Harborcreek Township Pollutant Reduction Plan

Prepared for Submittal with National Pollutant Discharge Elimination System (NPDES) Individual Permit to Discharge Stormwater from Small Municipal Separate Storm Sewer System (MS4) Application

Draft

August 9, 2022

Harborcreek Township
5601 Buffalo Road
Harborcreek, PA 16421

Harborcreek Township, Pennsylvania
Pollutant Reduction Plan

Draft – August 9, 2022

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Introduction

Harborcreek Township is located within Erie County in northwest Pennsylvania on the shore of Lake Erie. The Pennsylvania Department of Environmental Protection (DEP) has categorized one stream in Harborcreek Township as impaired due to siltation or sediment. This impairment is based on assessments of benthic macroinvertebrates (or aquatic insects) that were conducted in 2001. The impaired Unnamed Tributary to Lake Erie is identified locally as Five Mile Creek.

As part of its application for a new National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit, the Township is required to develop a Pollutant Reduction Plan (PRP) to reduce discharge of pollutants into local streams.

This PRP was prepared in accordance with guidance documents provided by DEP and others, including:

- "MS4 Requirements Table (Municipal)," revised November 18, 2019
- "PRP Instructions (3800-PM-BCW0100k)," revised March 2017
- "BMP Effectiveness Values (3800-PM-BCW0100m)," dated June 2018
- "PRP Development Process Summary," dated June 9, 2017
- "MS4 NPDES Permits Frequently Asked Questions (FAQ)," Version 1.4 revised April 20, 2022
- "Considerations of Stream Restoration Projects in Pennsylvania for eligibility as an MS4 Best Management Practice," dated May 11, 2018
- "MS4 Stream Restoration Eligibility Checklist" and "MS4 Stream Restoration Crediting Review Checklist – Expert Panel Protocols"
- "Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects," dated September 8, 2014 and "Consensus Recommendations for Improving the Application of the Prevented Sediment Protocol for Urban Stream Restoration Projects Built for Pollutant Removal Credit", dated February, 27, 2020

A. Public Participation

Harborcreek Township conducted a public comment period after initial review of the PRP by DEP as specified in the December 22, 2021 consent order.

Documentation of the public comment process, public comments, and the Township's responses will be provided in Appendix A.

B. Map

Under the MS4 permit, Harborcreek Township is responsible for all areas draining to a stormwater outfall owned or operated by the Township that is located within the 2010 Census urbanized area. The Township has developed a map of its stormwater infrastructure based on visual inspections of above ground features and a map of the Township's stormwater infrastructure prepared by Erie County. This map was used as the basis for identifying regulated MS4 outfalls to determine the PRP planning area. The PRP planning area was adjusted to remove or parse areas that are operating as PennDOT roads. Facilities operating under an industrial stormwater permit (PAG03) were identified based on the list available on the DEP website. There were no industrial permitted facilities located within the Five Mile Creek watershed and no sites were removed from the PRP planning area. A portion of the watershed draining from Lawrence Park Township was parsed out of the planning area.

Artificial conveyances and natural drainage features were thoroughly reviewed in a GIS environment by engineers and planners in order to accurately account for storm sewer drainage areas and determine break points between the manmade and natural hydrologic systems. Drainage areas were delineated to each MS4 outfall and the PRP planning area reflects regulated drainage to Five Mile Creek. The drainage areas were delineated using the contours and DEM obtained from the Pennsylvania Geospatial Data Clearinghouse (PASDA) for Pennsylvania Western Lidar 2020 QL2 – North.

The Township evaluated impervious surfaces using detailed impervious cover data available through PASDA. Woolpert and Pennsylvania State University, using funding from the Pennsylvania Sea Grant, collaborated to produce highly detailed impervious surface data based on 2012 LiDAR. The 2012 impervious surface data was compared to the most recent satellite imagery available from PASDA (Erie County PEMA 2018) and was found to align very closely. Minor adjustments to the impervious surface were made to capture additional impervious surfaces.

A map of the planning area is provided in Appendix B. The watershed map shows the PRP planning area, MS4 outfalls and associated drainage areas, parsed areas, and the extent of the 2010 Census urbanized area. A draft of this map was submitted to DEP for review on February 4, 2022 as specified in the December 22, 2021 consent order.

C. Pollutants of Concern

The MS4 Requirements Table (Municipal) developed by DEP, dated November 18, 2019, lists one stream in the Township that requires a PRP for siltation. The listed impaired water in the MS4 Requirements Table is Unnamed Tributary to Lake Erie. The Unnamed Tributary to Lake Erie is locally named Five Mile Creek. The location of this DEP-designated impaired water within Harborcreek Township is shown in Figure 1.

Figure 1 - Map of Impaired Waters in Harborcreek Township

Five Mile Creek in Harborcreek was determined to be impaired based on DEP assessments of biological conditions in the streams through evaluations of benthic macroinvertebrates or aquatic insects conducted in 2001. More information about DEP's steam assessment program is available at the following webpage: https://www.depgis.state.pa.us/macroinvertebrate/index.html. Per this website, Five Mile Creek has not been reassessed recently. Sediment or siltation is often considered a stressor that impacts the health of streams and benthic macroinvertebrates; however, DEP has not performed a Total Maximum Daily Load (TMDL) assessment for these streams to evaluate stressors and assign wasteload allocations.

Since all the impaired streams are listed for a siltation impairment the pollutant of concern for this PRP is sediment. In order to comply with its next MS4 permit, the Township is required to achieve a 10% sediment reduction as documented in the PRP Instructions (3800-PM-BCW0100k), dated March 2017.

D. Determine Existing Loading for Pollutants of Concern

The existing loading for sediment in each of the impaired streams is based on the simplified method developed by DEP. The loading rate in pounds per acre per year for each land use type (impervious developed, pervious developed, and undeveloped lands) was taken from Attachment B of the PRP Instructions and is summarized in Table 1. These rates were then applied to the land use data for Harborcreek as summarized in Section B and Appendix B.

Table 1 - Existing Sediment Loading Rate Summary

Land Use	Sediment Loading Rate (lb/acre/year)
Impervious Developed	1,839
Pervious Developed	264.96
Undeveloped Land	234.6

The Township may take credit for existing Best Management Practices (BMPs) that are demonstrated to reduce the sediment loading. There were six private stormwater BMPs identified in the watershed – see the PRP map in Appendix B for locations. The Erie County Conservation District provided a review of the BMP sites and provided available documentation for five of the sites with permit applications in Appendix C and details summarized in Table 2.

Table 2 - Summary of Existing BMPs

Name	Permit No.	BMP Type	Latitude	Longitude	Year Constructed
Eastlake Woods (Affordable Senior Housing)	PAG02002511024	Detention Pond	42.164776	-80.008471	2012
		Rain garden	Unknown		2012
		Vegetated swales	Unknown		2012
		Restoration: landscape	Unknown		2012
		Rooftop disconnection	Unknown		2012
Arneman Court	PAG02002512002	Wet pond	42.154197	-80.005370	2013
		Restoration buffers	Unknown		2013
		Protect Features	Unknown		2013
		WQ inserts	Unknown		2013
East Lake Road Alliance Church	PAG02002507008	Detention Basin	42.163259	-80.012072	2007
		Underground Detention	Unknown		2007
		Porous pavement	Unknown		2007
		Vegetated filter swales	Unknown		2007
Village of Foxwood	PAG02002505004	Detention basin 1 (North)	42.133390	-79.983653	2009
		Detention basin 2 (South)	42.129905	-79.987054	2009
		Vegetated filter swales	Unknown		2009

During field visits and desktop assessments of the watershed, the ponds were the only stormwater features that were located and therefor only these BMPs are included in credit calculations for existing BMPs. Drainage areas to the facilities were calculated based on the GIS data compiled for the watershed (see Section B). The total 10,198 pounds per year of sediment credit claimed is detailed in Table 3.

