CENTER FOR WATERSHED PROTECTION

The Long-Term Effects of BMP Implementation on Stream Channel Stability in Urban Watersheds

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Research Question

What is the effectiveness of stormwater best management practices (BMPs) at the catchment scale?

Hypotheses

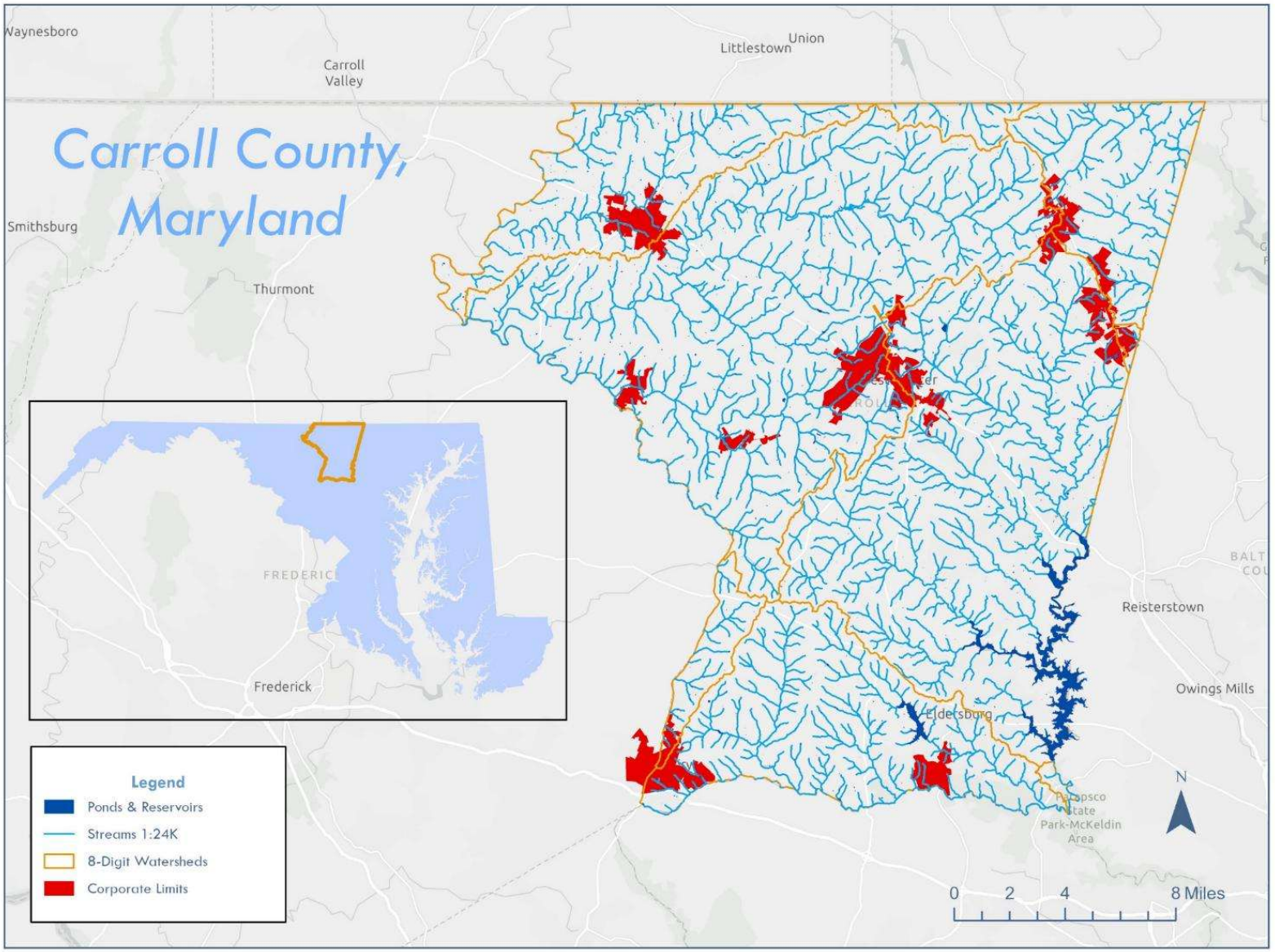
H1: The implementation of BMPs retrofitted to meet Carroll County's sand filter design standard will modify the runoff response from the watershed (hydrograph) resulting in a reduction in the magnitude, duration, and frequency of erosive flow rates that meet and or exceed MDE performance standards for stream channel protection.

H2: The implementation of these BMPs will create hydraulic conditions that lead to self-recovery of channel stability.

a. The bank erosion rate in treatment reaches will be lower than the control reaches due to reduction in magnitude, duration, and frequency in flows that contribute to bank erosion.

b. The treatment reaches will be aggrading due to the reduction in magnitude, duration, and frequency in flows resulting in sediment deposition on the streambed.

