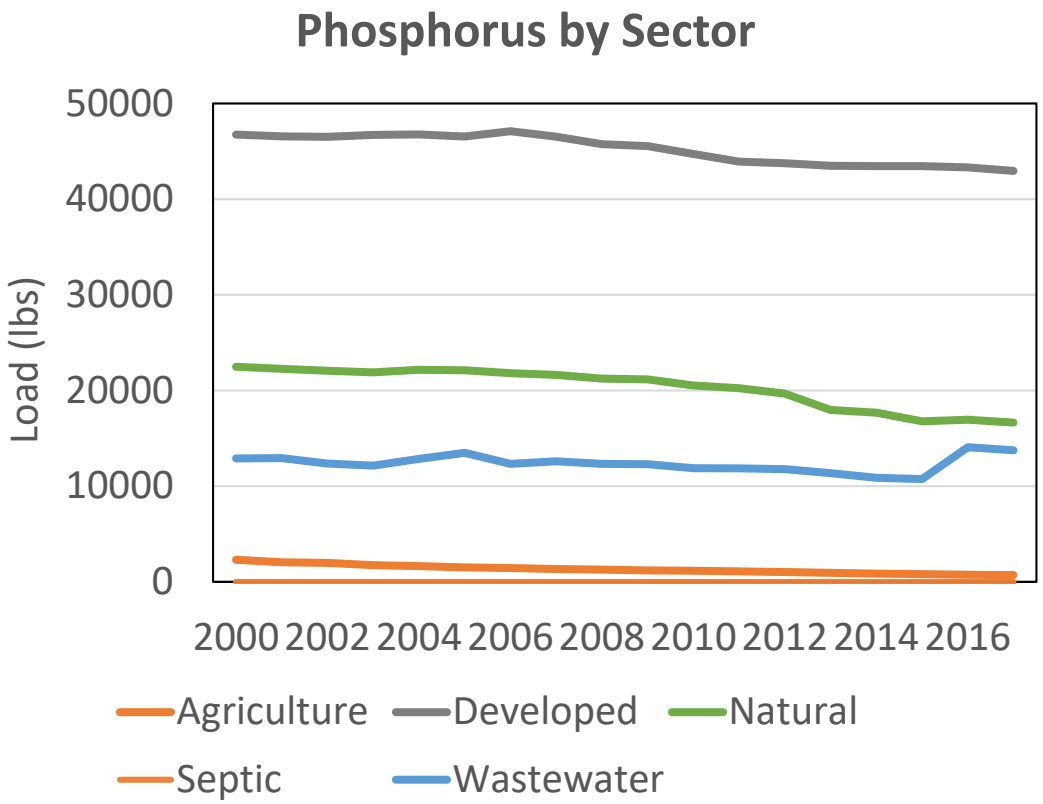


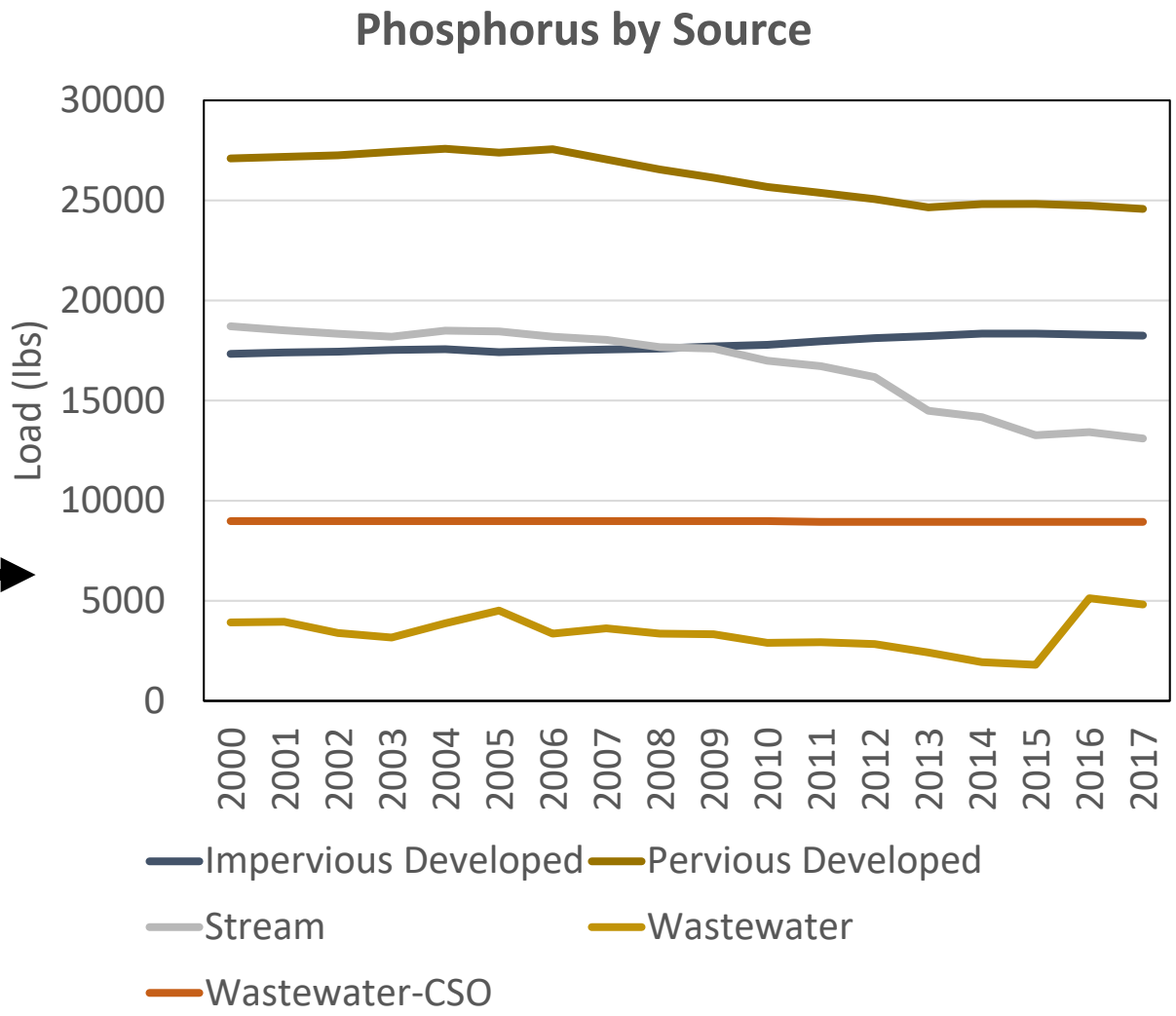
Phase 6 Watershed Model, http://cast.chesapeakebay.net

Addressing the Anacostia's sources of pollution

We may be seeing impacts from management practices in the Anacostia River watershed

- Decrease in sediments in tidal waters corresponds with improved clarity and SAV resurgence
- More research would be needed to identify correlation



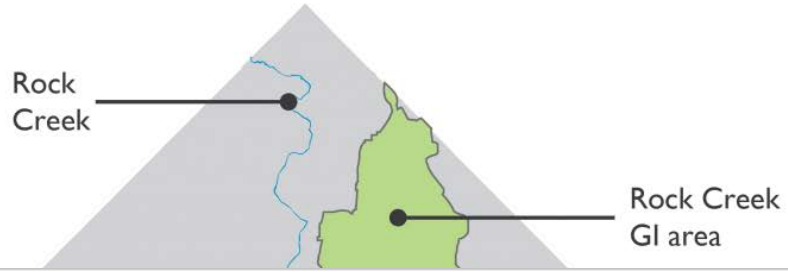


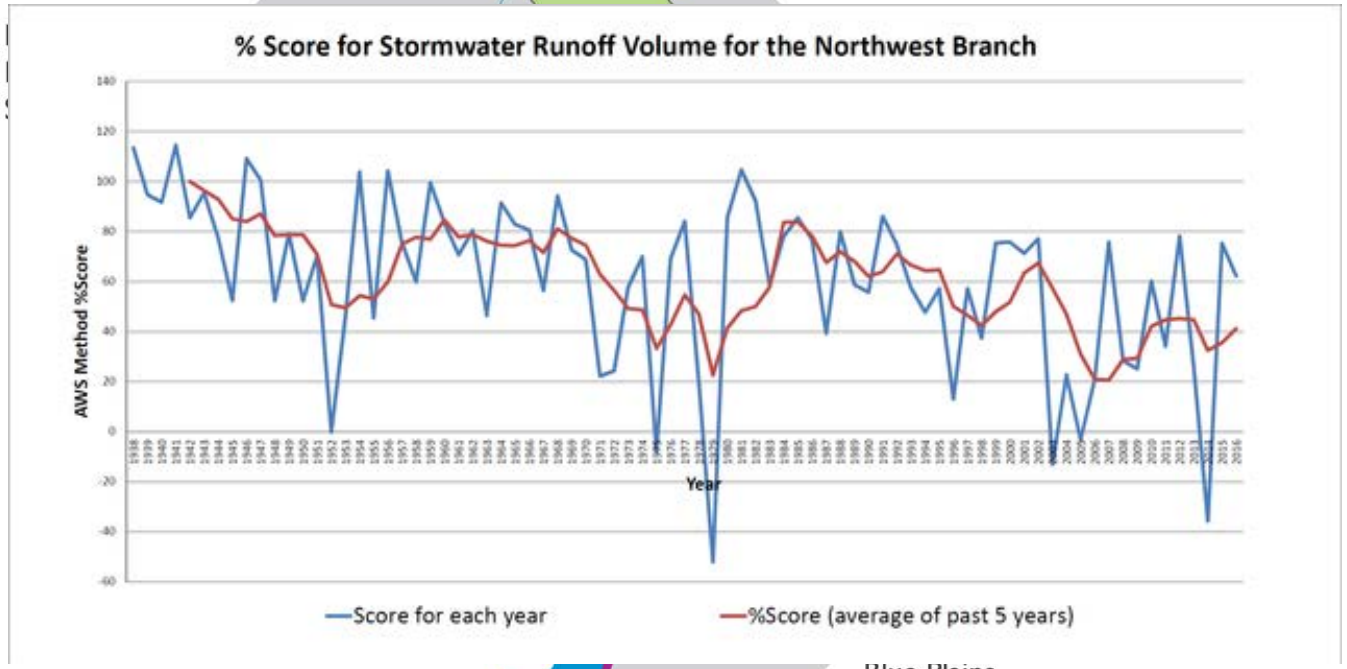
Phase 6 Watershed Model, http://cast.chesapeakebay.net

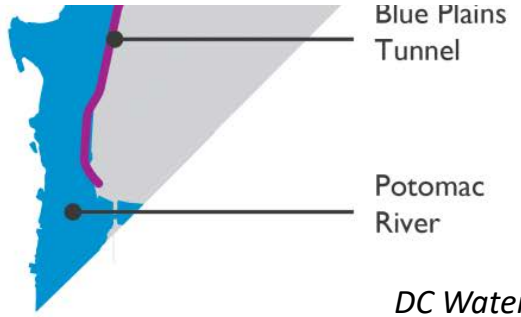
Addressing the Anacostia's sources of pollution

We may be seeing impacts from management practices in the Anacostia River watershed

- CSO upgrades like DC's tunnel projects have already decreased CSO loads to the Lower Anacostia and will continue to bring improvements
- The issue of stormwater, especially in the Maryland portion of the watershed, is still important
- Peak stream discharges are increasing in the Anacostia







Anacostia Watershed Society, https://www.anacostiaws.org

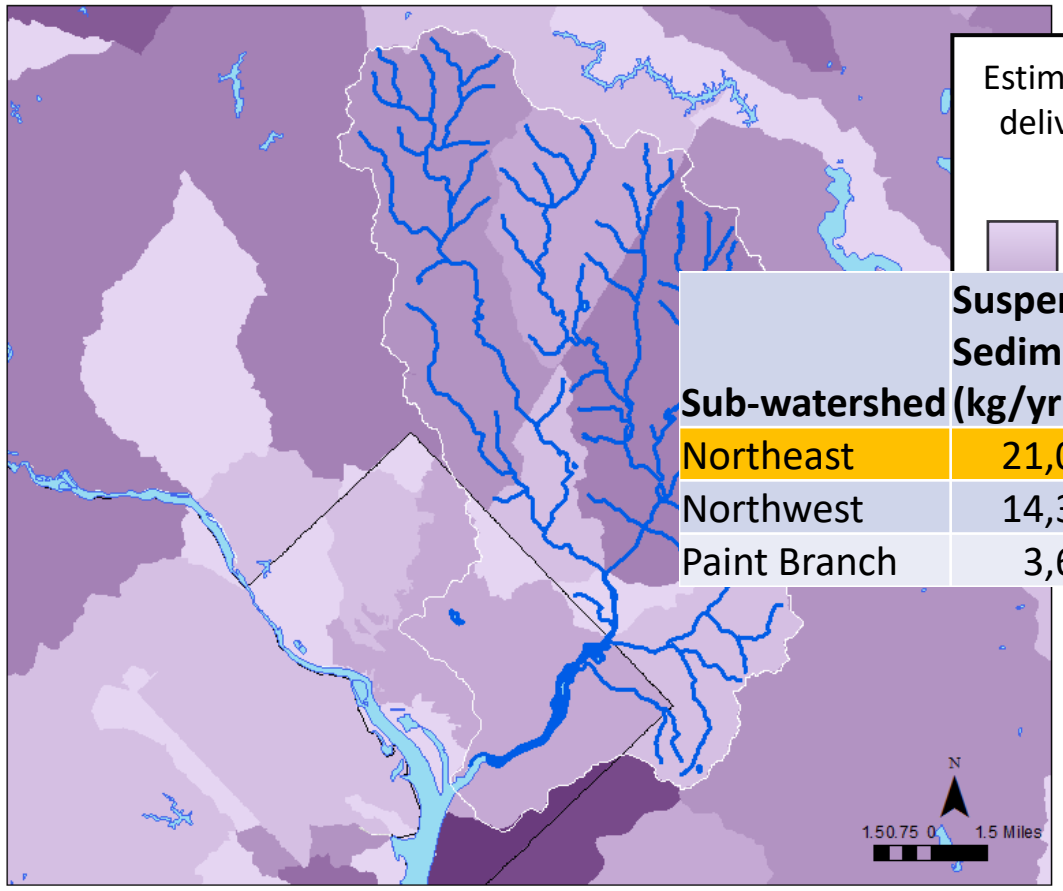
DC Water.

How can we focus our efforts moving forward?

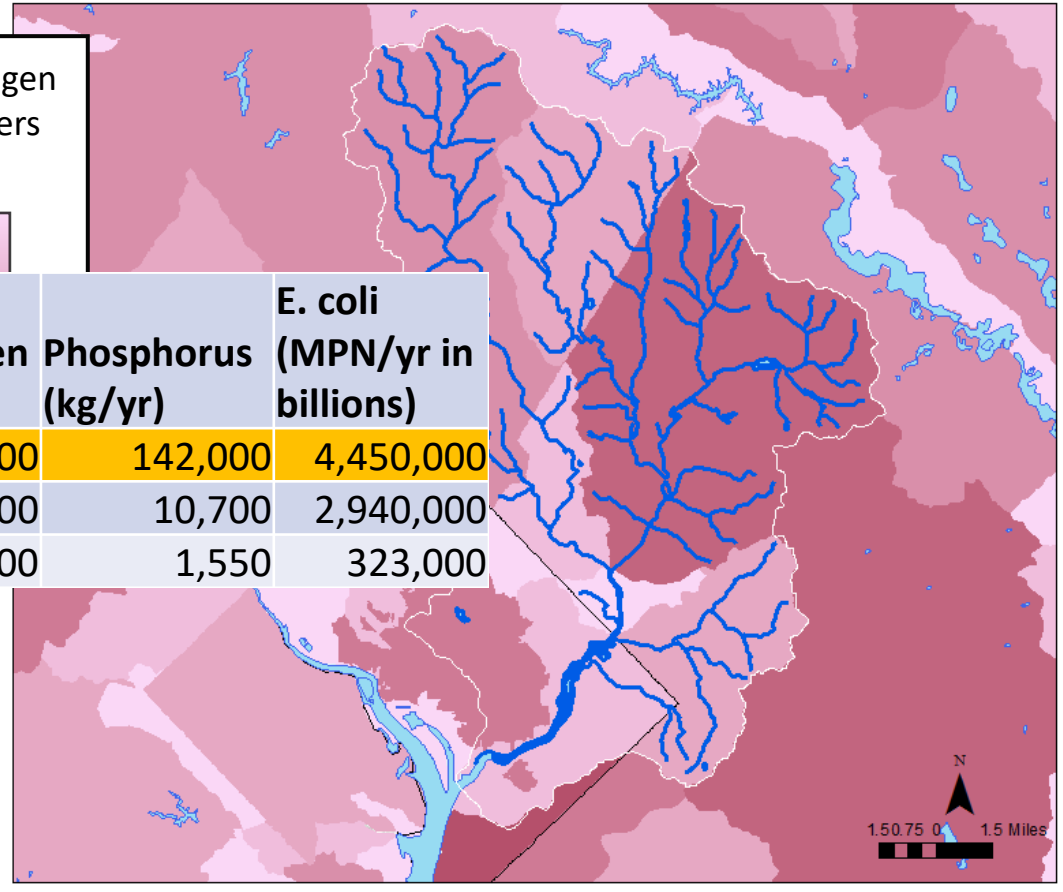
Targeting specific places for specific restoration practices is an effective way to focus restoration efforts

- The most water quality benefits can be gained from focusing efforts in the highest loading areas

Nitrogen



Phosphorus



Sub-watershed	Suspended Sediment (kg/yr)	Total Nitrogen (kg/yr)	Phosphorus (kg/yr)	E. coli (MPN/yr in billions)
Northeast	21,000,000	142,000	142,000	4,450,000
Northwest	14,300,000	98,200	10,700	2,940,000
Paint Branch	3,650,000	21,000	1,550	323,000

Miller, C. et al., 2013. USGS Open-File Report 2013-1034.