Table 3 - Summary of Existing BMP Reductions

Name	Pervious Acres	Impervious Acres	Undeveloped	TSS Load (lbs/yr)	Removal Efficiency*	Reduction in TSS Load (lbs/yr)
Eastlake Woods Detention Pond	0.49	0.65	0.00	1,325	10%	133
Arneman Court Wet Pond	4.73	3.16	0.00	7,065	60%	4,239
East Lake Road Alliance Church Detention Basin	1.91	1.19	0.00	2,694	10%	269
Foxwood North Detention Basin	40.94	17.85	0.00	43,674	10%	4,367
Foxwood South Detention Basin	11.60	4.80	0.00	11,901	10%	1,190
Total						**10,198**

* Removal efficiency from BMP Effectiveness Values (3800-PM-BCW0100m)," dated June 2018

Table 4 summarizes the existing pollutant loading for Five Mile Creek and the total area calculated using the DEP simplified method.

Table 4 - Existing Sediment Loading Summary

Watershed	Full Sewershed (AC)	Parsed Area (AC)	Total Planning Area (AC)	Pervious (AC)	Impervious (AC)	Undeveloped (AC)	Sum of TSS Load (lbs/year)
Five Mile Creek	775.13	36.94	738.19	584.85	153.35	-	436,973
Credit for Existing Stormwater Management BMPs							- 10,198
Adjusted Total Sediment Load							**426,775**
Sediment Reduction Goal (10% of Total Load)							**42,678**

E. Select BMPs to Achieve the Minimum Required Reductions in Pollutant Loading

The Township conducted an evaluation of BMP opportunities to achieve the minimum required 10% reduction of sediment. This minimum required sediment reduction is 42,678 pounds/year or 21.34 tons/year.

The following BMP is proposed to meet the required reduction in sediment. Additional information on the BMP and its associated sediment reduction is located in Appendix D.

Rolling Ridge Park Stream Restoration:
This project was identified by a field assessment of streams in the watershed and potential opportunities on public land.

The Township proposes a restoration project spanning approximately 700 feet on a tributary to Five Mile Creek that flows through Rolling Ridge Park to address areas of high bank erosion and near bank stress. The main goals are to stabilize the banks and reconnect the stream to the

floodplain to dissipate energy during high flow events. Measurements of bank erosion rates and near stress indicators were taken in the field in May 2022. The approved methodology from Protocol 1 of the "Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects" was used to compute sediment credit for this project. Using Protocol 1, the sediment reduction associated with this project was determined to be 71.6 tons per year or 143,200 pounds per year (see Appendix D for more detail about the sediment removal calculation).

Table 5 - Summary of Estimated Sediment Reduction

Project	Watershed	Estimated Sediment Load Reduction (lb/year)
Rolling Ridge Park Stream Restoration	Five Mile Creek	143,200

As demonstrated in Table 5, the proposed project exceeds the 10% sediment reduction goal of 42,678 pounds per year.

F. Implementation Schedule

The Township intends to implement the identified stream restoration project during the five-year term of its next MS4 permit.

G. Identify Funding Mechanisms

The Township intends to pursue a variety of grant opportunities to fund the proposed projects that may include:

- Growing Greener Watershed Protection Grants
- Coastal Zone Management Grant Program
- Nonpoint Source Implementation Program Grants (Section 319)
- Pennsylvania Infrastructure Investment Authority – Clean Water State Revolving Fund
- Community Development Block Grants
- Watershed Restoration and Protection Program
- National Oceanic and Atmospheric Administration (NOAA) Great Lakes Restoration Initiative
- National Fish and Wildlife Foundation Sustain Our Great Lakes Program
- American Rescue Plan Act (ARPA)

The Township currently finances stormwater projects and grant matches through its general fund for MS4 permit compliance.

H. Identify Responsible Parties for Operation and Maintenance of BMPs

The Township's Public Works Department will be responsible for managing the annual operation and maintenance of the proposed stream restoration project. Typical operation and maintenance activities for the stream restoration projects include:

- Post construction inspection to verify that vegetation is established;
- Inspection of vegetation and other stream restoration features after significant storm events;
- Replanting of vegetation, as necessary; and,
- Repair of stream restoration features, as necessary. If there is structural failure of a project feature, the Township will evaluate the cause of the failure and modify the design or construction methods if necessary.

Appendix A

Public Participation Documentation

Appendix B

Pollutant Reduction Plan Map

Pollution Reduction Plan Map

- Township Outfalls
- Stream River
- Existing Stormwater Facilities
- Township Planning Area
- Five Mile Creek Watershed (Shaded areas are not draining to Township storm sewer infrastructure)
- Parsed Areas
- PennDOT Roads
- Harborcreek Boundary
- 2010 Census Urbanized Area

0 0.5 1 Mile

Outfall	Full Sewershed Area (ac)	Parsed Area (ac)	Total Planning Area (ac)	Pervious Planning Area (ac)	Impervious Planning Area (ac)
5MI_01	34.62	0.97	33.64	24.02	9.62
5MI_02	48.73	0.73	48.00	39.36	8.64
5MI_03	83.94	29.96	53.98	44.98	9.00
5MI_04	7.01	0.00	7.01	4.97	2.05
5MI_05	7.89	0.19	7.70	4.68	3.02
5MI_06	6.74	0.00	6.74	4.10	2.64
5MI_07	17.16	0.00	17.16	12.48	4.67
5MI_08	13.04	0.00	13.04	9.91	3.13
5MI_09	0.92	0.00	0.92	0.52	0.40
5MI_10	4.97	0.00	4.97	3.82	1.15
5MI_11	2.96	0.00	2.96	1.99	0.97
5MI_12	5.04	0.00	5.04	2.96	2.08
5MI_13	47.24	0.00	47.24	41.65	5.60
5MI_14	2.27	0.00	2.27	1.24	1.03
5MI_15	69.75	0.00	69.75	56.48	13.26
5MI_16	12.65	0.00	12.65	9.29	3.36
5MI_17	0.55	0.00	0.55	0.35	0.20
5MI_18	2.23	0.00	2.23	1.55	0.68
5MI_19	3.83	0.00	3.83	2.92	0.91
5MI_20	1.02	0.00	1.02	0.62	0.40
5MI_21	2.87	0.00	2.87	2.09	0.78
5MI_22	0.10	0.00	0.10	0.04	0.06
5MI_23	0.76	0.00	0.76	0.47	0.28
5MI_24	0.59	0.00	0.59	0.43	0.16
5MI_25	2.42	0.00	2.42	1.66	0.77
5MI_26	0.48	0.00	0.48	0.11	0.38
5MI_27	0.60	0.00	0.60	0.43	0.16
5MI_28	2.95	0.00	2.95	1.81	1.14
5MI_29	1.27	0.00	1.27	0.63	0.64
5MI_30	0.02	0.00	0.02	0.01	0.01
5MI_31	12.84	0.00	12.84	9.31	3.53
5MI_32	1.32	0.00	1.32	0.98	0.34
5MI_33	0.15	0.00	0.15	0.08	0.07
5MI_34	115.25	0.00	115.25	88.07	27.18
5MI_35	59.43	0.00	59.43	50.00	9.43
5MI_36	32.38	0.00	32.38	23.44	8.94
5MI_37	0.53	0.00	0.53	0.36	0.17
5MI_38	65.58	3.19	62.39	54.89	7.50
5MI_39	81.59	1.90	79.69	66.26	13.43
5MI_40	21.43	0.00	21.43	15.88	5.55
Total	775.13	36.94	738.19	584.85	153.35

Pervious Sediment Load (lb/yr)	Impervious Sediment Load (lb/yr)
154,962	282,011

Appendix C

Existing BMP Documentation

3930-PM-WM0035 Rev. 11/2010

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT

OFFICIAL USE ONLY
ID # PAG02002511024
Date Received 7/26/2011

PERMIT APPLICATION
NOTICE OF INTENT FOR COVERAGE UNDER THE GENERAL (PAG-02) NPDES PERMIT
OR
APPLICATION FOR AN INDIVIDUAL NPDES PERMIT FOR STORMWATER DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITIES

PLEASE READ THE PERMIT SUMMARY SHEET AND INSTRUCTIONS PROVIDED IN THIS PERMIT APPLICATION PACKAGE BEFORE COMPLETING THIS FORM. COMPLETE THE ATTACHED CHECKLIST AND APPROPRIATE WORKSHEETS ATTACHED AFTER APPENDIX C OF THIS PERMIT APPLICATION. COMPLETE ALL APPLICABLE WORKSHEETS REFERENCED IN THE APPLICATION CHECKLIST.

