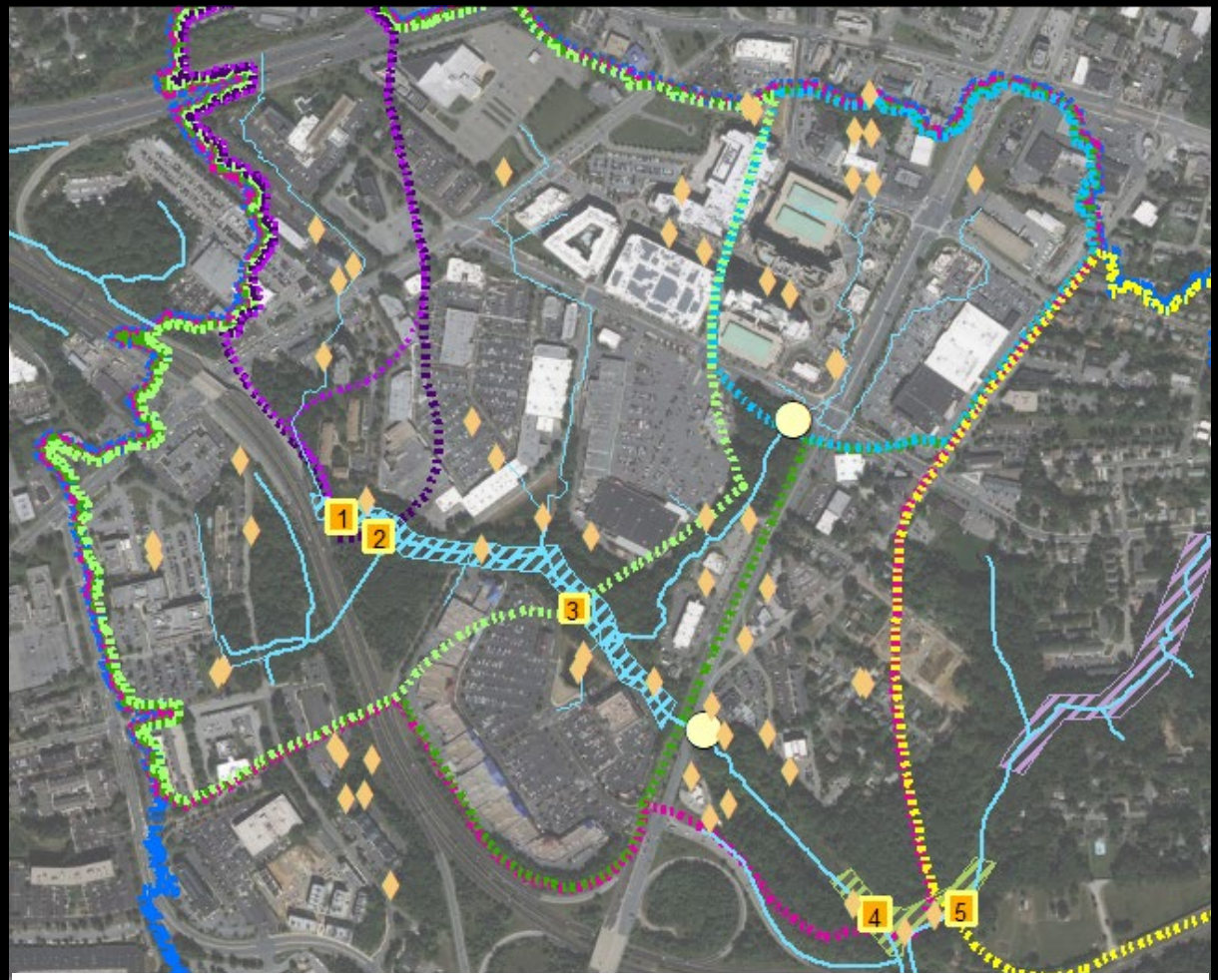
Watershed-Scale Effects of Urban BMPs on Loads of Nutrients and Suspended Solids



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Arundel Rivers FEDERATION

*Smithsonian Environmental Research Center

Two Main Questions:

- What are the effects of an urban stream restoration on loads of nutrients and total suspended solids (TSS)?
- What are the cumulative impacts of stream restorations and other BMPs on loads of nutrients and TSS in urban watersheds?

Hypotheses:

- Loads leaving the stream restoration will be lower than loads entering.
- Loads from watersheds will reflect the cumulative impact of BMPs within the watershed.
- Affects on loads of different forms of N and P will differ.

Why compare loads of different forms of N and P when TMDLs are for total N and total P?

- Different forms of N and P have different potentials for causing algal blooms.
- Dissolved inorganic forms are more bio-available than particulate and organic forms (Glibert et al. 2016).

- Mechanisms of N and P removal differ for different forms of N and P.
- Nitrate may be removed from stream water by denitrification and particulate N and P may be removed by sedimentation.

- The Chesapeake Bay Program concluded that it is important to consider the different impacts of different forms of N and P to manage eutrophication (Shenk et al. 2020).

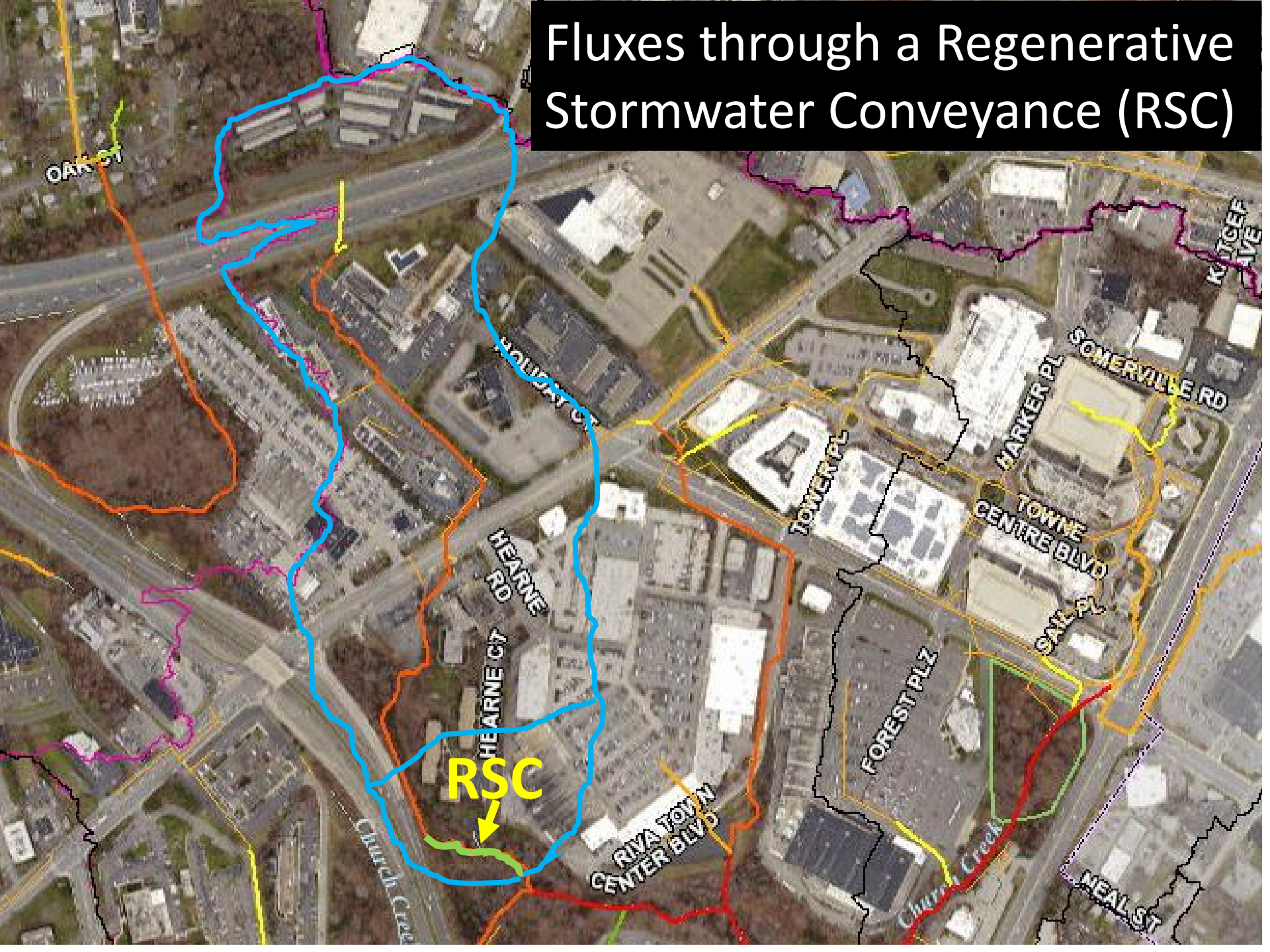
Glibert, P. M., Wilkerson, F. P., Dugdale, R. C., Raven, J. A., Dupont, C. L., Leavitt, P. R., Parker, A. E., Burkholder, J. M., and Kana, T. M. (2016), Pluses and minuses of ammonium and nitrate uptake and assimilation by phytoplankton and implications for productivity and community composition, with emphasis on nitrogen-enriched conditions. Limnology and Oceanography, 61: 165-197. Doi:10.1002/lno.10203.

