Regenerative Stormwater Conveyance Systems

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Outline:

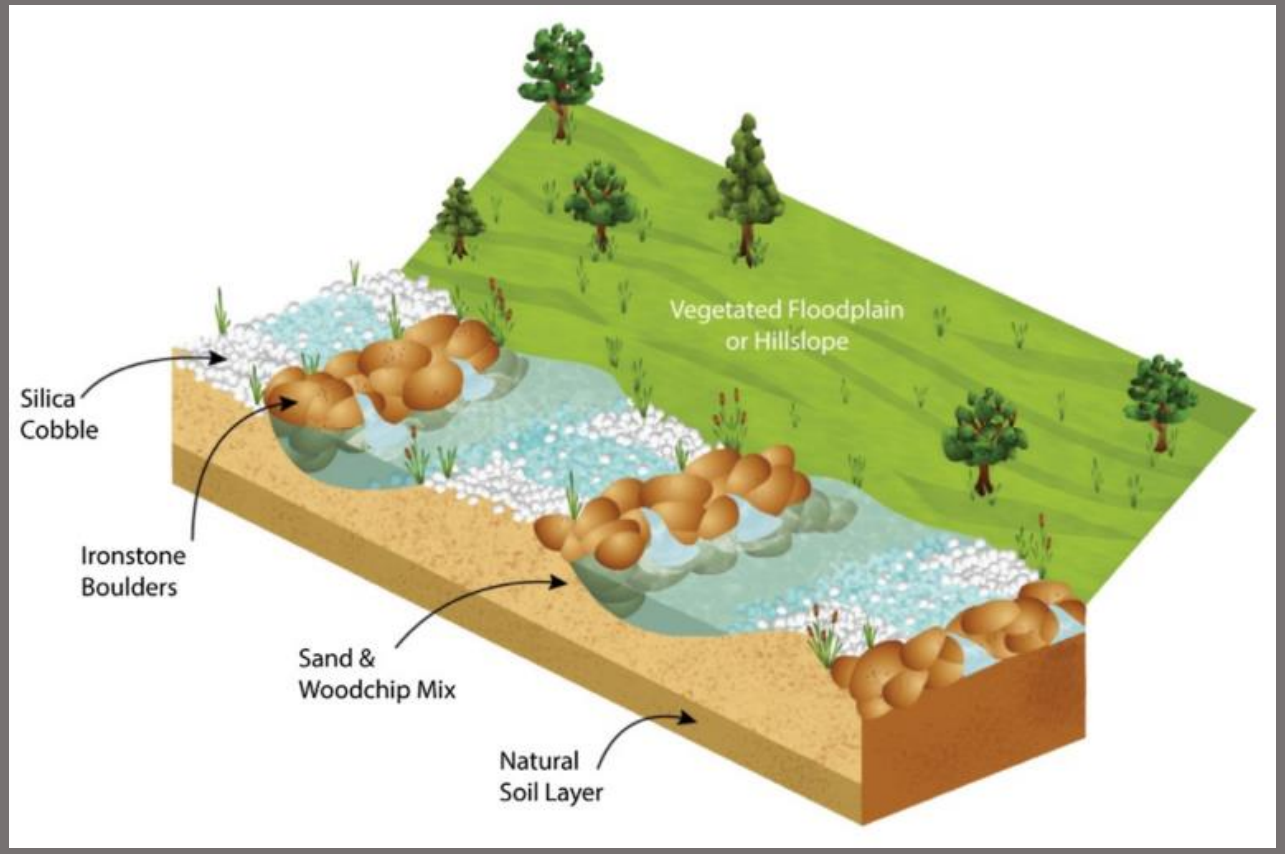
- Basic Design of an Regenerative Stormwater Conveyance (RSC) System
- Regulatory Background
- Scientific Research Background
- EPA Research Efforts
- Summary

What is an RSC?

Regenerative Stormwater Conveyance

AKA: regenerative streamwater conveyance, coastal plain outfall, regenerative step pool storm conveyance (SPSC), regenerative stream channel

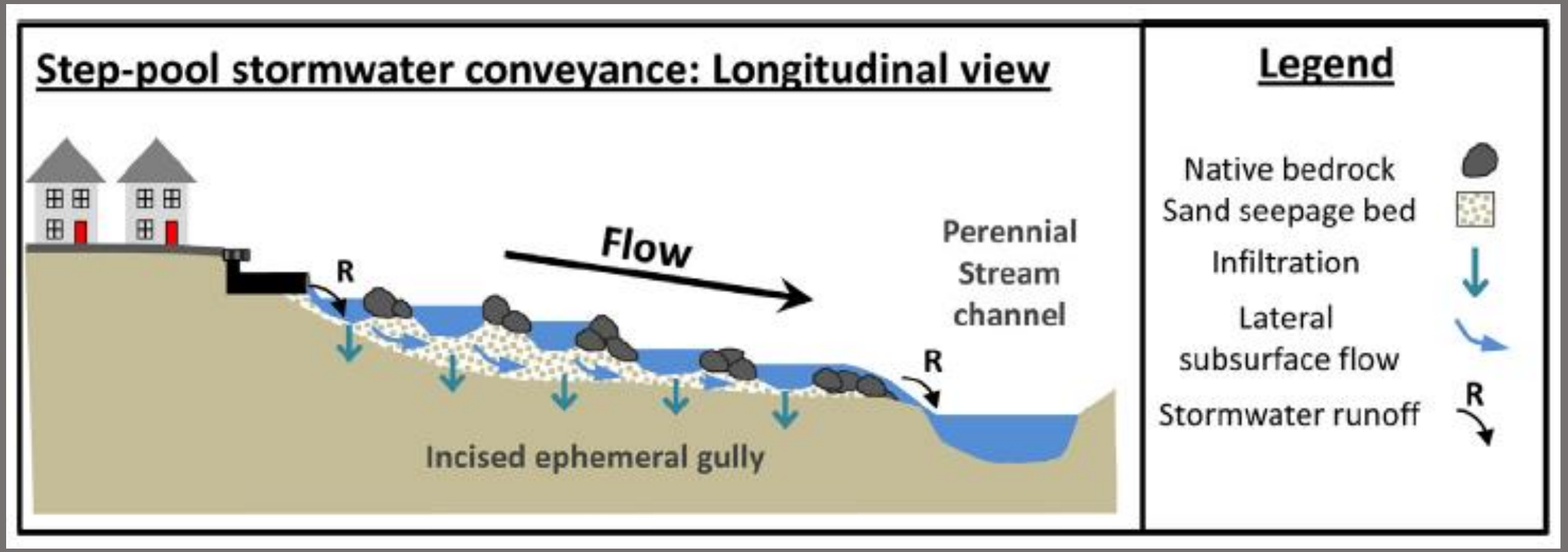
- ***Series of riffles and pools***
- ***Sand and* woodchip fill**
- **Rock weirs**



Williams, M. R., Wessel, B. M., & Filoso, S. (2016).

What are the goals of an RSC project?