PLEASE PRINT OR TYPE INFORMATION IN BLACK OR BLUE INK.

CHECK APPROPRIATE BOX	GENERAL ☐	INDIVIDUAL ☐		
APPLICATION TYPE	NEW ☒	RENEWAL ☐	MAJOR MODIFICATION ☐	PHASED ☐

SECTION A. APPLICANT INFORMATION

Applicant's Last Name: CLUNIE	First Name: GARY	MI	Phone: 716 688-8640	
Email Address: GCLUNIE@CLOVERCONSTRUCTION.COM			FAX:	
Organization Name or Registered Fictitious Name: AFFORDABLE SENIOR HOUSING OPPORTUNITIES OF WNY			Phone:	
Mailing Address: 348 HARRIS HILL ROAD	City: WILLIAMSVILLE		State: NY	ZIP + 4: 14221
Co-Applicant's Last Name (if applicable)	First Name	MI	Phone	
			FAX	
Email Address				
Organization Name or Registered Fictitious Name			Phone	
			FAX	
Mailing Address	City		State	ZIP + 4

SECTION B. PROJECT INFORMATION AND SITE ANALYSIS

1. Project Name: HARBORCREEK SENIOR HOUSING
2. Total Project Site (Acres): 9.1
3. Total Disturbed Area (Acres): 7.8
4. Project Description

☐ Residential Subdivision	☐ Sewerage/Water System	☐ Private Road/Residence
☒ Commercial/Industrial	☐ Public Road	☐ Government Facility
☐ Utility Facility/Transmission	☐ Recreational	☐ Remediation/Restoration

5. Project Location or Physical Address (if available):
4400 East Lake Road - Former Harborcreek Mall Site

6. County: Erie | Municipality: Harborcreek | City ☐ Boro ☐ Twp ☒

7. Latitude: 42 °/ 9 '/ 33.5" Longitude: 80 °/ 0 '/ 49.1 "

Collection Method: ☐ EMAP ☐ HGIS ☐ GISDR ☐ ITPMP ☒ GPS ☐ WAAS ☐ LORAN

Check the horizontal reference datum (or projection datum) employed in the collection method. EMAP and HGIS (PNDI) have known datum and do not require checking here. ☐ NAD27 ☒ NAD83 ☐ WGS84 (GEO84)

Enter the date of collection if the lat and long coordinates were derived from GPS, WAAS or LORAN. 4 mm 4 dd 2011 yyyy

8. U.S.G.S. Quad Map Name Erie North

9. Existing and Previous Uses of the Land Proposed for Construction (use separate sheet if necessary):

Existing Land Uses: ☐ Agriculture ☐ Forest/Woodland ☒ Barren ☐ Urban ☐ Brownfield ☐ Other

Description: Redevelopment site - most of site consists of pavement

Previous Land Uses: ☐ Agriculture ☐ Forest/Woodland ☐ Barren ☒ Urban ☐ Brownfield ☐ Other Subbase

Description: Former Harborcreek Mall Site

10. **Site Analysis**

a. Describe how Natural Resources features on the site (Worksheets 2 and 3 referenced in the Pa. Stormwater BMP Manual) were considered in: Location and Design of the project, E & S Plan Design, PCSM Plan Design. (attach additional sheet if necessary)

None - site previously developed

b. Identify naturally occurring geologic formations or soil conditions that may have the potential to cause pollution during earth disturbance activities and include BMPs to avoid or minimize potential pollution and its impacts from the formation.

None

11. Potential Toxic or Hazardous Pollutants: (Submit the following data if soil contaminant, geology or past or present land use provides a potential for contaminated runoff from the project site) N/A ☐ Use additional sheets if necessary.

Pollutant	Concentration w/Units	Source	Sample Type	Date(s) / Number of Samples

12. **Fill Material**

Based on a cut/fill analysis of the project site, will the site need to import fill, export fill or will the site balance? Be sure to read the instructions before completing this section. Clean Fill can not be placed in or on waters of the Commonwealth.

Check the appropriate box

☐ Import fill – the Operator will, in most situations, be responsible to perform environmental due diligence and determine that all fill imported to the site meets the department's definition of clean fill. The plan designer must include a note on the drawings to identify the operator(s) responsibility and provide the definition of Clean Fill and Environmental Due Diligence.

☒ Export fill – the Applicant is responsible for performing environmental due diligence at the time this application was submitted to determine that any fill exported from the site will be certified as clean fill.

☐ Balance all cuts and fills with the amount of rock and soil available on the site.

13. Estimated Timetable for Phased Projects Build Out (Complete for phased projects only)

Phase No. or Name	Proposed Type of Activity	Total Area	Disturbed Area	Start Date	End Date
1	DEVELOP SITE	9.1	7.8	9/2011	6/2012

14. Stormwater Discharges to nearest receiving stream (during construction). Check all that apply:

Waters of the Commonwealth ☒ Municipal Separate Storm Sewer ☐ Private Storm Sewer ☐ Non Surface Waters ☐

Impaired Waters According to Category 4 or 5 of PA Integrated Water Quality Monitoring and Assessment Report ☐

If waters are impaired list type of impairment: _____

Receiving Water/Watershed Name:	Chapter 93 Receiving Water Classification: (Designated use)	Existing Use (if different from the Designated use)
FIVE MILE CREEK	CWF; MF	
Name of Municipal Storm Sewer Operator:	**Name of Private Storm Sewer Operator:**	**Other: (including off-site discharges)**
HARBORCREEK TOWNSHIP		

Will you meet CG-1? ☒ Yes ☐ No

If no, you may need to use worksheets 11 through 13.

SECTION C. E & S AND POST CONSTRUCTION STORMWATER MANAGEMENT (PCSM) PLAN

Note: For projects involving multiple watershed boundaries, please submit a complete, separate Section C for each additional watershed.

1. Provide a brief summary of proposed BMPs and their performance to manage E & S for the project. If E & S BMPs and their application do not follow the guidelines referenced in the Pa. Erosion and Sediment Pollution Control Program Manual, provide documentation to demonstrate peformance equivalent to, or better than, the BMPs in the Manual.

E & S BMPs

TEMPORARY CONTROLS DURING CONSTRUCTION
STABILIZED CONSTRUCTION ENTRANCE, EQUIPMENT/MATERIAL STORAGE AREA, CONCRETE WASHOUT PIT, SILT FENCE, INLET SEDIMENT TRAPS
PERMANENT CONTROLS
LANDSCAPE RESTORATION, STORMWATER DETENTION POND, VEGETATED SWALE SEEDING, RIP RAP, CDS CHAMBER + STREET SWEEPING

2. **PCSM Plan Information** - The PCSM Plan should be designed to maximize volume reduction technologies, eliminate (where possible) or minimize point source discharges to surface waters, preserve the integrity of stream channels, and protect the physical, biological and chemical qualities of the receiving surface water. **The DEP recommends the use of Control Guideline 1 (CG1) referenced in the Pa. Stormwater BMP Manual to achieve this goal.**

Design standards applied to develop the PCSM Plan. Check those that apply.

