TMDL Reduction Credit for Stream Restoration Case Study and Comparison

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August 2018

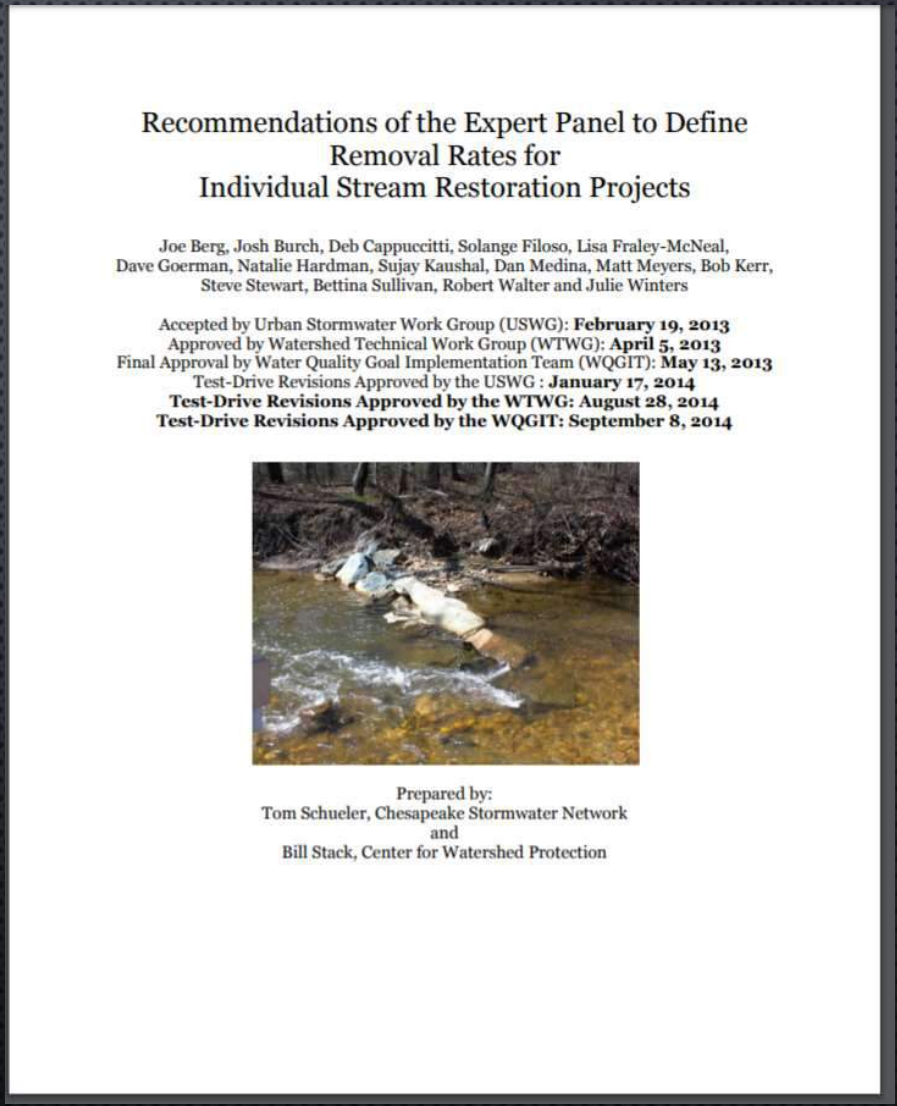
FREESE AND NICHOLS

CONTENTS

- Project Background
- Assessment Methodologies
- Root Dendrogeomorphology
- TMDL Reduction Assessment
- Project Take-aways

REGULATORY SETTING

- Focus in Bay Contributing States on TMDL
- Major Challenge with What Credit to Give
- Mostly used Hickey Run Curve or Default Rate
- Fails to Give Credit to Owner for Actual Reduction



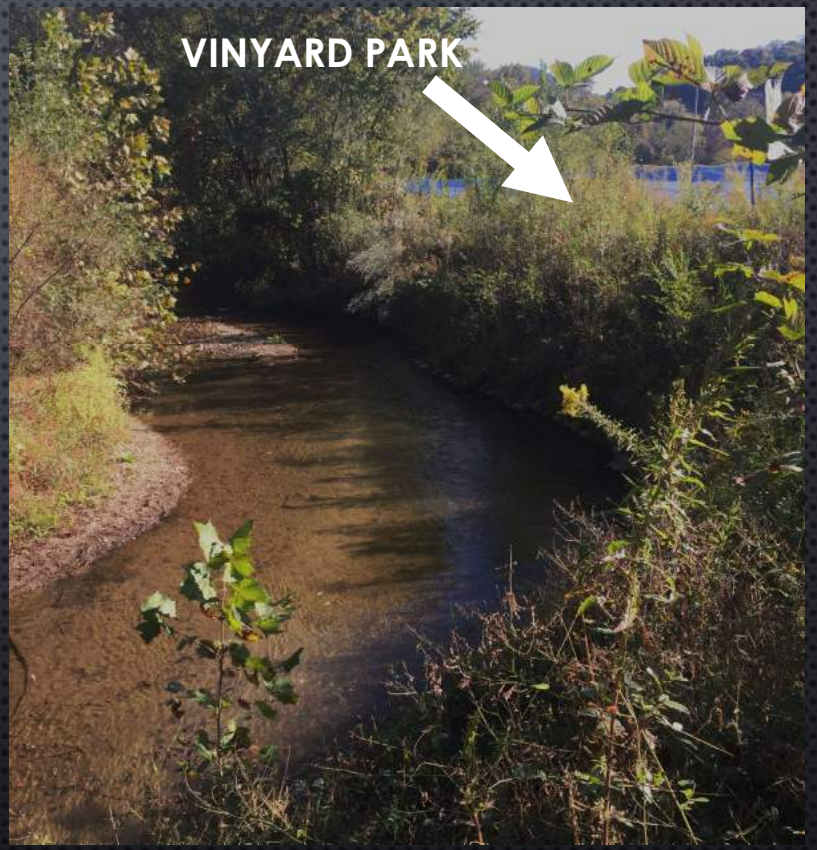
Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects

Joe Berg, Josh Burch, Deb Cappuccitti, Solange Filoso, Lisa Fraley-McNeal, Dave Goerman, Natalie Hardman, Sujay Kaushal, Dan Medina, Matt Meyers, Bob Kerr, Steve Stewart, Bettina Sullivan, Robert Walter and Julie Winters

Accepted by Urban Stormwater Work Group (USWG): **February 19, 2013**
Approved by Watershed Technical Work Group (WTWG): **April 5, 2013**
Final Approval by Water Quality Goal Implementation Team (WQGIT): **May 13, 2013**
Test-Drive Revisions Approved by the USWG : **January 17, 2014**
Test-Drive Revisions Approved by the WTWG: August 28, 2014
Test-Drive Revisions Approved by the WQGIT: September 8, 2014