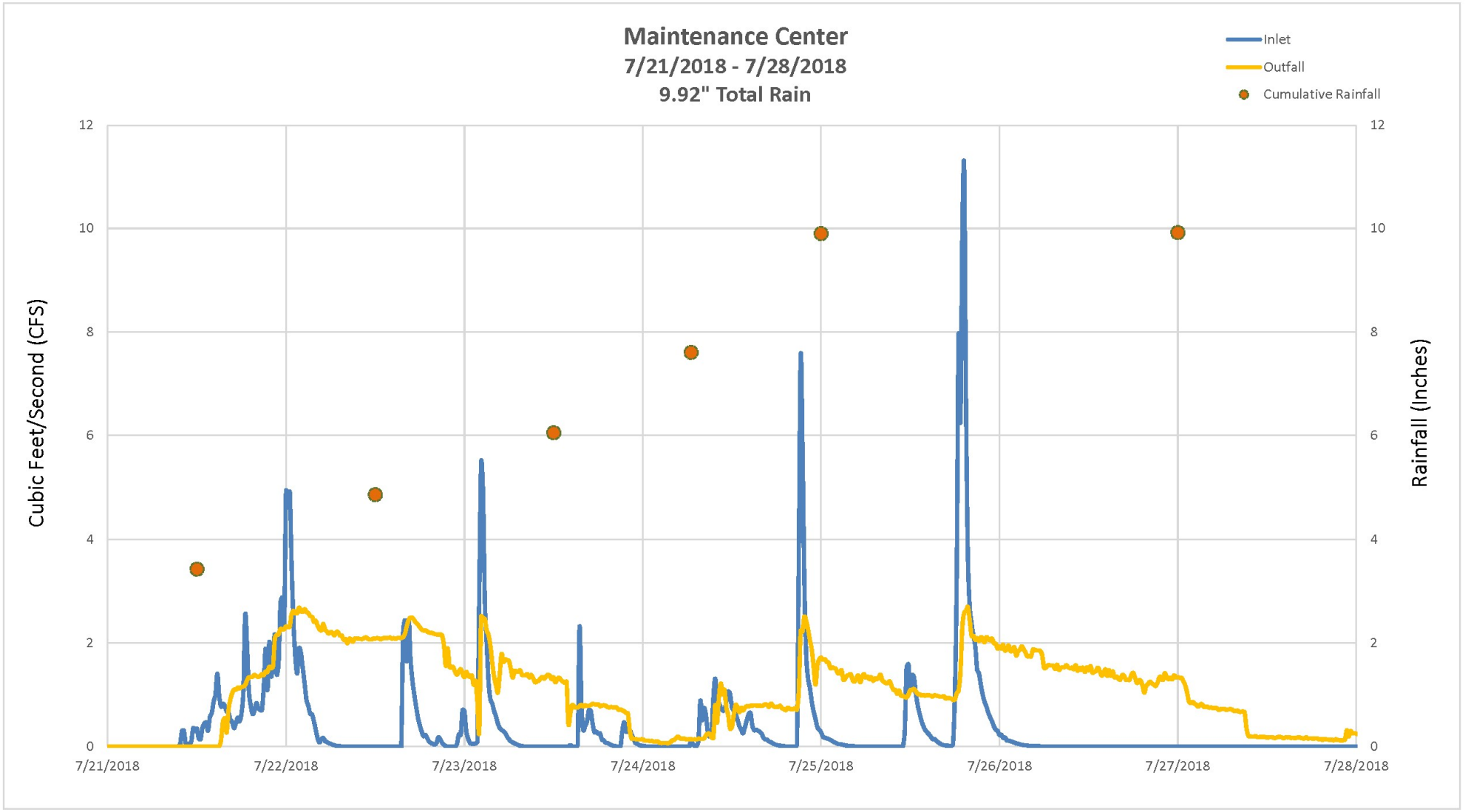
H3: The implementation of these BMPs will decrease sediment loadings downstream because of reduced bank erosion rates.


Carroll County, Maryland
Waynesboro
Carroll Valley
Union
Littlestown
Smithsburg
Thurmont
Frederick
Reisterstown
Owings Mills
Patapsco State Park-McKeldin Area
Legend
Ponds & Reservoirs
Streams 1:24K
8-Digit Watersheds
Corporate Limits
N
0 2 4 8 Miles

Carroll County Sand Filter Design

Unique Design Characteristics

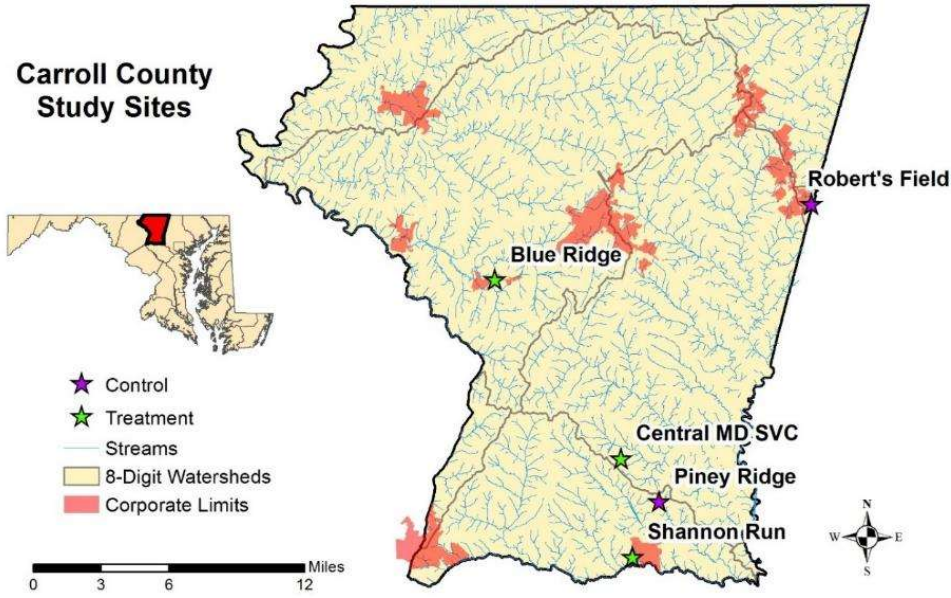
- No Riser - all design flows through sand control
- Drop Structures and Level Pipes
  - Turbulent to laminar flow
- Total Capture of 2 year storm, "difference in 10 year runoff volume"
  - Direct runoff difference – Meadow and Impervious
- Sand layer seeded w/ MDE mix
  - Prevents cracking/short circuiting of filter