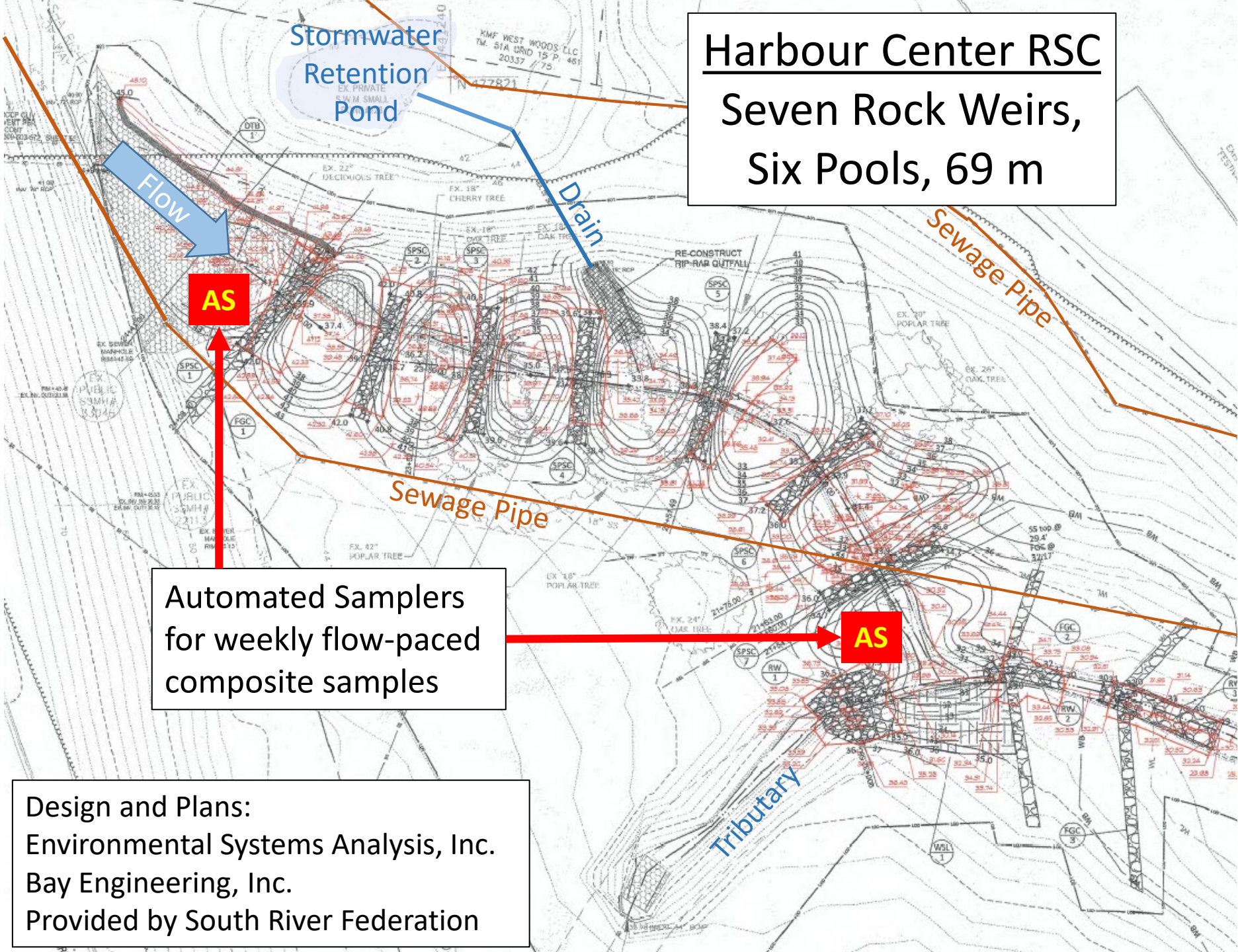
Shenk, G., Wainger, L., Wu, C., Capel, P., Friedrichs, M., Hubbart, J., Iho, A., Kleinman, P., Sellner, K., Stephenson, K. 2020. Assessing the environment in outcome units. STAC Publication Number 20-00x, Edgewater, MD. 34 pp.

Two Main Approaches for Assessing Effects of BMPs:

- Measured fluxes of nutrients and TSS through a stream restoration.

- Compared discharges of nutrients and TSS from watersheds with different management practices in place.


Fluxes through a Regenerative Stormwater Conveyance (RSC)
OAK CT
HOLIDAY CT
HEARNE RD
HEARNE CT
TOWER PL
HARKER PL
SOMERVILLE RD
TOWNE CENTRE BLVD
OAK PL
FOREST PLZ
RIVA TOWN CENTER BLVD
NEAL ST
RSC