Prepared by:
Tom Schueler, Chesapeake Stormwater Network
and
Bill Stack, Center for Watershed Protection

PROJECT BACKGROUND



- Threat to Infrastructure

PROJECT BACKGROUND

- Loss of land and channel capacity

PROJECT BACKGROUND

- Prioritization of areas of TMDL reduction

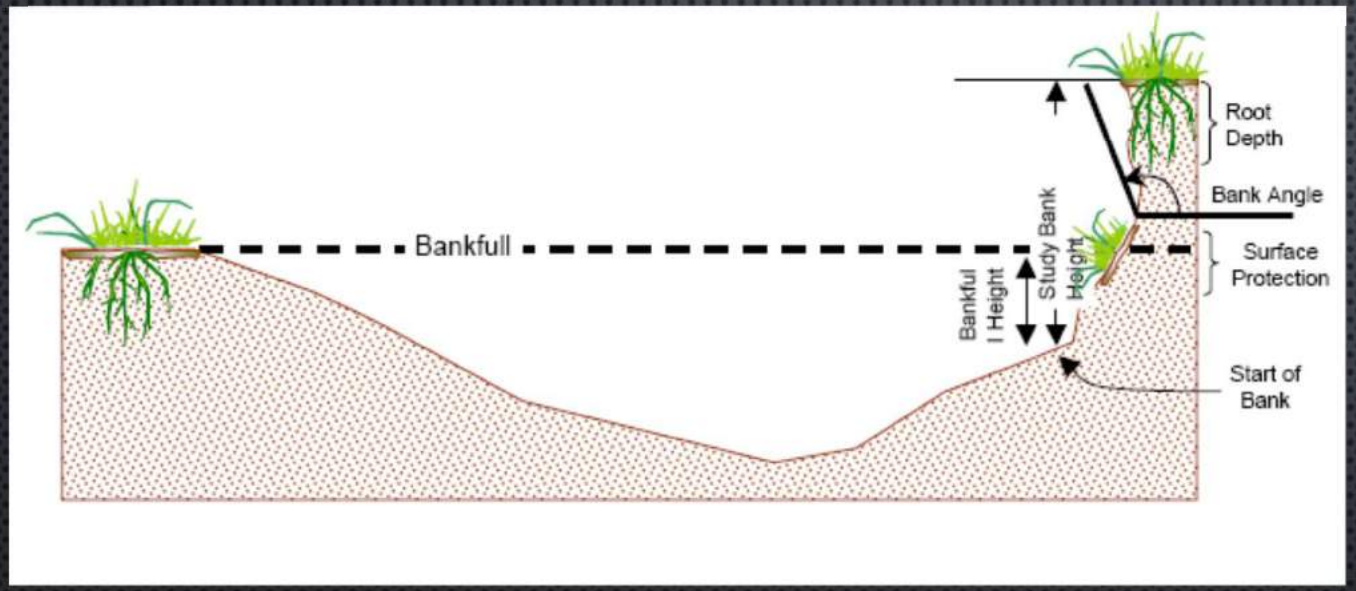
METHODS OF QUANTIFYING RIVERBANK EROSION

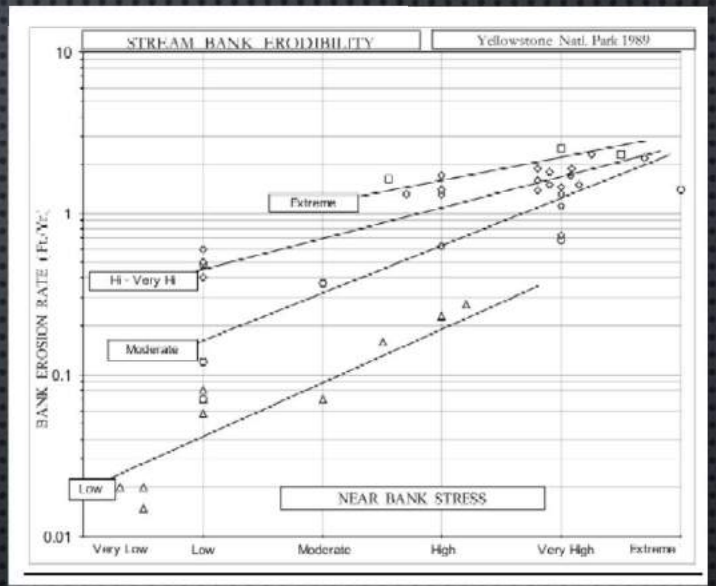
- Erosion Pins
- Historical Aerial Photographs

METHODS OF QUANTIFYING RIVERBANK EROSION

- Bank Surveys: Toe Pins | Scan
- Less Common: Photovoltaic | LiDAR
- Analytical Models: RUSLE | USADA Bank Stability Model

METHODS OF QUANTIFYING RIVERBANK EROSION





- Empirical models
  - BANCS model: Uses erosion rate curves which relate bank-specific ratings of erodibility to erosion rates.
- Erosion rate curve must be developed from other method

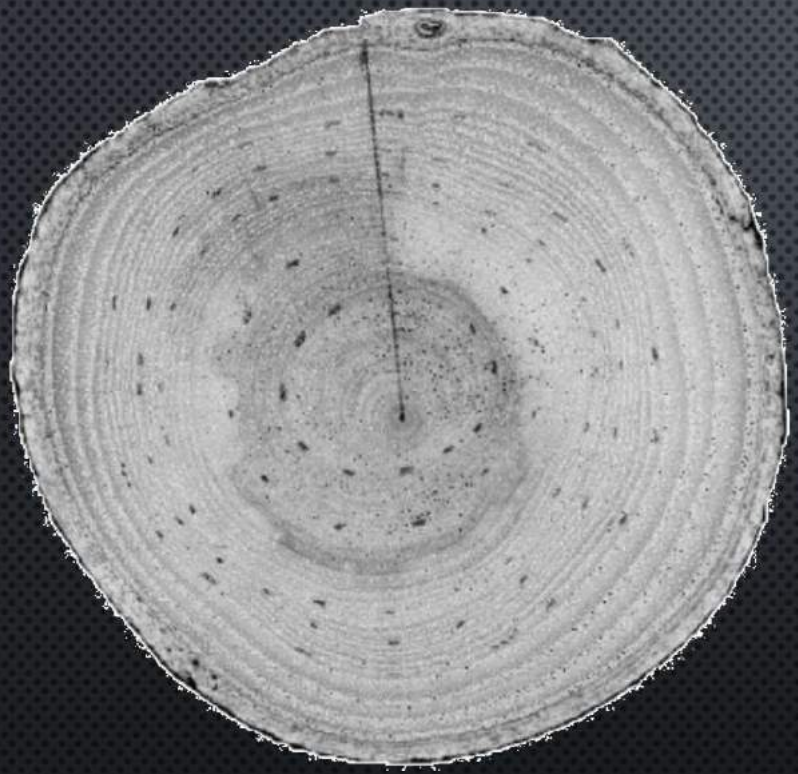
METHODS OF QUANTIFYING HILLSLOPE & RIVERBANK EROSION

- New Method: Dendrogeomorphology
  - Now mentioned by Chesapeake Expert Panel
  - Dick et al., River Research and Applications, 2013

WHAT IS DENDROGEOMORPHOLOGY?