Maintenance Center
7/21/2018 - 7/28/2018
9.92" Total Rain
Inlet
Outfall
Cumulative Rainfall
Cubic Feet/Second (CFS)
Rainfall (Inches)
0
2
4
6
8
10
12
7/21/2018
7/22/2018
7/23/2018
7/24/2018
7/25/2018
7/26/2018
7/27/2018
7/28/2018

Monitoring Locations

Pre-Treatment Monitoring
November 2016 – October 2017

Post-Treatment Monitoring
October 2018 – June 2026



Study Site	Treatment or Control	Drainage Area (ac)	Impervious Cover (%)	Study Reach Length (ft)	Existing BMP Type	Retrofit Type
Blue Ridge[1]	Treatment	33.6	26.9%	145	Retention	Sand Filter
Central MD SVC[1]	Treatment	91.7	31.3%	325	Detention	Sand Filter
Robert's Field[1]	Control	28.8	37.4%	157	Extended Detention	N/A
Shannon Run	Treatment	209	20%	366	Retention	Wet Pond
Piney Ridge	Control	91.1	36.1%	559	Retention	N/A

[1] Rain gauge located at site.

Ponds were originally designed for 2- and 10-year management. At the treatment sites, the ponds were retrofitted to provide channel protection volume.

Monitoring Methods

H1 Hydrology

- **Rain gauge at 3 locations**
  - •MD Central
  - •Roberts Field
  - •Blue Ridge
- **Pressure Transducers**
- **Flow measurements**

H2 Geomorphology

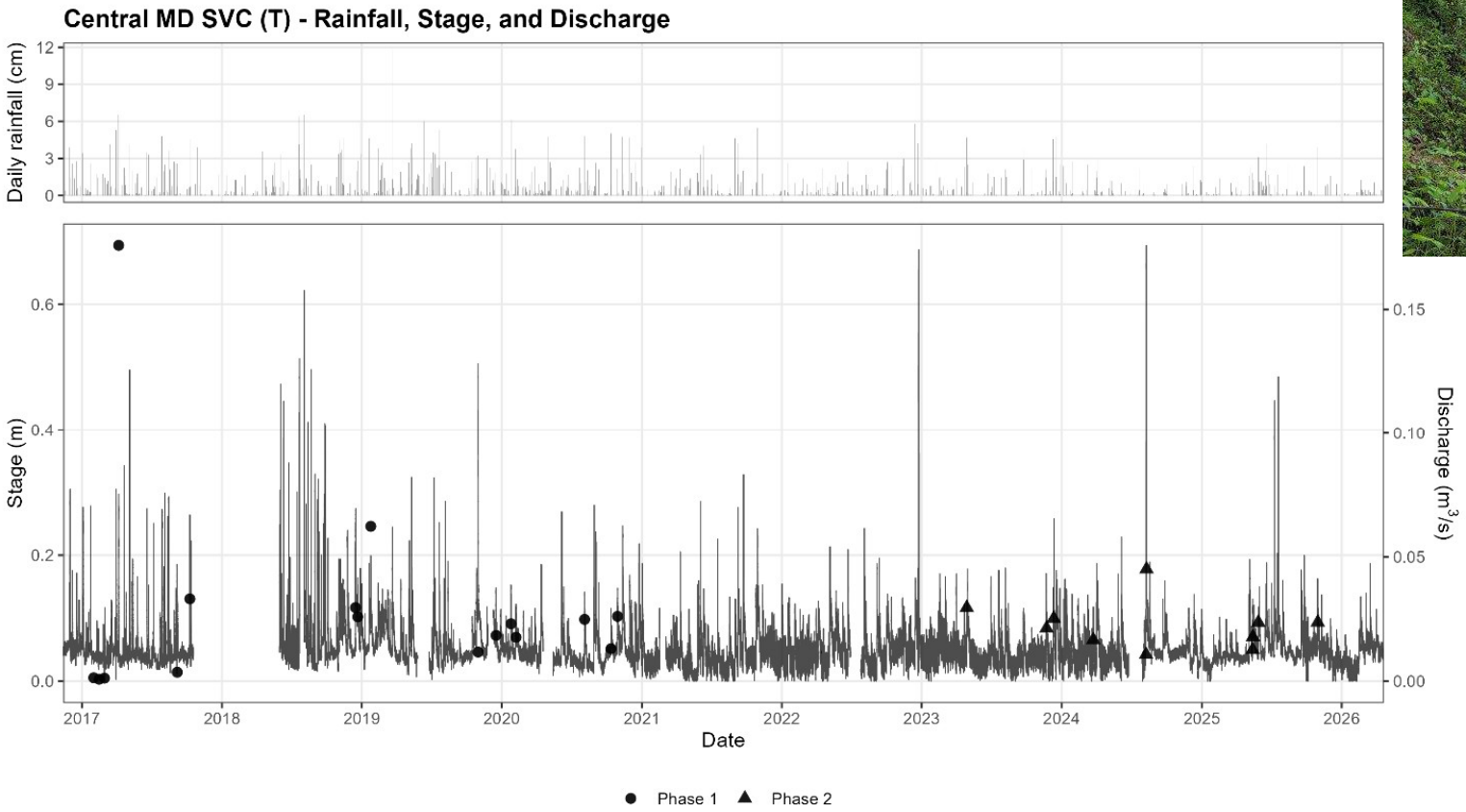
- **Monumented Cross Sections**
- **Longitudinal Profiles**
- **Bank Pins**
- **Pebble Count**
- **Riparian Vegetation**