☐ Act 167 Plan - The attached PCSM plan is consistent with an applicable approved Act 167 Plan. **A letter of consistency from the Municipal or County Engineer should be provided with the application.** Complete and submit all applicable worksheets referenced in the application checklist as part of the permit application for each approved Act 167 Plan.

Complete the following table for all applicable approved Act 167 Stormwater Management Plans. (use additional sheets if necessary)

ACT 167 Plan Name	Date Adopted	Consistency Letter Included ☐ / Consistency Letter Pending ☐
_____	_____	

☐ The attached PCSM plan is consistent with all applicable local stormwater management ordinances, including MS4 (NPDES Permit to Discharge Stormwater Through a Municipal Separate Storm Sewer System) ordinances. **A letter of consistency from the Municipal or County Engineer should be provided with the application.** Complete and submit all applicable worksheets referenced in the application checklist as part of the permit application.

Complete the following table for all applicable Municipalities. (use additional sheets if necessary)

Municipality Name	Ordinance Number	Consistency Letter Included ☐
_____	_____	Consistency Letter Pending ☐

The PCSM Plan must satisfy either subparagraph A, B or C below. Check those that apply.

A. ☐ Act 167 Plan approved on or after January 2005 – The attached PCSM Plan, in its entirety, is consistent with all requirements pertaining to rate, volume, and water quality from an Act 167 Stormwater Management Plan approved by DEP on or after January 2005.

B. ☒ The PCSM Plan meets the standard design criteria from the PA Stormwater BMP Manual.

OR

C. ☐ Alternative Design Standard – The attached PCSM plan was developed using approaches other than 102.8(g)(2). Demonstrate/explain in the space provided how this standard will be either more protective than what is required in 102.8(g)(2) or will maintain and protect existing water quality and existing and designated uses.

3. **Riparian Buffers**

A. Will you be protecting, converting or establishing a riparian buffer or a riparian forest buffer as a part of this project?
☒ Yes ☐ No

B. If the regulations require a riparian buffer or riparian forest buffer and you are not providing one, please list the waiver provisions in the Chapter 102 regulations, Section 102.14(d)(2)(*i*)-(*vi*), that you are requesting and provide additional documentation to demonstrate reasonable alternatives for compliance with 102.14 requirements.

C. Will you be protecting, converting or establishing a voluntary riparian forest buffer as part of this project? ☐ Yes ☐ No

If yes you must include a Riparian Forest Buffer Management Plan as part of the PCSM plans.

4. **Summary Table for Supporting Calculation and Measurement Data**

Please reference the Stormwater Methodology used (Numbers generated in this table should be consistent with worksheets 1-5.)

	Pre-construction	Post Construction	Net Change
Design storm frequency 2 YEAR Rainfall amount 3.35 inches			
Impervious area (acres)	1 5.89	2 4.20	3 -1.69
Volume of stormwater runoff ☐ acre-feet or ☐ cubic feet without planned stormwater BMPs (check appropriate box)	4 73,222	5 70,827	6 -2,398
Volume of stormwater runoff ☐ acre-feet or ☐ cubic feet with planned stormwater BMPs (check appropriate box)		7 30,000	8 -43,222
Stormwater peak discharge rate for the design frequency storm (cubic feet per second)	9 14.94	10 1.25	11 -13.69

Box 1. **Pre-construction impervious area**: The total acres of impervious area on the project site before construction activities begin, based on land use for five years preceding the planned project.

Box 2. **Post construction impervious area**: The total acres of impervious area on the project site after construction activities have been completed.

Box 3. **Net change of impervious area**: The difference between the acres of impervious area listed in Box 1 and Box 2. Zero or negative values are acceptable.

Box 4. **Pre-construction stormwater runoff volume without planned BMPs**: The amount of stormwater runoff volume from the project site that would result from the design storm occurrence before construction activities begin, based on land use for five years preceding the project.

Box 5. **Post construction stormwater runoff volume without planned BMPs**: The amount of stormwater runoff volume from the project site that would result from the design storm occurrence after construction activities have finished assuming that no stormwater infiltration or retention BMPs have been installed.

Box 6. **Net change in stormwater volume without planned BMPs**: The difference between the amounts of stormwater runoff volume listed in Box 4 and Box 5.

Box 7. **Post construction stormwater runoff volume with planned BMPs**: The amount of stormwater runoff volume from the project site that would result from the design storm occurrence after construction activities have finished and the planned stormwater infiltration or retention BMPs have been installed.

Box 8. **Net change in stormwater runoff volume with planned BMPs**: The difference between the amounts of stormwater runoff volume listed in Box 4 and Box 7.

Box 9. **Pre-construction stormwater discharge rate**: The stormwater runoff discharge rate for the design frequency storm as determined by the land use for the past five years.

Box 10. **Post construction stormwater discharge rate**: The stormwater runoff discharge rate for the design frequency storm event after all planned stormwater BMPs are installed.

Box 11. **Net change stormwater discharge rate**: The difference between the stormwater runoff discharge rates listed in Box 9 and Box 10.

5. **Summary Description of Post Construction Stormwater BMPs (consistent with the design or applicable worksheets)**

Key: **RC = Rate Control** **VC = Volume Control** **WQ = Water Quality**

In the lists below, check the BMPs identified in the PCSM Plan, and their function(s) using the above Key. More than one function may be checked for a BMP. List the stormwater volume and area of runoff to be treated by each BMP type. If any BMP in the PCSM Plan is not listed below, describe it in the space provided after "Other".

BMP	Function(s)	Volume of stormwater treated	Acres treated
☐ Wet ponds	☐ VC ☐ RC ☐ WQ		
☐ Constructed wetlands	☐ VC ☐ RC ☐ WQ		
☐ Retention basins	☐ VC ☐ RC ☐ WQ		
☐ Detention basin	☐ VC ☒ RC ☒ WQ		7.9 ACRES
☐ Underground detention	☐ VC ☐ RC ☐ WQ		
☐ Dry Extended detention basin	☐ VC ☐ RC ☐ WQ		
☐ Sediment fore bay	☐ VC ☐ RC ☐ WQ		
☐ Infiltration trench	☐ VC ☐ RC ☐ WQ		
☐ Infiltration Berm/Retentive Grading	☐ VC ☐ RC ☐ WQ		
☐ Subsurface Infiltration bed	☐ VC ☐ RC ☐ WQ		
☐ Infiltration basin	☐ VC ☐ RC ☐ WQ		
☐ Pervious pavement	☐ VC ☐ RC ☐ WQ		
☐ Dry well/Seepage pit	☐ VC ☐ RC ☐ WQ		
☐ Bio-infiltration areas	☐ VC ☐ RC ☐ WQ		
☐ Rain gardens/Bio-retention	☐ VC ☒ RC ☒ WQ		1.1 ACRES
☐ Vegetated swales	☒ VC ☒ RC ☒ WQ		0.8 ACRES
☐ Constructed filters	☐ VC ☐ RC ☐ WQ		
☐ Protect Sensitive & Special Value Features	☐ VC ☐ RC ☐ WQ		
☐ Protect/Convert/Establish Riparian buffers	☐ VC ☐ RC ☐ WQ		
☐ Restoration: Buffers/ Landscape/Floodplain	☒ VC ☒ RC ☒ WQ		1.69 ACRES
☐ Disconnection from storm sewers	☐ VC ☐ RC ☐ WQ		
☐ Rooftop disconnection	☐ VC ☒ RC ☒ WQ		0.33 ACRES
☐ Vegetated roofs	☐ VC ☐ RC ☐ WQ		
☐ Runoff capture/Reuse	☐ VC ☐ RC ☐ WQ		
☐ Oil/grit separators	☐ WQ		
☐ Water quality inserts/inlets	☐ WQ		
☐ Street sweeping	☒ WQ		PAVED AREAS
☐ Other _____	☐ VC ☐ RC ☐ WQ		
☐ Other _____	☐ VC ☐ RC ☐ WQ		

6. **Off Site Discharge Analysis**

Does the project propose any off-site discharges to areas other than surface waters? ☐ **Yes** ☒ **No**

If yes, the applicant must have appropriate easement that provides the legal authority for this off-site discharge.