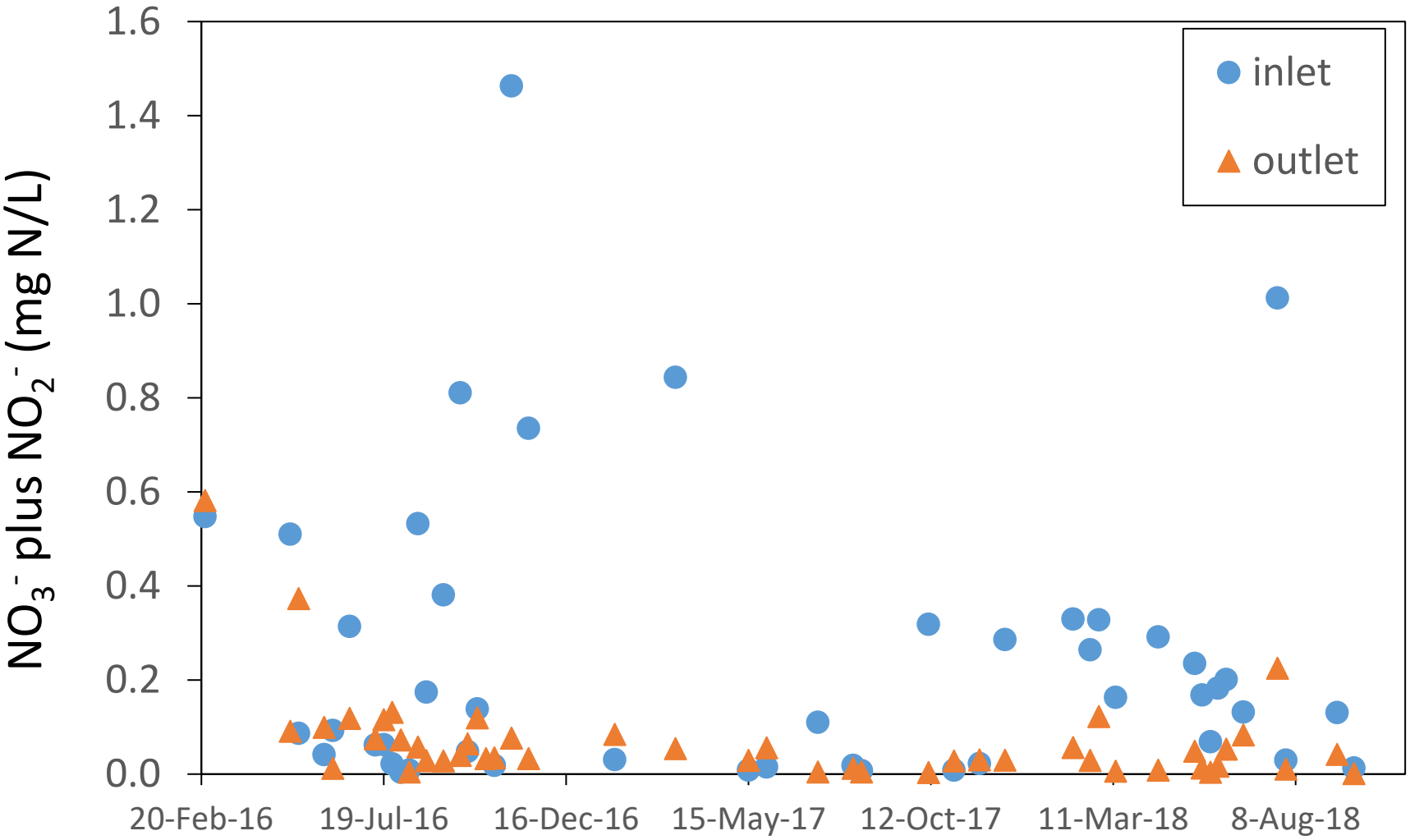
Harbour Center RSC

Seven Rock Weirs, Six Pools, 69 m

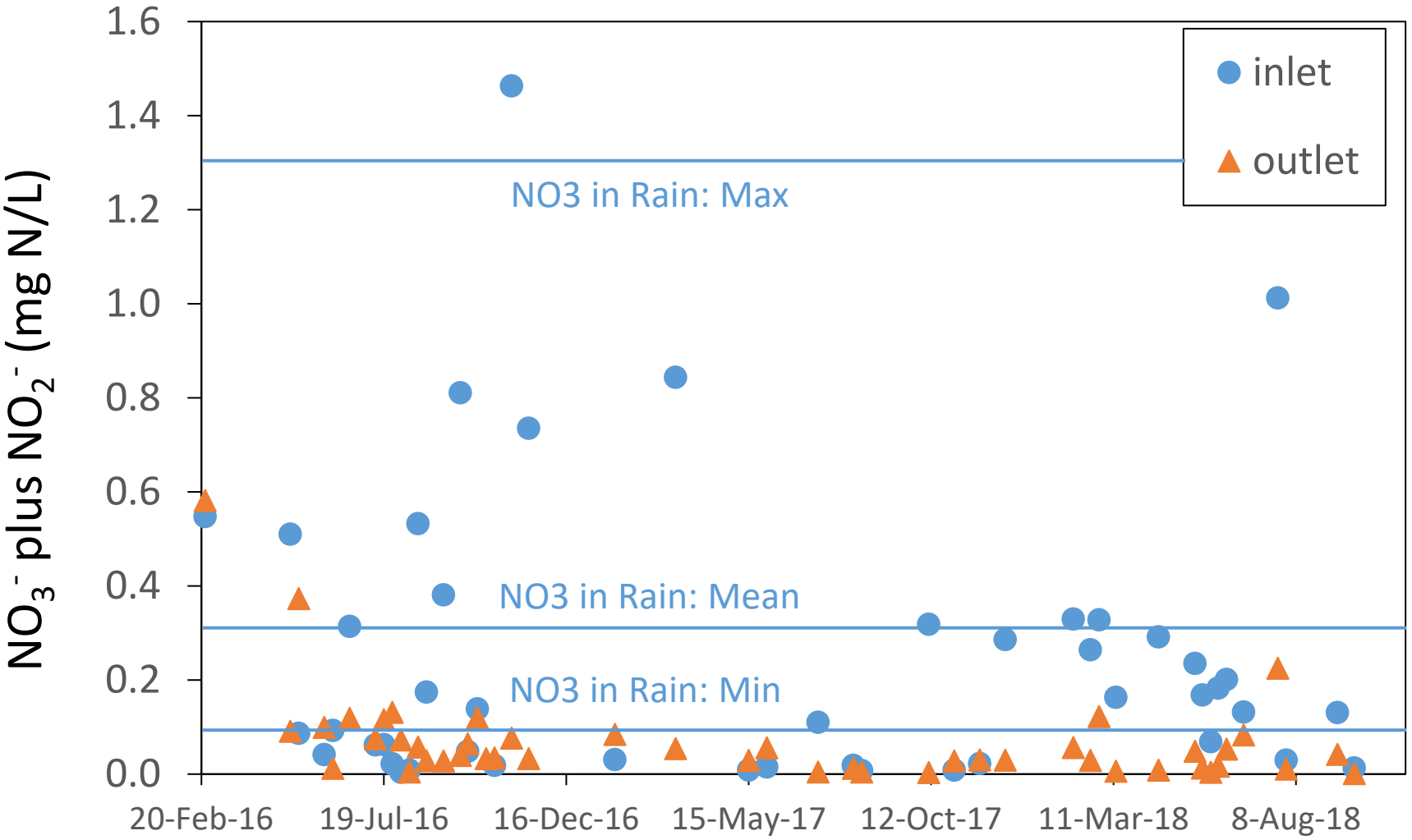
Automated Samplers for weekly flow-paced composite samples

Design and Plans:
Environmental Systems Analysis, Inc.
Bay Engineering, Inc.
Provided by South River Federation

Evidence for redeuction of nitrate plus nitrite: Lower concentrations at RSC outlet than at inlet



Evidence for reduction of nitrate plus nitrite: Lower concentrations at RSC outlet than in rain



Calculating Reduction

Concentration X Water Flow = Load

Load in – Load Out = Amount Reduced

% Reduction = (Amount Reduced / Load In) X 100

Nitrate plus nitrite loads were reduced by 70%

Inlet and outlet loads were significantly different ($p<0.01$, paired T test)

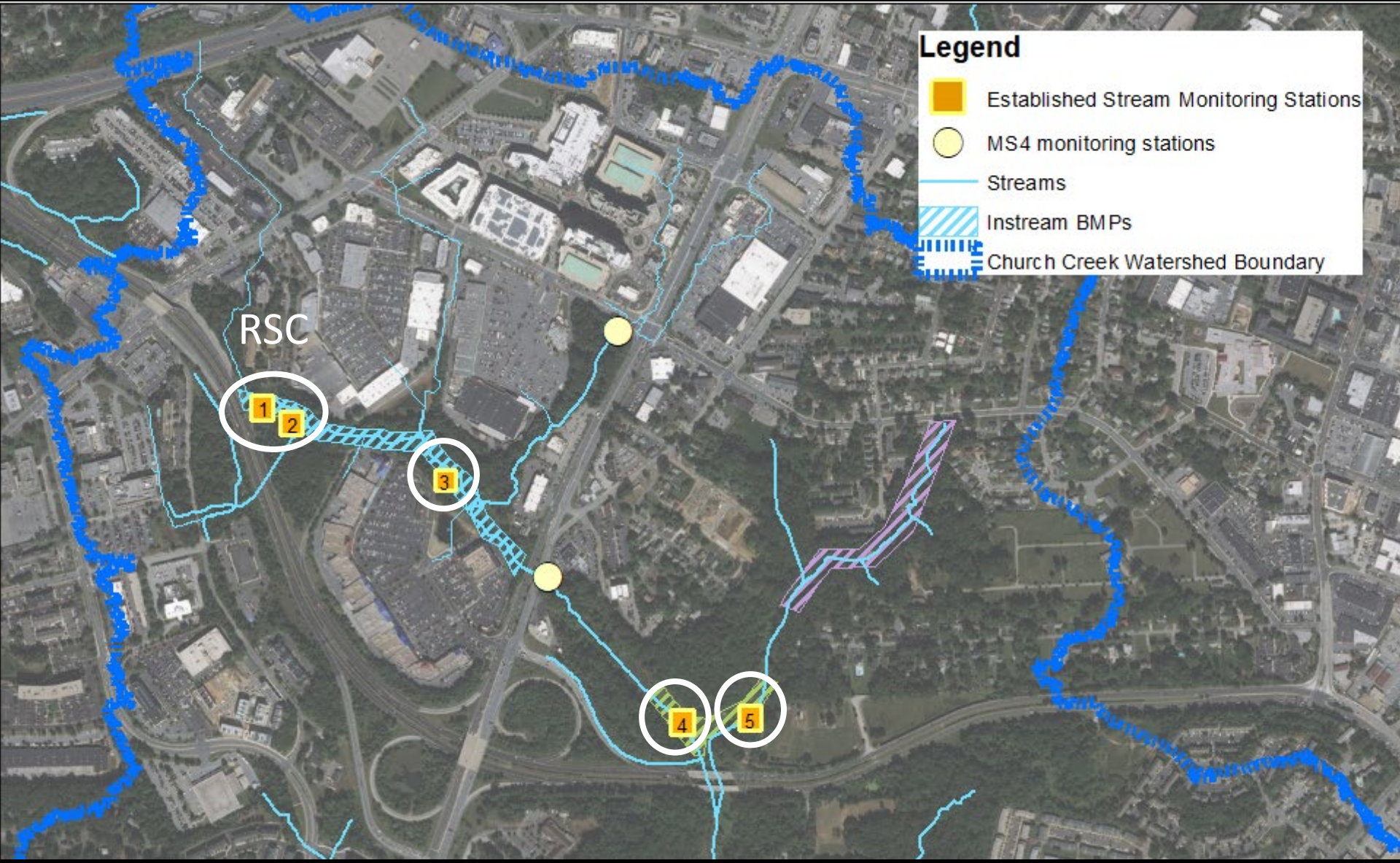
RSC effects on loads of other nutrients and TSS?

No significant differences between inlet and outlet loads of:

TSS, P forms, or N forms (except nitrate plus nitrite).

$p>0.10$ paired T test.

What are the watershed-scale effects of BMPs?



Comparing watersheds with different management practices.