Phase 6 Watershed Model, http://cast.chesapeakebay.net

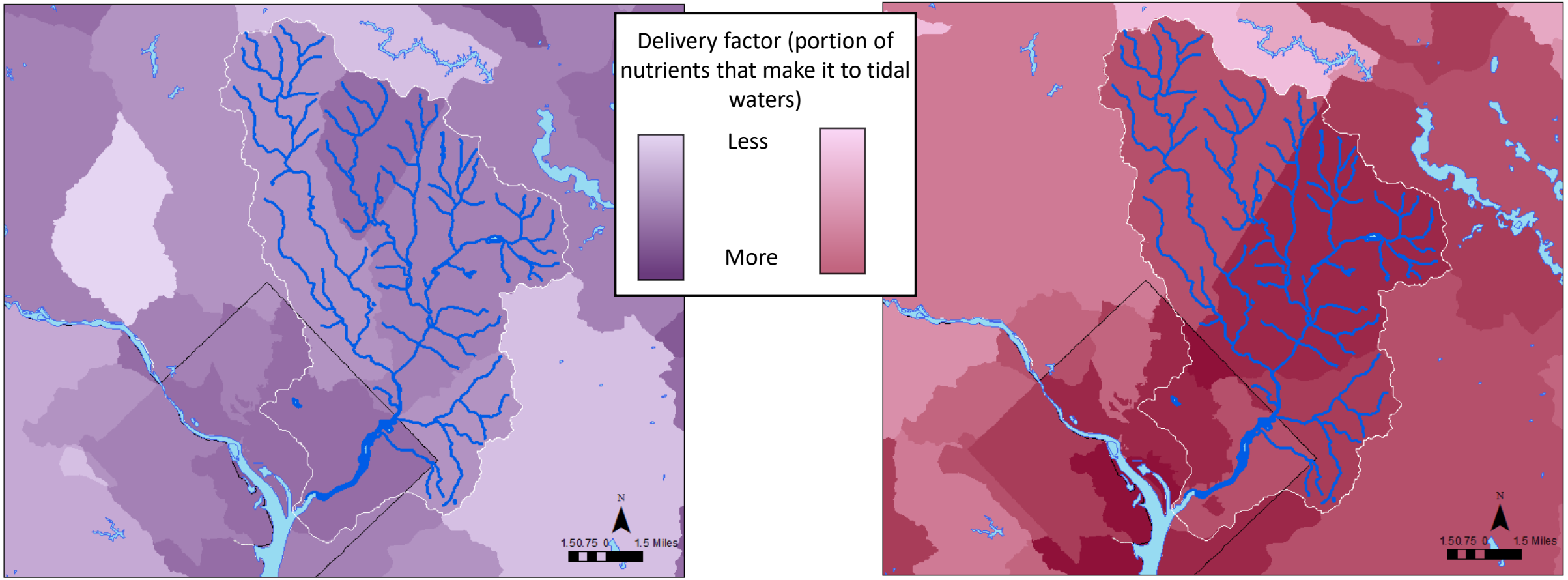
How can we focus our efforts moving forward?

Targeting specific places for specific restoration practices is an effective way to focus restoration efforts

- We can also focus geographically based on the areas with the most efficient delivery of nutrients to the tidal waters

Nitrogen

Phosphorus



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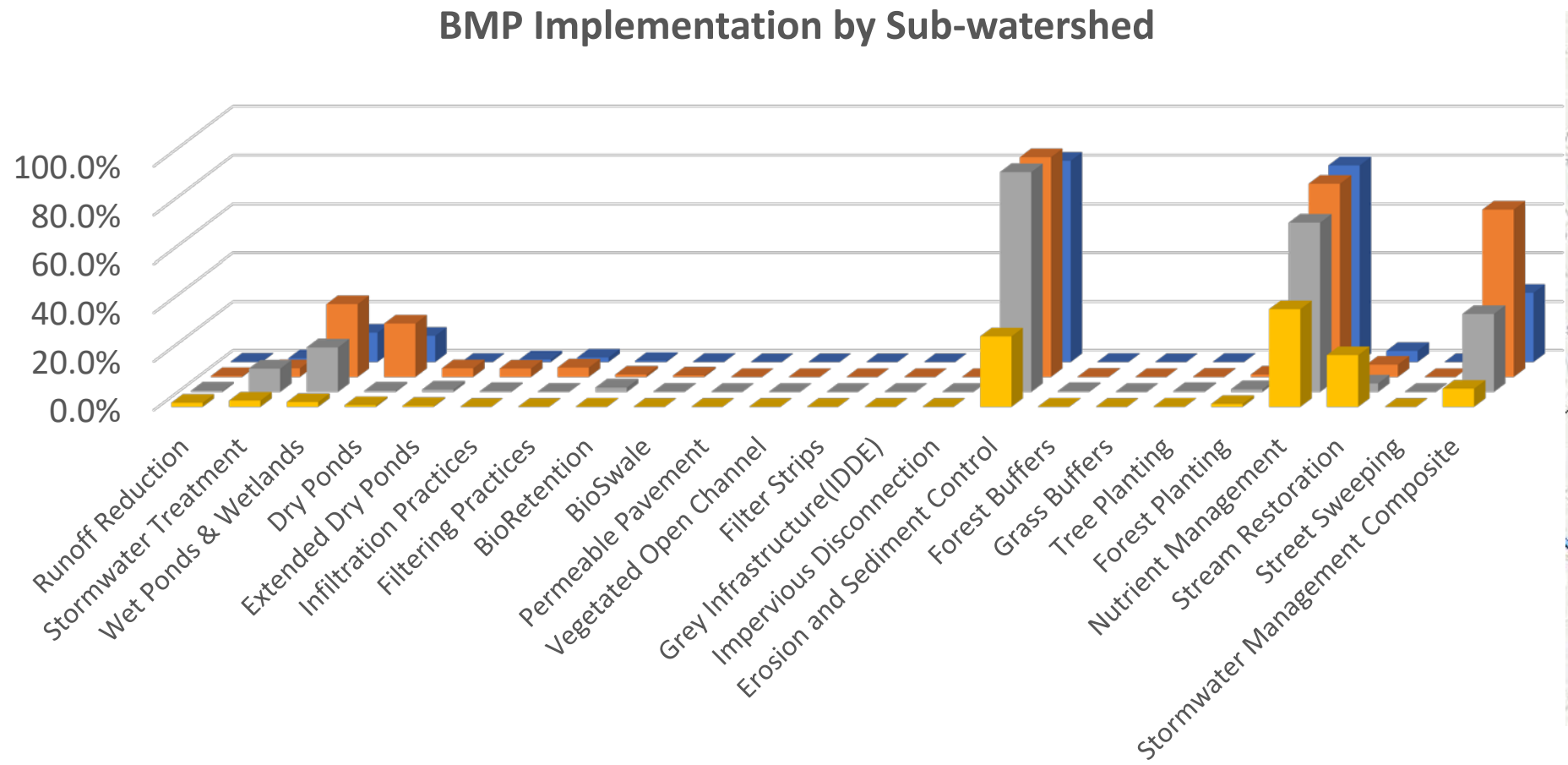
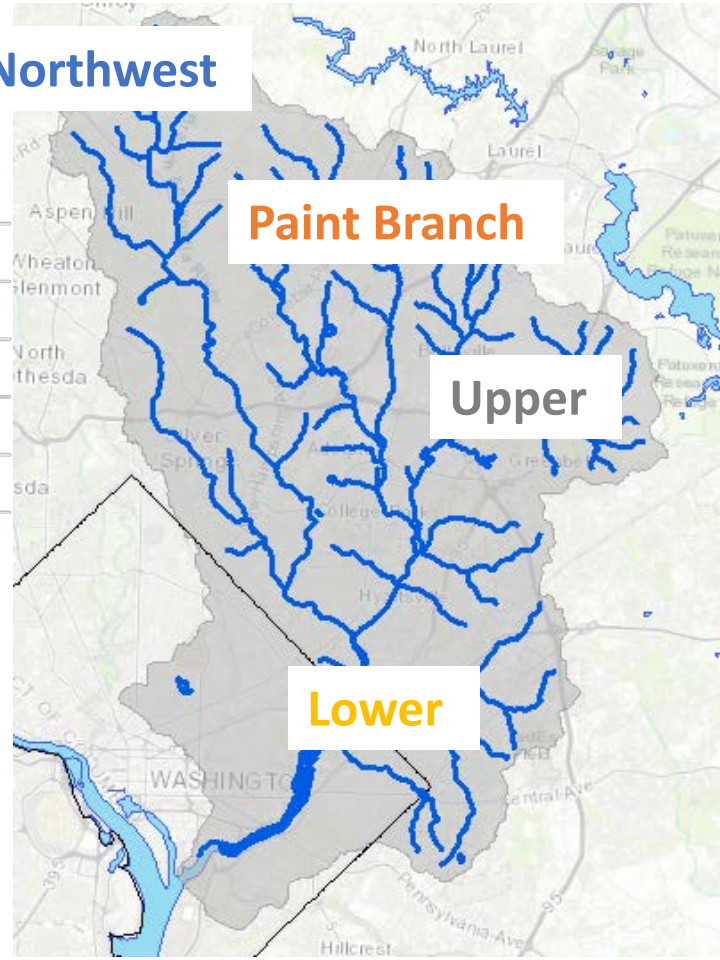




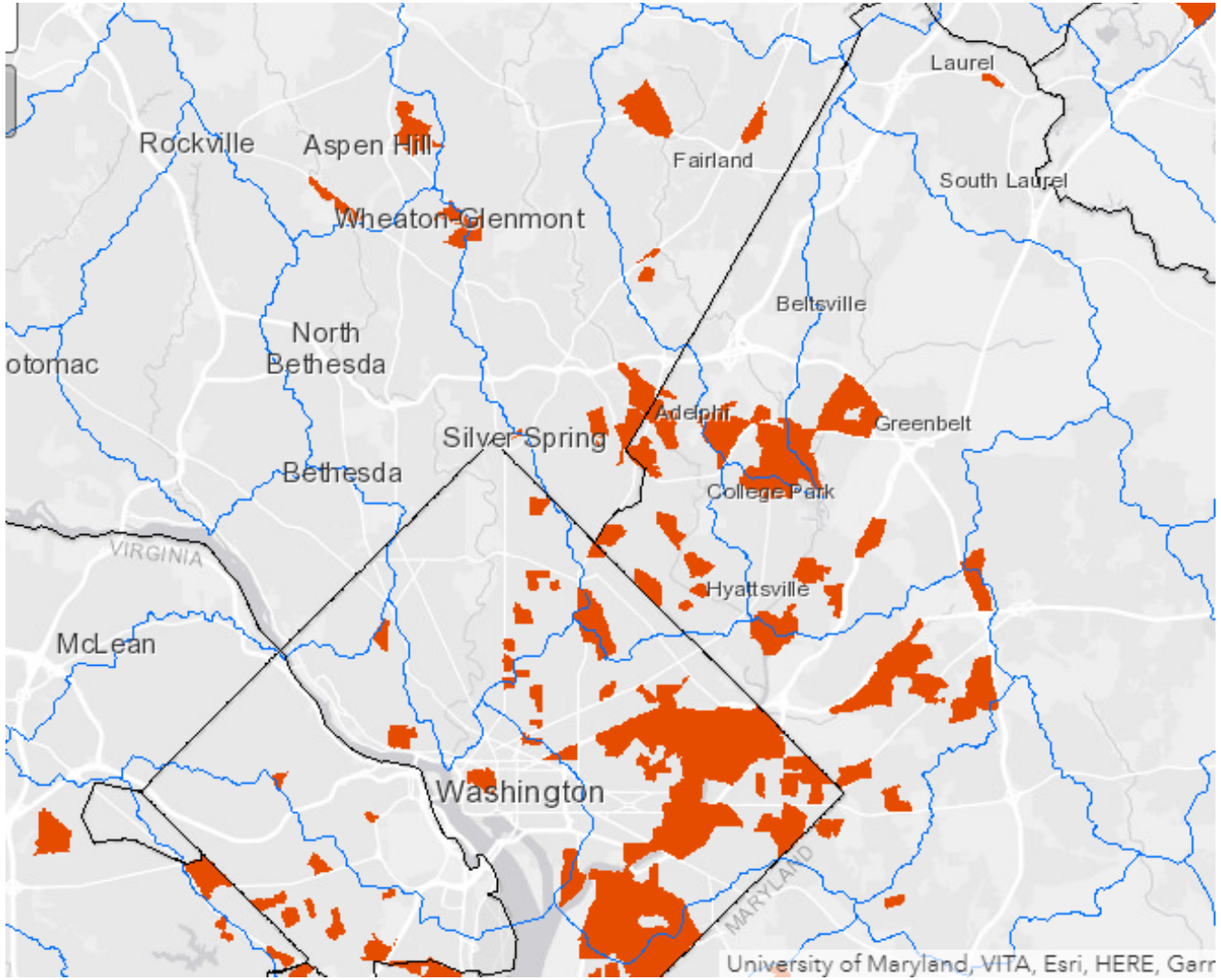
Phase 6 Watershed Model, http://cast.chesapeakebay.net

How can we focus our efforts moving forward?

Targeting specific places for specific restoration practices is an effective way to focus restoration efforts

- We can also focus geographically based on any number of other priorities we have for goals and objectives of our restoration efforts
- The Bay Program is going through efforts to identify areas that provide multiple benefits