H3 Load Estimation

- **BANCS**
- **Measured Change in Stream Channel**
- **Bulk Density**

H1: Hydrology

Central Maryland Service Center Treatment Site



Note: Negative stage values were excluded from the plot for visualization purposes.

H1: Hydrology

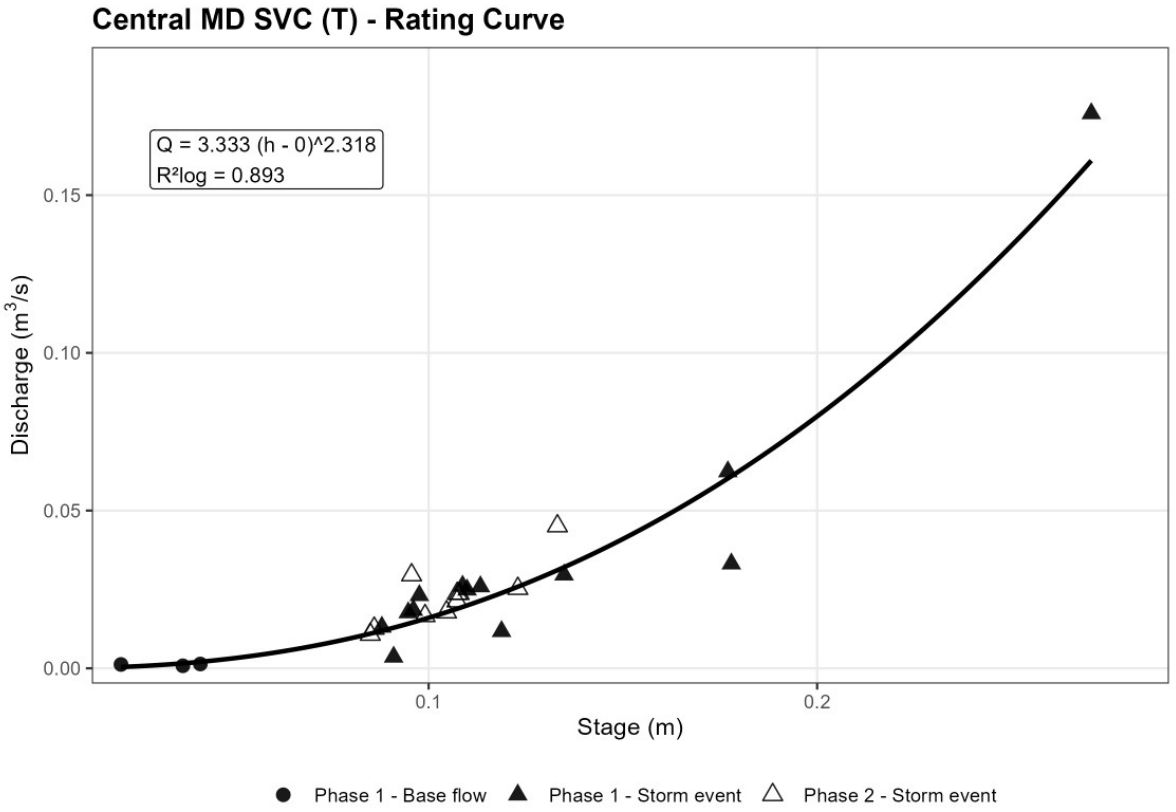
Flow Measurement and Calculations

Measurement Changes

- Additional barometric pressure transducers in late 2024
- 2 x-sections measured per reach (down from 3)

Re-Evaluate Stage-Discharge Curves

- Add new “Phase 2” data to initial stage-discharge curves.
- Do we need a new curve based on:
  - Additional observations (improvement), or
  - Channel geometry changes
  - Possible revised methodology for flows beyond the range of the curve.



Rating curve was constructed using Phase 1 discharge measurements.

H1: Hydrology

Preliminary Post-Pre Comparisons

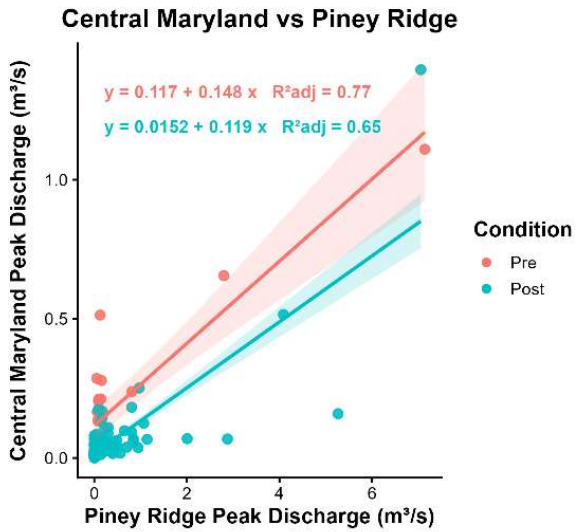
Paired Watershed/ mBACI Approach

- Compared both Discharge and flow volume relationships between Control and Treatment Sites.
- In Phase 2, continued to add data to these evaluations.