- Treat quantity and quality of stormwater runoff
- Reduce transportation of sediment and nutrients downstream
- Increase denitrification in the stream reach and adjacent floodplain
- Provide habitat diversity


Step-pool stormwater conveyance: Longitudinal view
Flow
R
R
Perennial
Stream
channel
Incised ephemeral gully
Legend
Native bedrock
Sand seepage bed
Infiltration
Lateral
subsurface flow
Stormwater runoff
R

Typical RSC’s in perennial channels

Regulatory Background:

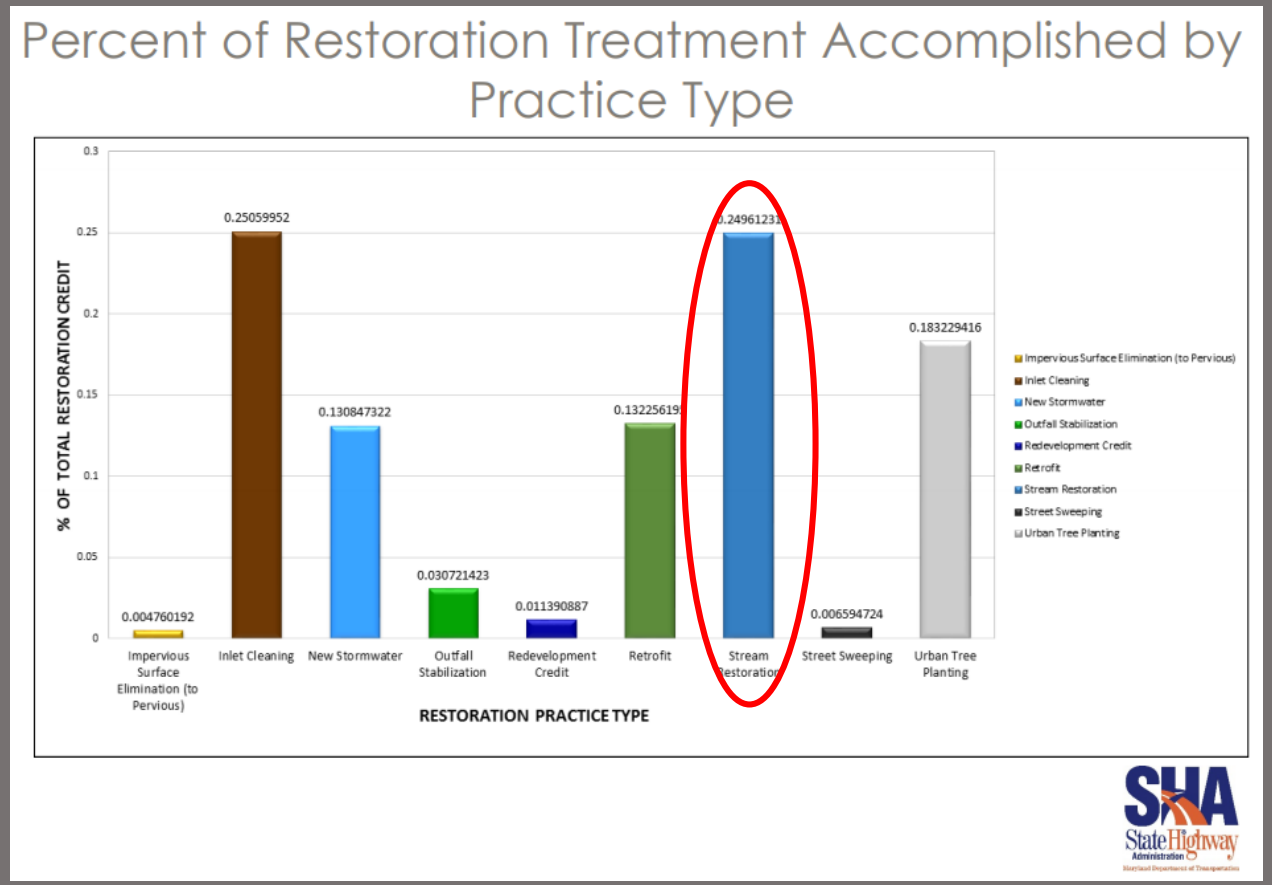
Drivers of projects:

Chesapeake Bay TMDL

- Urban stream restoration BMP
- WIP goal: 441 miles

MS4 permit requirements

- Impervious treatment
- TMDL implementation plans



Regulatory Background:

Permitting of RSC's includes ecological requirements:

CWA Section 404 review

- **Nationwide 27**

remove non-native invasive, exotic, or nuisance vegetation; and other related activities. Only native plant species should be planted at the site.

This NWP authorizes the relocation of non-tidal waters, including non-tidal wetlands and streams, on the project site provided there are net increases in aquatic resource functions and services.

Except for the relocation of non-tidal waters on the project site, this NWP does not authorize the conversion of a stream or natural wetlands to another aquatic habitat type (e.g., stream to wetland or vice versa) or uplands. Changes in wetland plant communities that occur

- **Bay TMDL RGP**

include, but are not limited to, the retrofit of existing stormwater management facilities, the retrofit of existing stormwater management outfalls, and the restoration and enhancement of non-tidal streams and non-tidal wetlands. Stream and wetland restoration and enhancement projects must meet nutrient and sediment load reduction targets under the Chesapeake Bay TMDL and restore functions that support and/or enhance aquatic biological resources at the project site.

This Bay TMDL RGP provides a streamlined form of Department of the Army authorization for activities that provide nutrient and sediment reductions mandated by the Chesapeake Bay TMDL. The development of permit streamlining measures

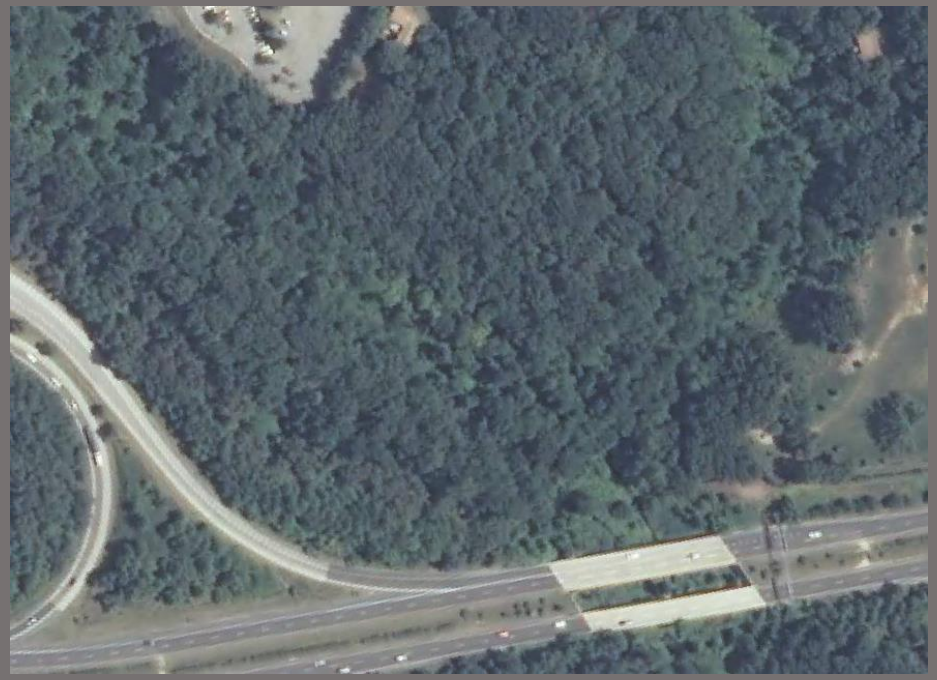
Scientific Research Background:

Address Questions about:

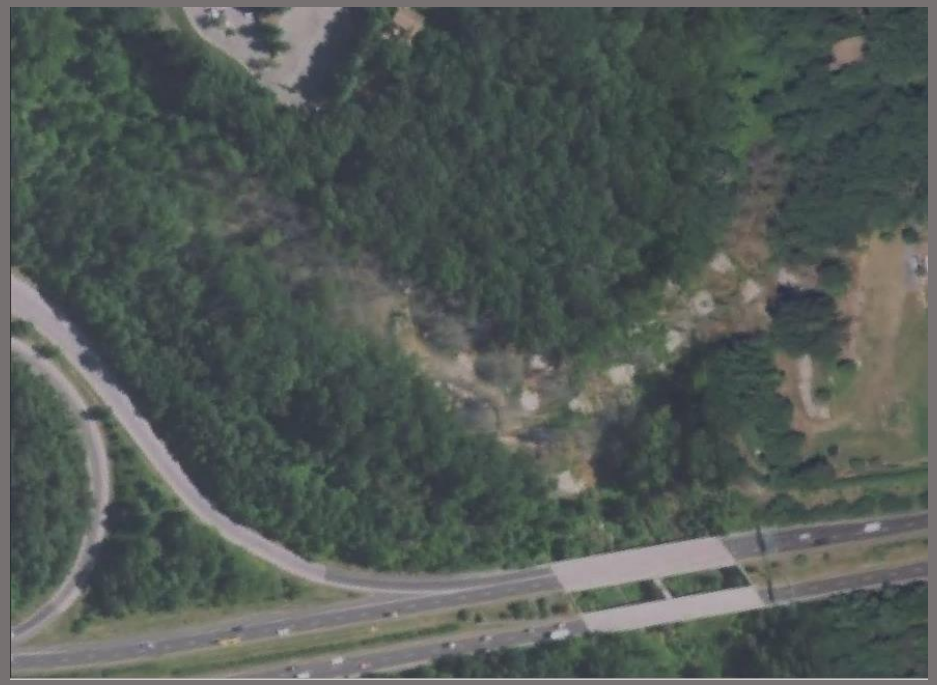
- Nutrient removal
- Stormwater attenuation
- Unintended ecological consequences:
  - Tree loss
  - Iron flocculate
  - Low flow/no flow
  - Structural failures
  - Habitat degradation/conversion

Tree Loss

Before



After



Iron flocculate

Published Literature:

Palmer et al. (2015)

- ✓ Decreased peak flows, longer receding limb
- ✓ Sediment and nitrogen load reductions (up to 0.75 in of rainfall)

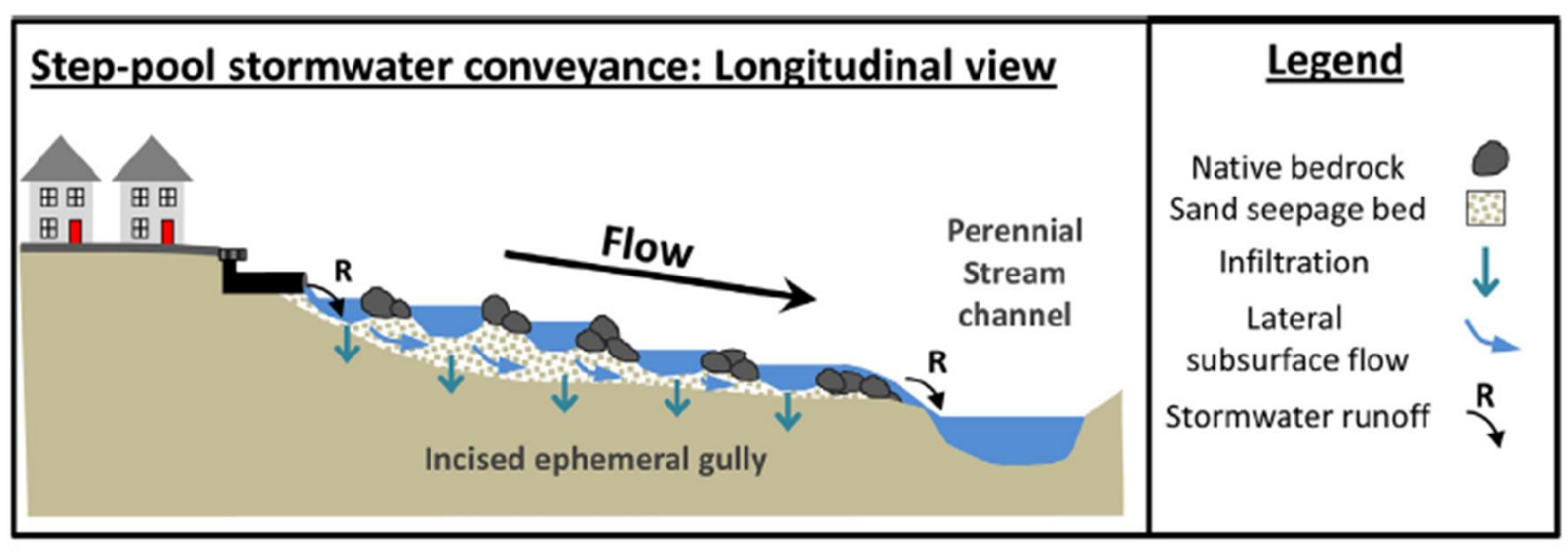
Fanelli et al (2017)

- ✓ Restored hydrological function in 1 of 3 restored urban watersheds treated with RSC
- ✓ Highly variable hydrological responses in 3 restored watersheds

Published Literature:

Williams et al. (2016)

Iron from groundwater + Iron from construction material + Organic carbon from woodchips = Floc