Low Income Household areas

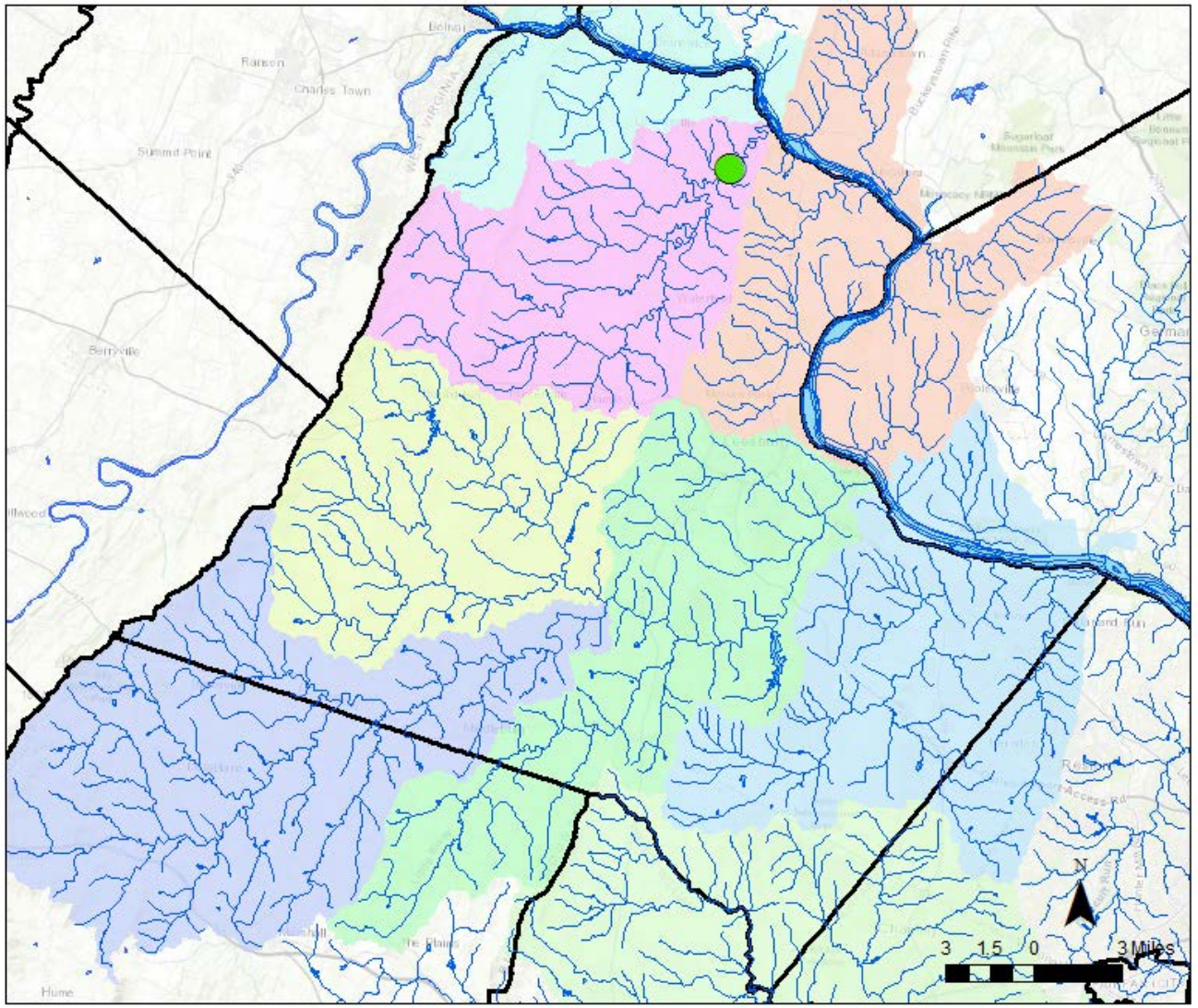


Cross-Goal Team Mapping, http://cast.chesapeakebay.net

Loudoun County faces unique challenges in water quality

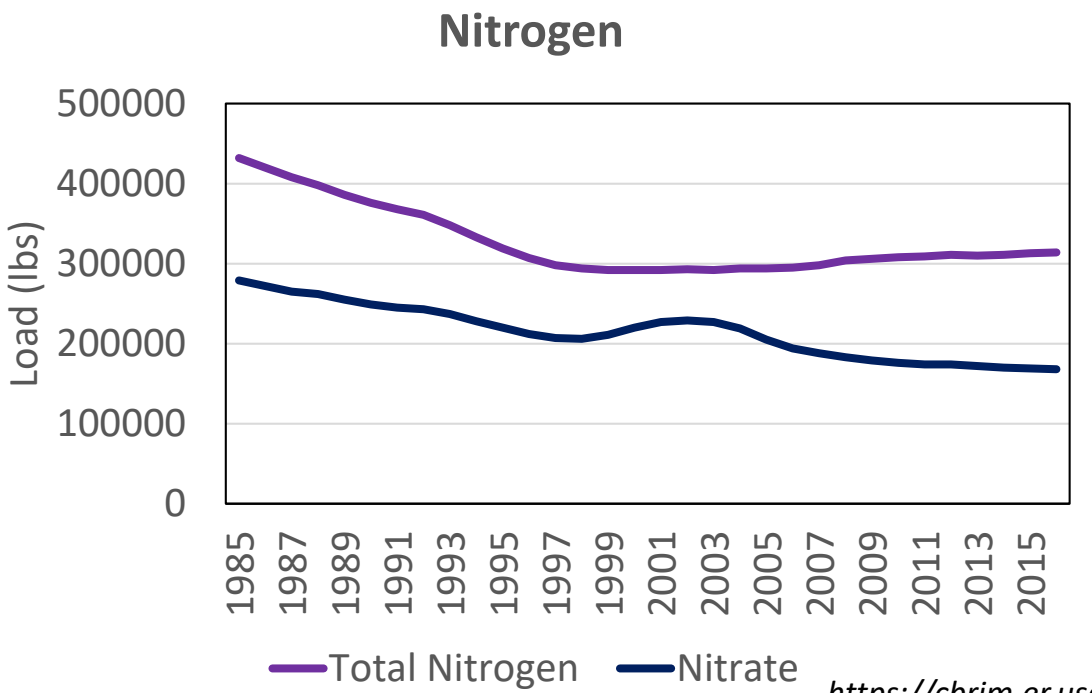
- Loudoun County contains a unique mix of agricultural land and rapidly developing areas
- Many streams in Loudoun County often face problems with fecal bacteria and sediment
- The conversion of forest or farmland to developed or urban areas represents its own set of challenges for water quality

Loudoun County

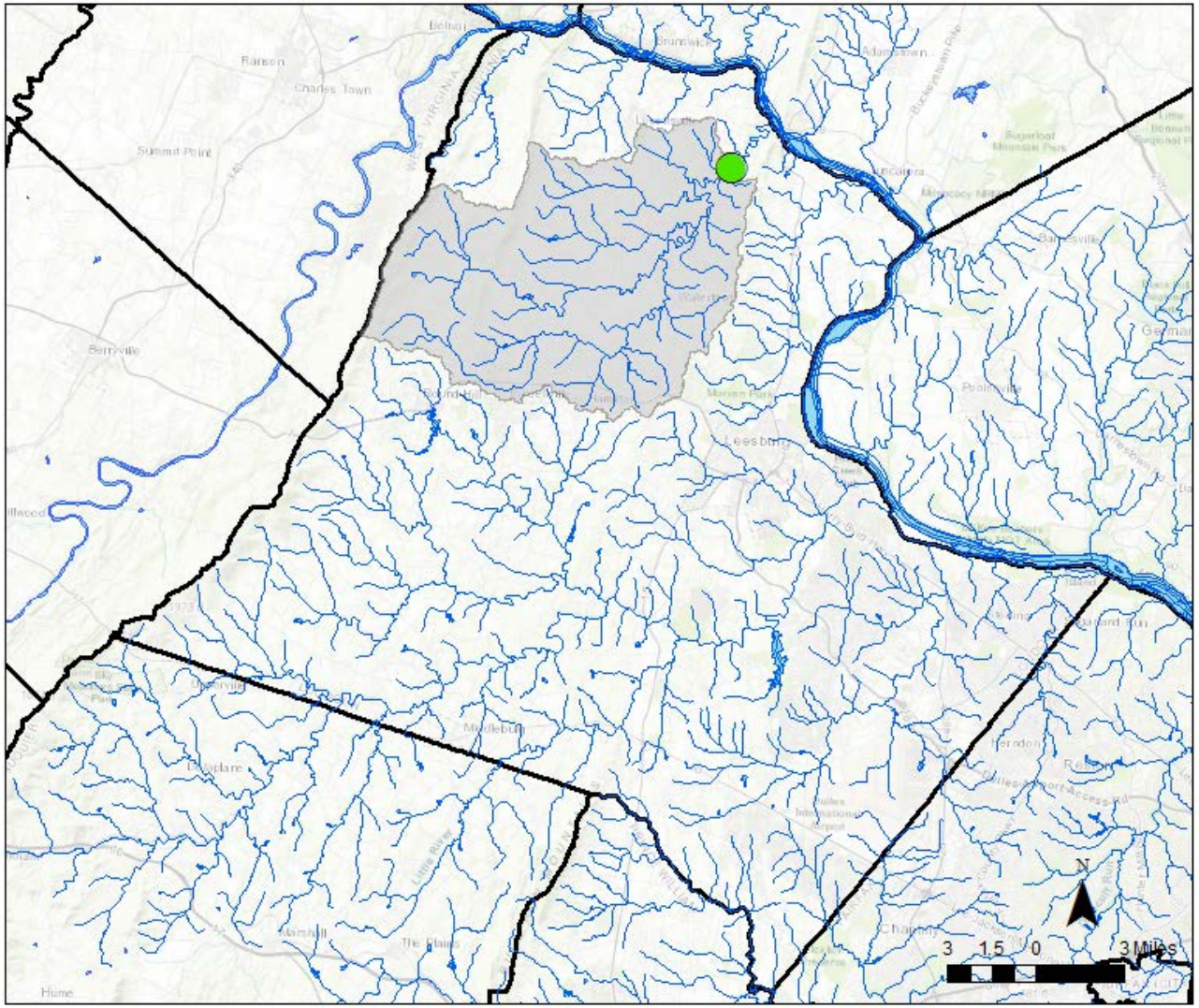


Water quality in Catoctin Creek has improved

- Nitrogen levels have been improving in the long-term at Catoctin Creek, but increasing in the last 10 years
- Nitrate has been decreasing and continues to improve



USGS Catoctin Creek monitoring station



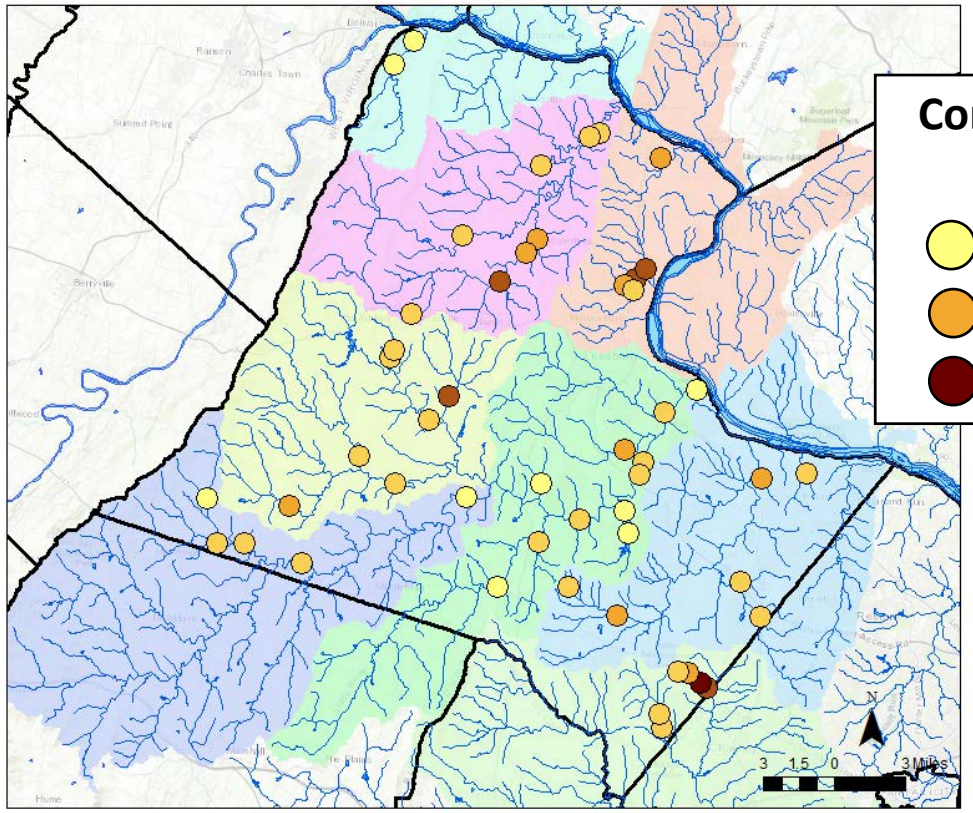
https://cbrim.er.usgs.gov

Water quality varies throughout the county's watersheds

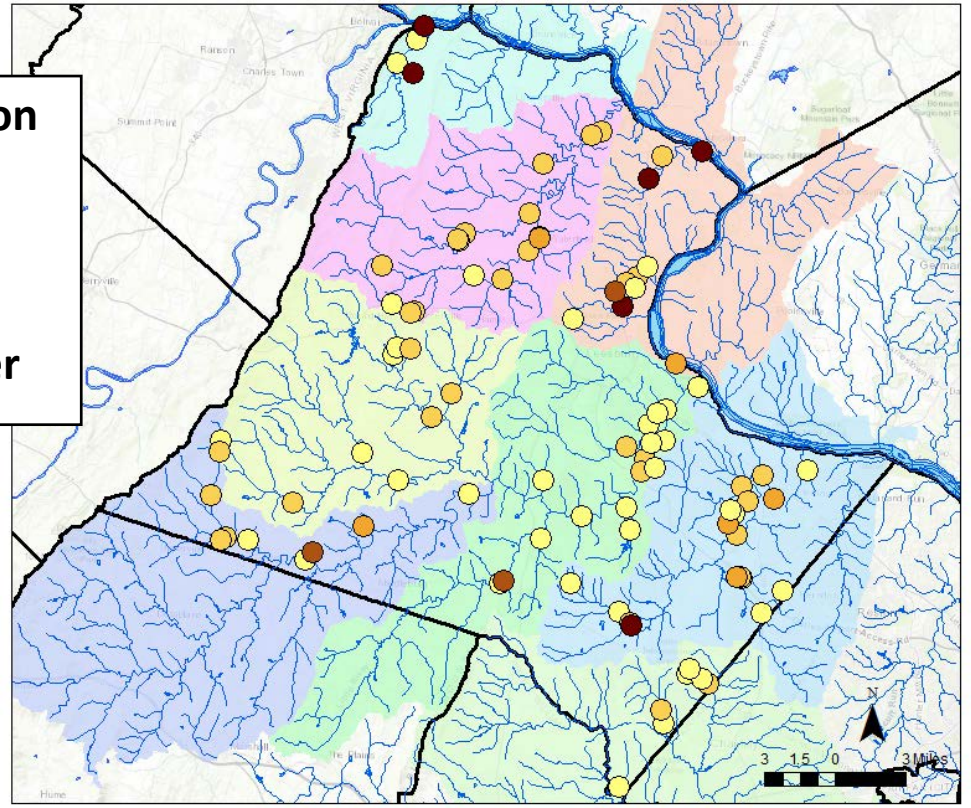
- Even without trends analyses, sampling over time can be informative of water quality throughout the county
- Average water quality sampling results show some streams with high concentrations of nutrients

Water Quality Data Portal, https://www.waterqualitydata.us/

Nitrogen

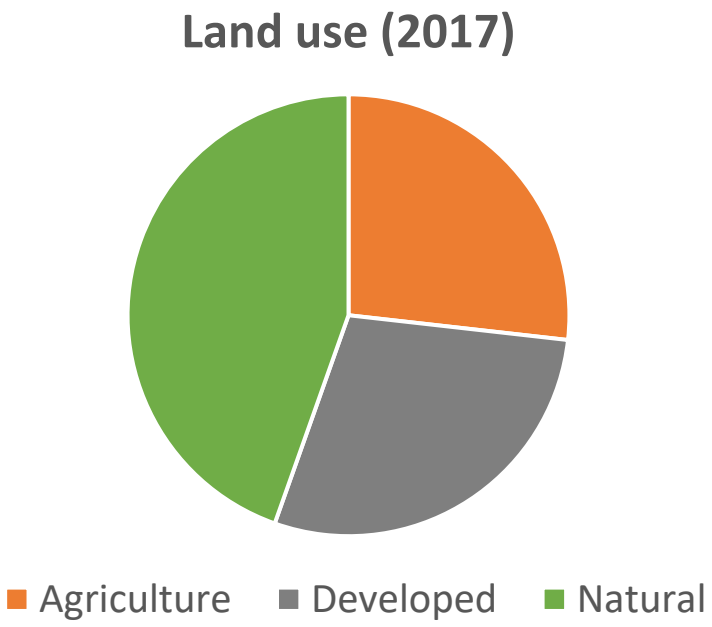


Phosphorus



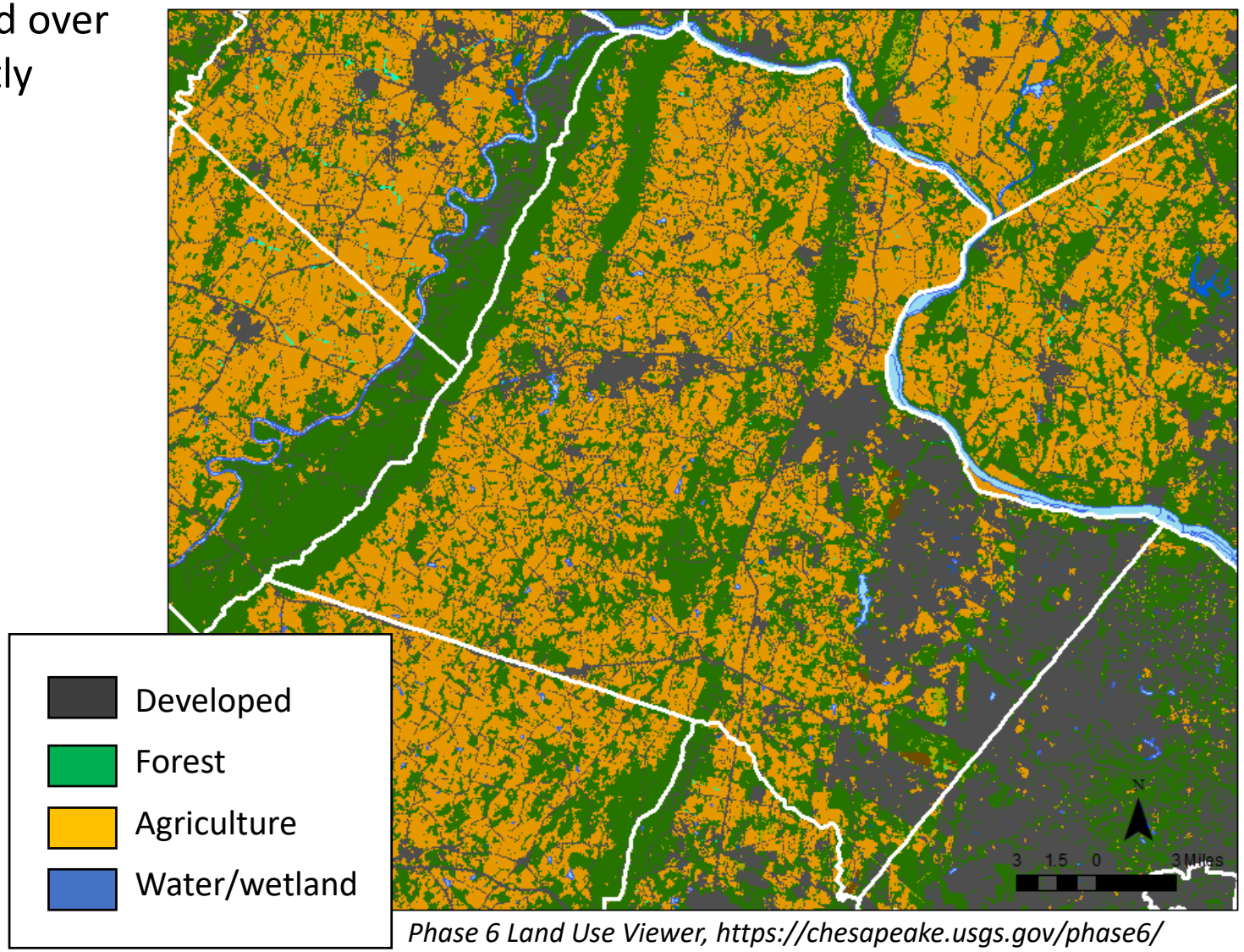
Water quality is strongly tied to land use