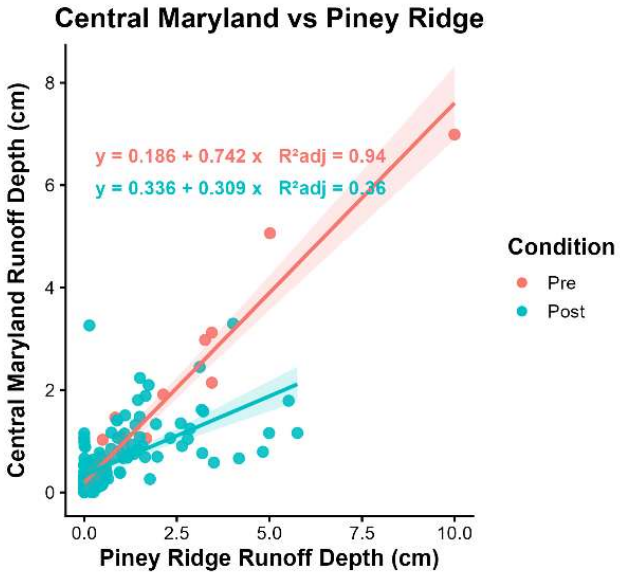
Key questions:

- Does the improvement from Treatment sites persist over time?
- Do the new data strengthen or weaken the original conclusions?

Peak Discharge Comparison



Runoff Volume Comparison



H2: Geomorphology

Shannon Run (Treatment)

May 2025

November 2016

May 2020

H2: Geomorphology

Shannon Run (Treatment)

May 2025

August 2025
(after riser low-flow orifice clog)