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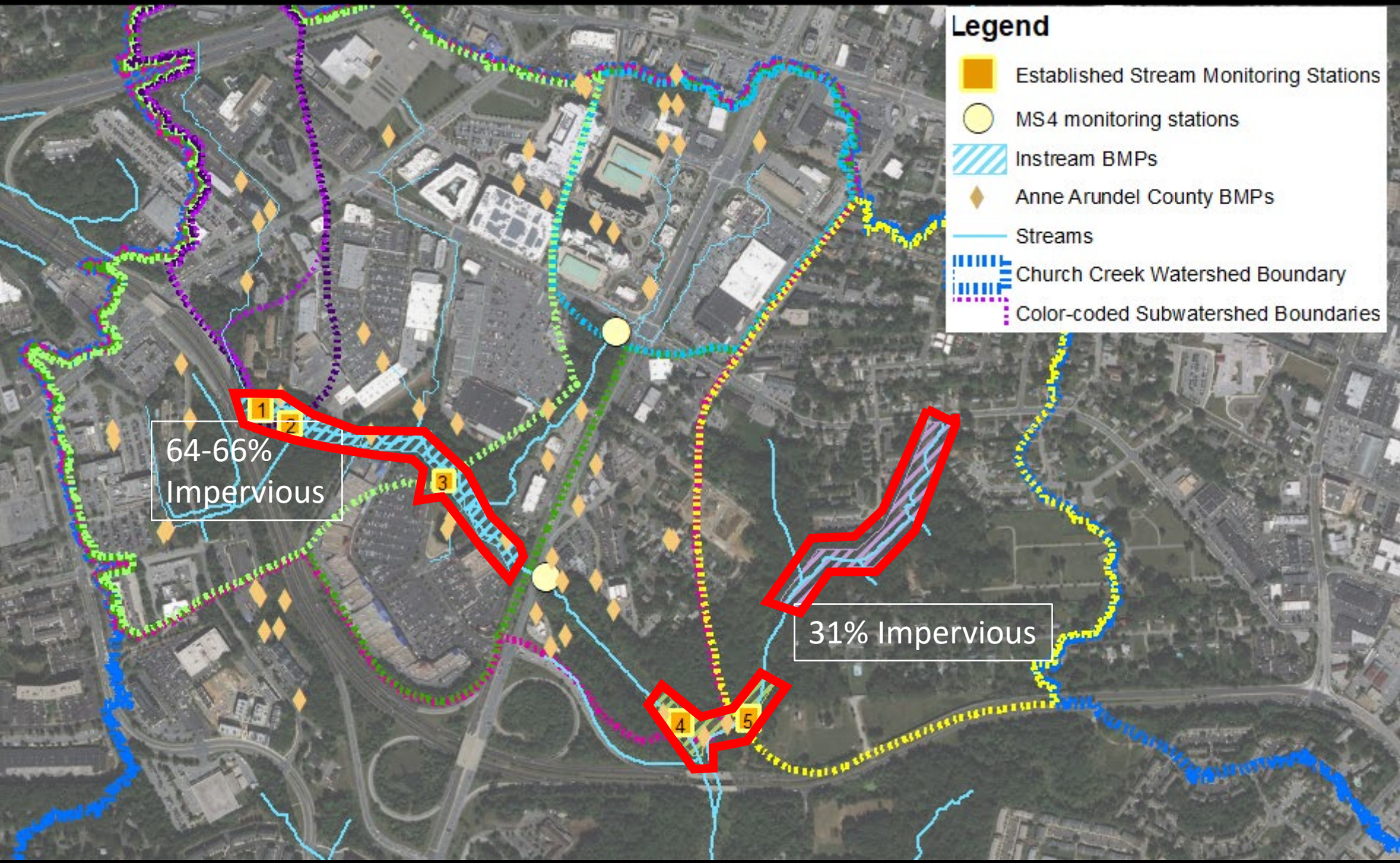
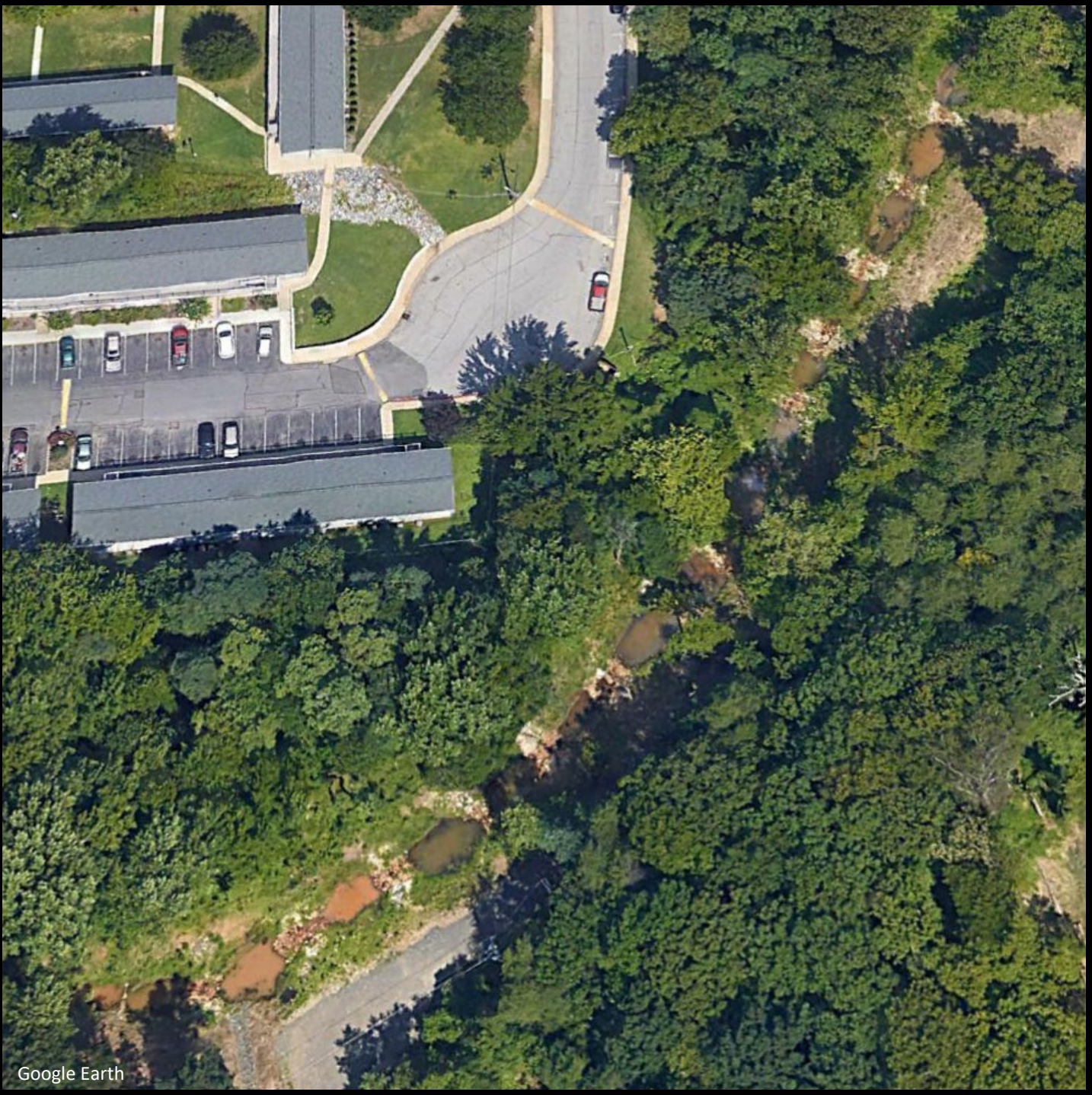


Comparing watersheds with different management practices.

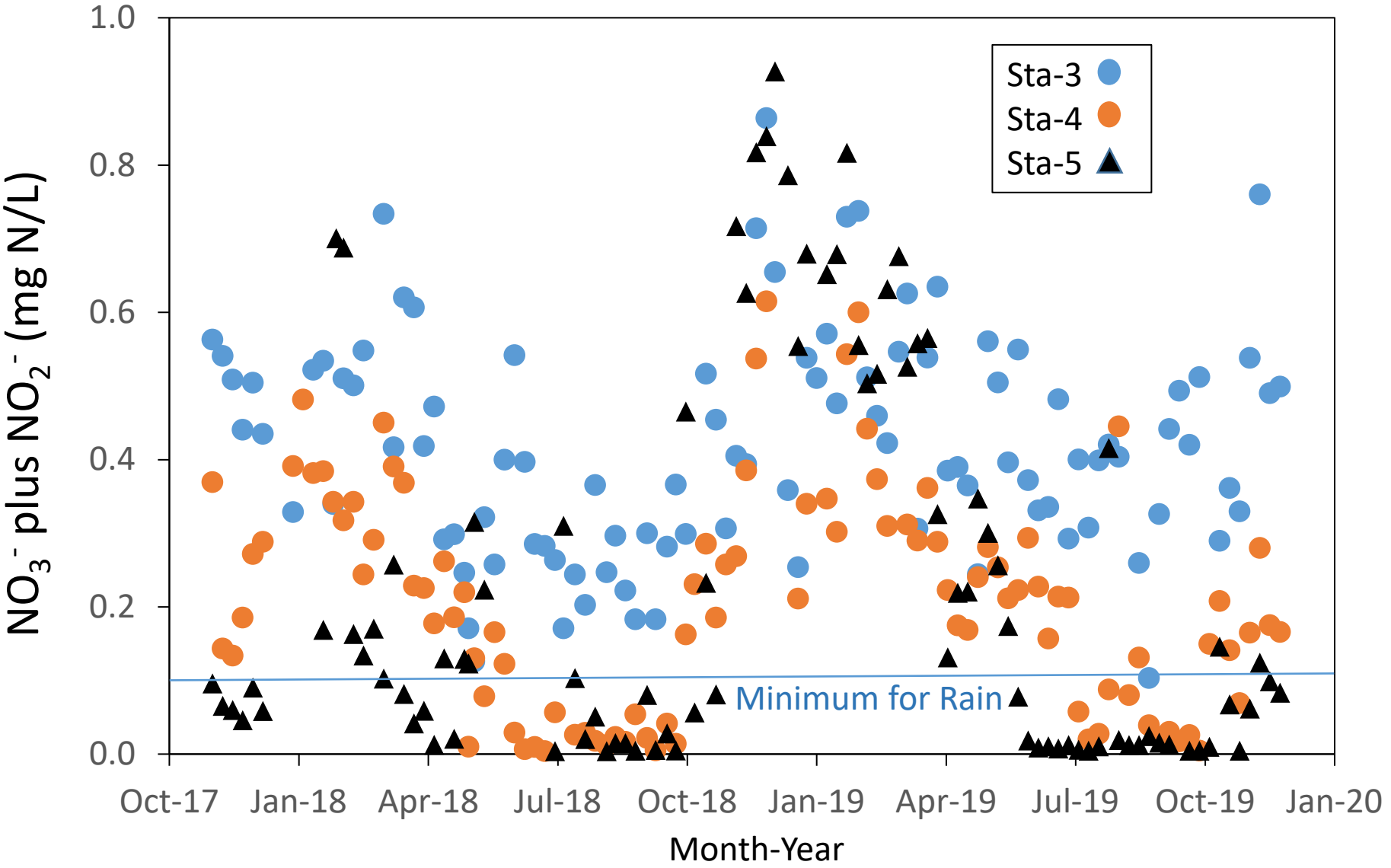
Rock weirs at junction of West and Allen Branches: Automated Samplers 4 and 5