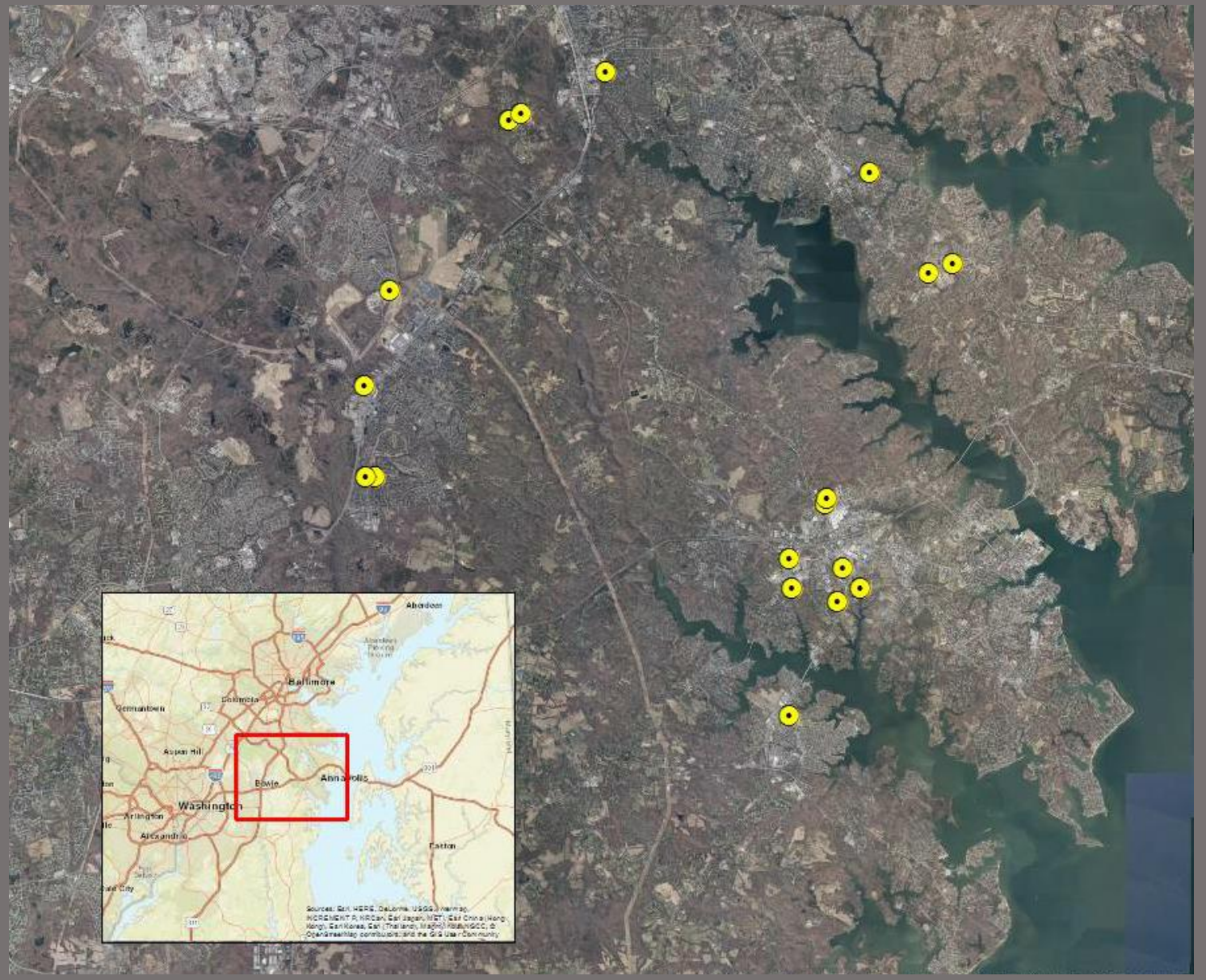


WPD/EAID Research Goals:

- Characterize basic ecology of RSC's
- Determine whether there are tradeoffs exist between pollution reduction goals and local ecological health

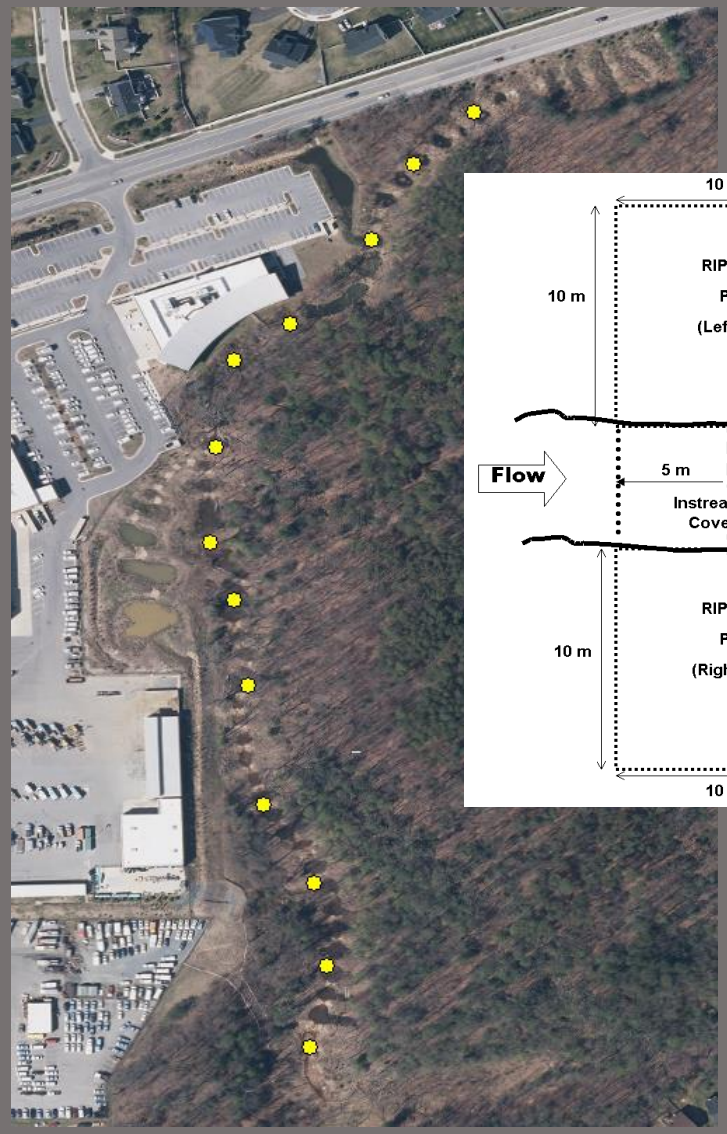
Study Design:

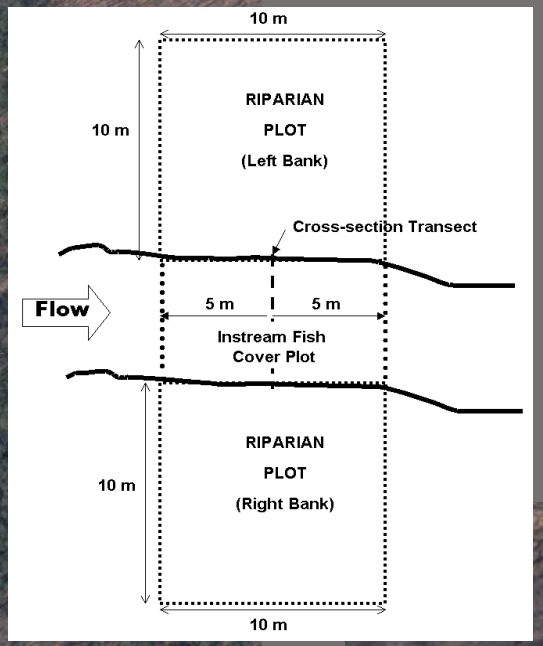
- 15 restored sites
- 2 proposed sites
- All perennial streams
- Basic water quality
- Riparian vegetation survey
- Leaf litter