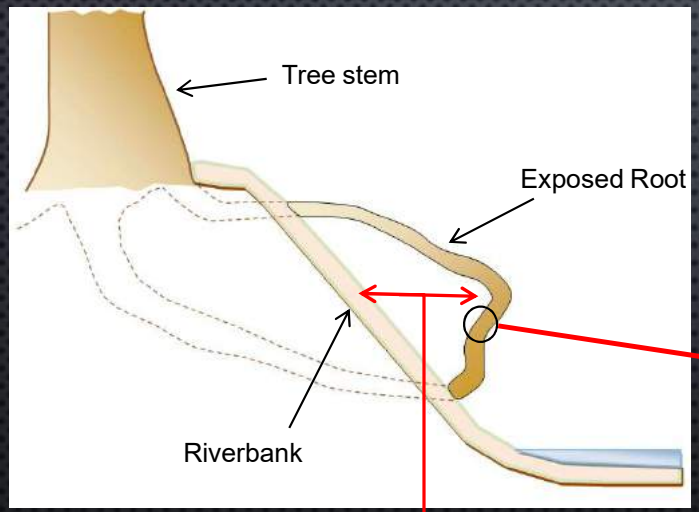
- Dendrogeomorphology: Use of tree growth rings to identify dates of changes in earth surface processes
- Tree rings change in response to environmental factors (e.g. landslide, streambank, and hillslope erosion)

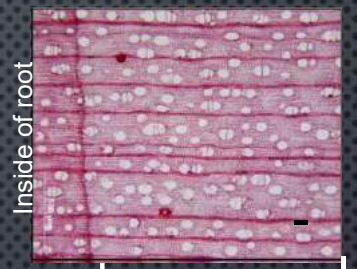
WHAT IS DENDROGEOMORPHOLOGY?



- Used since the 1960s
- Most research done in Europe
- Most research done on conifers
- Initial studies on fluvial erosion in the U.S. in 2008

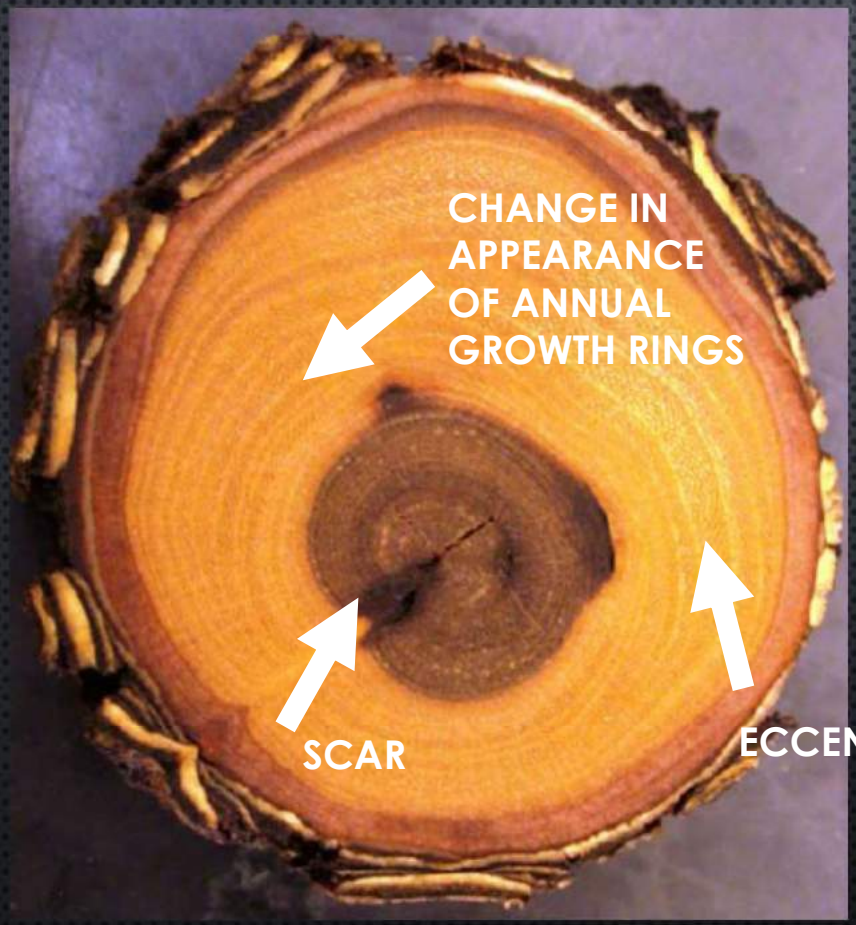
WHAT IS DENDROGEOMORPHOLOGY?