- Land use in Loudoun County has changed over time from being mostly forested to mostly developed
- Developed land has recently surpassed agriculture



Phase 6 Watershed Model, http://cast.chesapeakebay.net

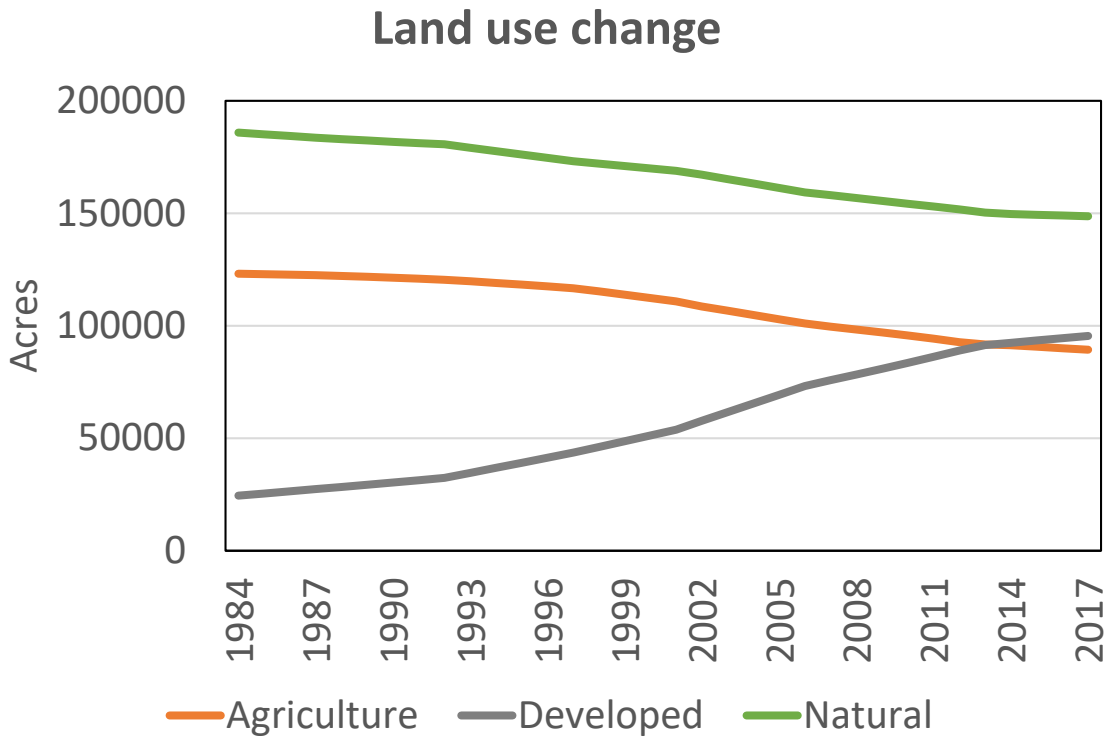
Land Use (2013)



Phase 6 Land Use Viewer, https://chesapeake.usgs.gov/phase6/

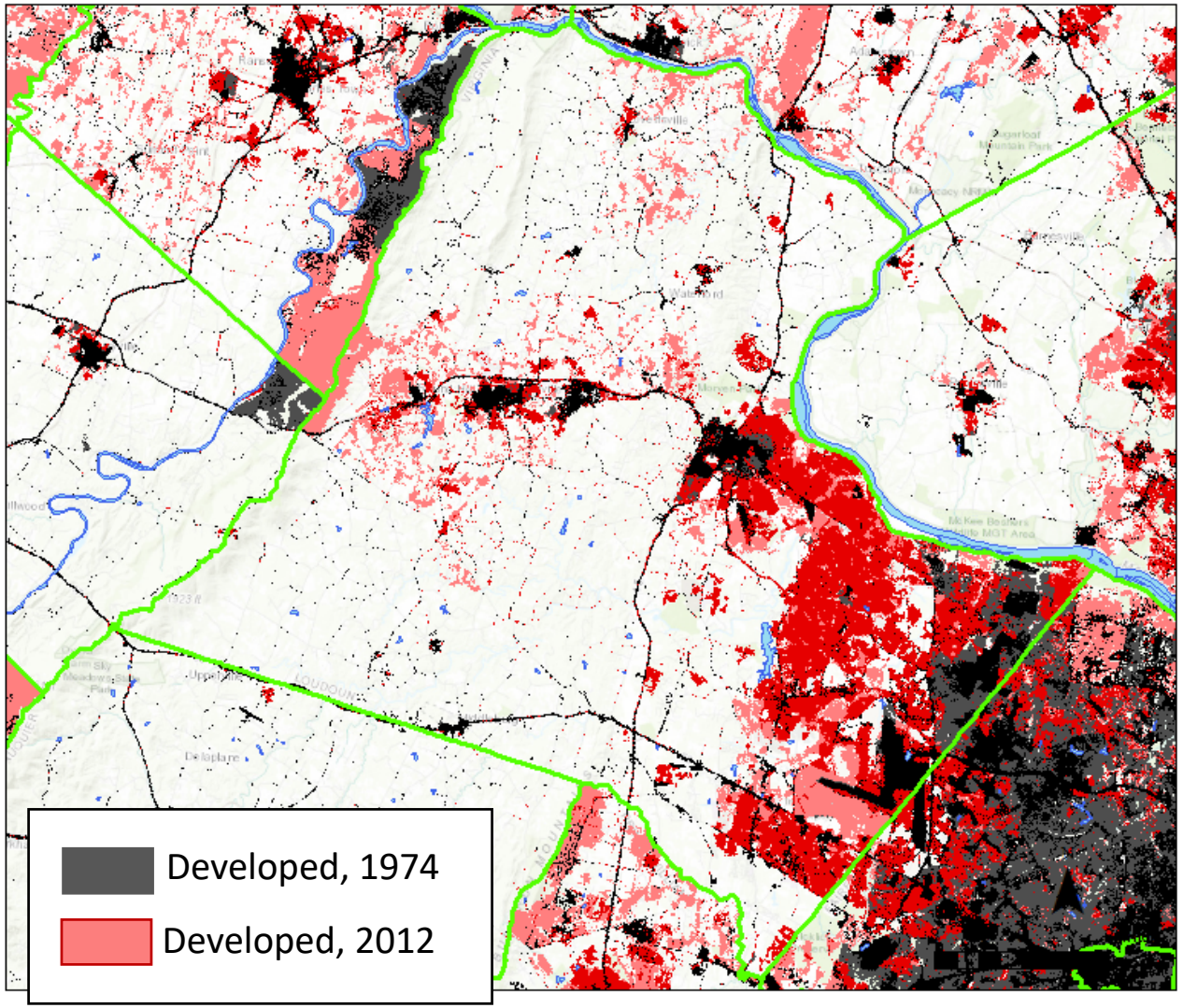
Water quality is strongly tied to land use

- Land use in Loudoun County has changed over time from being mostly forested to mostly developed
- Developed land has recently surpassed agriculture



Phase 6 Watershed Model, http://cast.chesapeakebay.net

Land Use Change

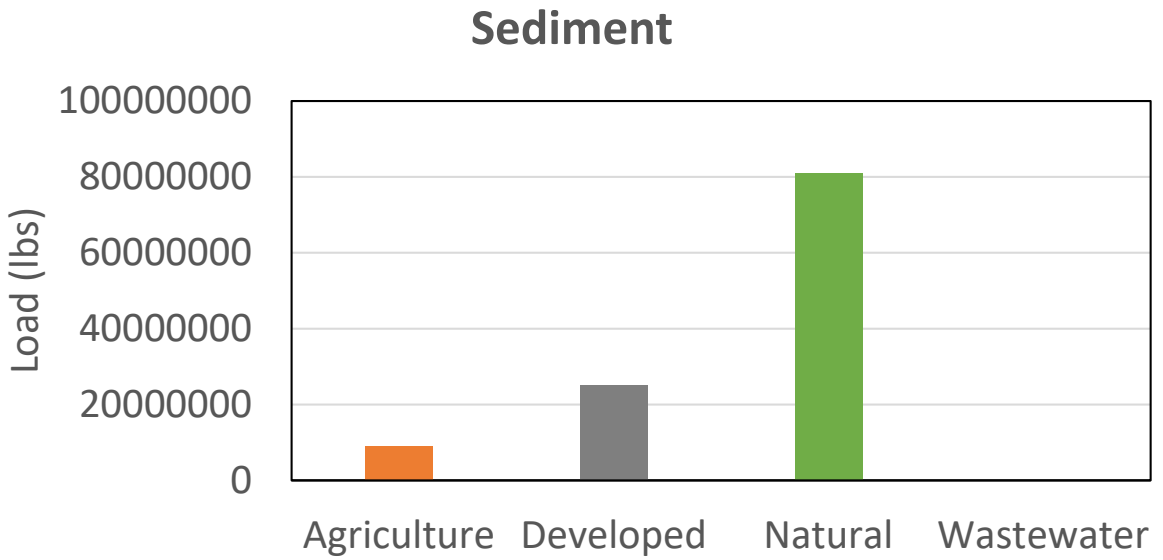


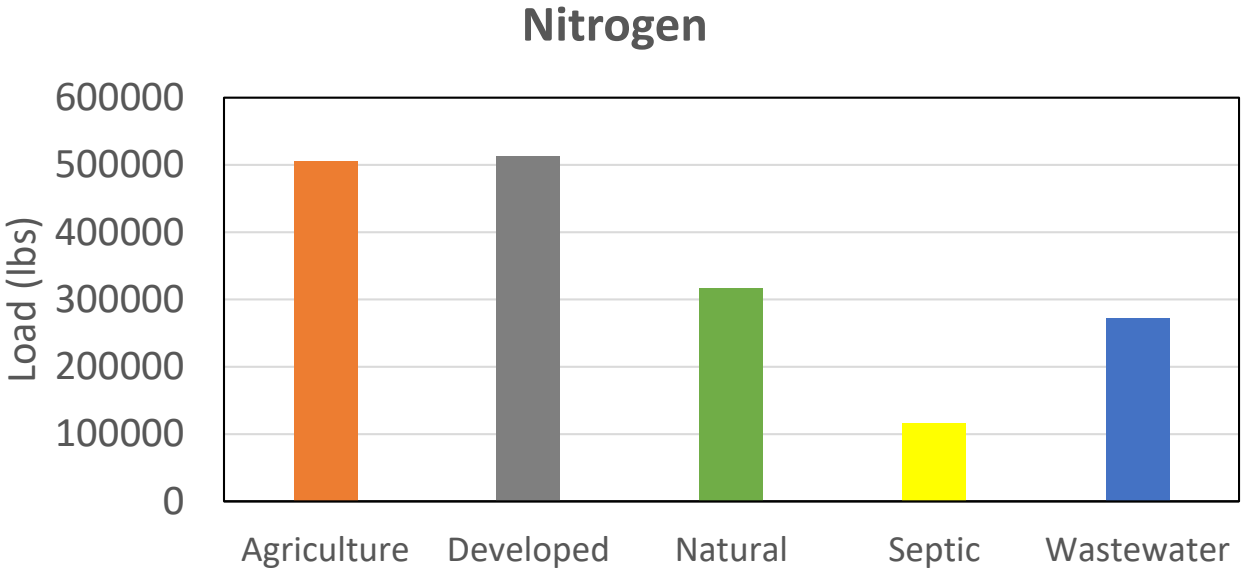
Falcone, J. et al., 2015.

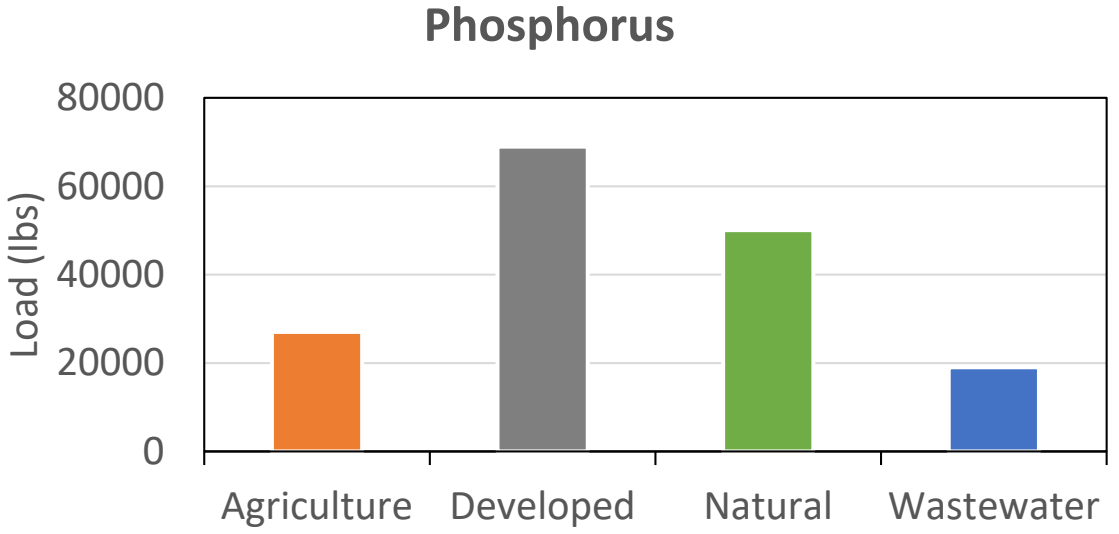
Where are nutrients and sediment coming from?

Loudon County's mixed land uses result in a variety of sources to be controlled

- Developed and urban land has become a major source of nutrients and sediment
- Agriculture is still a significant source of nitrogen
- Streambank erosion is the major source of sediment





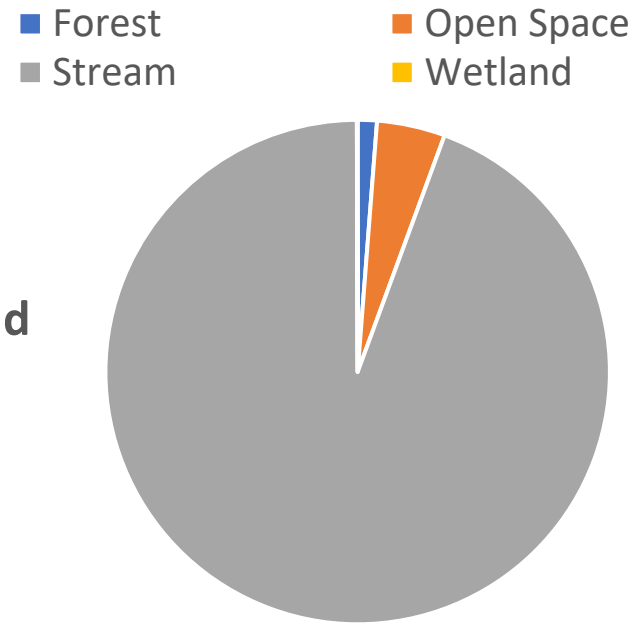


Where are nutrients and sediment coming from?