Study Design:

- Transects representing 20% of stream reach
- DO, pH, temperature, conductivity
- Fall, spring, summer sampling
- Riparian vegetation survey
- Leaf litter collection and tree survey at a subset of sites





Site Characteristics

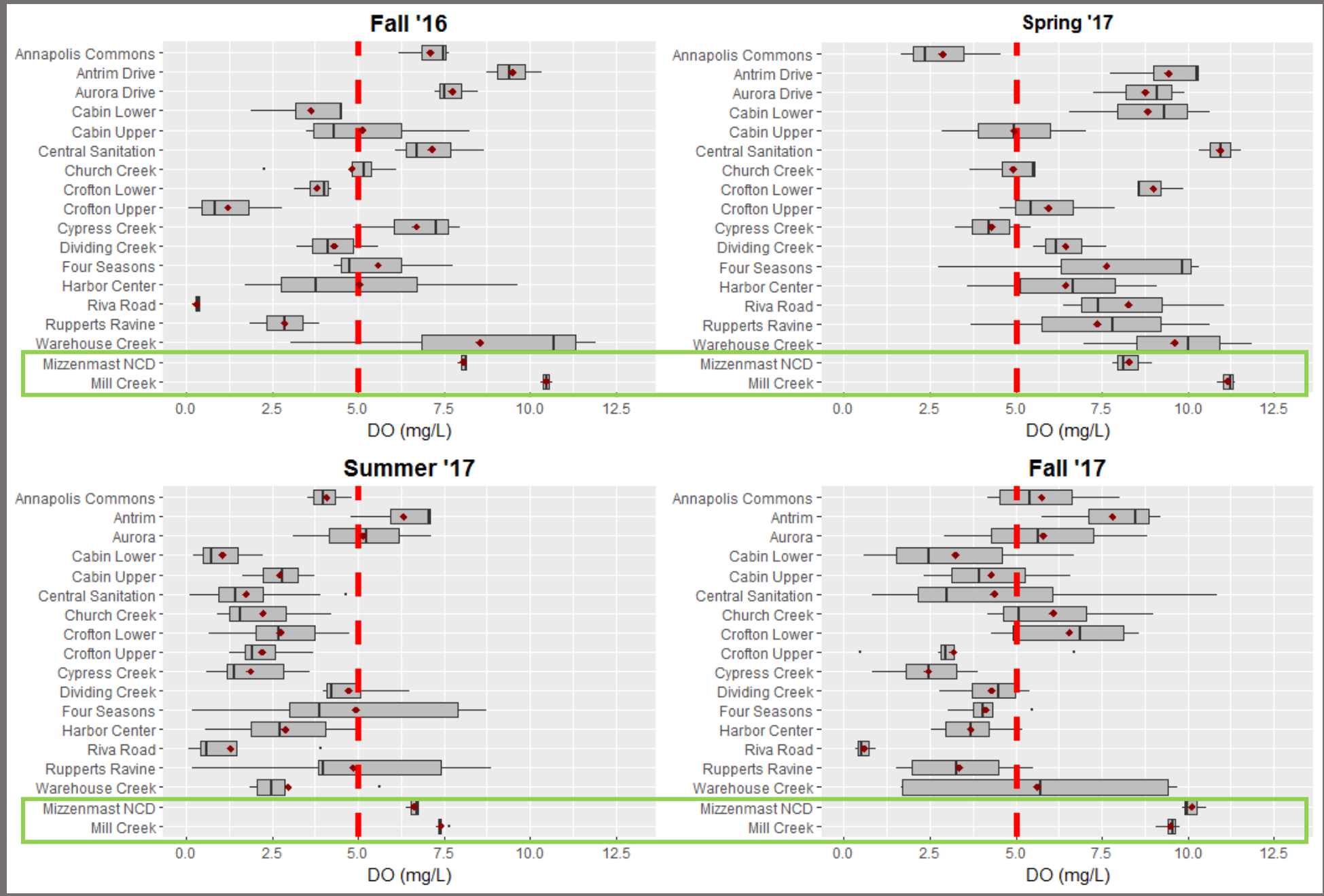
- Build dates between 2007 and 2015
- Most streams 1st or 2nd order, one 4th order

	Min	Median	Mean	Max
Reach Length (linear feet)	295	737	849	2029
Catchment Size (acres)	18.4	136.4	205.2	680.3
Percent Impervious	12.0	28.6	33.2	61.3

Preliminary Results:

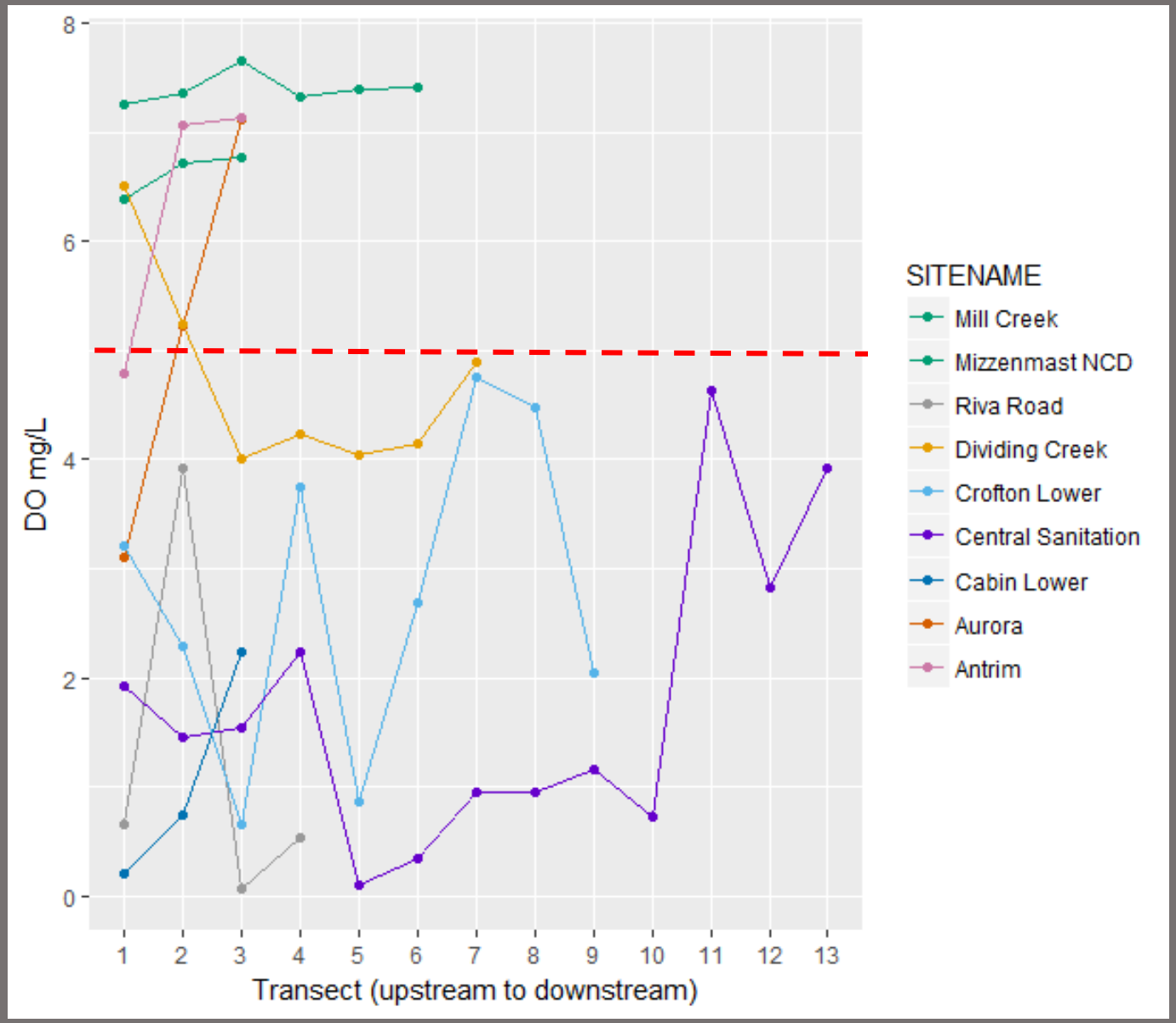
DO levels below 5 mg/L were common

Variability high within and among sites



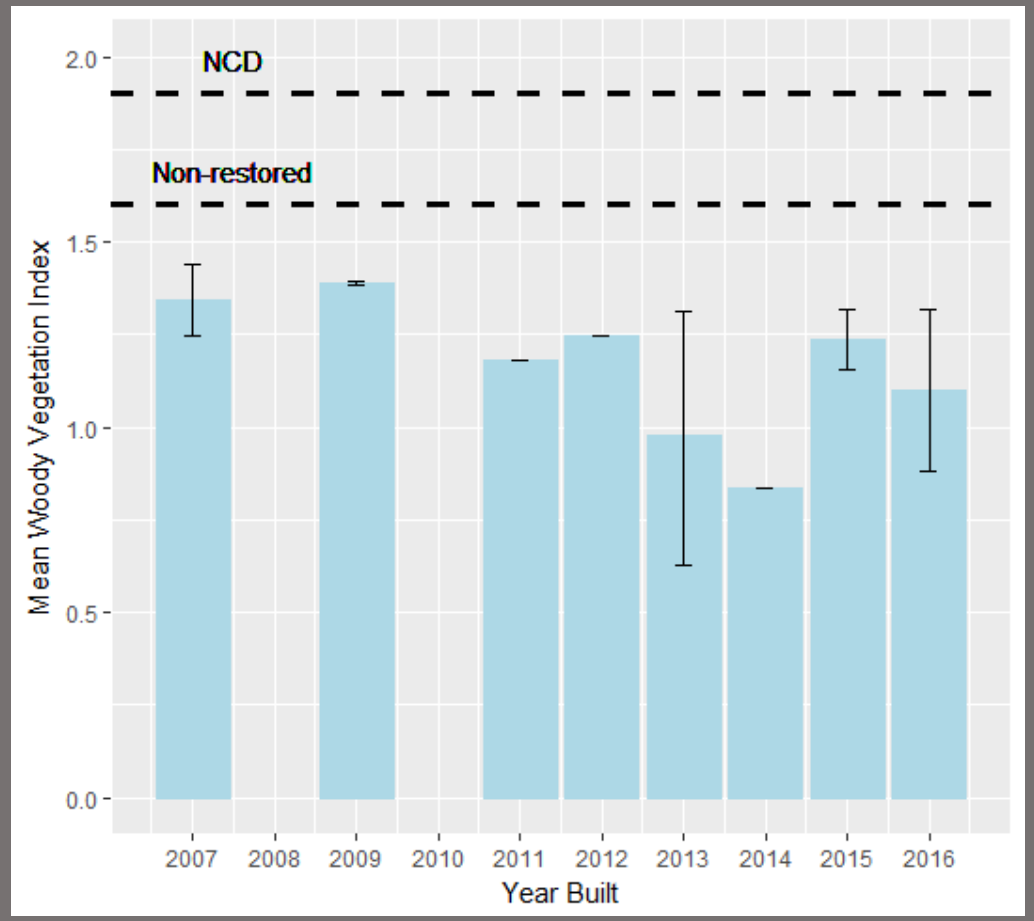
Preliminary Results:

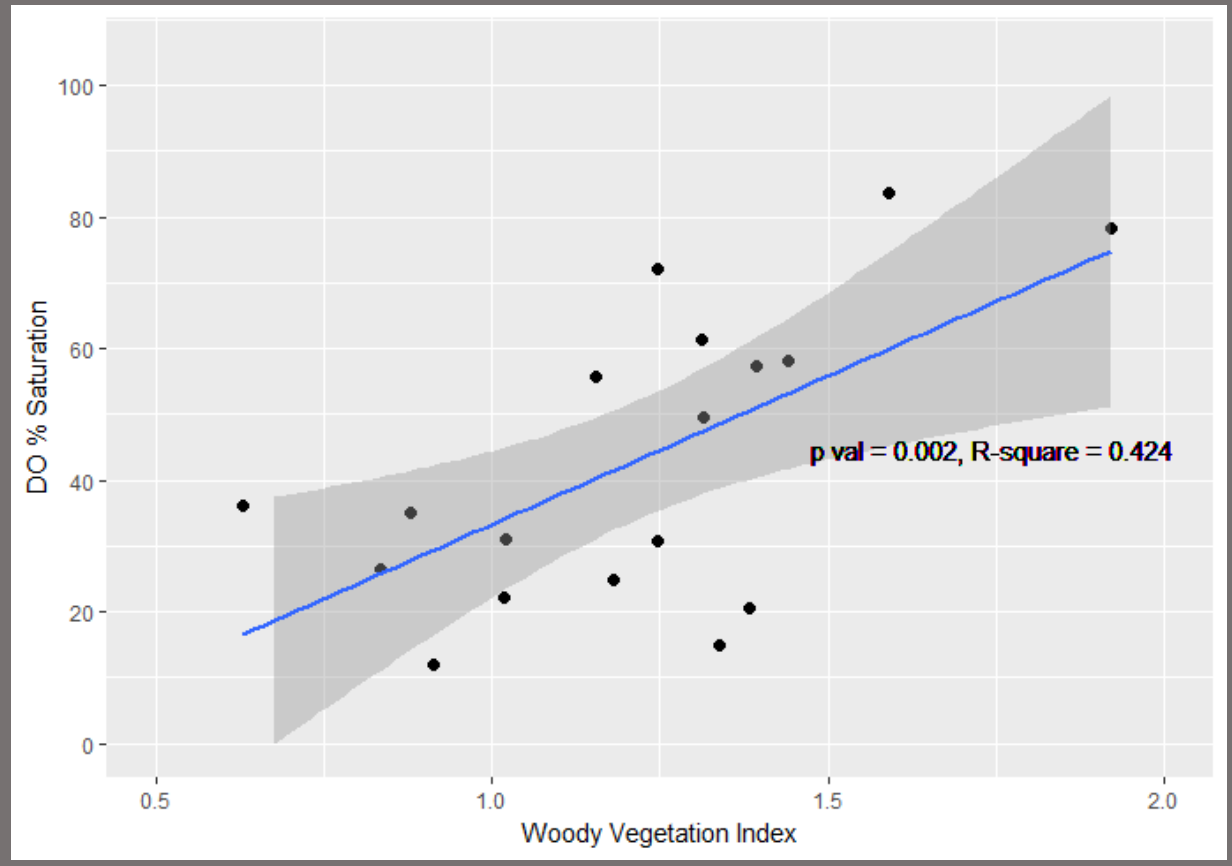
- Summer DO
- Benthic sampling sites
- Typical RSC's
- Extreme variability