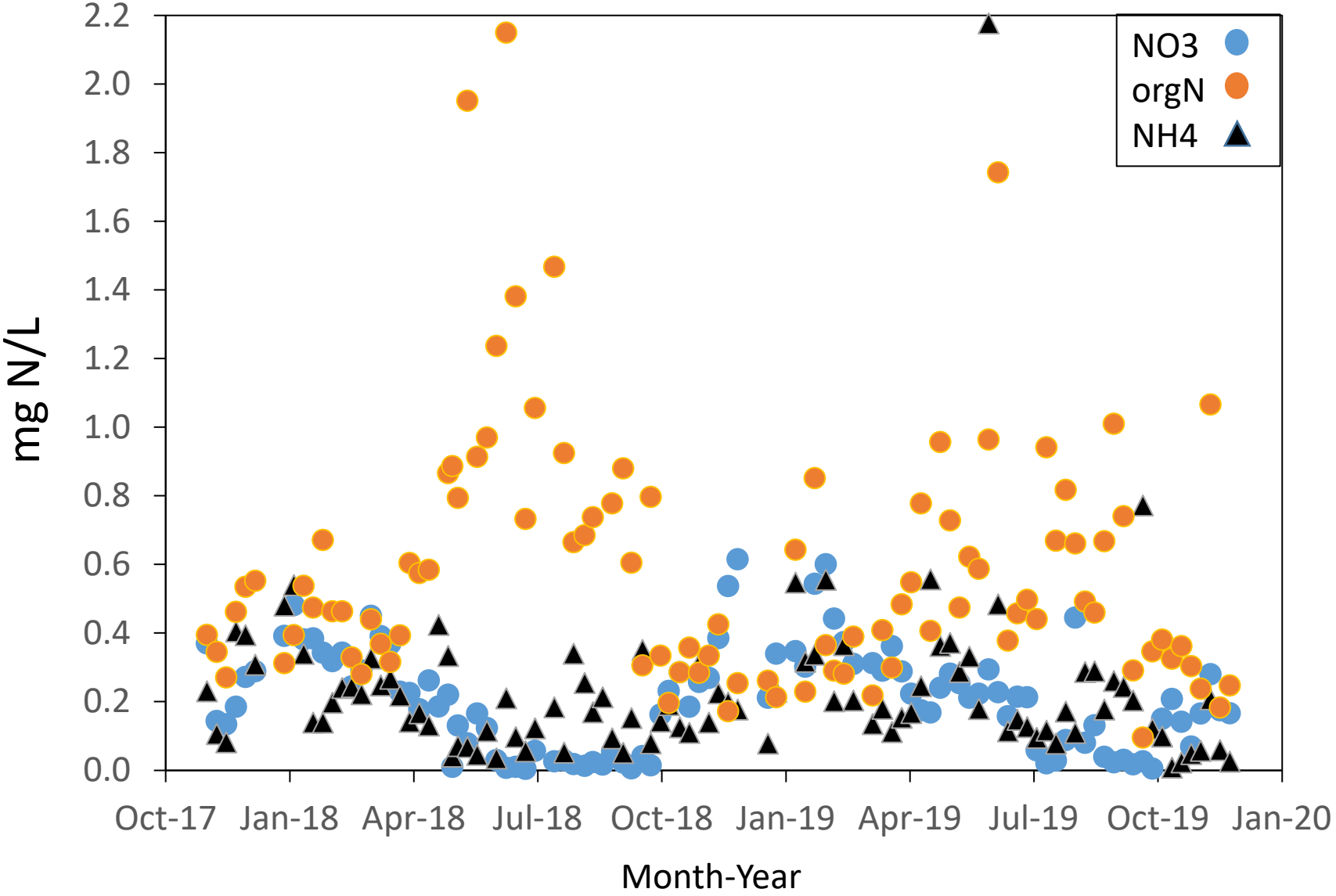
Allen Branch
RSC
Watershed 5

Step Pools and
Rock Weirs

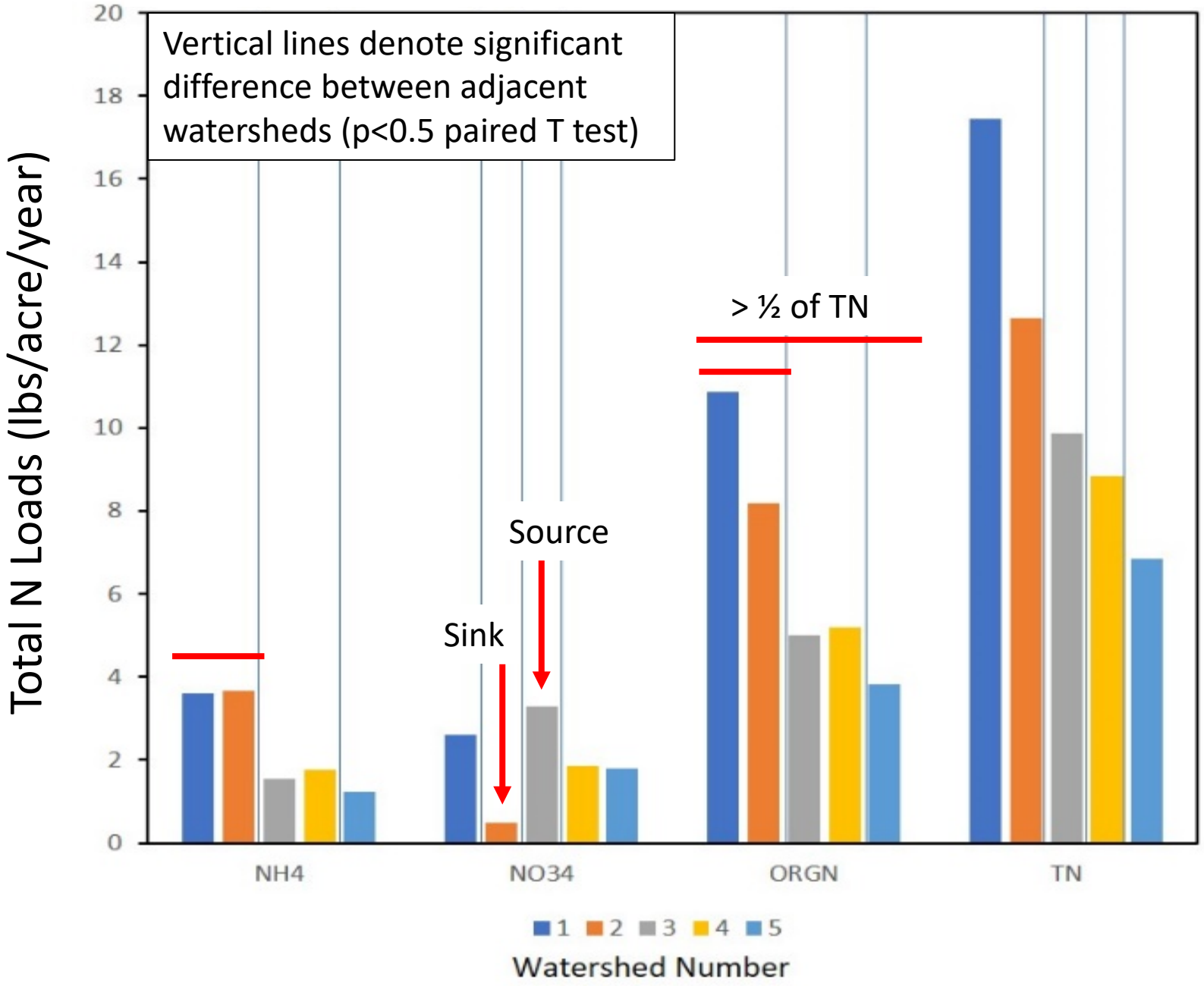
Evidence for reduction of nitrate plus nitrite: Summer drawdown below concentration in rain