Applicant must provide a demonstration in both the E&S and PCSM plans that the discharge will not cause erosion, damage, or nuisance to off-site properties.

7. **Thermal Impacts Analysis**

Please explain how thermal impacts associated with this project were avoided, minimized, or mitigated.

THE SITE WILL BE LESS IMPERVIOUS AS PROPOSED THAN IT WAS AS HARBORCREEK MALL. ADDITIONALLY, AS MUCH BUILDING AS POSSIBLE WAS DISCONNECTED FROM THE STORM SEWER AND THE DETENTION POND IS OVER-SIZED TO STORE RUNOFF AS LONG AS POSSIBLE.

8. Identify the critical stages of implementation of the PCSM plan for which a licensed professional or designee shall be present on site:

- PRIOR TO CLEARING TO ENSURE PROPER INSTALLATION OF BMP'S
- WEEKLY OR AFTER A 0.5" RAINFALL EVENT
- DURING INSTALLATION OF THE CDS CHAMBER AND CONSTRUCTION OF THE RAIN GARDEN.
- AT FINAL GRADING PRIOR TO FINAL RESTORATION
- AFTER ESTABLISHMENT OF VEGETATIVE GROUND COVER TO OKAY REMOVAL OF TEMPORARY BMP'S.

SECTION D. ANTIDEGRADATION ANALYSIS MODULE

This Section is to be completed for Special Protection Watershed Only. (HQ/EV and EV Wetlands)

PART 1 NON-DISCHARGE ALTERNATIVES EVALUATION

The applicant must consider and describe any and all non-discharge alternatives for the entire project area which are environmentally sound and will:

- **Minimize accelerated erosion and sedimentation during the earth disturbance activity**
- **Achieve no net change from pre-development to post-development volume, rate and concentration of pollutants in water quality**

E & S Plan	Official Use Only	PCSM Plan	Official Use Only
Check off the environmentally sound non-discharge Best Management Practices (BMPs) listed below to be used prior to, during, and after earth disturbance activities that have been incorporated into your E & S Plan based on your site analysis. For BMPs not checked, provide an explanation of why they were not utilized. (attach additional sheets if necessary)		Check off the environmentally sound non-discharge Best Management Practices (BMPs) listed below to be used after construction that have been incorporated into your PCSM Plan based on your site analysis. For BMPs not checked, provide an explanation of why they were not utilized. (attach additional sheets if necessary)	
Non-discharge BMPs ☐ Alternative Siting ☐ Alternative location ☐ Alternative configuration ☐ Alternative location of discharge ☐ Limited Disturbed Area ☐ Limiting Extent & Duration of Disturbance (Phasing, Sequencing) ☐ Riparian Buffers (150 ft min) ☐ Riparian Forest Buffer (150 ft min) ☐ Other _____		**Non-discharge BMPs** ☐ Alternative Siting ☐ Alternative location ☐ Alternative configuration ☐ Alternative location of discharge ☐ Low Impact Development (LID / BSD) ☐ Riparian Buffers (150 ft min) ☐ Riparian Forest Buffer (150 ft min) ☐ Infiltration ☐ Water Reuse ☐ Other _____	

Part 2 Antidegradation Best Available Combination of Technologies (ABACT)

If the net change in stormwater discharge from or after construction is not fully managed by non-discharge BMPs, the applicant must utilize ABACT BMPs to manage the difference. The Applicant must specify whether the discharge will occur during construction, post-construction or both, and identify the technologies that will be used to ensure that the discharge will be a non-degrading discharge. ABACT BMPs include but are not limited to:

E & S Plan	Official Use Only	PCSM Plan	Official Use Only
☐ **Treatment BMPs:** ☐ Sediment basin with skimmer ☐ Sediment basin ratio of 4:1 or greater (flow length to basin width) ☐ Sediment basin with 4-7 day detention ☐ Flocculants ☐ **Land disposal:** ☐ Vegetated filters ☐ Riparian buffers <150ft. ☐ Riparian Forest Buffer <150ft. ☐ Immediate stabilization ☐ **Pollution prevention:** ☐ PPC Plans ☐ Street sweeping ☐ Channels, collectors and diversions lined with permanent vegetation, rock, geotextile or other non-erosive materials ☐ **Stormwater reuse technologies:** ☐ Sediment basin water for dust control ☐ Sediment basin water for irrigation ☐ **Other** _____		☐ **Treatment BMPs:** ☐ Infiltration Practices ☐ Wet ponds ☐ Created wetland treatment systems ☐ Vegetated swales ☐ Manufactured devices ☐ Bio-retention/infiltration ☐ Green Roofs ☐ **Land disposal:** ☐ Vegetated filters ☐ Riparian Buffers <150ft. ☐ Riparian Forest Buffer <150ft. ☐ Disconnection of roof drainage ☐ Bio-retention/bio-infiltration ☐ **Pollution prevention:** ☐ Street sweeping ☐ Nutrient, pesticide, herbicide or other chemical application plan alternatives ☐ PPC Plans ☐ Non-structural Practices ☐ Land Preservation ☐ Restoration BMPs ☐ **Stormwater reuse technologies:** ☐ Cisterns ☐ Rain barrels ☐ Dry hydrant with underground storage ☐ Spray/Drip Irrigation ☐ **Other** _____	
Are the ABACT BMPs selected sufficient to minimize E & S discharges to the extent that existing or designated surface water uses are protected? ☐ Yes ☐ No. If no, and the project is located in a HQ water, proceed to Part 3.		Are the ABACT BMPs selected sufficient to achieve no net change to the extent that existing or designated surface water uses are protected? ☐ Yes ☐ No. If no, and the project is located in a HQ water, proceed to Part 3.	

Part 3 Social or Economic Justification (SEJ) (for projects in high quality waters only)

If the applicant cannot demonstrate that the net change in discharge will protect the existing quality of the receiving surface waters, for projects in HQ waters, the applicant may pursue the SEJ process for demonstrating that lowering water quality is necessary to accommodate important economic or social development in the area in which the waters are located, in accordance with Chapter 10 of the Water Quality Antidegradation Implementation Guidance Manual, DEP Document ID No. 391-0300-002.

SECTION E. CONSULTANT FOR THIS PROJECT

Last Name	First Name	MI
HOEFLER	DONALD	J

Title	Consulting Firm
SENIOR PROJECT ENGINEER	WM SCHUTT & ASSOCIATES 37 ~~CENTRAL~~ AVE, LA

Mailing Address: 37 CENTRAL AVENUE

City	State	ZIP+4
LANCASTER	NY	14086

Email: DHOEFLER@WMSCHUTT.COM

Phone 716-683-5961 Ext 125

FAX 716-683-0169

SECTION F. COMPLIANCE HISTORY REVIEW

Is/was the applicant(s) in violation of any permits issued by DEP or any regulated activities within the past five years?

☐ Yes ☒ No

If yes, list each permit or project that is/was in violation and provide compliance status of the activity (use additional sheets to provide information on all permits).