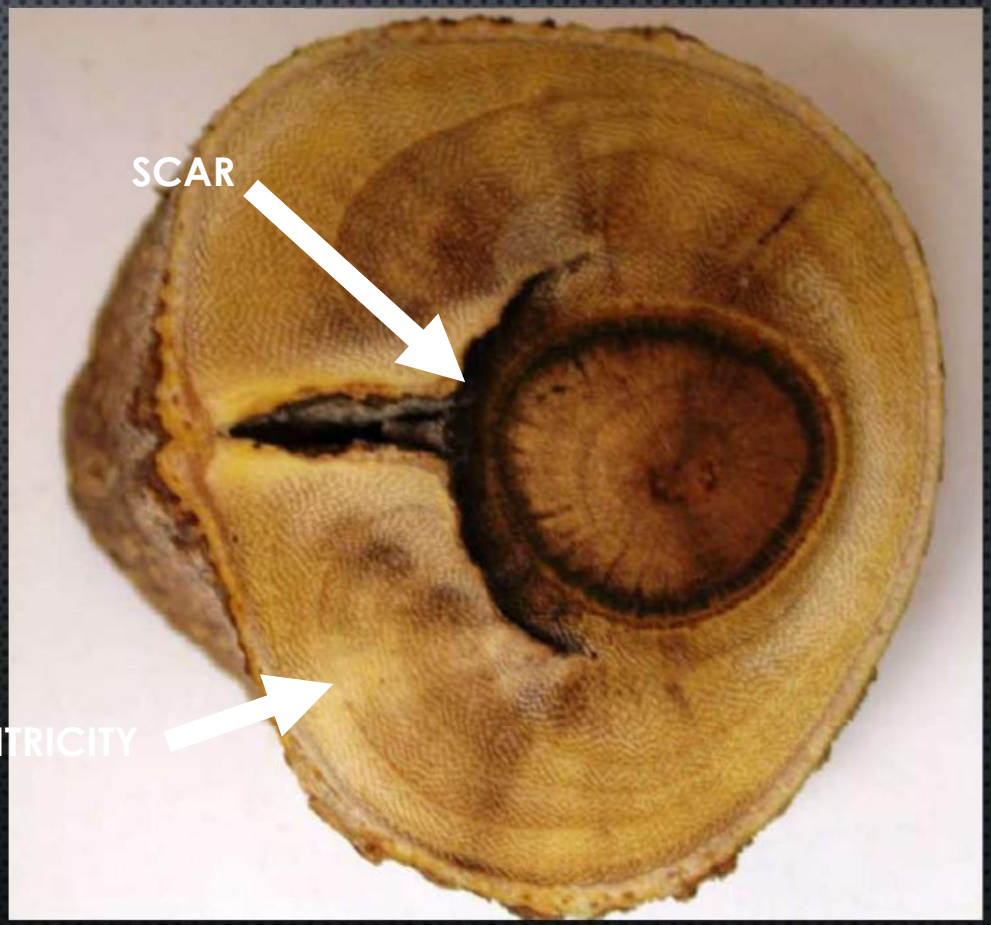


Distance of exposed root from riverbank ÷ **Years of Exposure** = **Annual Erosion Rate**

USING DENDROGEOMORPHOLOGY



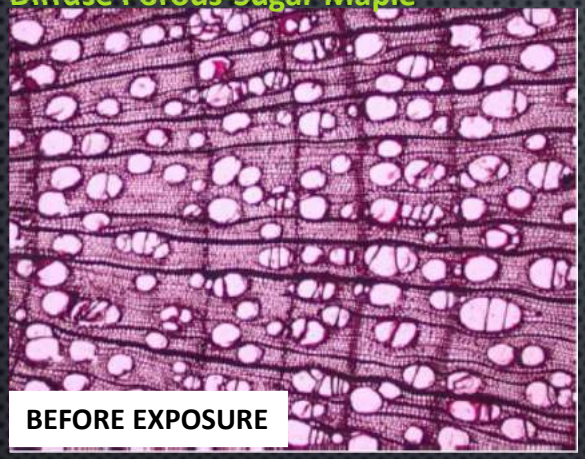
Cut disk of hackberry root (*Celtis spp.*)

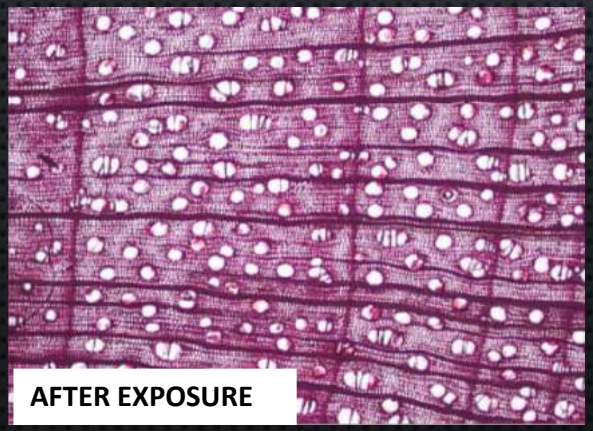


Cut disk of elm root (*Ulmus rubra*)

MICROSCOPIC INDICATORS

Diffuse Porous-Sugar Maple

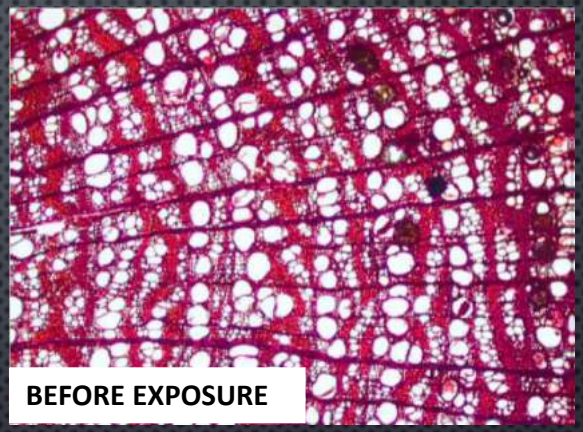




Diffuse-Porous Species

- Decrease in size and increase in number of cells in post-exposure rings
- Division into earlywood and latewood