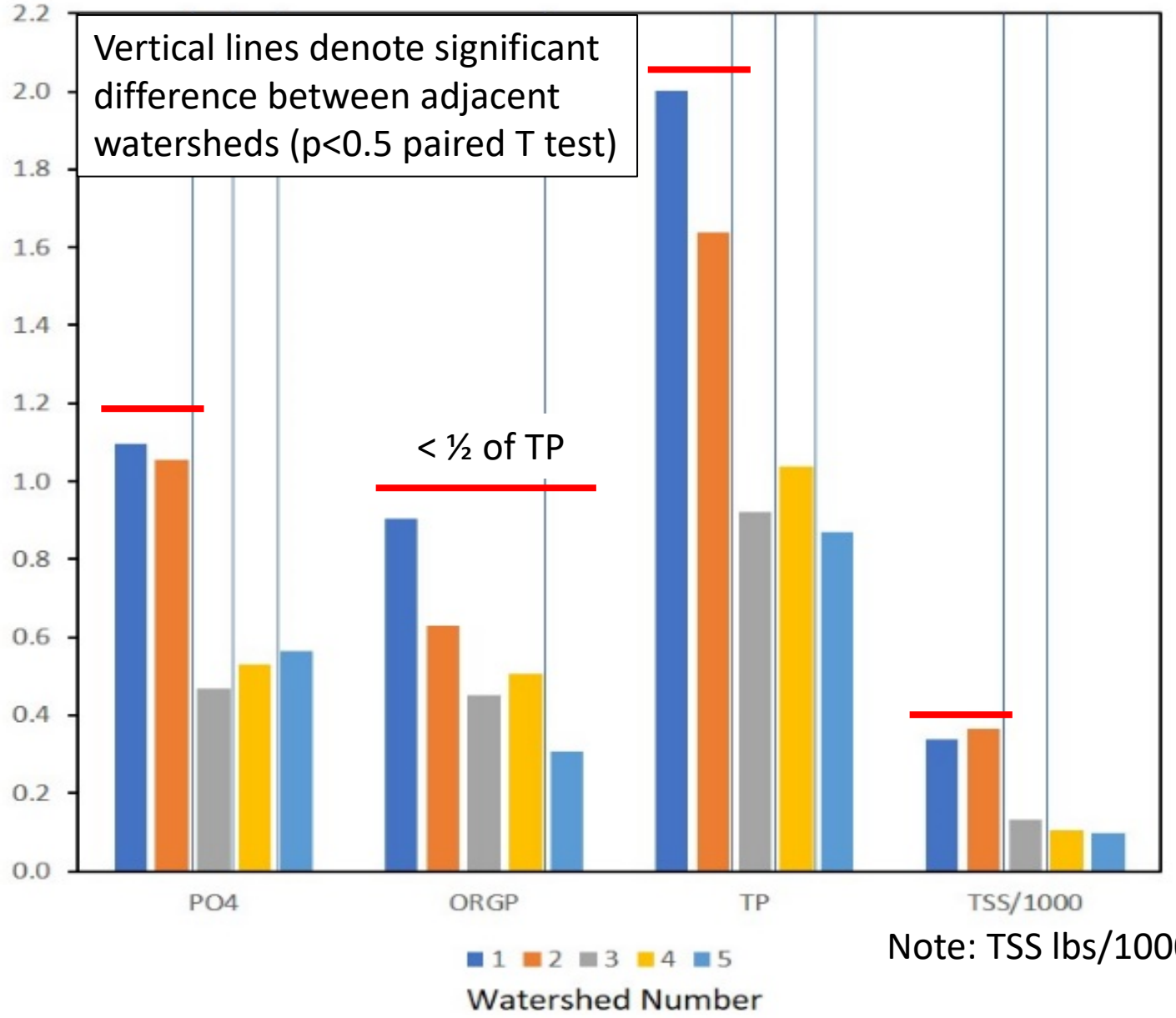
Evidence for reduction of ammonium and addition of organic N at station 4



Do loads of total N reflect the effects of BMPs?

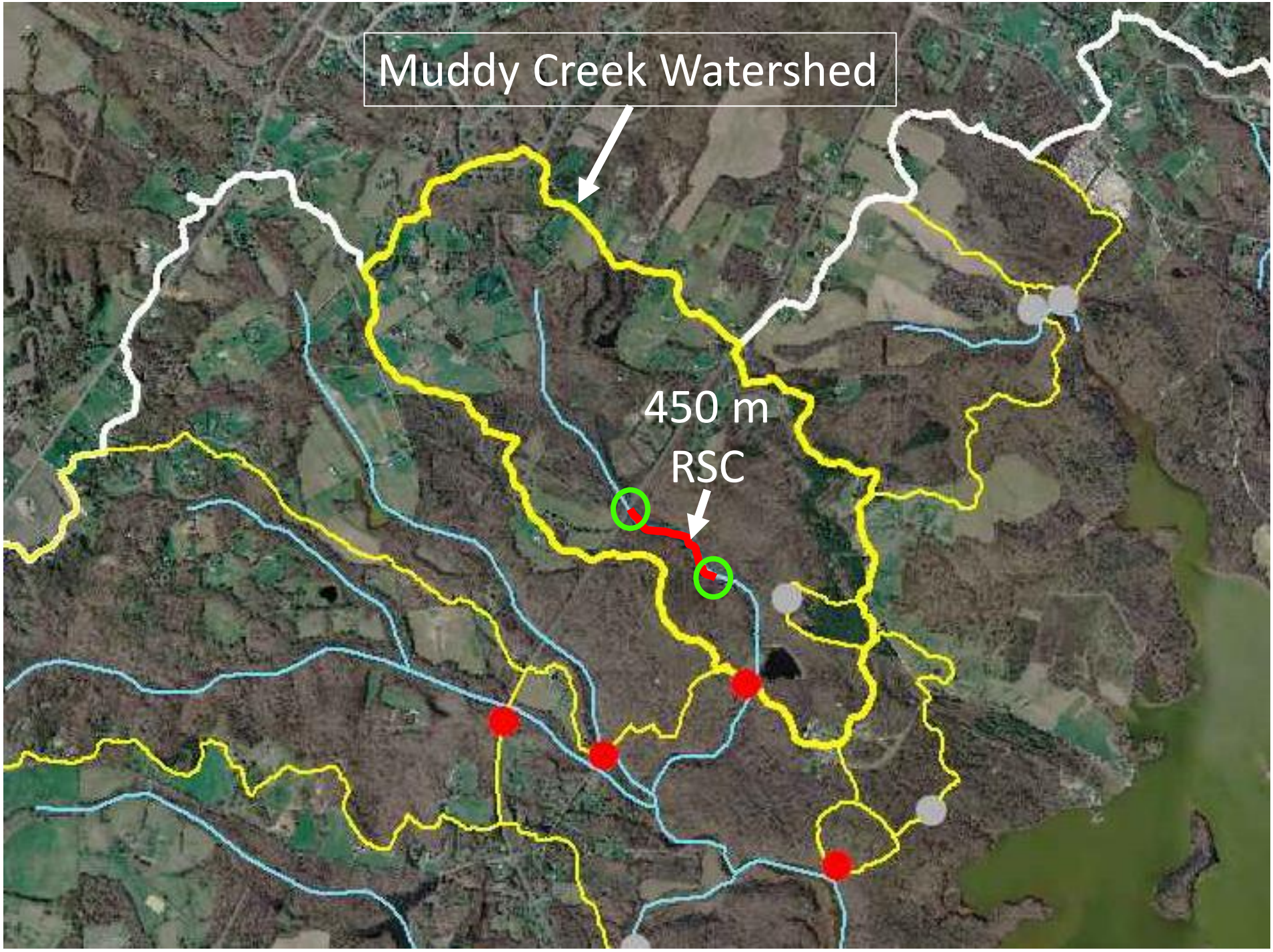


Do loads of total P and TSS reflect the effects of BMPs?