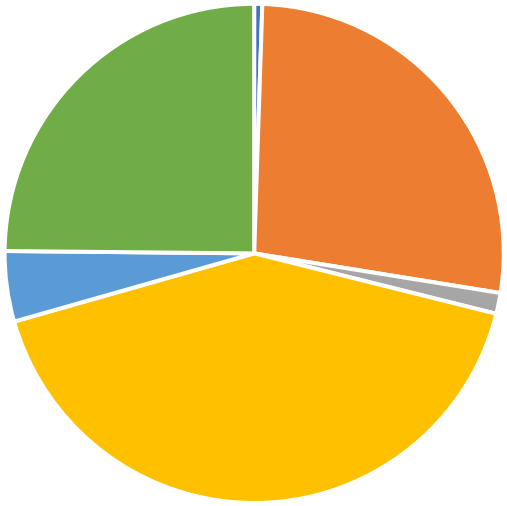
Loudon County's mixed land uses result in a variety of sources to be controlled

- Agricultural land related to the county's livestock populations generates the most nitrogen load
- Most developed land is un-regulated, and pervious turf grass generates the most phosphorus
- Sediment is primarily from streambank erosion

Sediment from Natural Land

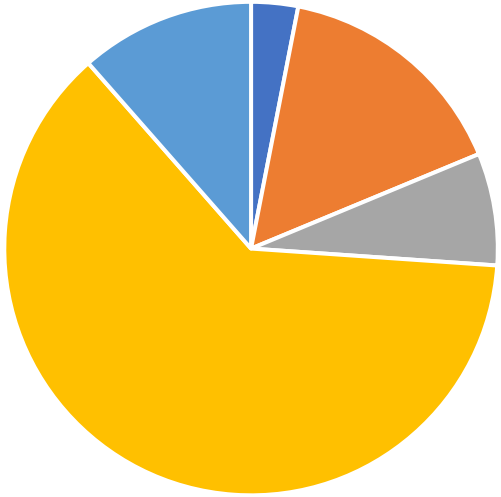


Agricultural Nitrogen



Feeding Space · Hay · Other Ag · Pasture · Riparian Pasture · Row Crops

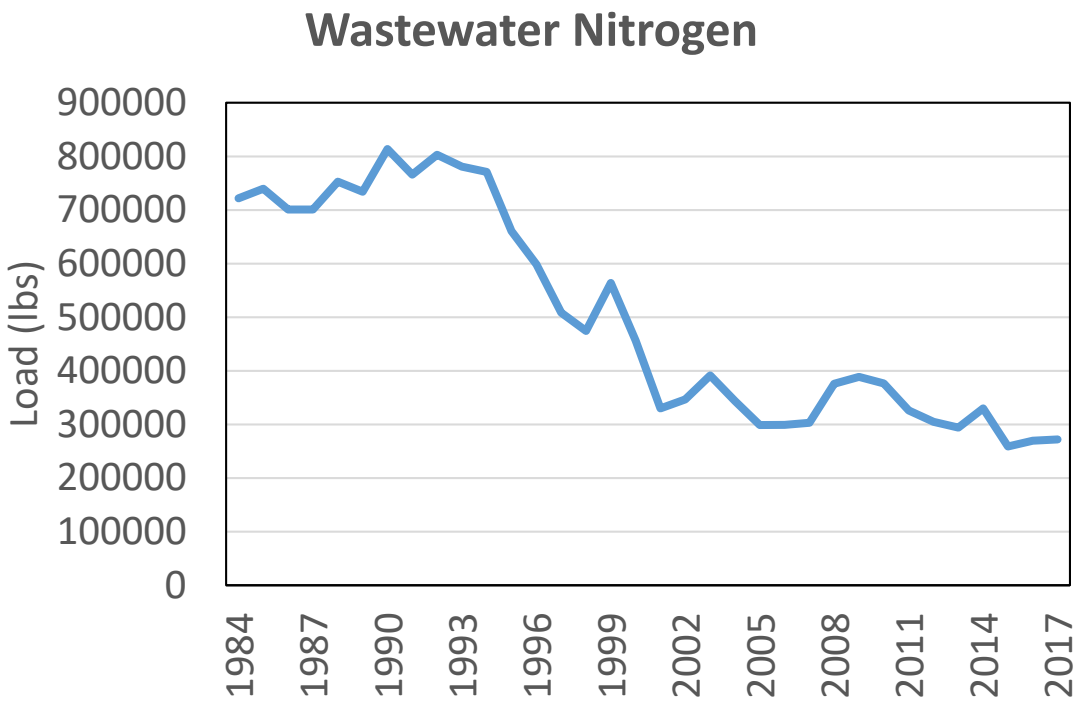
Phosphorus from Developed Land



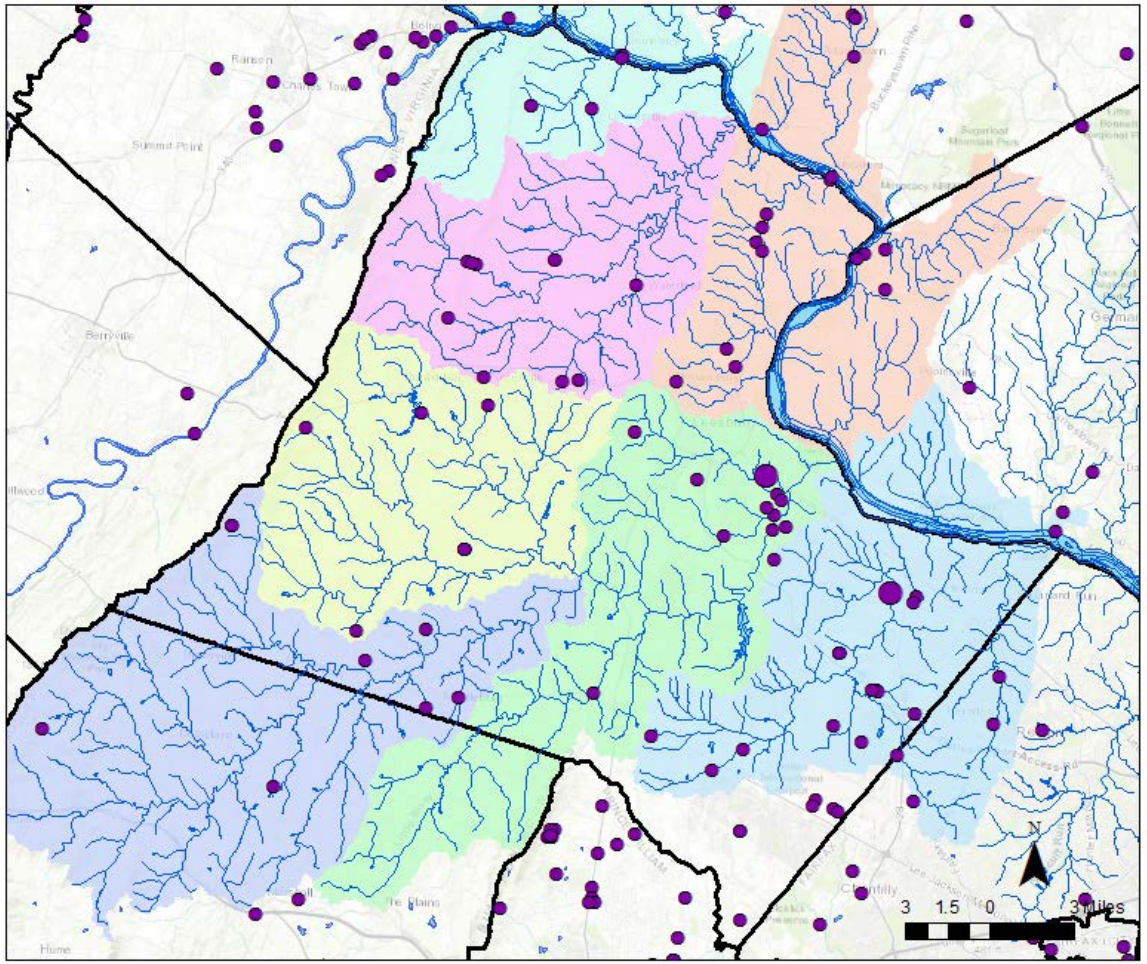
Construction Total · Impervious non-regulated · Impervious regulated · Pervious non-regulated · Pervious Regulated

Wastewater discharges have decreased over time

- Wastewater discharges have decreased over time, especially for nitrogen
- Wastewater is no longer a major contributor of loads



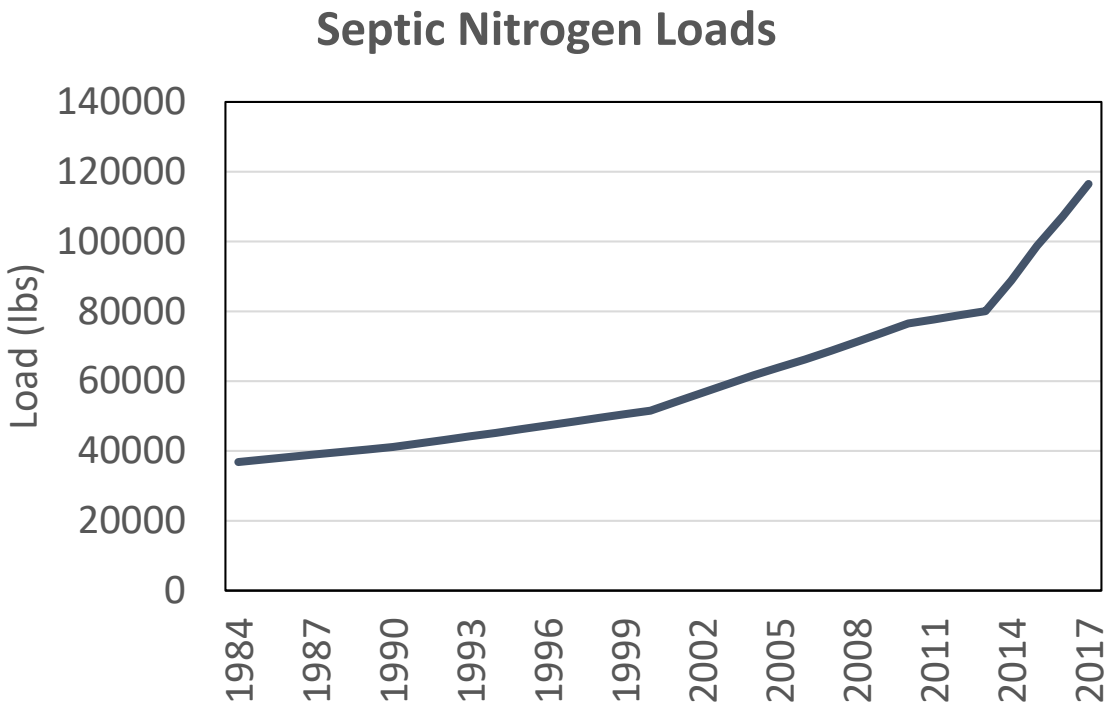
Wastewater Treatment Plants



Phase 6 Watershed Model, http://cast.chesapeakebay.net

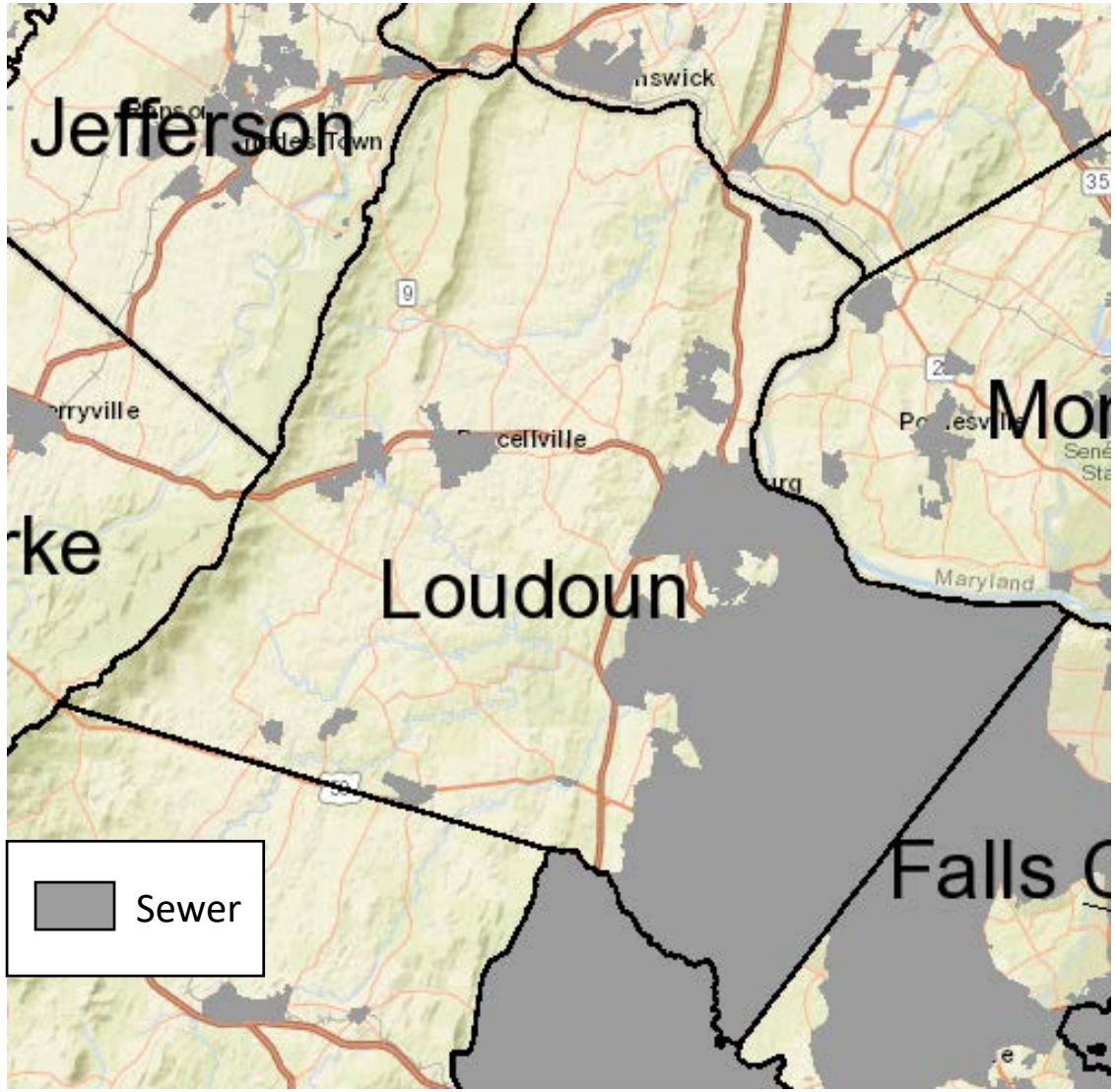
Septic nitrogen loads can be important locally

- Increasing residential development can lead to higher densities of septic systems
- Leaking or failing septic tanks not only contribute nitrogen, but also fecal contamination



Phase 6 Watershed Model, http://cast.chesapeakebay.net

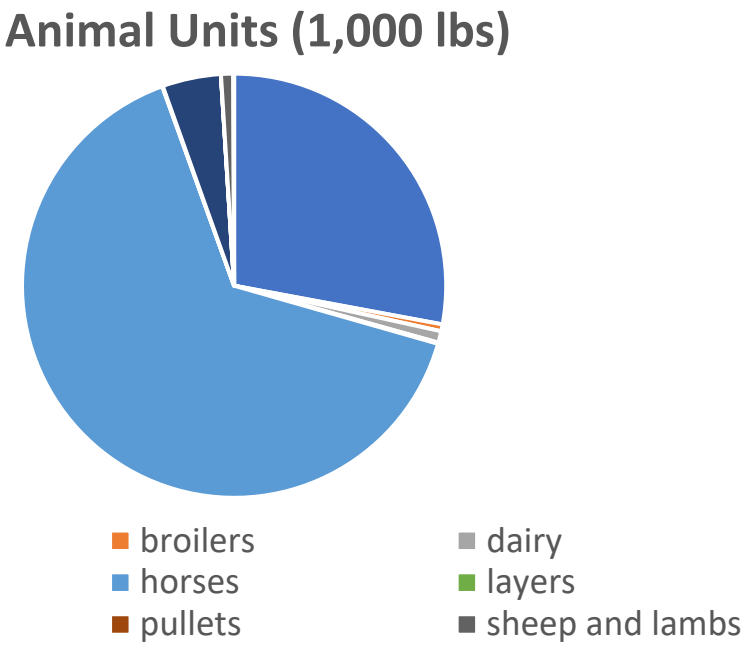
Sewer Service Areas



Phase 6 Land Use Viewer, https://chesapeake.usgs.gov/phase6/

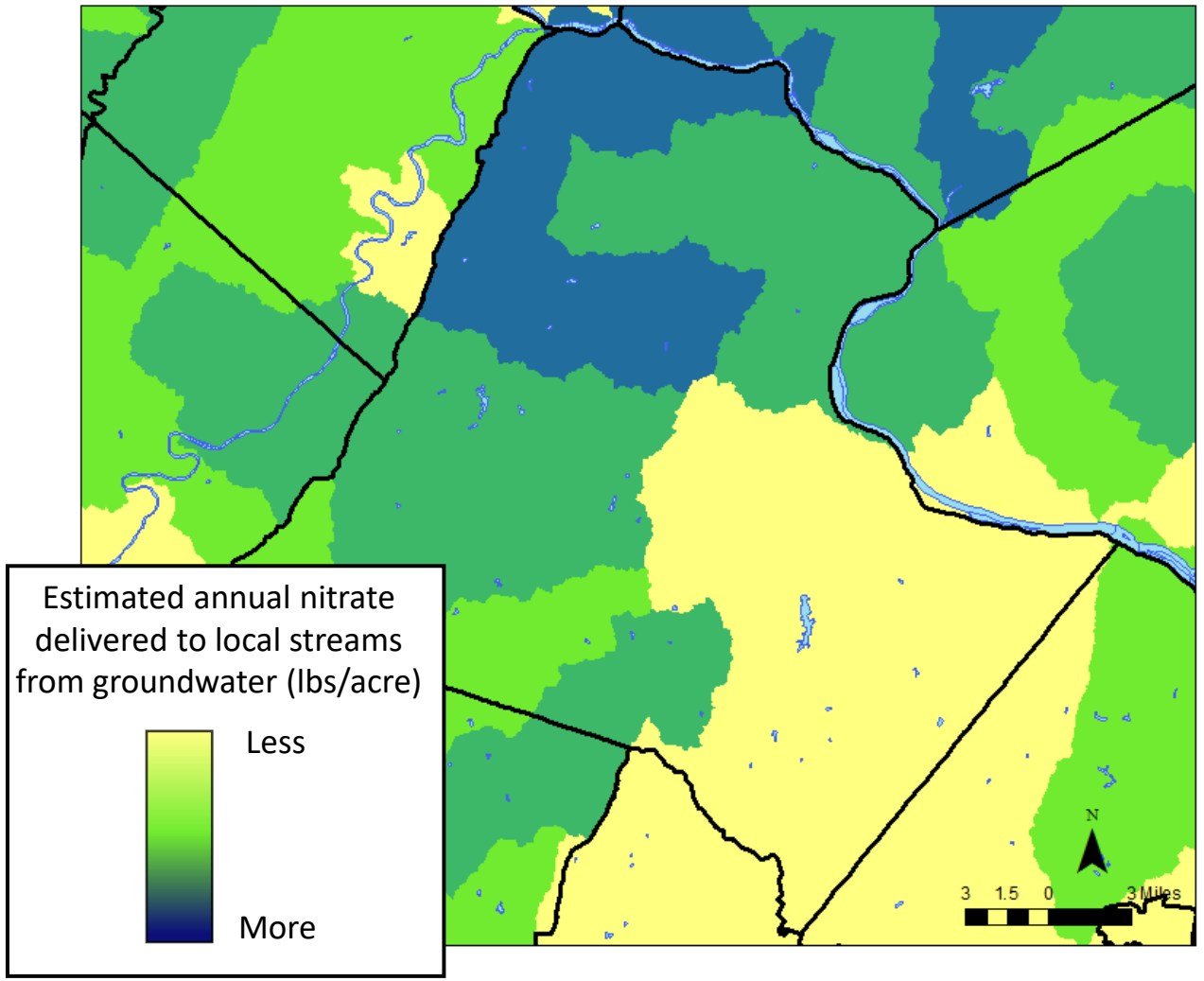
Agriculture is still an important source of nitrogen