Permit Program or Activity:

Permit Number (if applicable):

Brief description of non-compliance:

Steps taken to achieve compliance	Date(s) Compliance Achieved

Current Compliance Status: ☒ In-Compliance ☐ In Non-Compliance

If the applicant is not in compliance with any permit requirement of DEP Regulations or regulated activity, provide a narrative description of how the applicant will achieve compliance with the permit requirement or activity, including the schedule for achieving compliance with appropriate milestones.

SECTION G. PERMIT COORDINATION

Does the applicant (owner and/or operator) have, have pending, or require any other environmental permits for this project and any additional planning requirements?

☐ Yes ☒ No If yes, list each permit or approval, permit number, and description.

Coordination Questions

1. Does the project involve any of the following: Placement of fill, excavation within or a placement of a structure located in, along, across, or projecting into a water course, floodway or body of water (including wetlands)?

   ☐ Yes ☒ No If yes, identify which authorization under Chapter 105 is applicable.

   ☐ Joint Permit ☐ General Permit ☐ Waiver

2. What is your 537 Plan status? Please note that 537 Plan approval is required prior to initiation of earth disturbance activity.

3. Is your project associated with a Brownfield's Remediation? ☐ Yes ☒ No If yes, please indicate any coordination to date with the Environmental Cleanup Program (Act 2 or Superfund).

4. Are there any additional permits or approvals that may be required for this project? ☒ Yes ☐ No If yes, please list them.

   TOWN OF HARBORCREEK SITE PLAN APPROVAL

SECTION H. CERTIFICATION

Applicant Certification

I certify under penalty of law that this application and all related attachments were prepared by me or under my direction or supervision by qualified personnel to properly gather and evaluate the information submitted. Based on my own knowledge and on inquiry of the person or persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. The responsible official's signature also verifies that the activity is eligible to participate in the NPDES permit, and that BMP's, E&S Plan, PPC Plan, PCSM Plan, and other controls are being or will be, implemented to ensure that water quality standards and effluent limits are attained. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment or both for knowing violations pursuant to Section 309(c)(4) of the Clean Water Act and, 18 Pa. C.S. §§4903-4904.

Applicant	**Co-Applicant (if applicable)**
GARY CLUNIE	
Print Name and Title of Person Signing	Print Name and Title of Person Signing
(716) 698-8640	( )
Telephone Number of Person Signing	Telephone Number of Person Signing
Signature of Applicant	Signature of Co-Applicant
7/18/2011	
Date Signed	Date Signed

Please note below the name, address and telephone number of the individual that should be contacted in the event additional information is required.

Name: DONALD HOEFLER, WM. SCHUTT AND ASSOCIATES

Address: 37 CENTRAL AVENUE, LANCASTER, NY 14086

Telephone: (716) 683-5961 FAX: (716) 683-0169

Notarization:

Commonwealth of Pennsylvania

County of _____

Sworn to and Subscribed to Before Me This

18 Day of July, 2011

NOTARY

SEAL

SUSAN A. BRIGNON
NOTARY PUBLIC, STATE OF NEW YORK
QUALIFIED IN NIAGARA COUNTY
MY COMMISSION EXPIRES DEC. 31, 2013

Susan A Brignon

Notary Public

My Commission Expires: _____

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT

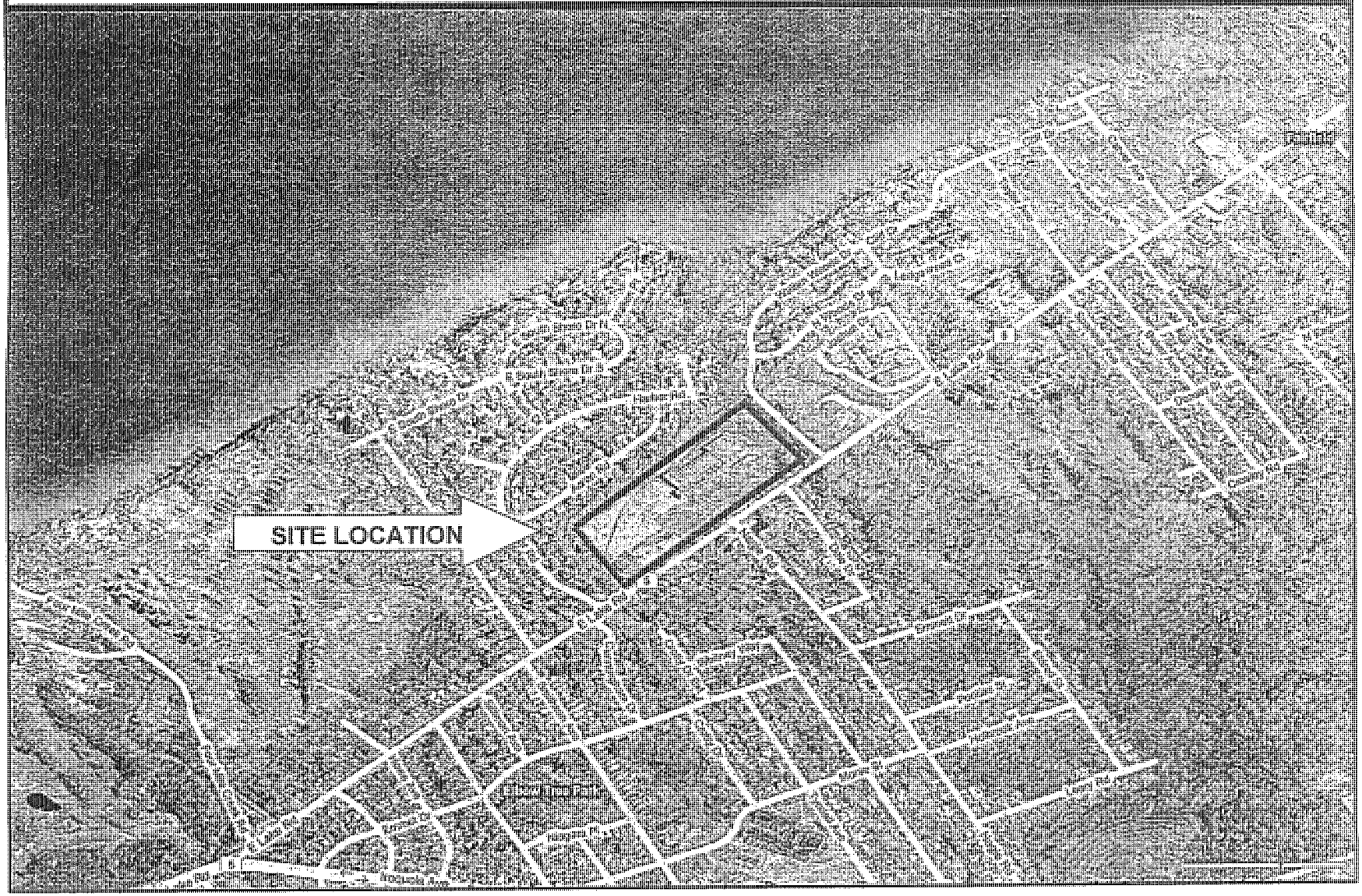
APPLICATION CHECKLIST
GENERAL NPDES PERMIT FOR STORMWATER DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITIES

Please check the following list to make sure that you have included all the required information. Place a check mark in the column provided for all items completed and/or provided. Failure to provide all of the requested information will delay the processing of the application and may result in the application being placed ON HOLD with NO ACTION, or being considered withdrawn and the application file closed.