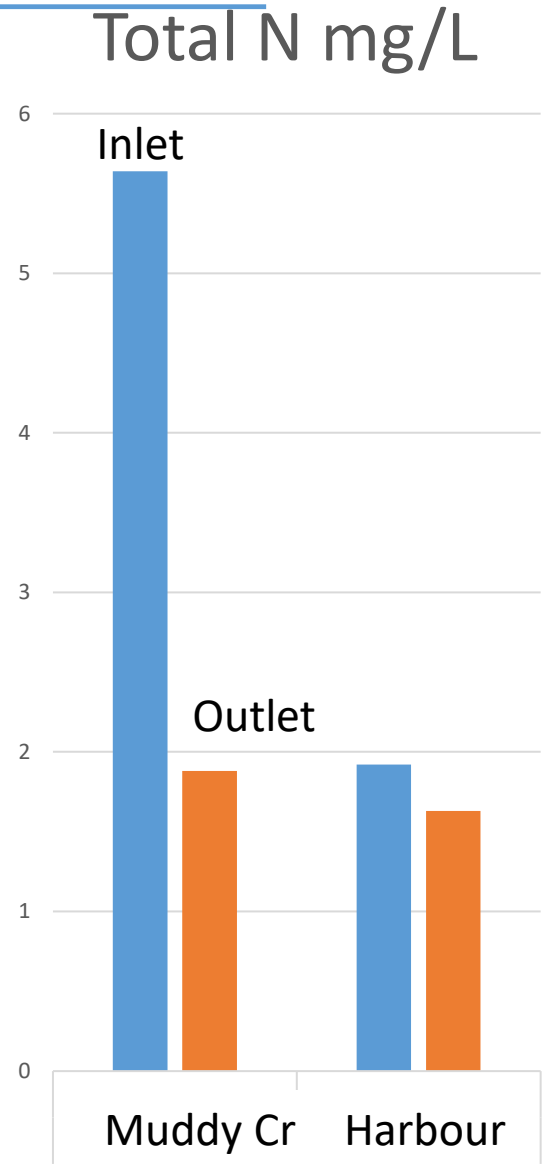
Note: TSS lbs/1000

Why was nitrate plus nitrite the only nutrient reduced by the Harbour Center RSC and reduced to concentrations below those in rain?


Muddy Creek Watershed
450 m
RSC

Higher concentration may enhance reduction

Comparing flow weighted mean concentrations at the inlets and outlets of the two restored stream reaches.



Data for Muddy Creek are from Thompson et al. 2018. Ecological Engineering 124:7-18
Data for the Harbour Center RSC are unpublished.

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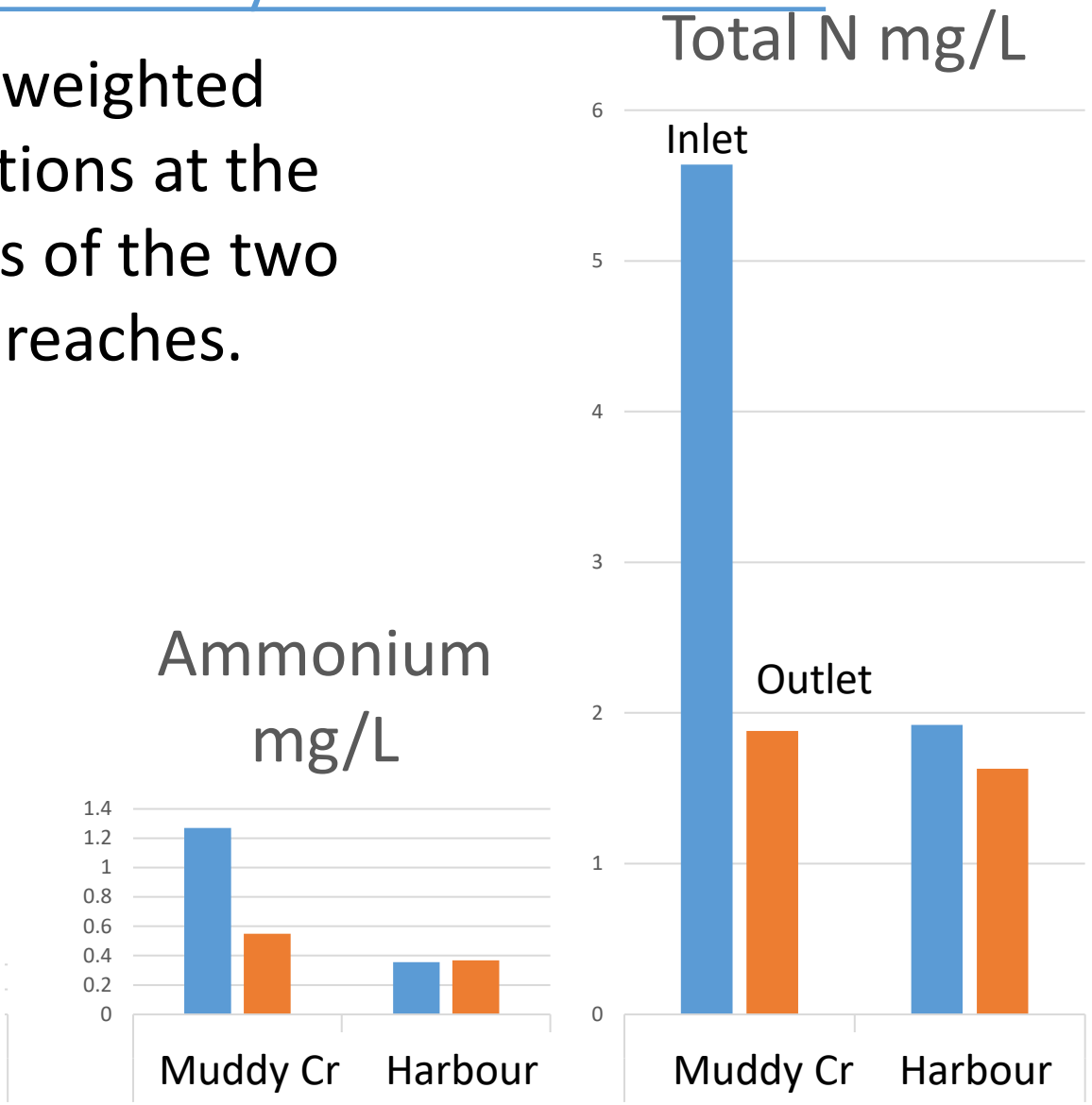

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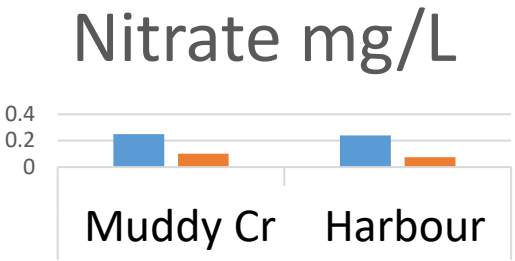

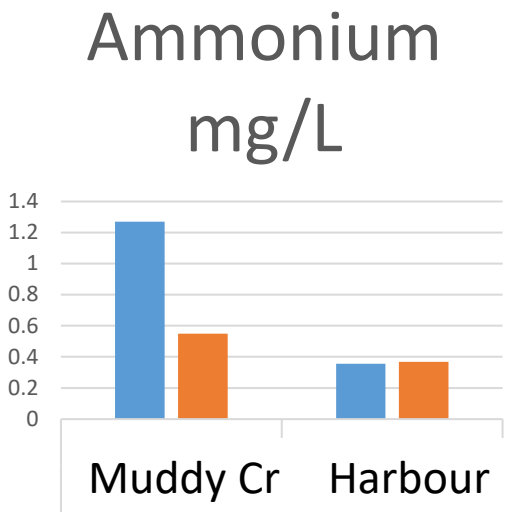

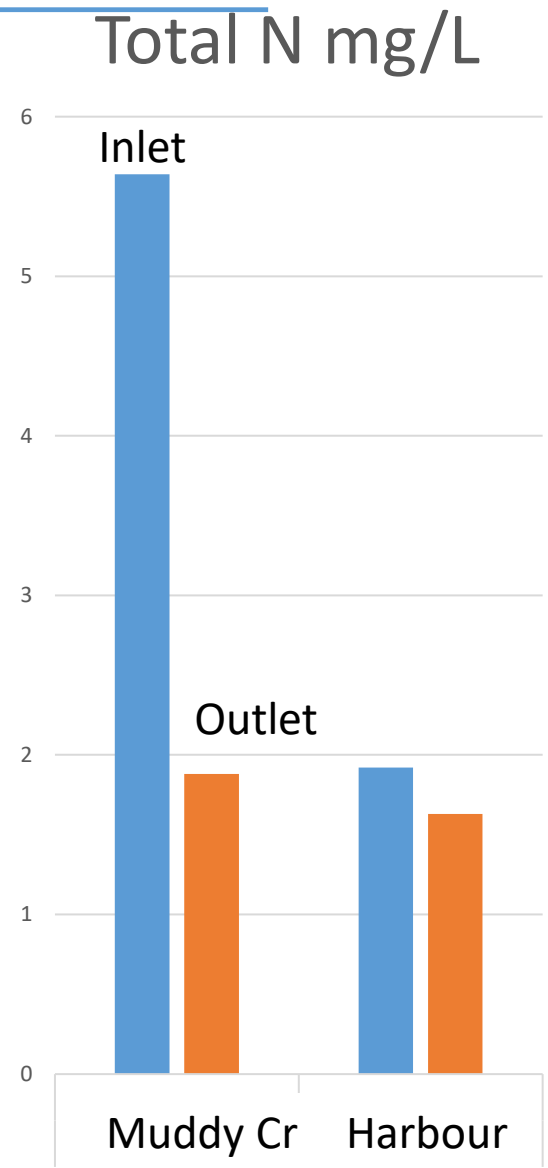

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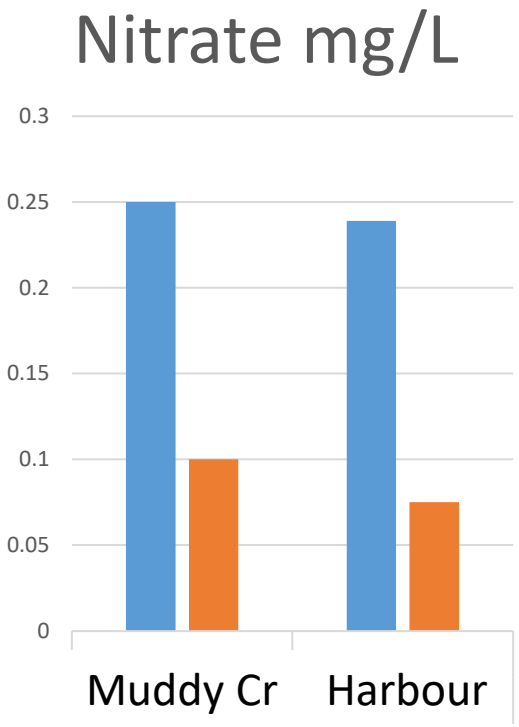