- Agricultural loads come primarily from pasture and hay to support livestock populations in Loudoun County
- Nitrogen often enters streams as groundwater through nitrate in agricultural areas
- These can be good areas to focus practices like cover crops and nutrient management



Phase 6 Watershed Model, http://cast.chesapeakebay.net

Estimated groundwater nitrate load



Agriculture is still an important source of nitrogen

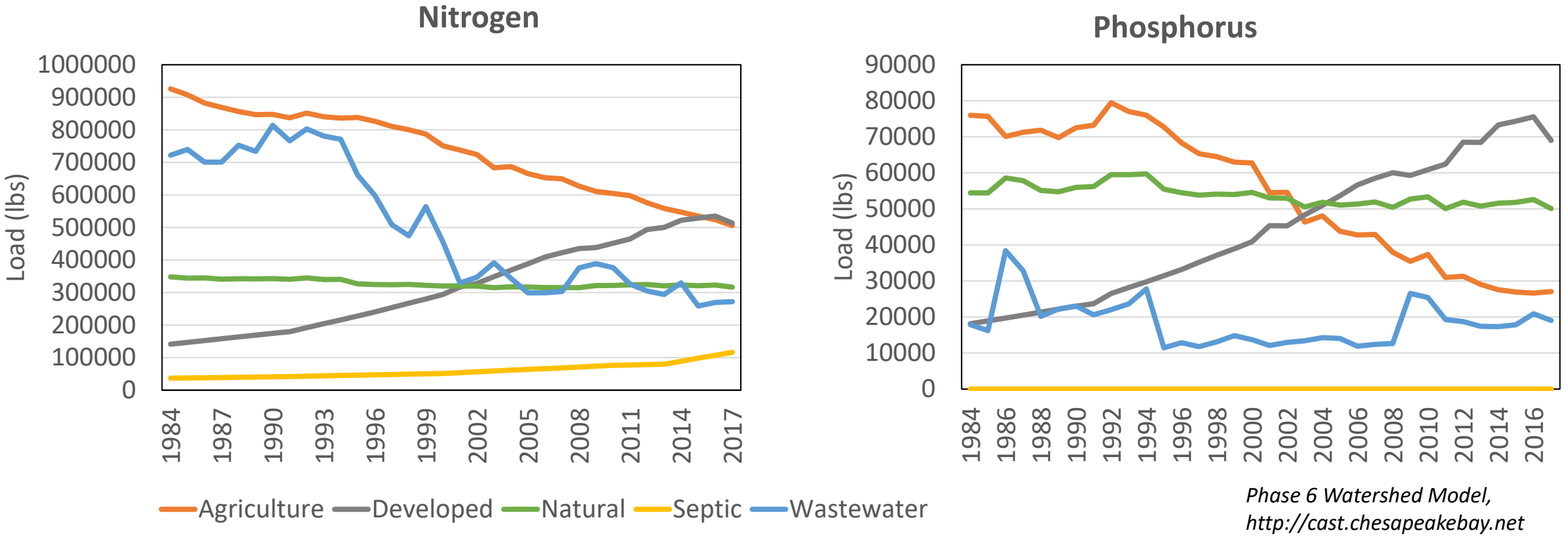
- Some key practices addressing local sources are being implemented like conservation tillage, prescribed grazing, barnyard runoff control and off stream watering
- Fencing cattle out of streams is an effective way to address nitrogen pollution, streambank erosion, and fecal contamination

		$/lb reduced/year		
Management Practice	**2017 Progress**	**Nitrogen**	**Phosphorus**	**Sediment**
Conservation Tillage	67.1%	0	0	0
Forest Buffer	0.3%	1.97	65.31	0.05
Grass Buffer	0.2%	2.47	-329.88	0.04
Grass Buffer with Exclusion Fencing	1.1%	3.15	12.11	0.02
Wetland Restoration	0.0%	6.73	152.77	0.18
Forest Buffer with Exclusion Fencing	0.0%	6.86	27.04	0.04
Tree Planting	0.6%	11.14	319.44	0.25
Commodity Cover Crop	57.6%	23.21	0	0
Manure Incorporation	0.0%	34.56	230.2	0
Prescribed Grazing	18.7%	48.07	392.22	1.57
Barnyard Runoff Control	30.7%	60.25	2379.97	0.32
Cover Crops	1.3%	77.58	0	0
Off Stream Watering Without Fencing	11.1%	100.69	1222.61	4.97
Agricultural Stormwater Management	0.0%	168.81	3612.48	0.71
Nitrogen Nutrient Management	5.7%	175.1	0	0
Horse Pasture Management	0.0%	502.11	378.95	0.96

Phase 6 Watershed Model, http://cast.chesapeakebay.net

Controlling stormwater is increasingly important as the county develops

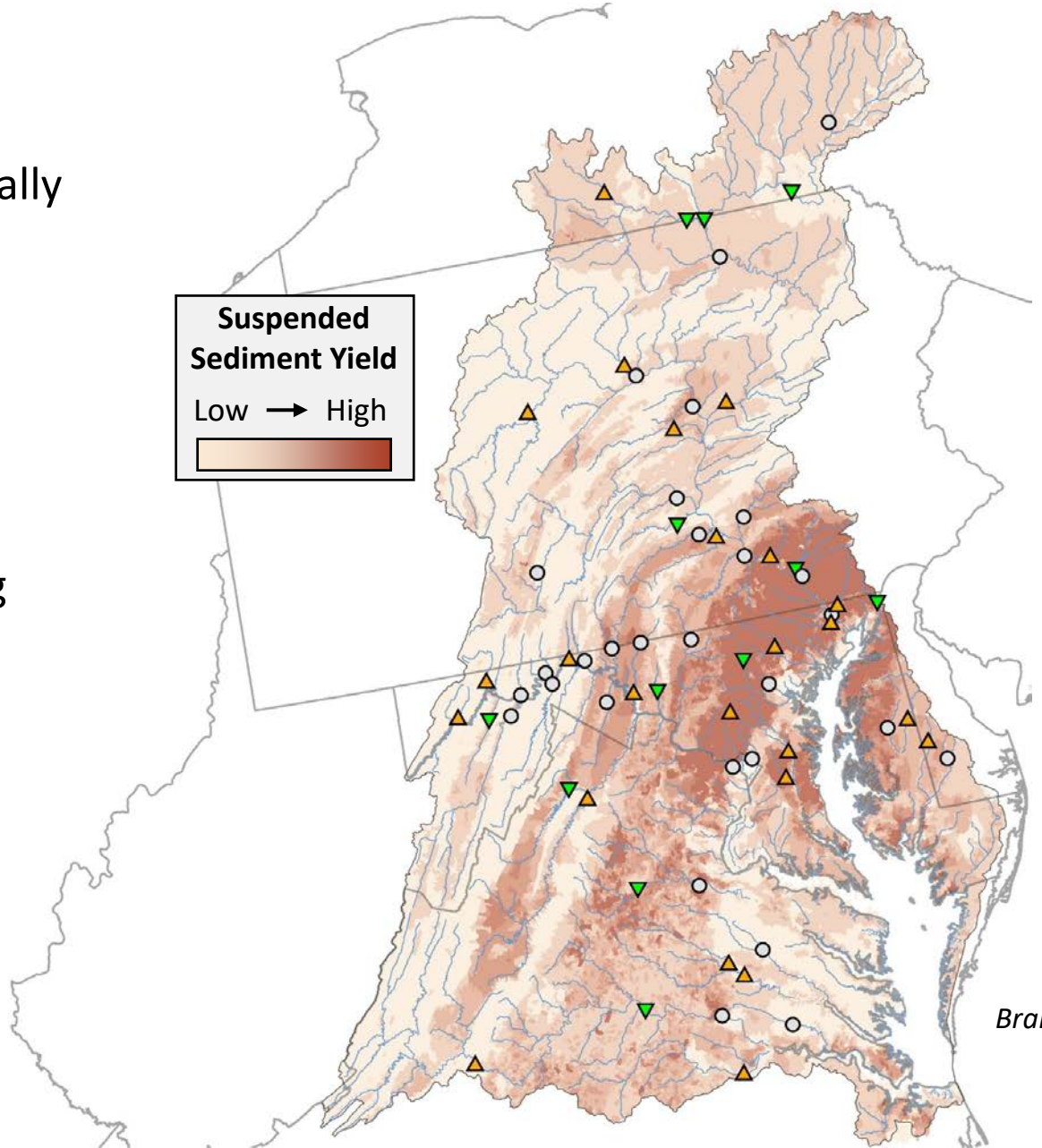
- Increases in stormwater loads have kept pace with decreases in wastewater and agriculture, so overall loads haven't decreased as much
- Converting forest to urban land will increase nutrient loads, whereas converting farmland to urban land tends to decrease nutrient loads



Phase 6 Watershed Model, http://cast.chesapeakebay.net

Urban Piedmont headwater streams are sediment hotspots

- Loudoun county's urban streams are especially vulnerable to sediment erosion
- Converting forest or farmland to urban land tends to increase sediment loads
- Stream restoration and retrofits are more costly management practices, so preventing streambank erosion and promoting green infrastructure in the first place can mitigate increases in sediment loads

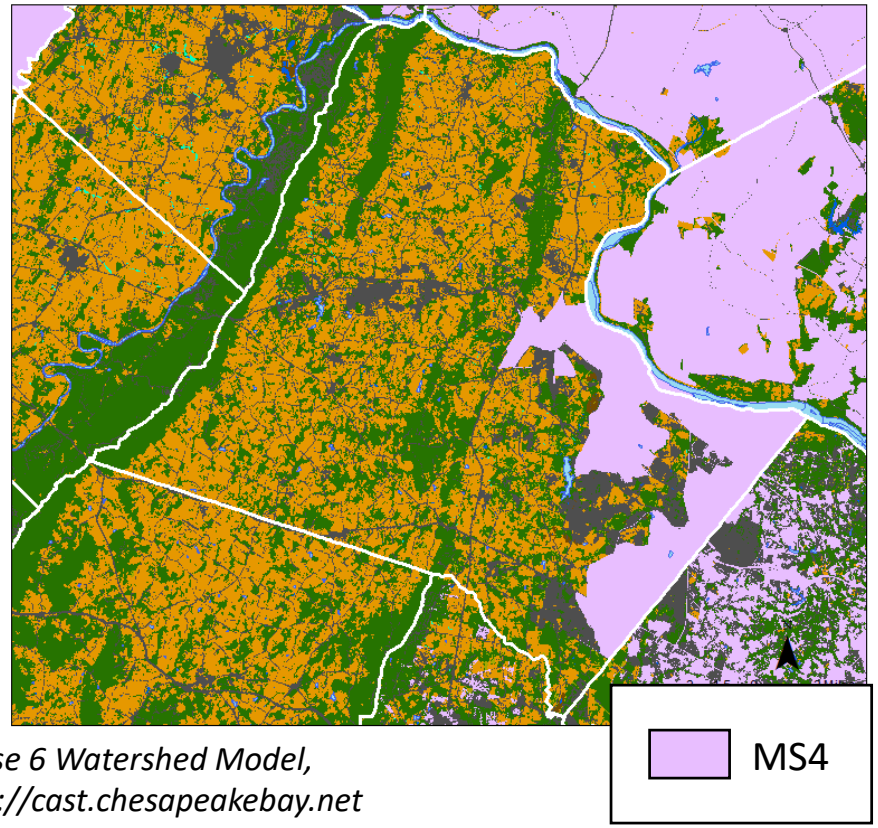


Brakebill, J. et al., 2010

Urban Piedmont headwater streams are sediment hotspots

- Since most of the loads from developed land are non-regulated, finding ways to promote stormwater practice adoption throughout the rest of the county is important

Loudoun MS4 Areas



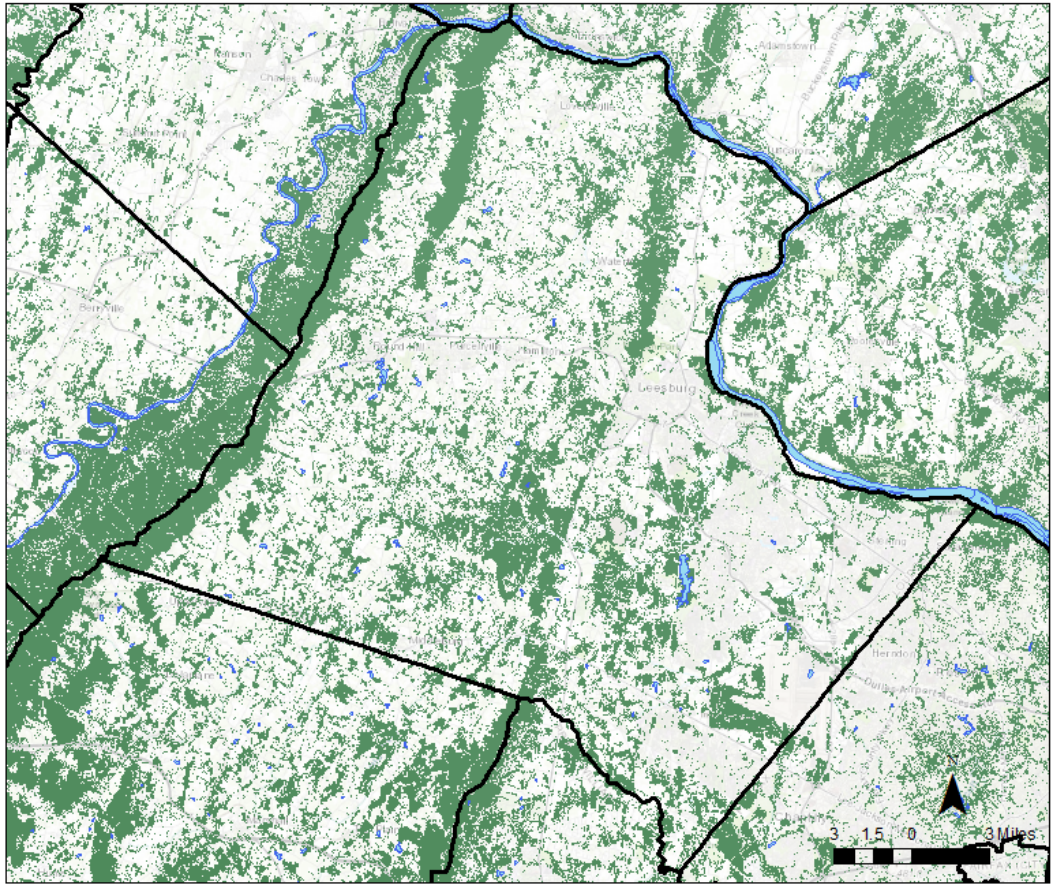
Phase 6 Watershed Model, http://cast.chesapeakebay.net

		$/lb reduced/year		
Management Practices	**2017 Progress**	**Nitrogen**	**Phosphorus**	**Sediment**
Urban Nutrient Management	2.2%	0	0	0
Forest Buffer	0.0%	5.6	20.56	0.04
Forest Planting	0.0%	8.06	31.35	0.09
Tree Planting	0.0%	97.98	341.04	0.22
Grey Infrastructure (IDDE)	0.0%	175.05	4463.68	0
Bioswale	0.0%	202.38	1203.27	1.23
Infiltration Practices	0.1%	223.74	1340	1.3
Wet Ponds and Wetlands	10.8%	266.57	764.86	0.62
Extended Detention Dry Ponds	4.0%	276.39	1784.95	0.65
Vegetated Open Channels	0.0%	296.74	1895.16	1.32
Bioretention/raingardens	0.2%	686.44	2452.11	2.18
Filtering Practices	0.0%	946.82	4037.4	3.29
Stormwater Treatment	0.0%	1128.8	5634.77	3.77
Runoff Reduction	0.0%	1309.81	8606.13	6.84
Dry Ponds	5.9%	2316.14	7892.04	8.6
Stream Restoration	0.0%	2785.59	3914.73	1.86
Filter Strip Runoff Reduction	0.0%	3506.13	8387.37	8.78
Erosion & Sediment (E&S) Control	93.1%	4687.51	0	0.24
Street Sweeping	0.0%	4837.07	0	449.96
Impervious Disconnection	0.0%	15177.97	83478.84	84.94