June 2026

H2: Geomorphology

Control Sites

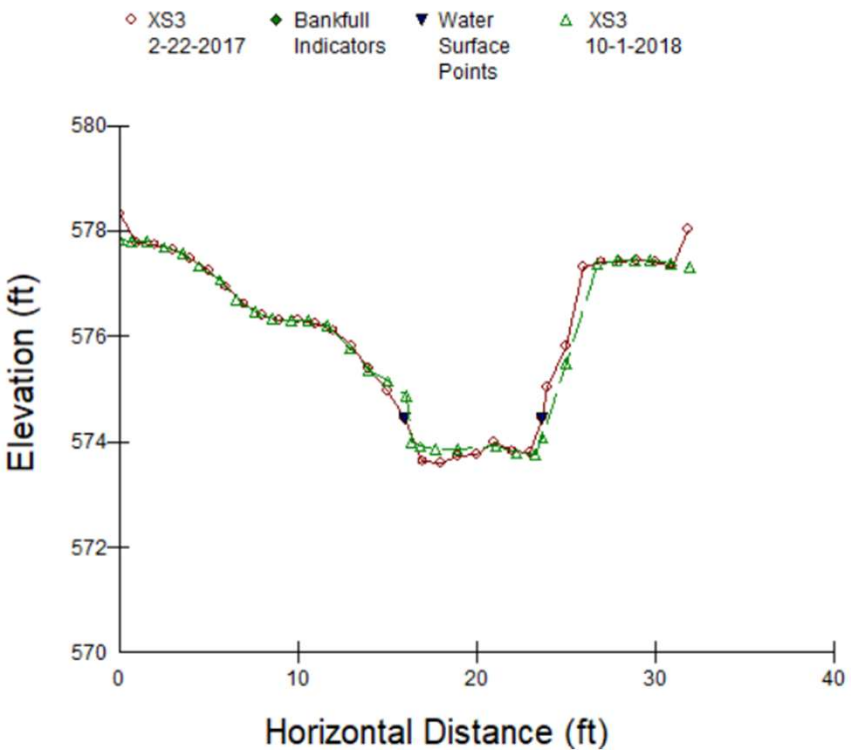
Piney Ridge
May 2026

Robert's Field
July 2024

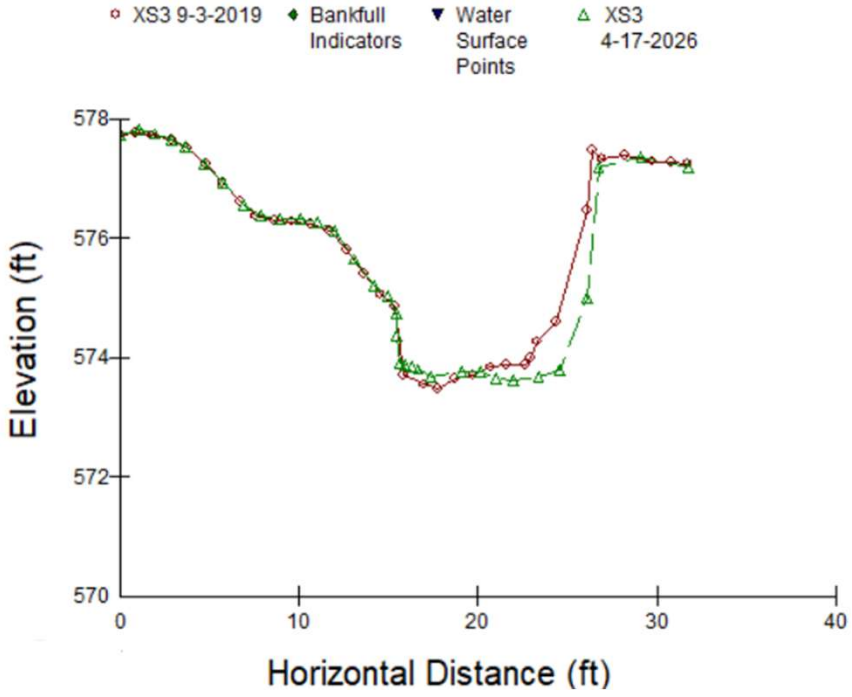
H2: Geomorphology

Cross Section Surveys

Piney Ridge XS3 (C) Pretreatment

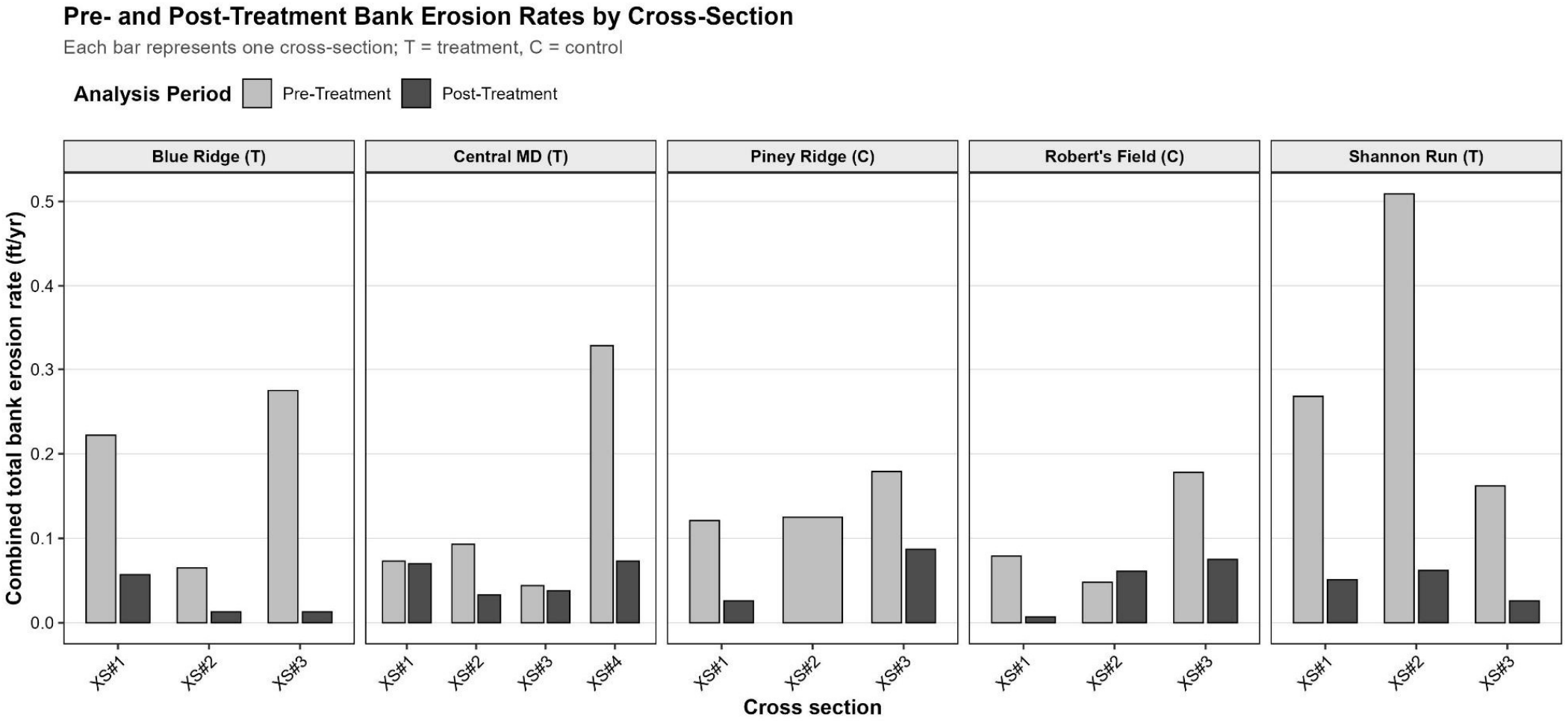


Piney Ridge XS3 (C) Posttreatment



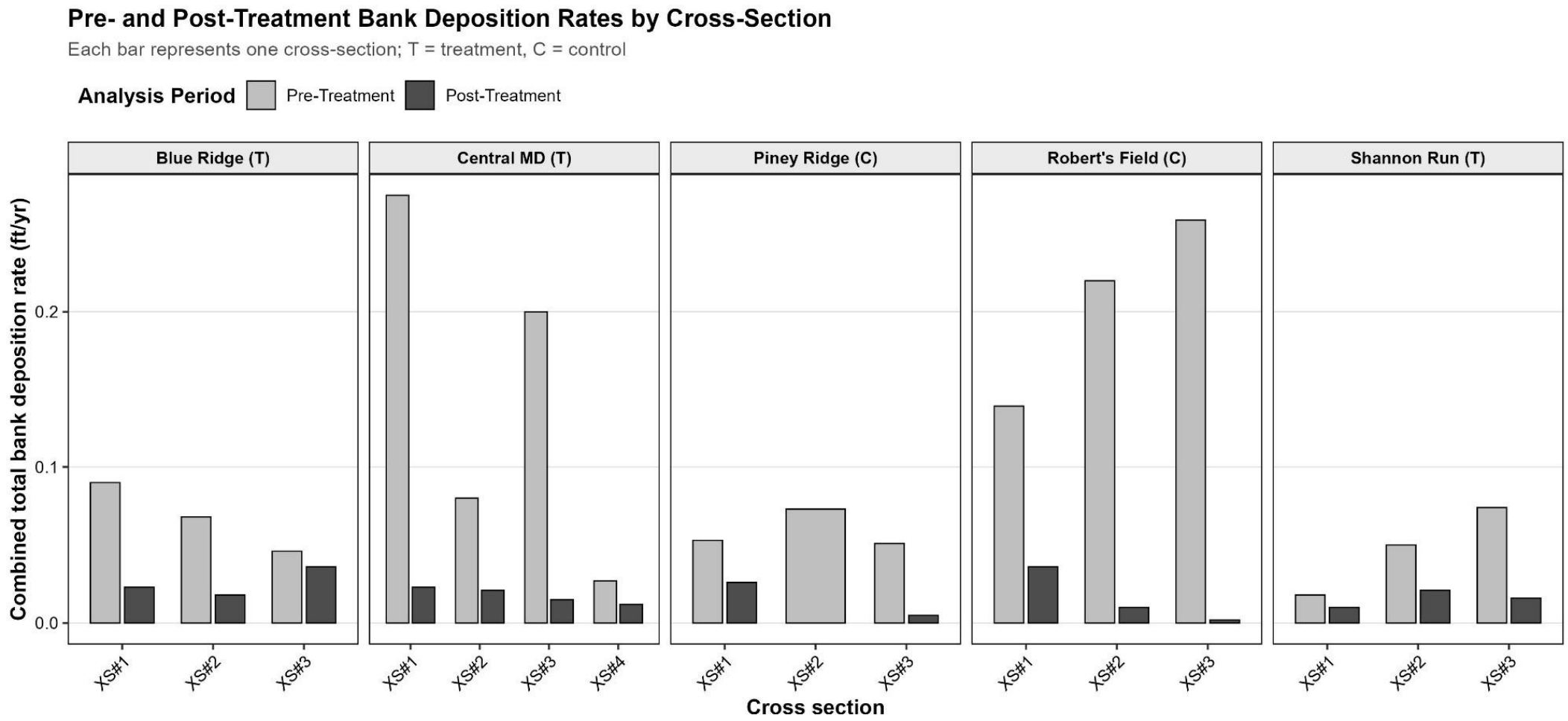
H2: Geomorphology

Bank Erosion Rates – Cross-Sections



H2: Geomorphology

Bank Deposition Rates – Cross-Sections

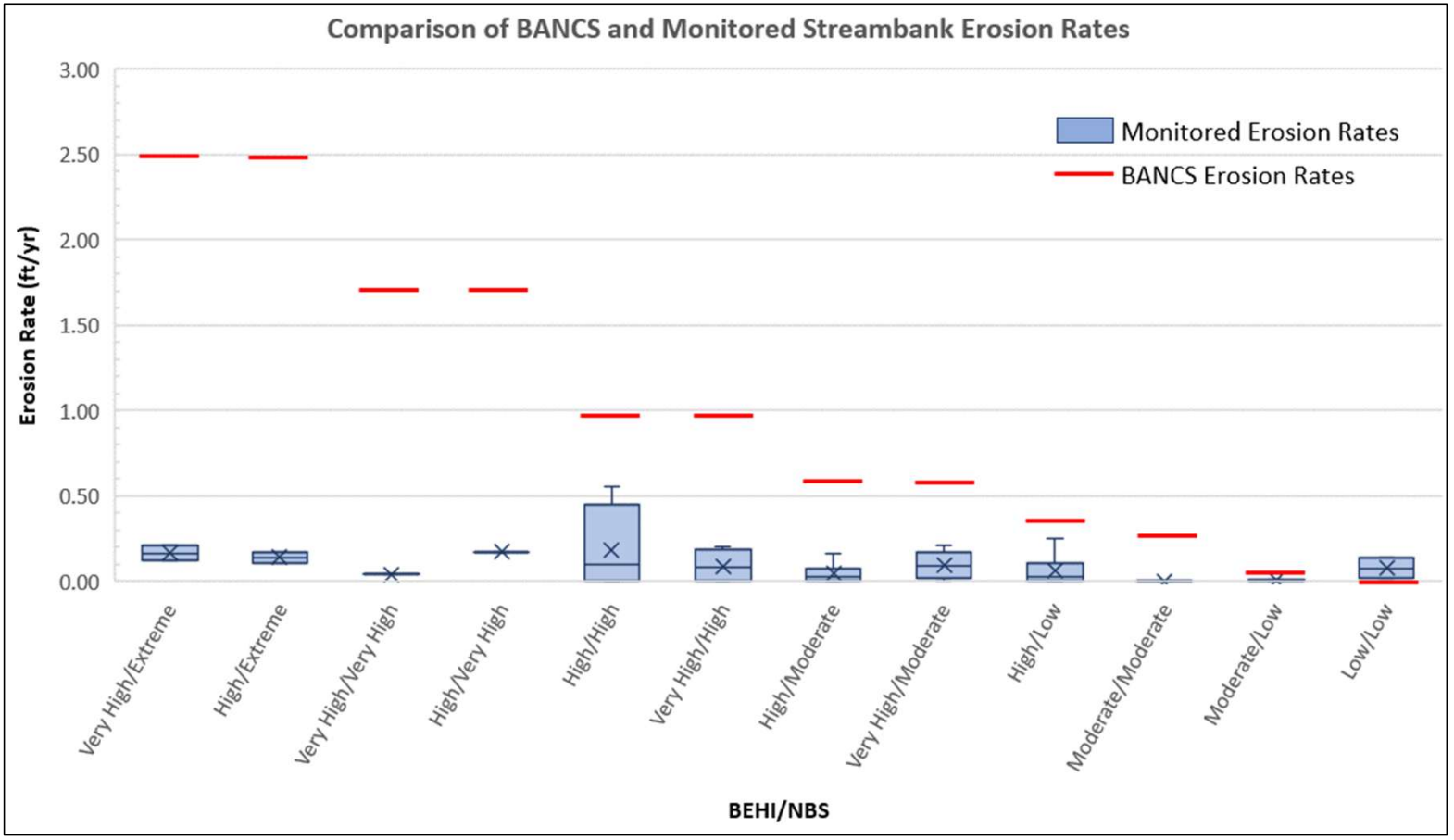


H2: Geomorphology

Bank Erosion Rates – Bank Pins

H3: Load Estimation

BANCS Overestimates Erosion Rates



H3: Load Estimation

	BANCS		Monitoring Data		
Study Site	Pretreatment Total TSS Load[1] (tons/yr)	Post-Treatment Total TSS Load[1] (tons/yr)	Pretreatment TSS Load (tons/yr)	Post-Treatment TSS Load (tons/yr)	% of Total Bank Length with Representative Monitoring Location[2]
Central MD SVC (T)	42.11	45.04	3.42	8.92	89.8%
Piney Ridge (C)	59.25	75.9	0.72	0.40	31.3%
Shannon Run (T)	54.49	56.54	11.06	7.35	52.5%
Robert's Field (C)	24.26	27.21	1.01	1.83	91.5%

[1]The loads represent the total load at edge-of-stream without a sediment delivery factor or stream restoration efficiency applied as per the CBP stream restoration crediting protocols.

[2]Total bank length obtained from the top of bank survey from the longitudinal profile and includes both the left and right bank lines.

Additional Analyses to be Completed

- Comparison of longitudinal profiles pre/post treatment
- Complete channel change analysis (in addition to the bank erosion/deposition results presented today)