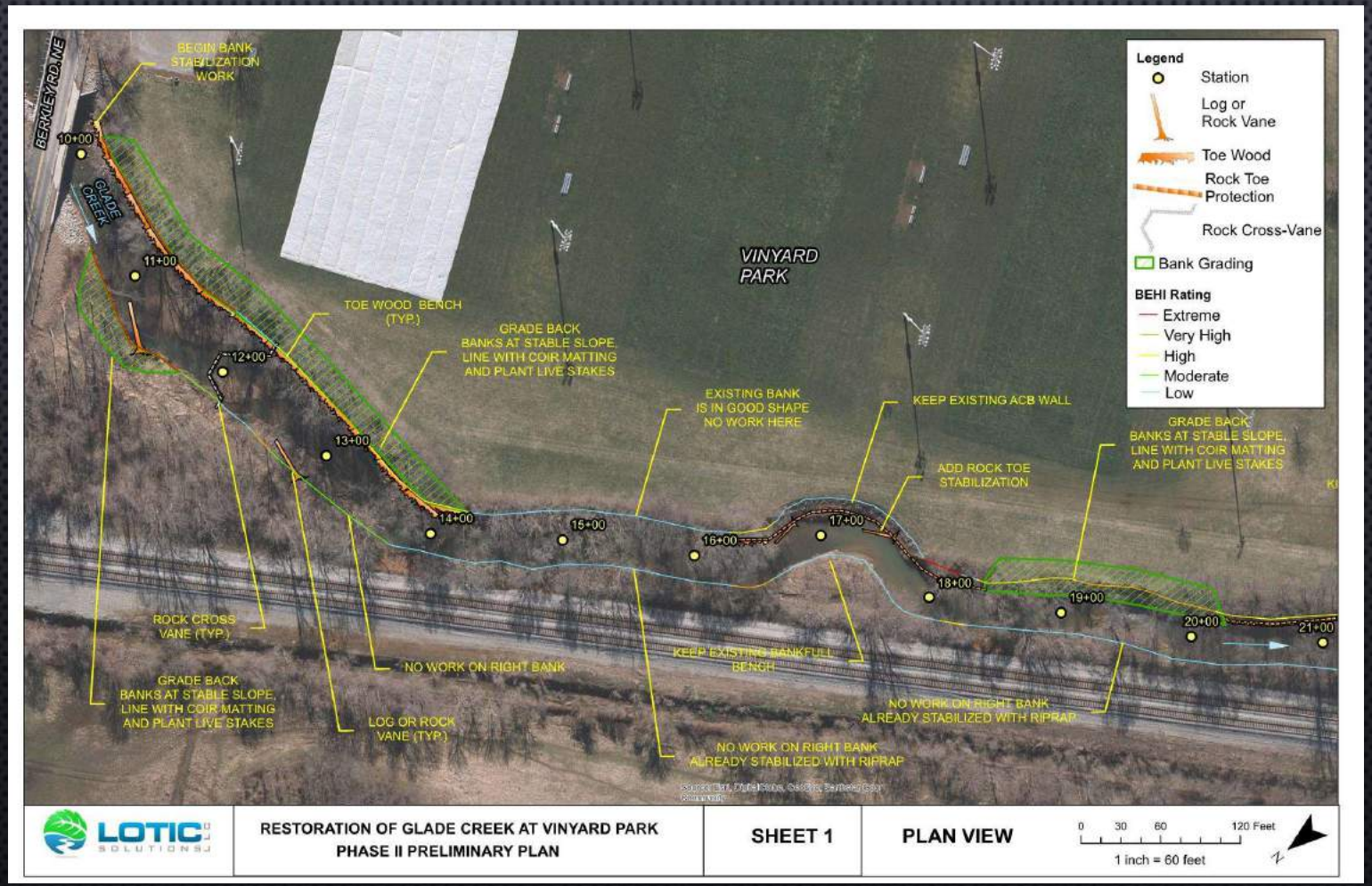
Ring Porous- Slippery Elm



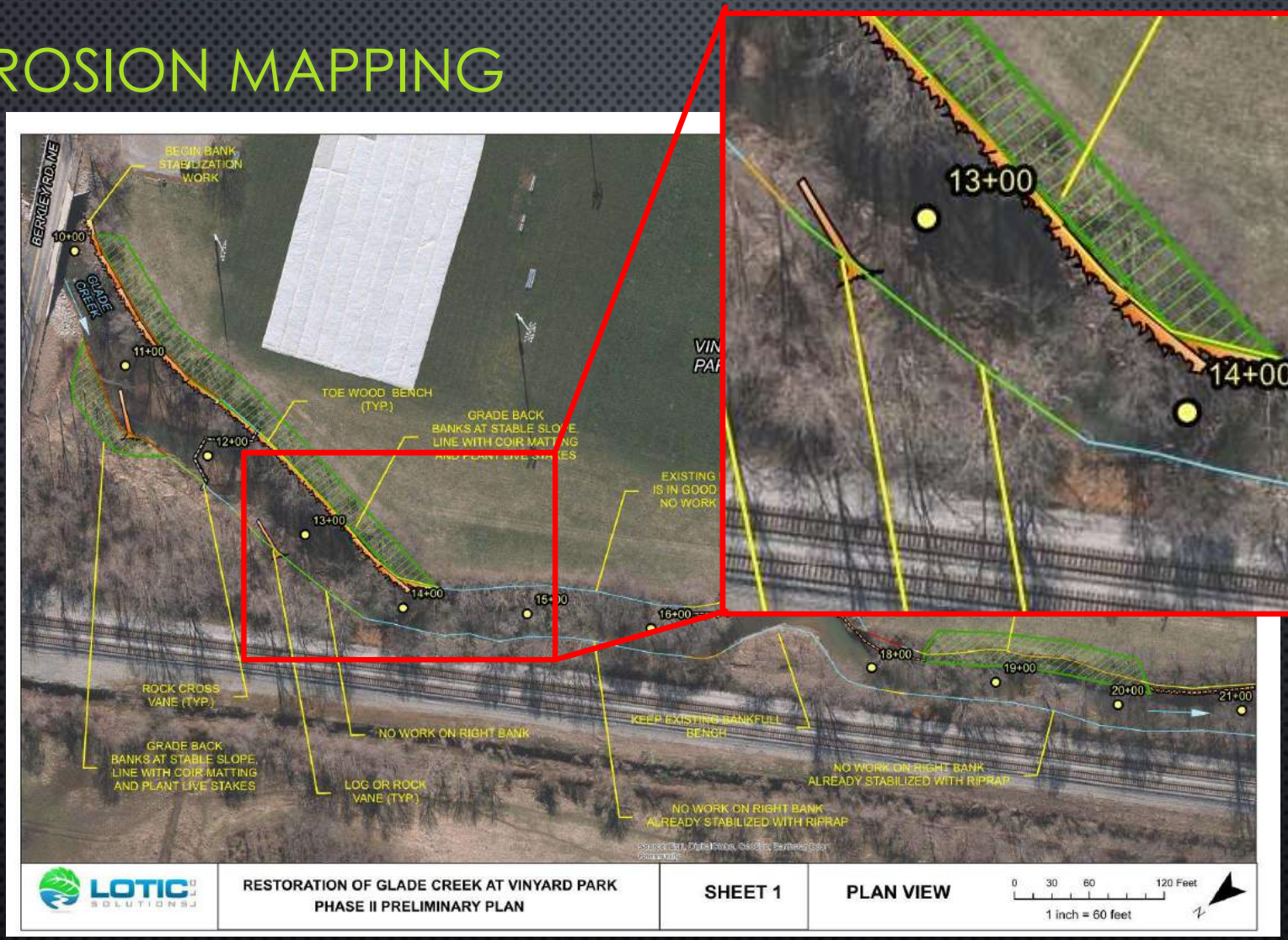
Ring-Porous Species

- Change from diffuse-porous cell anatomy to ring-porous anatomy (resembling more the stem)