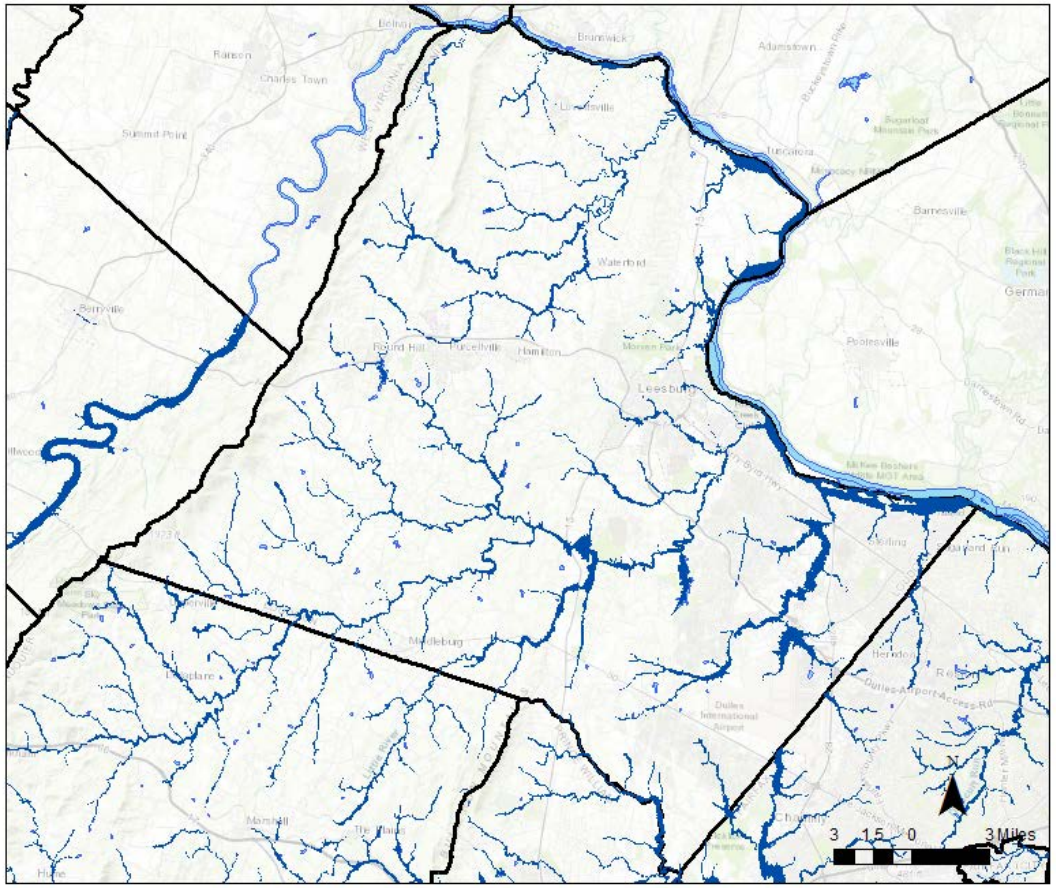
Smart growth and conservation practices can help mitigate loads as development occurs

- Maintaining the integrity of floodplains and large forest tracts can mitigate the increase in loads from developing land

Forest tracts



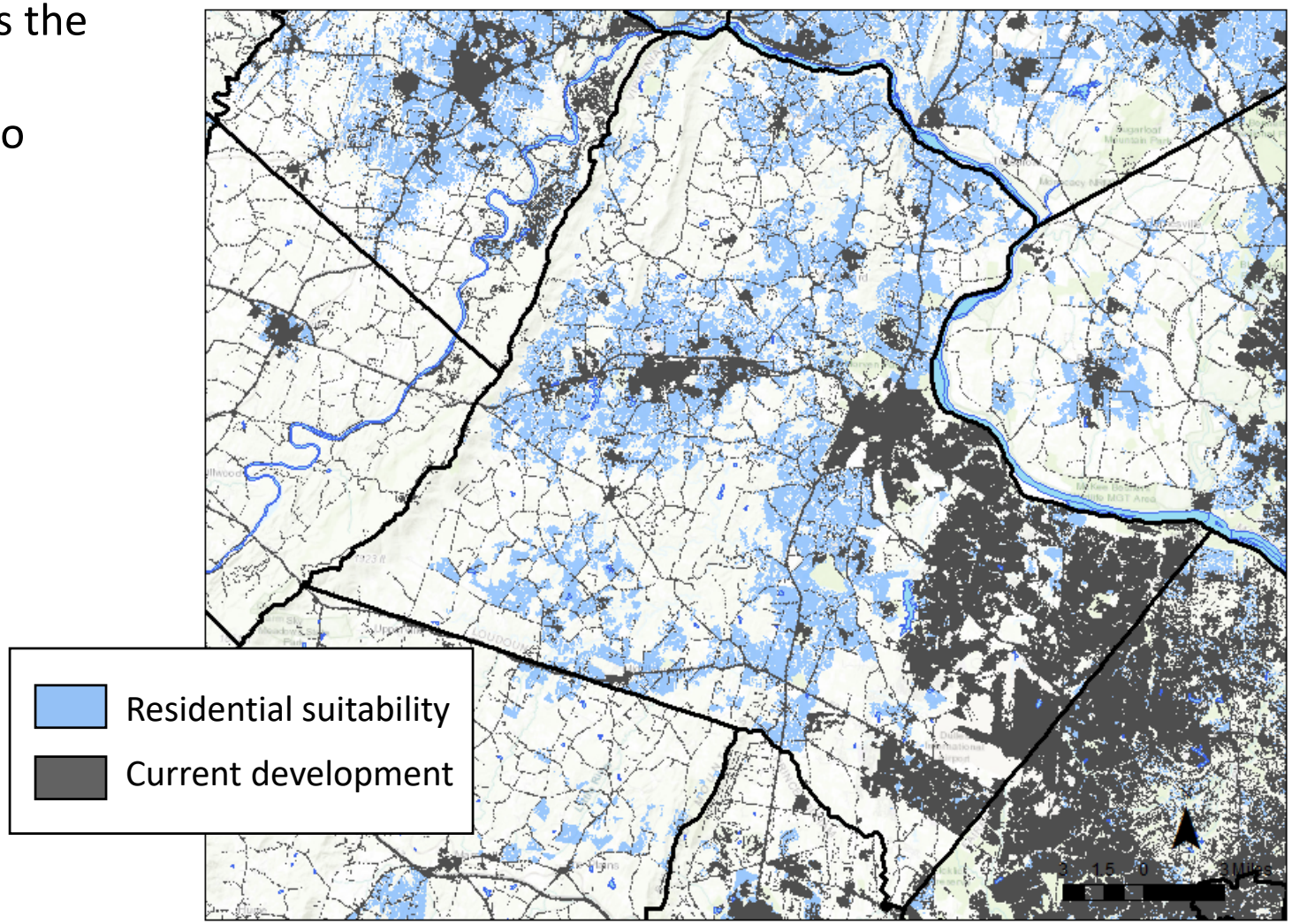
100-year floodplains



Smart growth and conservation practices can help mitigate loads as development occurs

- Promoting new development where it has the least impact can help mitigate loads
- Only ~40% of future growth is projected to occur through infill and redevelopment

Suitability for residential growth

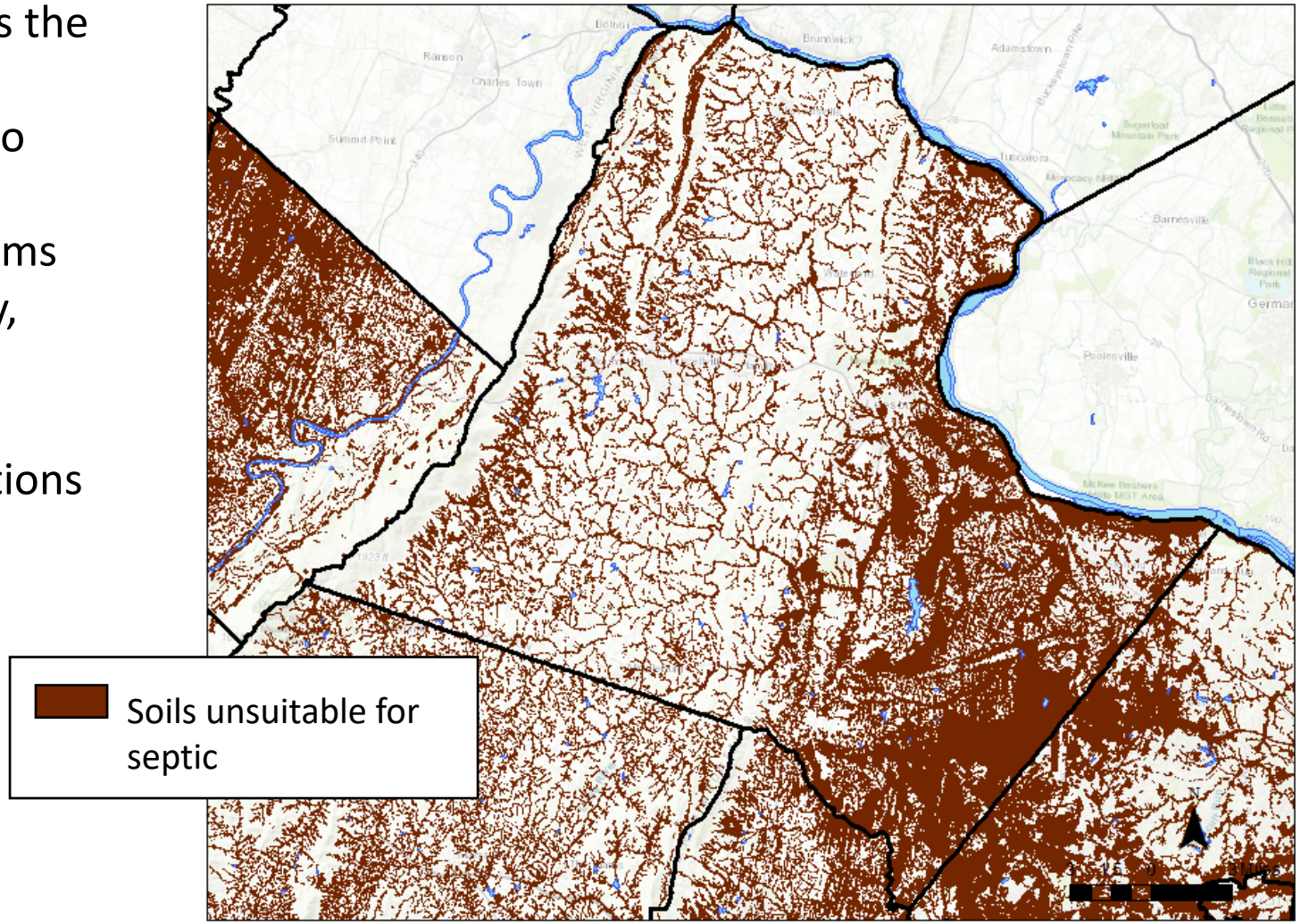


Phase 6 Land Use Viewer, https://chesapeake.usgs.gov/phase6/

Smart growth and conservation practices can help mitigate loads as development occurs

- Promoting new development where it has the least impact can help mitigate loads
- Only ~40% of future growth is projected to occur through infill and redevelopment
- For example, because leaking septic systems can be important pollution sources locally, avoiding growth on septic in areas with unsuitable soils can mitigate loads, or prioritizing those areas for sewer connections

Soils unsuitable for septic



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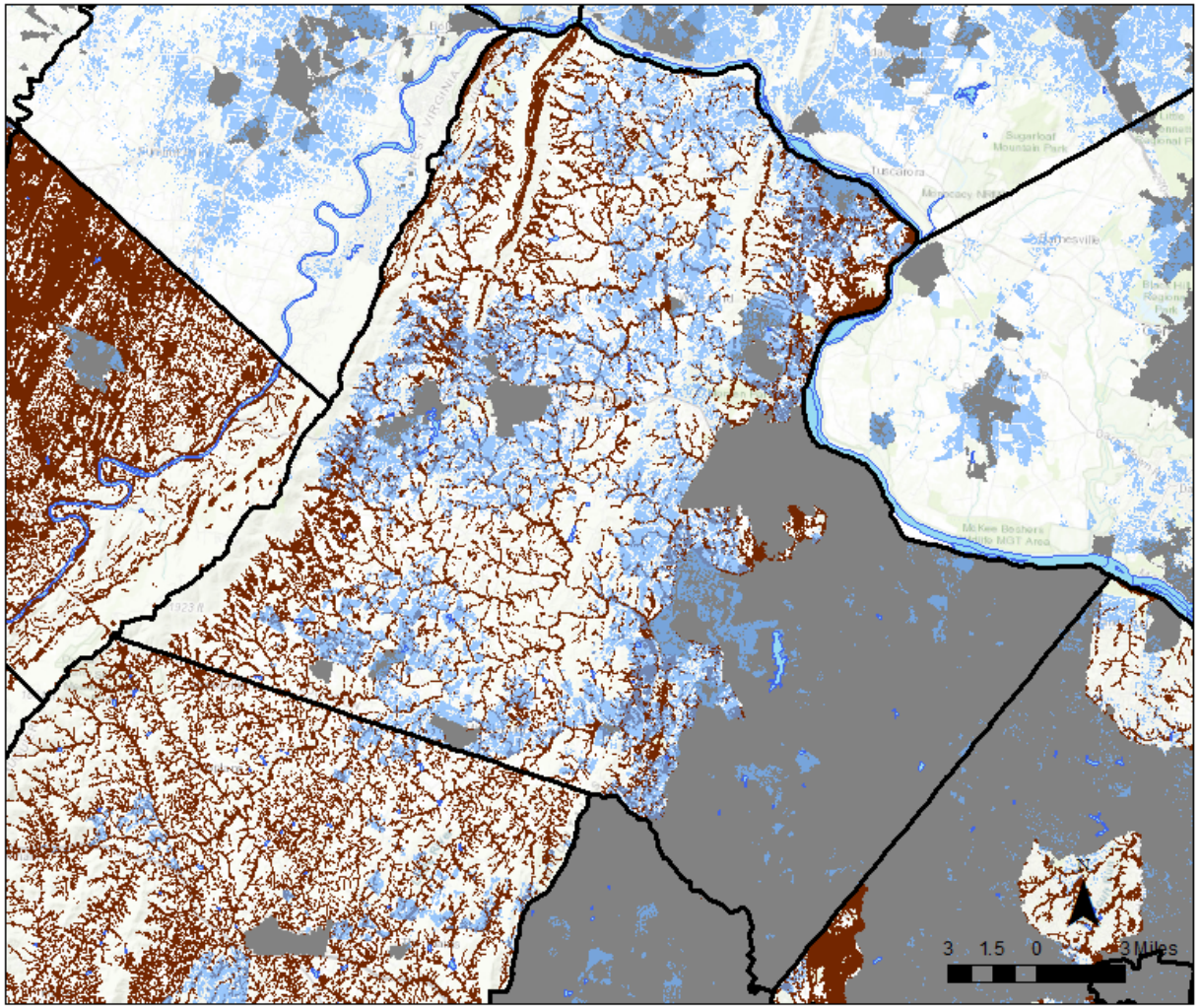
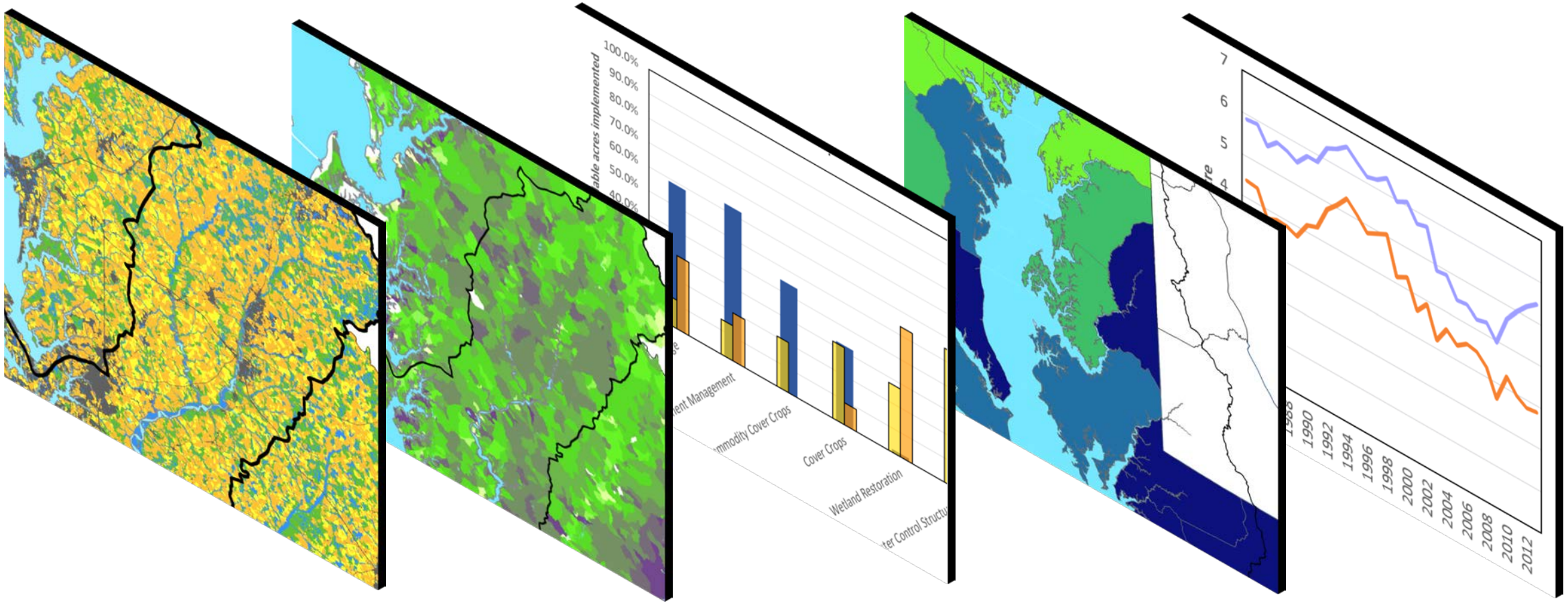