Preliminary Results:

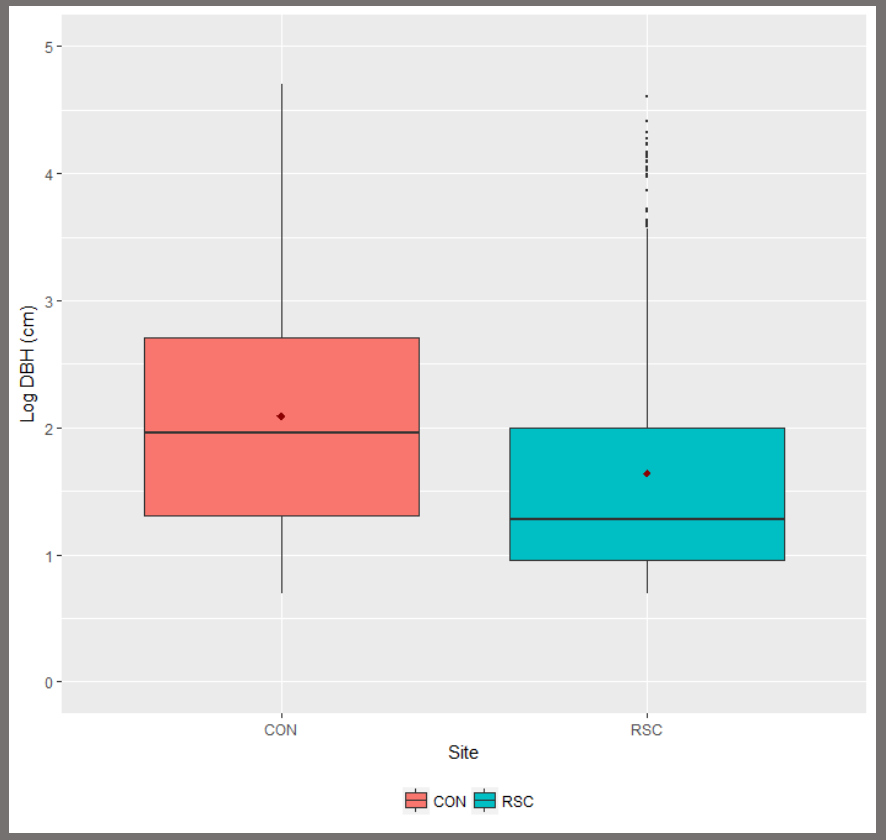
- Woody vegetation lowest at sites built within the last 4 years
- Significantly correlated with dissolved oxygen levels in summer



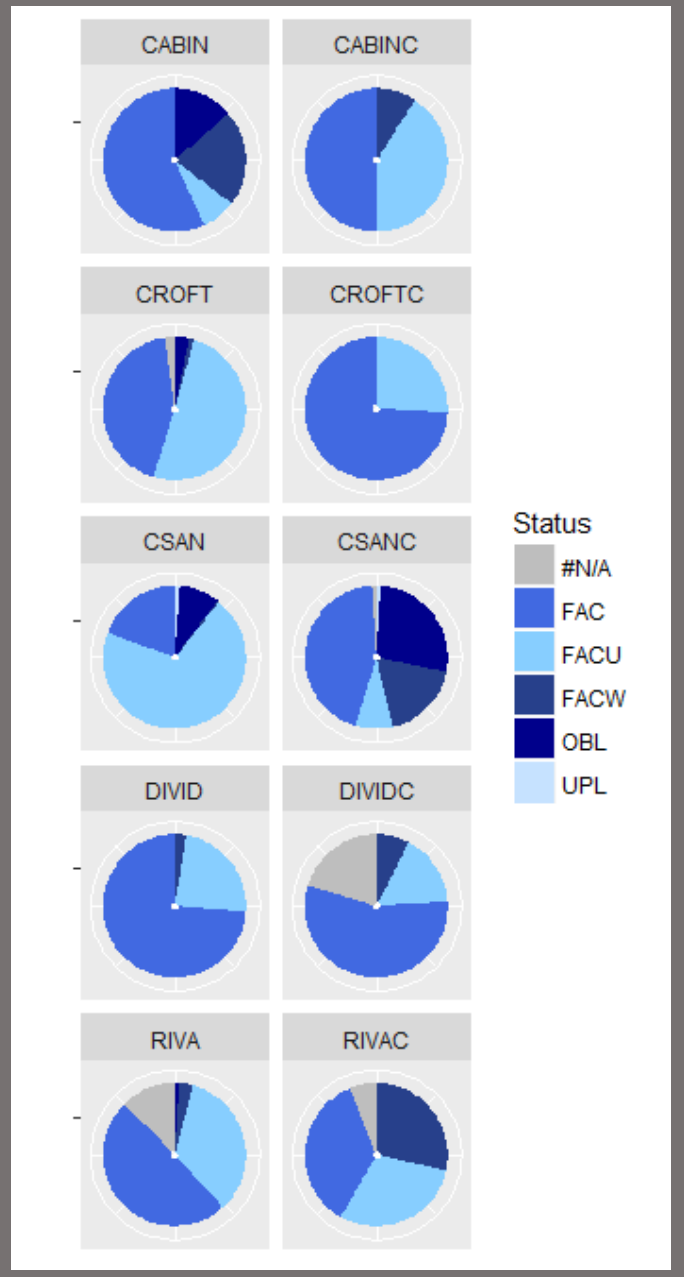


Preliminary Results:

- Average DBH significantly higher in control sites

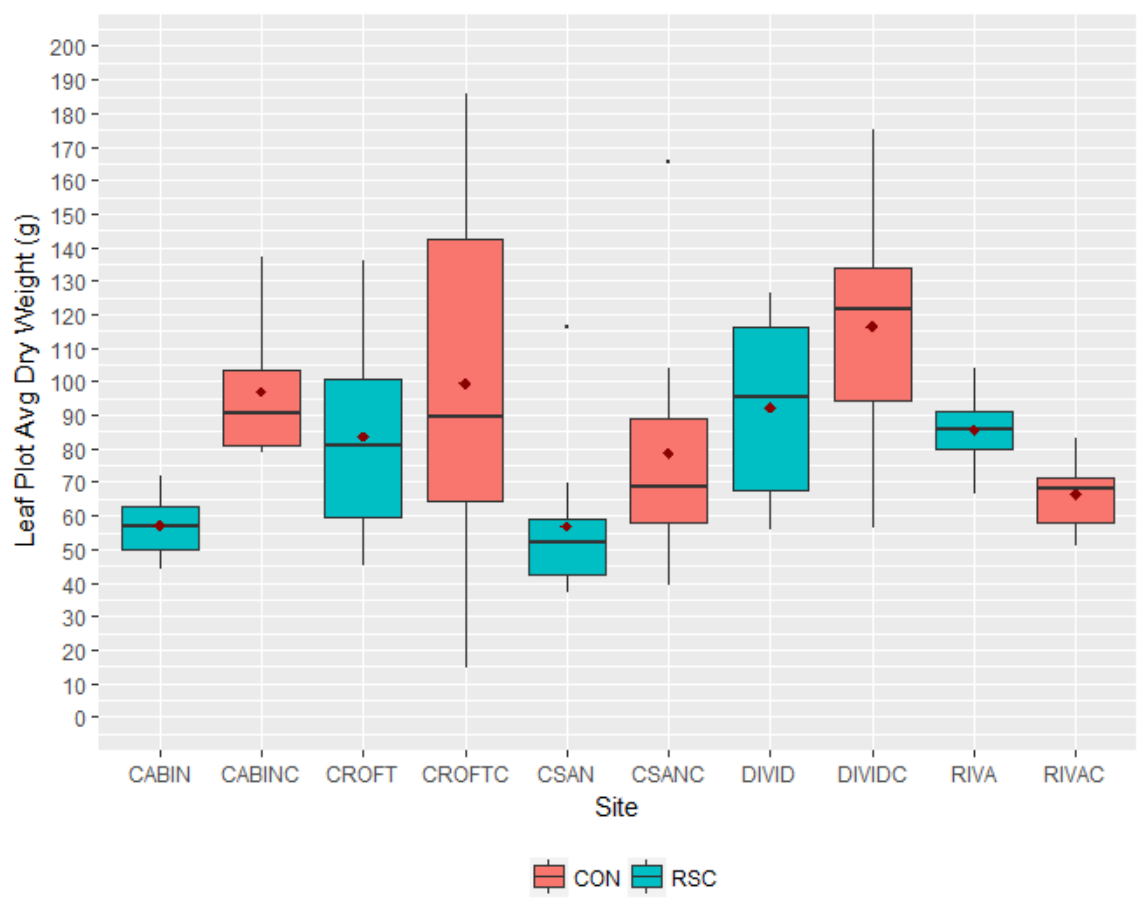


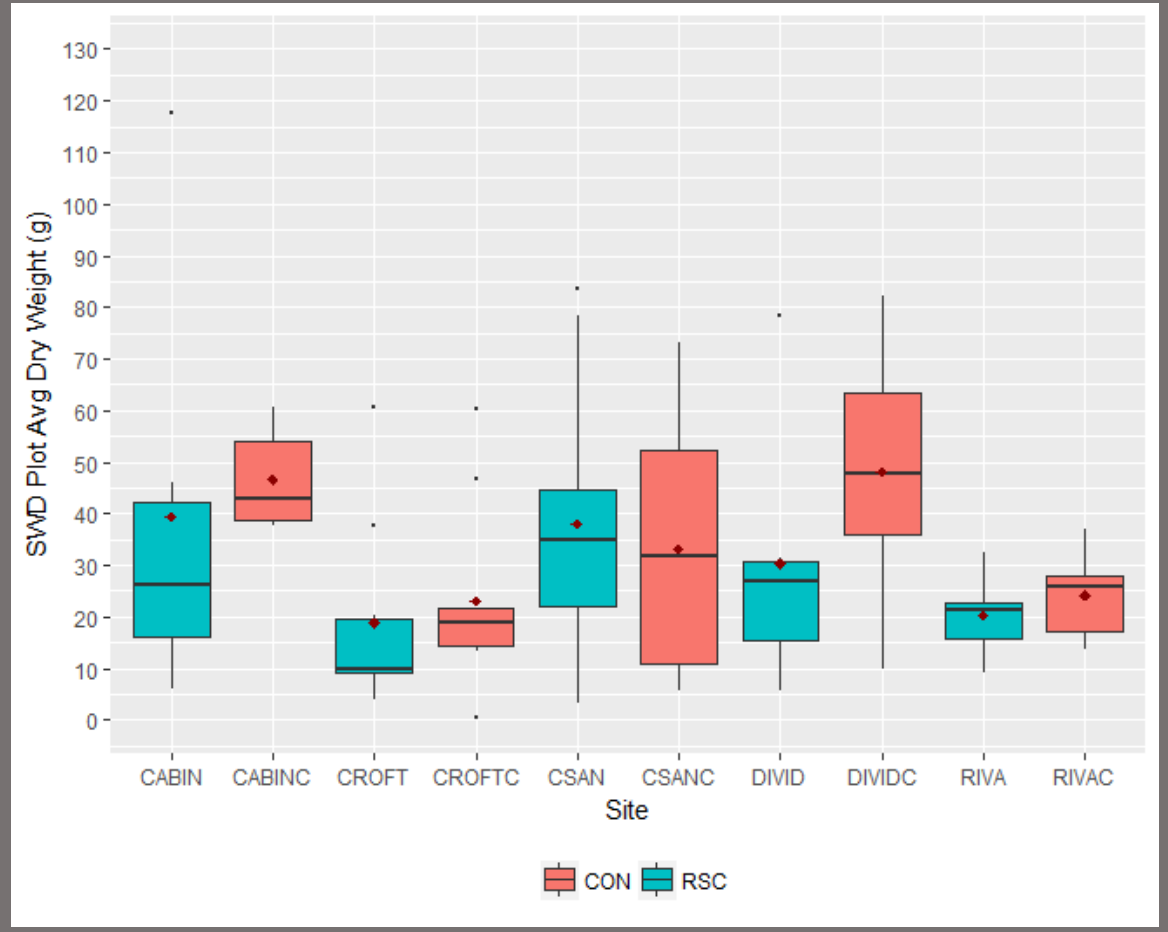
- Species by wetland indicator status
- Baseline data to assess shift in riparian communities



Preliminary Results:

- Leaf litter and woody debris higher at control in 4 of 5 pairs





Summary of preliminary results:

- RSC’s are highly variable
- May be trade-off between water quality goals for the bay and local ecology
- More research is needed to determine where RSC’s will have the greatest overall benefit

Collaborations and Future Research:

- Organic matter inputs
- Benthic macroinvertebrates
- Water chemistry