EROSION MAPPING



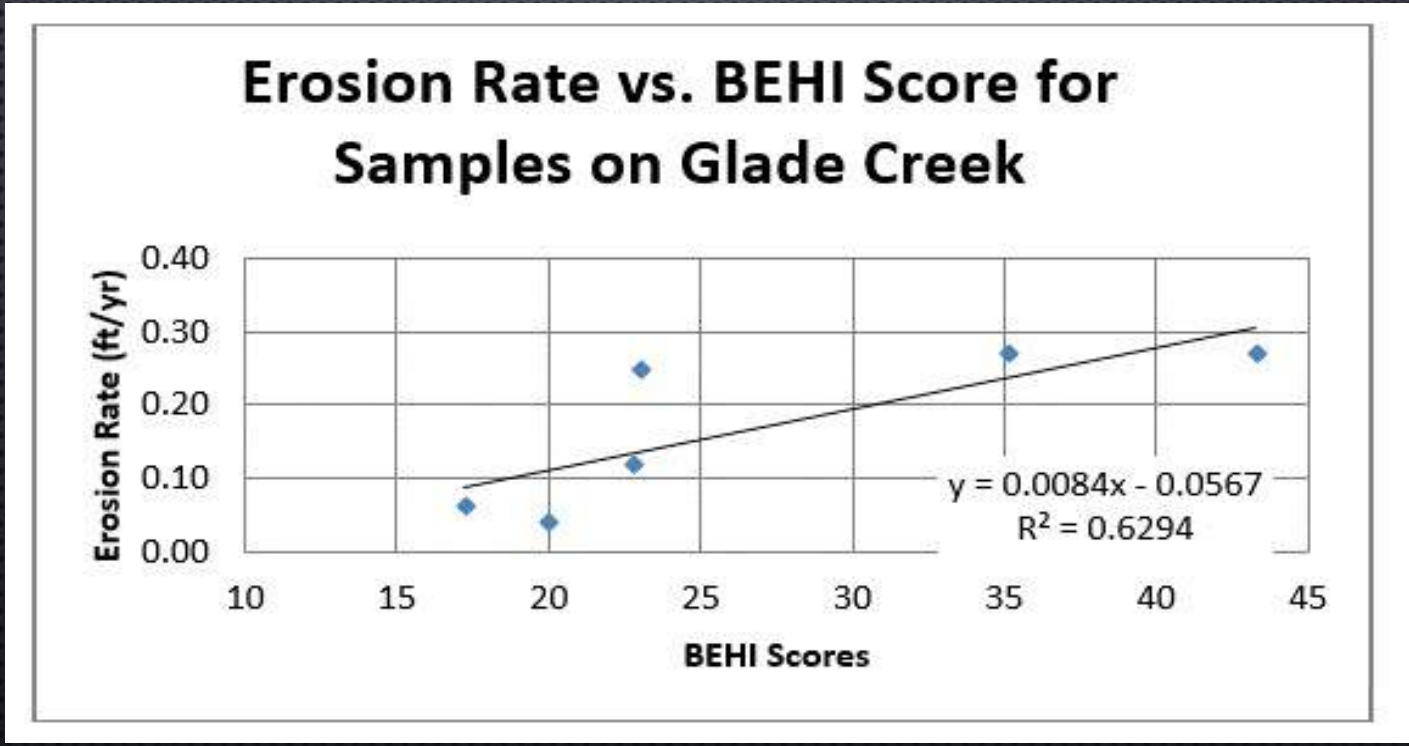
EROSION MAPPING



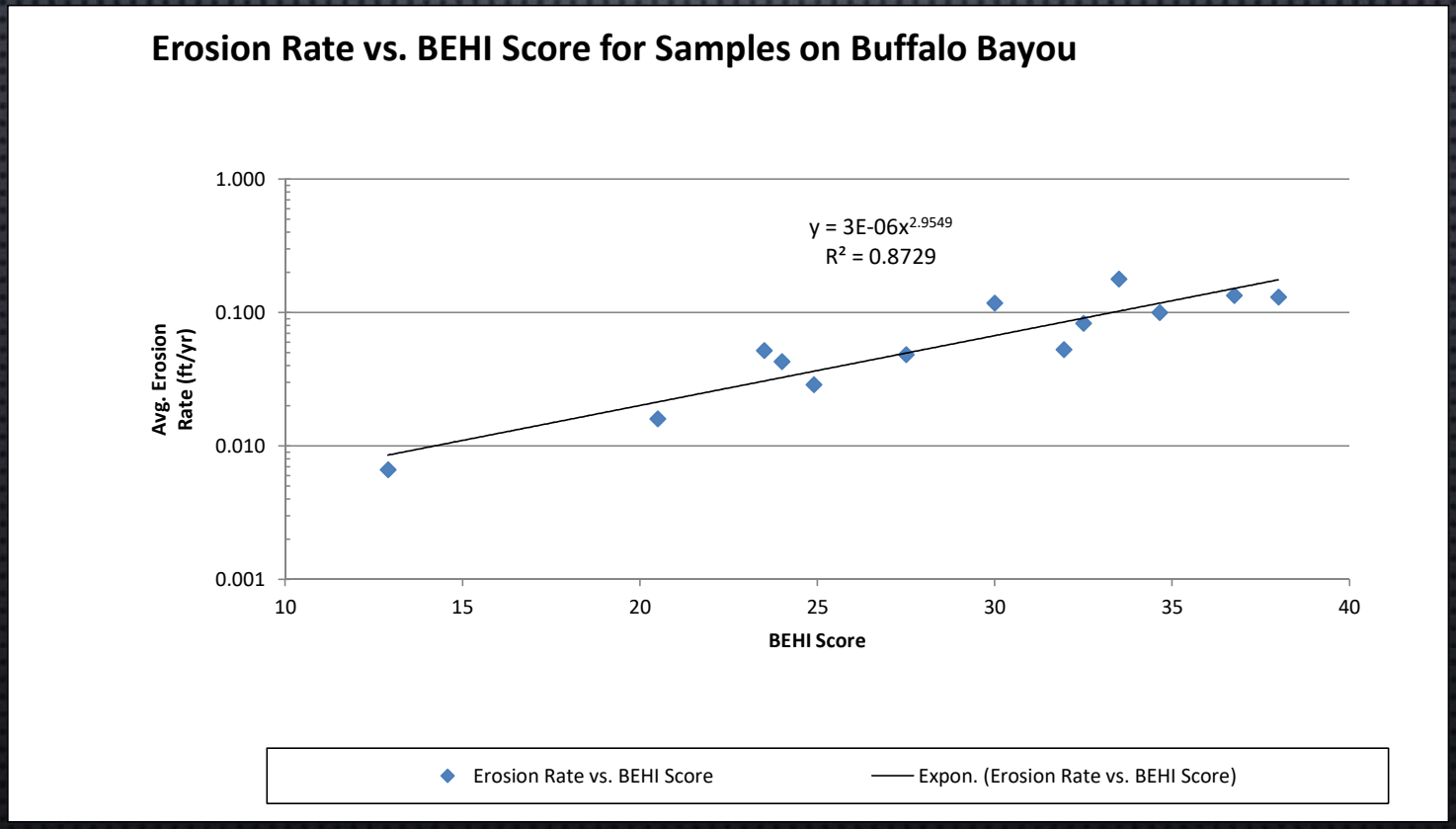
BEHI Rating

- Extreme
- Very High
- High
- Moderate
- Low

STREAMBANK EROSION RATE CURVE



STREAMBANK EROSION RATE CURVE



TMDL REDUCTION ASSESSMENT

Table 1. Phase II Glade Creek at Vinyard Park Existing Streambank Erosion and Nutrient Export Estimate