A LOT of new and updated info available…

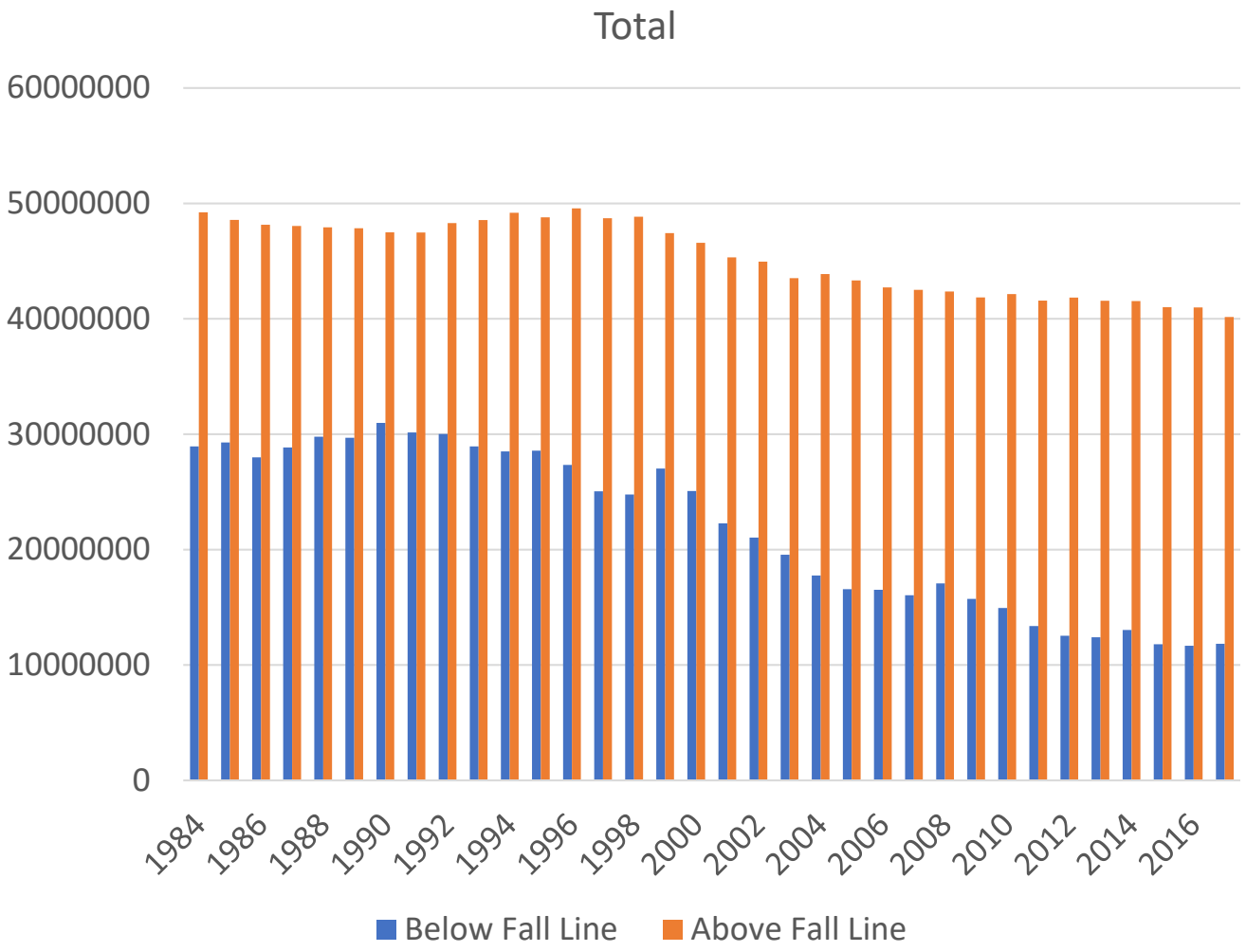


That can be used to help identify restoration opportunities and focus efforts…

Emily Trentacoste

trentacoste.emily@epa.gov

410-267-5797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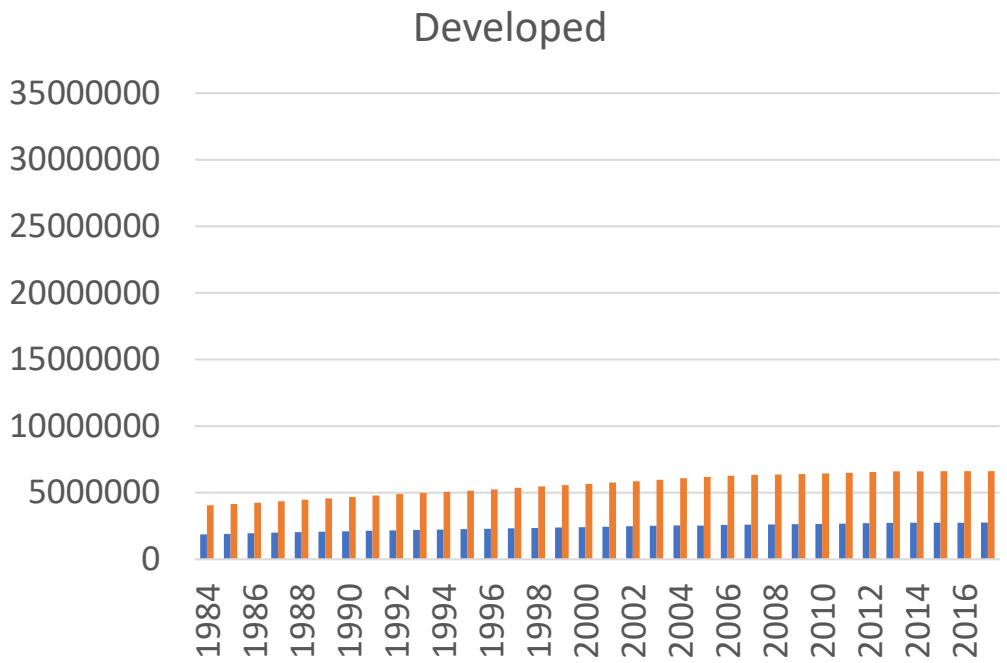
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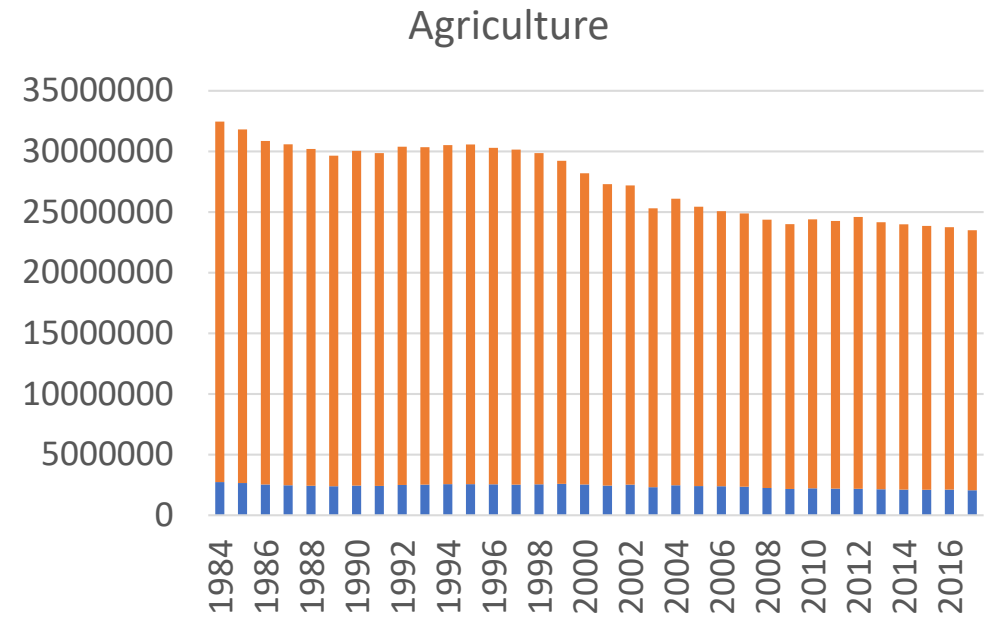
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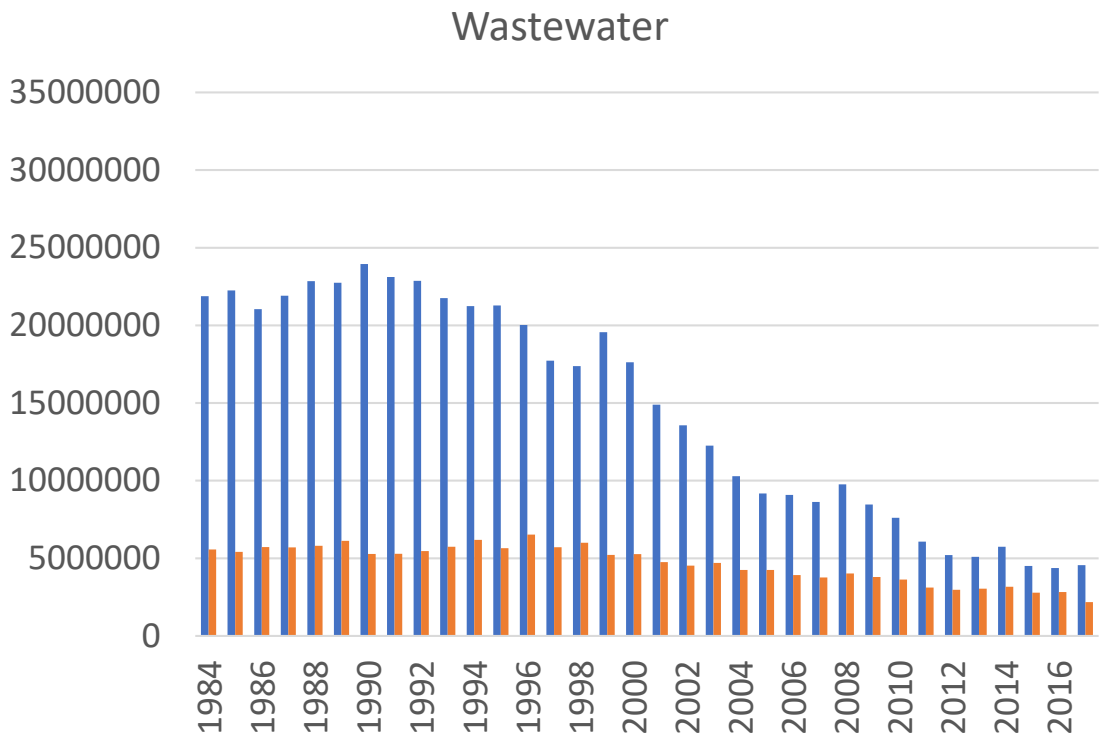
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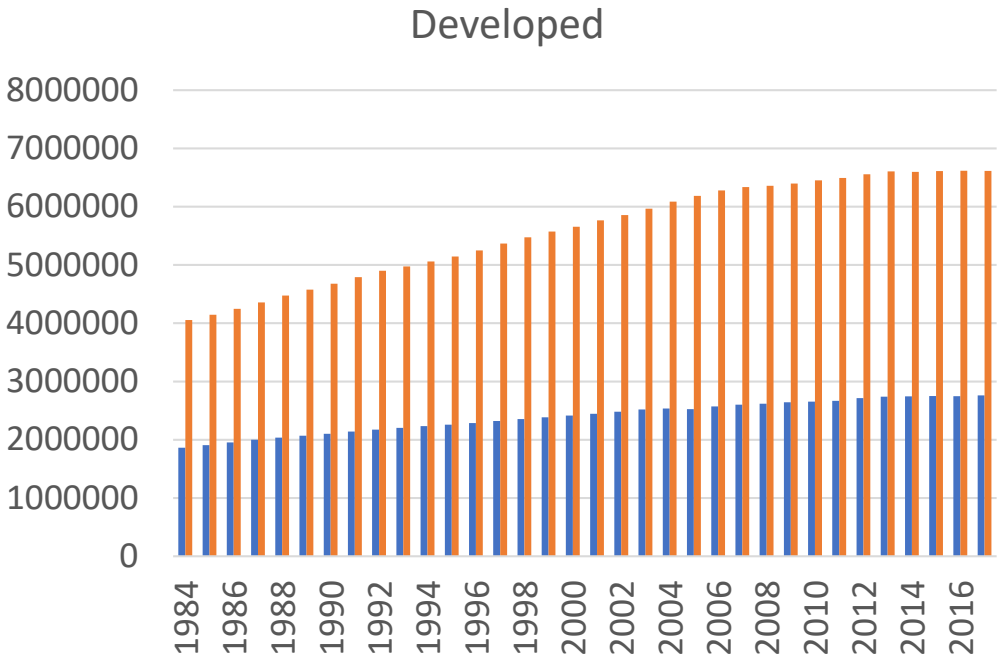
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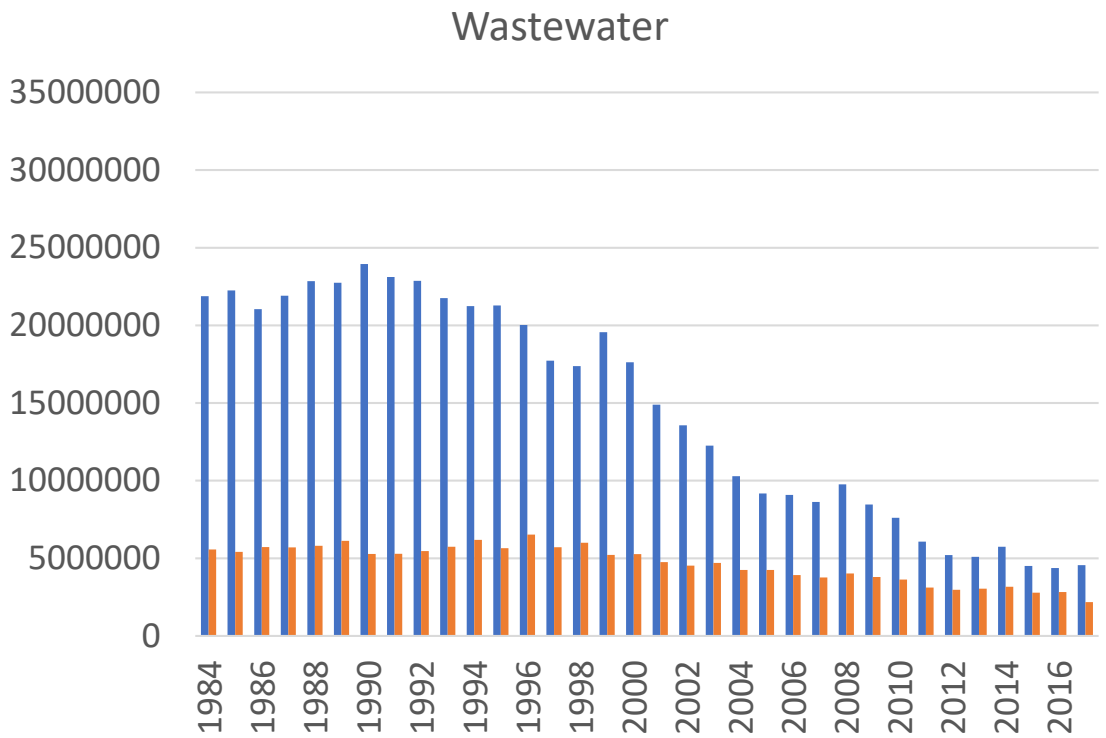
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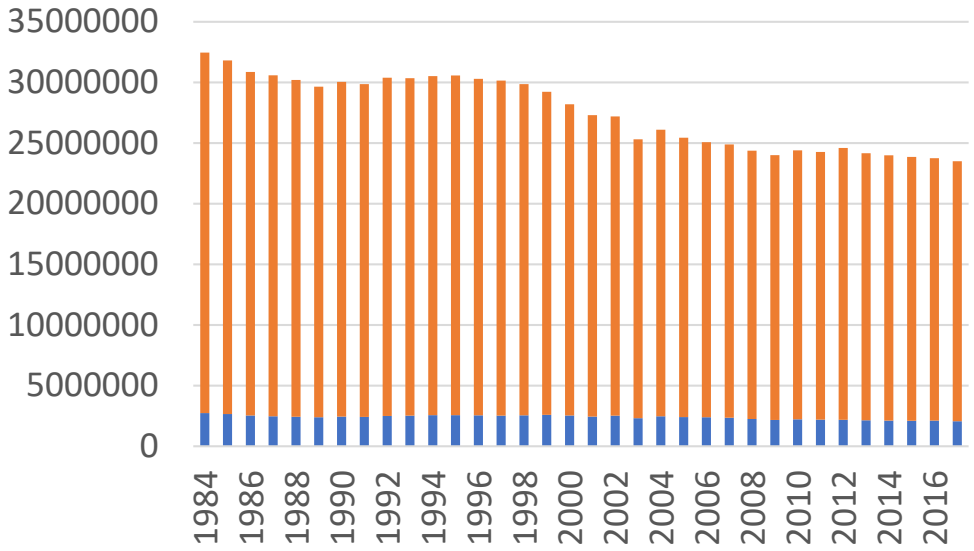
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