THIS CHECKLIST MUST BE COMPLETED AND ENCLOSED WITH YOUR GENERAL PERMIT APPLICATION FORM

	✓CHECKLIST FOR NEW GENERAL NPDES PERMIT APPLICATION			Applicant Check √ If Included	Official Use Only
1.	Fully completed, properly signed and notarized Notice of Intent Form (1 original and 2 copies).			☒	☐
2.	Complete Erosion and Sediment Control Plans. (3 copies) Location: Drawings (D), Narrative (N).			☒	☐
	a. Written Narrative *(Must be labeled "E&S Plan" or "Erosion & Sediment Control Plan", be complete & legible, and be the final plan for construction)* Written Narrative Includes the following:	Location N	Page ____	☒	☐
	i. USGS map with outline of project site	Location N	Page Fig 1	☒	☐
	ii. Soils information (including hydric soils) Types, depth, slope and locations of soils	Location N	Page App E	☒	☐
	iii. Physical characteristics and limitations of soils	Location N	Page App C	☒	☐
	iv. Supporting calculations to show anticipated peak flows for the design storms	Location N	Page App I	☒	☐
	v. Analysis of the impact that runoff from the project site will have on existing downstream watercourses resistance to erosion	Location N	Page Page 4	☒	☐
	vi. Provide supporting calculations, standard worksheet, and narrative description of the location for all proposed E&S Control BMPs used before, during and after earth disturbance including but not limited to the following:				
	A. Channels	Location N	Page ____	☐ N/A	☐
	B. Sediment Basins	Location N	Page ____	☐ N/A	☐
	C. Sediment Traps	Location N	Page 19	☒	☐
	D. Filter Fabric Fencing	Location N	Page 19	☒	☐
	E. Outlet Protection	Location N	Page 8	☒	☐
	F. Other BMPs (Specify) Temporary Soil Stockpile, Concrete Washout Pit, Equipment / Material Storage & Temporary Stabilized Entrance	Location N	Page 8	☒	☐

Proposed Harborcreek Senior Apartments
4400 East Lake Road
(T) Harborcreek — Erie County, PA



pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT

OFFICIAL USE ONLY
ID # PAG02 0025 1202
Date Received 2-10-12

PERMIT APPLICATION
NOTICE OF INTENT FOR COVERAGE
UNDER THE GENERAL (PAG-02) NPDES PERMIT
OR
APPLICATION FOR AN INDIVIDUAL NPDES
PERMIT FOR STORMWATER DISCHARGES
ASSOCIATED WITH CONSTRUCTION ACTIVITIES

PLEASE READ THE PERMIT SUMMARY SHEET AND INSTRUCTIONS PROVIDED IN THIS PERMIT APPLICATION PACKAGE BEFORE COMPLETING THIS FORM. COMPLETE THE ATTACHED CHECKLIST AND APPROPRIATE WORKSHEETS ATTACHED AFTER APPENDIX C OF THIS PERMIT APPLICATION. COMPLETE ALL APPLICABLE WORKSHEETS REFERENCED IN THE APPLICATION CHECKLIST.

PLEASE PRINT OR TYPE INFORMATION IN BLACK OR BLUE INK.

CHECK APPROPRIATE BOX	**GENERAL** ☒		**INDIVIDUAL** ☐	
APPLICATION TYPE	**NEW** ☒	**RENEWAL** ☐	**MAJOR MODIFICATION** ☐	**PHASED** ☐

SECTION A. APPLICANT INFORMATION

Applicant's Last Name Cooper, Jr.	First Name David	MI	Phone FAX	614-396-3200 614-396-3243
Email Address: Dcooper@wodagroup.com				
Organization Name or Registered Fictitious Name Arneman Place LP			Phone FAX	614-396-3200
Mailing Address 229 Huber Village Road	City Westerville		State OH	ZIP + 4 43081
			Employer ID (EIN)	
Co-Applicant's Last Name (if applicable)	First Name	MI	Phone FAX	
Email Address				
Organization Name or Registered Fictitious Name			Phone FAX	
Mailing Address	City		State	ZIP + 4

SECTION B. PROJECT INFORMATION AND SITE ANALYSIS

1. Project Name: Arneman Place
2. Total Project Site (Acres): 12.2
3. Total Disturbed Area (Acres): 6.5
4. Project Description

Re-development of a former drive-in movie theater. The proposed project will consist of the construction of 50 apartment units (12 buildings) with a community center and additional appurtenances.

☒ Residential Subdivision	☐ Sewerage/Water System	☐ Private Road/Residence
☐ Commercial/Industrial	☐ Public Road	☐ Government Facility
☐ Utility Facility/Transmission	☐ Recreational	☐ Remediation/Restoration

5. Project Location or Physical Address (if available):

The project is located on the North side of Iroquois Avenue (SR 0955) just east of Nagle Road

6. County	Municipality	City	Boro	Twp
Erie	Harborcreek	☐	☐	☒
		☐	☐	☐

7. Latitude: 42 °/ 09 '/ 12 " Longitude: 80 °/ 00 '/ 20 "

Collection Method: ☒ EMAP ☐ HGIS ☐ GISDR ☐ ITPMP ☐ GPS ☐ WAAS ☐ LORAN

Check the horizontal reference datum (or projection datum) employed in the collection method. EMAP and HGIS (PNDI) have known datum and do not require checking here. ☐ NAD27 ☐ NAD83 ☐ WGS84 (GEO84)

Enter the date of collection if the lat and long coordinates were derived from GPS, WAAS or LORAN. _____ mm _____ dd _____ yyyy

8. U.S.G.S. Quad Map Name Erie North

9. Existing and Previous Uses of the Land Proposed for Construction (use separate sheet if necessary):

Existing Land Uses: ☐ Agriculture ☐ Forest/Woodland ☒ Barren ☐ Urban ☐ Brownfield ☐ Other

Description: _____

Previous Land Uses: ☐ Agriculture ☐ Forest/Woodland ☐ Barren ☐ Urban ☐ Brownfield ☒ Other

Description: Drive In Theater

10. Site Analysis

a. Describe how Natural Resources features on the site (Worksheets 2 and 3 referenced in the Pa. Stormwater BMP Manual) were considered in: Location and Design of the project, E & S Plan Design, PCSM Plan Design. (attach additional sheet if necessary)

The wetlands on-site that are to be mitigated has been minimized to the futheest extent practical and the the existing wetlands that are to remain and the new wetlands are to be protected during construction and placed in a conservation easement.

b. Identify naturally occurring geologic formations or soil conditions that may have the potential to cause pollution during earth disturbance activities and include BMPs to avoid or minimize potential pollution and its impacts from the formation.

N/A

11. Potential Toxic or Hazardous Pollutants: (Submit the following data if soil contaminant, geology or past or present land use provides a potential for contaminated runoff from the project site) N/A ☐ Use additional sheets if necessary.

Pollutant	Concentration w/Units	Source	Sample Type	Date(s) / Number of Samples

12. Fill Material

Based on a cut/fill analysis of the project site, will the site need to import fill, export fill or will the site balance? Be sure to read the instructions before completing this section. Clean Fill can not be placed in or on waters of the Commonwealth.

Check the appropriate box

☒ Import fill – the Operator will, in most situations, be responsible to perform environmental due diligence and determine that all fill imported to the site meets the department's definition of clean fill. The plan designer must include a note on the drawings to identify the operator(s) responsibility and provide the definition of Clean Fill and Environmental Due Diligence.

☐ Export fill – the Applicant is responsible for performing environmental due diligence at the time this application was submitted to determine that any fill exported from the site will be certified as clean fill.

☐ Balance all cuts and fills with the amount of rock and soil available on the site.