Stream Bank Side	Bank Length (ft)	BEHI Rating	NBS Rating	Stream Bank Height (ft)	Bulk Density (lb/cf)	Erosion Rate (ft/yr) (Glade Creek Curve)	Erosion Rate (ft/yr) (Hickey's Run, MD Curve)	Erosion Rate (tons/year) (Local Curve)	Erosion Rate (tons/year) (Hickey's Run Curve)
Left	524.1	High	Low	10	125	0.24	0.4	77.0	131.0
Left	167.2	Extreme	Low	2	125	0.35	1.2	7.2	25.1
Left	41.2	Low	Low	12	125	0.07	0.02	2.1	0.6
Left	55.0	High	Low	12	125	0.24	0.4	9.7	16.5
Left	49.6	Very High	Low	12	125	0.30	0.4	11.2	14.9
Left	50.5	High	Low	12	125	0.24	0.4	8.9	15.1
Left	41.1	High	Low	12	125	0.24	0.4	7.2	12.3
Left	68.6	Low	Low	10	125	0.07	0.02	2.9	0.9
Left	128.9	Low	Low	10	125	0.07	0.02	5.4	1.6
Left	35.7	High	Very High	10	125	0.24	1.8	5.2	40.2
Left	136.7	Low	High	10	125	0.07	0.4	5.7	34.2
Left	31.0	Extreme	Low	10	125	0.35	1.2	6.7	23.3
Left	12.0	Low	Low	10	125	0.07	0.02	0.5	0.2
Left	76.4	High	Low	12	125	0.24	0.4	13.5	22.9
Left	107.6	Very High	Low	12	125	0.30	0.4	24.2	32.3
Left	274.9	High	Low	10	125	0.24	0.4	40.4	68.7
Left	19.7	Low	Low	10	125	0.07	0.02	0.8	0.2
Left	165.3	High	Low	11	125	0.24	0.4	26.7	45.5
Left	128.9	High	Low	11	125	0.24	0.4	20.8	35.4
Left	119.9	Very High	Low	10	125	0.30	0.4	22.5	30.0
Left	116.6	Moderate	Low	10	125	0.15	0.13	11.0	9.5
Left	84.9	Very High	Low	10	125	0.30	0.4	15.9	21.2
Left	75.0	Extreme	Low	10	125	0.35	1.2	16.2	56.2
Left	71.0	Moderate	Low	10	125	0.15	0.13	6.7	5.8
Left	117.1	Extreme	Low	10	125	0.35	1.2	25.4	87.8
Left	41.5	Extreme	Low	10	125	0.35	1.2	9.0	31.1
Right	1294.1	Moderate	Low	10	125	0.15	0.13	122.3	105.1
Right	118.9	Extreme	Very High	10	125	0.35	3.4	25.8	252.7
Right	35.4	Moderate	Low	10	125	0.15	0.13	3.3	2.9
Right	36.0	Low	Low	2	125	0.07	0.02	0.3	0.1
Right	19.4	Very High	Low	12	125	0.30	0.4	4.4	5.8
Right	52.5	Moderate	Low	8	125	0.15	0.13	4.0	3.4
Right	58.5	Moderate	Low	8	125	0.15	0.13	4.4	3.8
Right	264.5	Low	Low	10	125	0.00	0	0.0	0.0
Right	31.0	Very High	Low	7	125	0.30	0.4	4.1	5.4
Right	97.7	Low	Low	2.5	125	0.07	0.02	1.0	0.3
Right	22.4	Low	Low	2.5	125	0.07	0.02	0.2	0.1
Right	32.3	Low	Low	2.5	125	0.07	0.02	0.3	0.1
Right	19.8	High	Low	10	125	0.24	0.4	2.9	5.0
Right	647.6	Low	Low	10	125	0.00	0	0.0	0.0
							Total	556.2	1147.2

	Glade Creek Local Erosion Curve	*Hickey's Run, MD Erosion Curve*
TN Export Rate (lbs/yr)	3009.0	6206.4
TP Export Rate (lbs/yr)	990.0	2042.0

**TN and TP calculation based on Mean Concentrations of TN & TP found at Scotts Mill Branch and Powdermill Run in MD, as reported in Recommendations of the Expert Panel to Define Removal Rates for Individual Projects, 2014

Erosion Rate (ft/yr) (Hickey's Run, MD Curve)	Erosion Rate (tons/year) (Local Curve)	Erosion Rate (tons/year) (Hickey's Run Curve)
0.4	77.0	131.0
1.2	7.2	25.1
0.02	2.1	0.6
0.4	9.7	16.5
0.4	11.2	14.9
0.4	8.9	15.1
0.4	7.2	12.3
0.02	2.9	0.9
0.02	5.4	1.6
1.8	5.2	40.2
0.4	5.7	34.2
1.2	6.7	23.3
0.02	0.5	0.2
0.4	13.5	22.9
0.4	24.2	32.3
0.4	40.4	68.7
0.02	0.8	0.2
0.4	26.7	45.5
0.4	20.8	35.4
0.4	22.5	30.0
0.13	11.0	9.5
0.4	15.9	21.2
1.2	16.2	56.2
0.13	6.7	5.8
1.2	25.4	87.8
1.2	9.0	31.1
0.13	122.3	105.1
3.4	25.8	252.7
0.13	3.3	2.9
0.02	0.3	0.1
0.4	4.4	5.8
0.13	4.0	3.4
0.13	4.4	3.8
0	0.0	0.0
0.4	4.1	5.4
0.02	1.0	0.3
0.02	0.2	0.1
0.02	0.3	0.1
0.4	2.9	5.0
0	0.0	0.0
Total	556.2	1147.2

	Glade Creek Local Erosion Curve	*Hickey's Run, MD Erosion Curve*
TN Export Rate (lbs/yr)	3009.0	6206.4
TP Export Rate (lbs/yr)	990.0	2042.0

TMDL REDUCTION ASSESSMENT

Table 2. Phase II Glade Creek at Vinyard Park Proposed Streambank Erosion and Nutrient Export Estimate