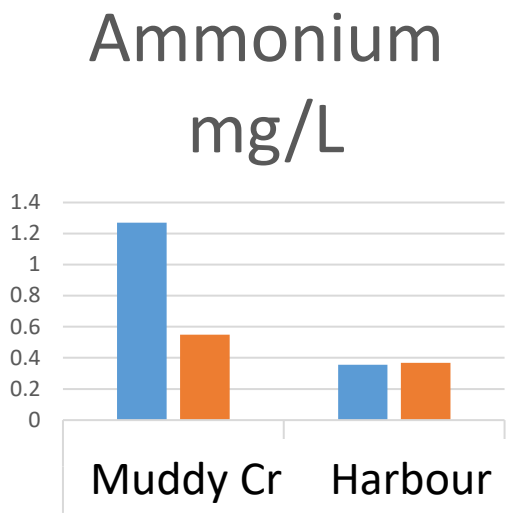

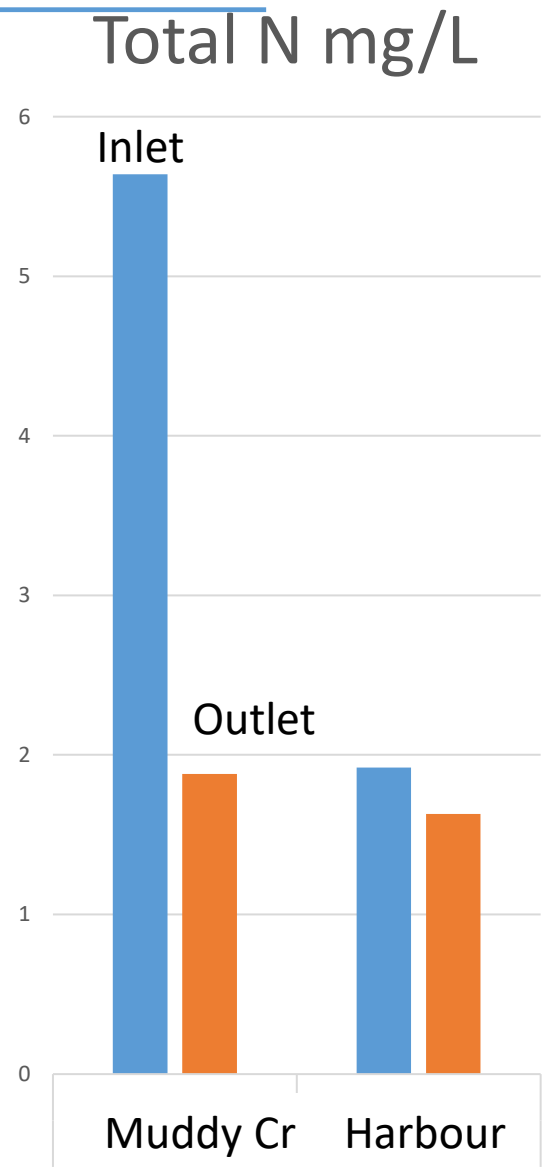

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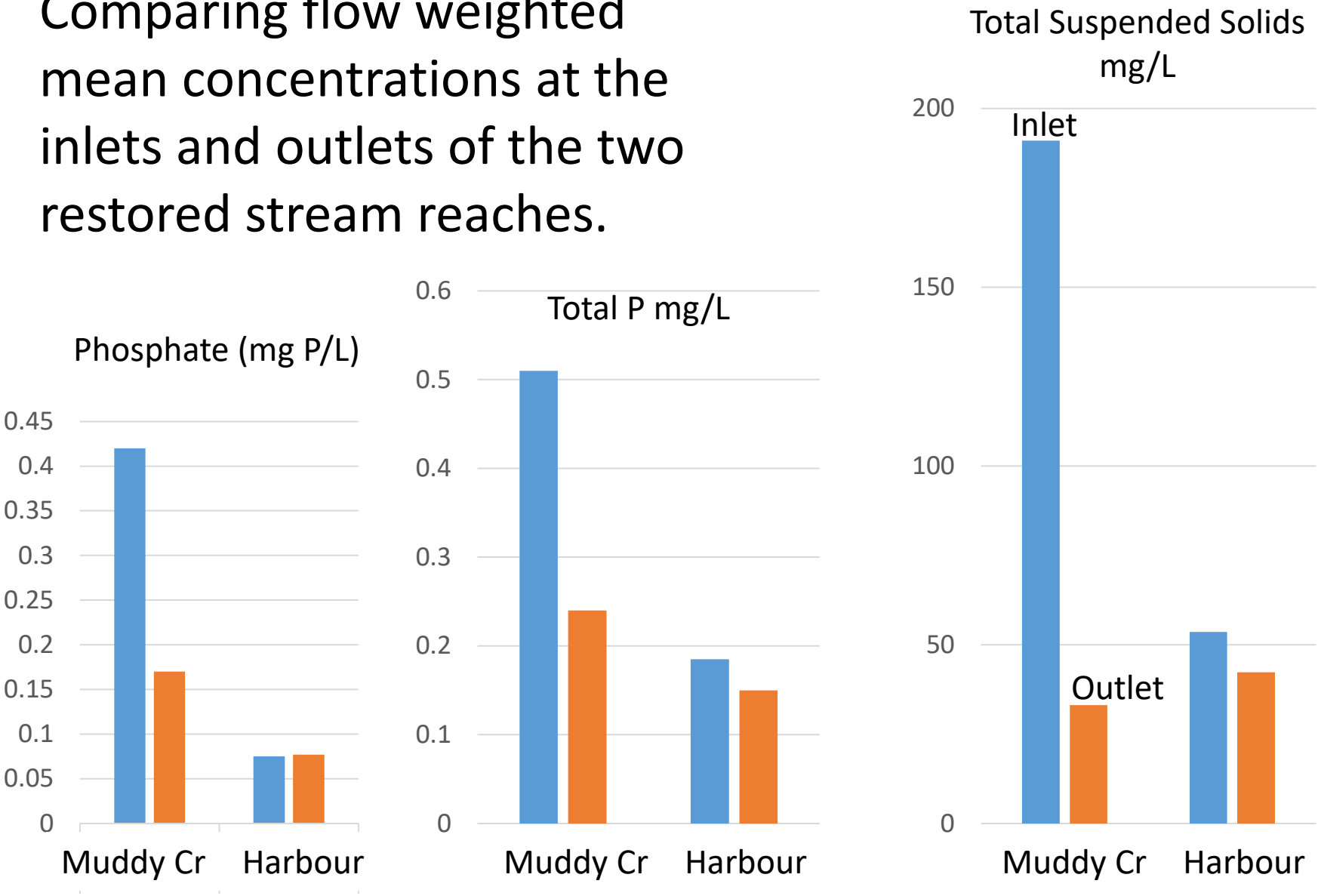

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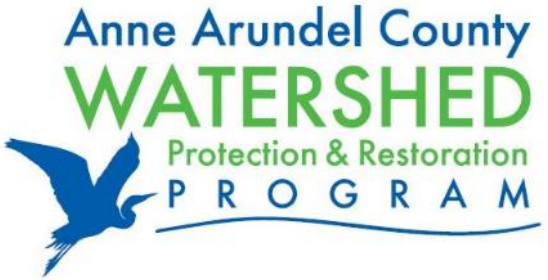
Implications for Management:

Low concentrations of nutrients and TSS may decrease the potential and the need for reductions.

Concentrations should be measured before restorations to gauge the need and expectations for reductions.

We thank these organizations for support:

Rathmann Family Foundation



Possible “Translation” Points:

For Regulators:

Stormwater BMPs, including stream restoration, particularly in series, appear to be effective in terms of reducing TN, TP, and TSS, even without accounting for the benefits of prevented sediment associated with stream restoration.

Urban environments may not be contributing nearly the same levels of nutrient and sediment pollution to downstream waterways as agricultural watersheds, particularly once stream corridors are stabilized.

For Regulators and Practitioners:

It will likely require a critical mass of stormwater practices installed in an individual sub-watershed to achieve significant pollutant reductions.

Practices need to be installed within the watershed locations where they will actually intercept/arrest pollutants.