- Particle size distribution analysis
- Measured curve number comparison to the theoretical predevelopment, post development, and retrofit design curve numbers
- Channel Stability - frequency of bankfull flow exceedance before and after treatment
- Revise stage-discharge curves and storm event definitions for remaining sections and add all observed data to our hydrology analyses.
- Complete an analysis of the curve number for additional storm events.
- In Phase 1, we abandoned the Blue Ridge treatment site due to ongoing construction but now we have a (delayed) post-treatment data for this site.

Thoughts and Lessons Learned

- Geomorphic changes take a while to see. We didn't see some changes in Phase 1 that are now present.
- Methods for estimating streambank sediment load can significantly affect results.
- Importance of pond retrofit maintenance. Malfunctions can undo the treatment results as we saw with Shannon Run.
- Make sure you have a "backup" pressure transducer to avoid gaps in measurement.
- Initial assessments suggest that the practices continue to mitigate storm flows, and we will understand this in more detail as we look at more data.

Funding & Acknowledgments

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The Pooled Monitoring Initiative funds applied science to advance restoration research for cumulative impacts, comparative effectiveness of stormwater practices, pollutants of emerging concern, and trade-offs with new research questions added annually.

https://cbtrust.org/grants/restoration-research/

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Thank You

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Translation Slides

What are the take home points? What does this mean for me?

Translation Slides by Deborah J. Cappuccitti,
Maryland Department of the Environment

What are the take home points?

- All ponds provided 2 and 10-year peak control prior to retrofit
  - Peak control known to increase the duration and magnitude of erosive flows
- Observations after cp_v retrofit show evidence of stream recovery
- Recovery is difficult to quantify:
  - Time: Recovery is slow - need time to observe improvements
  - Not consistent: Other watershed factors influence conditions (examples where the control at Piney is showing better results then the retrofit at Central)
  - Limits of existing tools: BEHI/NBS data are not useful for predicting recovery
    - Erosion rates are significantly over-estimated when compared to actual field conditions
    - Need better regional curves data to support use of the “one” Hickey Run curve
    - Recovery is observed with bank pin data but it takes years to get this data

What does this mean for me?

What do I take from this if I am a practitioner:

- Need for better regional curve data – to provide more accurate estimates of erosion rates to help predict channel recovery
- Better regional curve data can help improve accuracy for stream restoration crediting

What do I take from this if I am a regulator:

- Results show promise for future MS4 crediting. Need additional data to better understand applicability.
- In the meantime: Field data showing pollutant load reductions may justify a site-specific credit (i.e. Shannon Run)