Stream Bank Side	Bank Length (ft)	BEHI Rating	NBS Rating	Stream Bank Height (ft)	Bulk Density (lb/cf)	Erosion Rate (ft/yr) (Glade Creek Curve)	Erosion Rate (ft/yr) (Hickey's Run, MD Curve)	Erosion Rate (tons/year) (Local Curve)*	Erosion Rate (tons/year) (Hickey's Run Curve)*
Left	524.1	Low	Low	10	125	0.07	0.02	11.0	3.3
Left	167.2	Low	Low	2	125	0.07	0.02	0.7	0.2
Left	41.2	Low	Low	12	125	0.07	0.02	1.0	0.3
Left	55.0	Low	Low	12	125	0.07	0.02	1.4	0.4
Left	49.6	Low	Low	12	125	0.07	0.02	1.3	0.4
Left	50.5	Low	Low	12	125	0.07	0.02	1.3	0.4
Left	41.1	Low	Low	12	125	0.07	0.02	1.0	0.3
Left	68.6	Low	Low	10	125	0.07	0.02	1.4	0.4
Left	128.9	Low	Low	10	125	0.07	0.02	2.7	0.8
Left	35.7	Low	Low	10	125	0.07	0.02	0.7	0.2
Left	136.7	Low	High	10	125	0.07	0.4	2.9	17.1
Left	31.0	Low	Low	10	125	0.07	0.02	0.7	0.2
Left	12.0	Low	Low	10	125	0.07	0.02	0.3	0.1
Left	76.4	Low	Low	12	125	0.07	0.02	1.9	0.6
Left	107.6	Low	Low	12	125	0.07	0.02	2.7	0.8
Left	274.9	Low	Low	10	125	0.07	0.02	5.8	1.7
Left	19.7	Low	Low	10	125	0.07	0.02	0.4	0.1
Left	165.3	Low	Low	11	125	0.07	0.02	3.8	1.1
Left	128.9	Low	Low	11	125	0.07	0.02	3.0	0.9
Left	119.9	Low	Low	10	125	0.07	0.02	2.5	0.7
Left	116.6	Low	Low	10	125	0.07	0.02	2.4	0.7
Left	84.9	Low	Low	10	125	0.07	0.02	1.8	0.5
Left	75.0	Low	Low	10	125	0.07	0.02	1.6	0.5
Left	71.0	Low	Low	10	125	0.07	0.02	1.5	0.4
Left	117.1	Low	Low	10	125	0.07	0.02	2.5	0.7
Left	41.5	Low	Low	10	125	0.07	0.02	0.9	0.3
Right	1294.1	Moderate	Low	10	125	0.15	0.13	122.3	105.1
Right	118.9	Low	Moderate	10	125	0.07	0.8	5.0	59.5
Right	35.4	Moderate	Low	10	125	0.15	0.13	3.3	2.9
Right	36.0	Low	Low	2	125	0.07	0.02	0.3	0.1
Right	19.4	Very High	Low	12	125	0.30	0.4	4.4	5.8
Right	52.5	Moderate	Low	8	125	0.15	0.13	4.0	3.4
Right	58.5	Moderate	Low	8	125	0.15	0.13	4.4	3.8
Right	264.5	Low	Low	10	125	0.00	0	0.0	0.0
Right	31.0	Very High	Low	7	125	0.30	0.4	4.1	5.4
Right	97.7	Low	Low	2.5	125	0.07	0.02	1.0	0.3
Right	22.4	Low	Low	2.5	125	0.07	0.02	0.2	0.1
Right	32.3	Low	Low	2.5	125	0.07	0.02	0.3	0.1
Right	19.8	High	Low	10	125	0.24	0.4	2.9	5.0
Right	647.8	Low	Low	10	125	0.00	0	0.0	0.0
							Total	209.4	224.7

	Glade Creek Local Erosion Curve	*Hickey's Run, MD Erosion Curve*
TN Export Rate (lbs/yr)**	1132.8	1215.6
TP Export Rate (lbs/yr)**	372.7	399.9

*Proposed Erosion rates from all banks with stream restorationon measures has been reduced by 50%

**TN and TP calculation based on Mean Concentrations of TN & TP found at Scotts Mill Branch and Powdermill Run in MD, as reported in Recommendations of the Expert Panel to Define Removal Rates for Individual Projects, 2014

Erosion Rate (ft/yr) (Hickey's Run, MD Curve)	Erosion Rate (tons/year) (Local Curve)*	Erosion Rate (tons/year) (Hickey's Run Curve)*
0.02	11.0	3.3
0.02	0.7	0.2
0.02	1.0	0.3
0.02	1.4	0.4
0.02	1.3	0.4
0.02	1.3	0.4
0.02	1.0	0.3
0.02	1.4	0.4
0.02	2.7	0.8
0.02	0.7	0.2
0.4	2.9	17.1
0.02	0.7	0.2
0.02	0.3	0.1
0.02	1.9	0.6
0.02	2.7	0.8
0.02	5.8	1.7
0.02	0.4	0.1
0.02	3.8	1.1
0.02	3.0	0.9
0.02	2.5	0.7
0.02	2.4	0.7
0.02	1.8	0.5
0.02	1.6	0.5
0.02	1.5	0.4
0.02	2.5	0.7
0.02	0.9	0.3
0.13	122.3	105.1
0.8	5.0	59.5
0.13	3.3	2.9
0.02	0.3	0.1
0.4	4.4	5.8
0.13	4.0	3.4
0.13	4.4	3.8
0	0.0	0.0
0.4	4.1	5.4
0.02	1.0	0.3
0.02	0.2	0.1
0.02	0.3	0.1
0.4	2.9	5.0
0	0.0	0.0
Total	209.4	224.7

	Glade Creek Local Erosion Curve	*Hickey's Run, MD Erosion Curve*
TN Export Rate (lbs/yr)**	1132.8	1215.6
TP Export Rate (lbs/yr)**	372.7	399.9

TMDL REDUCTION ASSESSMENT

Table 3. Phase II Glade Creek at Vinyard Park, Summary of Erosion and Nutrient Removal Rates from Stream Restoration

Erosion Estimate Method	Total Project Bank Length (ft)	Existing TN Export Rate (lbs/year)	Proposed TN Export Rate (lbs/year)	Existing TP Export Rate (lbs/year)	Proposed TP Export Rate (lbs/year)	TN Removal Rate (lbs/year)	TP Removal Rate (lbs/year)	Sediment Removal Rate (tons/year)
Glade Creek Erosion Curve*	**5470.3**	**1268.1**	**405.7**	**584.0**	**186.8**	**862.4**	**397.2**	**378.2**
Hickey Run Erosion Curve**	5470.3	2615.6	527.8	1204.6	243.1	2087.8	961.5	915.7
Revised Default Rate***	5470.3	---	---	---	----	410.3	372.0	122.8

**recommend using Glade Creek Local Erosion Curve as the best estimate*

***accounts for conservative approach of assuming only 50% effectiveness of stream restoration to reduce erosion*

**** from Recommendations of the Expert Panel to Define Erosion Removal Rates for Individual Stream Restoration Projects (0.068 lbs/ft /yr P , 0.075 lbs/ft /yr N)*

PROJECT TAKE-AWAYS

- Upland or channel erosion assessment is equally possible
- Data where none existed prior to the initiation of concern of a particular study area
- Local curves provide more realistic estimates for nutrient removal
- Quickly get accurate erosion data on variety of time scales
- Becoming an accepted standard – Chesapeake Bay
- Cost effective – Nutrient reduction per pound

Questions?

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FREESE AND NICHOLS