13. Estimated Timetable for Phased Projects Build Out (Complete for phased projects only)

Phase No. or Name	Proposed Type of Activity	Total Area	Disturbed Area	Start Date	End Date
1	Development	12.2	6.5	04/12	10/13

14. Stormwater Discharges to nearest receiving stream (during construction). Check all that apply:

Waters of the Commonwealth ☒ Municipal Separate Storm Sewer ☐ Private Storm Sewer ☐ Non Surface Waters ☐

Impaired Waters According to Category 4 or 5 of PA Integrated Water Quality Monitoring and Assessment Report ☐

If waters are impaired list type of impairment: _____

Receiving Water/Watershed Name:	Chapter 93 Receiving Water Classification:	Existing Use (if different from the Designated use)
Five Mile Creek	(Designated use) CWF; MF	
Name of Municipal Storm Sewer Operator:	**Name of Private Storm Sewer Operator:**	**Other: (including off-site discharges)**
Harborcreek Township		

Will you meet CG-1? ☒ Yes ☐ No

If no, you may need to use worksheets 11 through 13.

SECTION C. E & S AND POST CONSTRUCTION STORMWATER MANAGEMENT (PCSM) PLAN

Note: For projects involving multiple watershed boundaries, please submit a complete, separate Section C for each additional watershed.

1. Provide a brief summary of proposed BMPs and their performance to manage E & S for the project. If E & S BMPs and their application do not follow the guidelines referenced in the Pa. Erosion and Sediment Pollution Control Program Manual, provide documentation to demonstrate peformance equivalent to, or better than, the BMPs in the Manual.

E & S BMPs

Non Structural - Minimizing Disturbed Areas

Structural - Rock Construction Entrance, Silt Fence, Inlet Protection

2. **PCSM Plan Information** - The PCSM Plan should be designed to maximize volume reduction technologies, eliminate (where possible) or minimize point source discharges to surface waters, preserve the integrity of stream channels, and protect the physical, biological and chemical qualities of the receiving surface water. **The DEP recommends the use of Control Guideline 1 (CG1) referenced in the Pa. Stormwater BMP Manual to achieve this goal.**

Design standards applied to develop the PCSM Plan. Check those that apply.

☐ Act 167 Plan - The attached PCSM plan is consistent with an applicable approved Act 167 Plan. **A letter of consistency from the Municipal or County Engineer should be provided with the application.** Complete and submit all applicable worksheets referenced in the application checklist as part of the permit application for each approved Act 167 Plan.

Complete the following table for all applicable approved Act 167 Stormwater Management Plans. (use additional sheets if necessary)

ACT 167 Plan Name	Date Adopted	Consistency Letter Included ☐ / Consistency Letter Pending ☐
_____	_____	

☒ The attached PCSM plan is consistent with all applicable local stormwater management ordinances, including MS4 (NPDES Permit to Discharge Stormwater Through a Municipal Separate Storm Sewer System) ordinances. **A letter of consistency from the Municipal or County Engineer should be provided with the application.** Complete and submit all applicable worksheets referenced in the application checklist as part of the permit application.

Complete the following table for all applicable Municipalities. (use additional sheets if necessary)

Municipality Name	Ordinance Number	Consistency Letter Included ☐
Harborcreek Township SWM Ordinance	1993	Consistency Letter Pending ☒

The PCSM Plan must satisfy either subparagraph A, B **or** C below. Check those that apply.

A. ☐ Act 167 Plan approved on or after January 2005 – The attached PCSM Plan, in its entirety, is consistent with all requirements pertaining to rate, volume, and water quality from an Act 167 Stormwater Management Plan approved by DEP on or after January 2005.

B. ☒ The PCSM Plan meets the standard design criteria from the PA Stormwater BMP Manual.

OR

C. ☐ Alternative Design Standard – The attached PCSM plan was developed using approaches other than 102.8(g)(2). Demonstrate/explain in the space provided how this standard will be either more protective than what is required in 102.8(g)(2) or will maintain and protect existing water quality and existing and designated uses.

3. **Riparian Buffers**

A. Will you be protecting, converting or establishing a riparian buffer or a riparian forest buffer as a part of this project?
☐ Yes ☒ No

B. If the regulations require a riparian buffer or riparian forest buffer and you are not providing one, please list the waiver provisions in the Chapter 102 regulations, Section 102.14(d)(2)(*i*)-(*vi*), that you are requesting and provide additional documentation to demonstrate reasonable alternatives for compliance with 102.14 requirements.

C. Will you be protecting, converting or establishing a voluntary riparian forest buffer as part of this project? ☐ Yes ☒ No

If yes you must include a Riparian Forest Buffer Management Plan as part of the PCSM plans.

4. **Summary Table for Supporting Calculation and Measurement Data**

Please reference the Stormwater Methodology used (Numbers generated in this table should be consistent with worksheets 1-5.)

SCS

	Pre-construction	Post Construction	Net Change
Design storm frequency 2 yr Rainfall amount 2.62 inches			
Impervious area (acres)	1 0	2 2.92	3 +2.92
Volume of stormwater runoff ☐ acre-feet or ☒ cubic feet without planned stormwater BMPs (check appropriate box)	4 19,063	5 35,048	6 +15,985
Volume of stormwater runoff ☐ acre-feet or ☒ cubic feet with planned stormwater BMPs (check appropriate box)		7 18,514	8 -549
Stormwater peak discharge rate for the design frequency storm (cubic feet per second)	9 6.6	10 2.4	11 -4.2

Box 1. **Pre-construction impervious area**: The total acres of impervious area on the project site before construction activities begin, based on land use for five years preceding the planned project.

Box 2. **Post construction impervious area**: The total acres of impervious area on the project site after construction activities have been completed.

Box 3. **Net change of impervious area**: The difference between the acres of impervious area listed in Box 1 and Box 2. Zero or negative values are acceptable.

Box 4. **Pre-construction stormwater runoff volume without planned BMPs**: The amount of stormwater runoff volume from the project site that would result from the design storm occurrence before construction activities begin, based on land use for five years preceding the project.

Box 5. **Post construction stormwater runoff volume without planned BMPs**: The amount of stormwater runoff volume from the project site that would result from the design storm occurrence after construction activities have finished assuming that no stormwater infiltration or retention BMPs have been installed.

Box 6. **Net change in stormwater volume without planned BMPs**: The difference between the amounts of stormwater runoff volume listed in Box 4 and Box 5.

Box 7. **Post construction stormwater runoff volume with planned BMPs**: The amount of stormwater runoff volume from the project site that would result from the design storm occurrence after construction activities have finished and the planned stormwater infiltration or retention BMPs have been installed.

Box 8. **Net change in stormwater runoff volume with planned BMPs**: The difference between the amounts of stormwater runoff volume listed in Box 4 and Box 7.

Box 9. **Pre-construction stormwater discharge rate**: The stormwater runoff discharge rate for the design frequency storm as determined by the land use for the past five years.

Box 10. **Post construction stormwater discharge rate**: The stormwater runoff discharge rate for the design frequency storm event after all planned stormwater BMPs are installed.

Box 11. **Net change stormwater discharge rate**: The difference between the stormwater runoff discharge rates listed in Box 9 and Box 10.

5. **Summary Description of Post Construction Stormwater BMPs (consistent with the design or applicable worksheets)**

Key: **RC = Rate Control** **VC = Volume Control** **WQ = Water Quality**

In the lists below, check the BMPs identified in the PCSM Plan, and their function(s) using the above Key. More than one function may be checked for a BMP. List the stormwater volume and area of runoff to be treated by each BMP type. If any BMP in the PCSM Plan is not listed below, describe it in the space provided after "Other".

BMP	Function(s)	Volume of stormwater treated	Acres treated
☒ Wet ponds	☒ VC ☒ RC ☐ WQ	16,492	5.03
☐ Constructed wetlands	☐ VC ☐ RC ☐ WQ		
☐ Retention basins	☐ VC ☐ RC ☐ WQ		
☐ Detention basin	☐ VC ☐ RC ☐ WQ		
☐ Underground detention	☐ VC ☐ RC ☐ WQ		
☐ Dry Extended detention basin	☐ VC ☐ RC ☐ WQ		
☐ Sediment fore bay	☐ VC ☐ RC ☐ WQ		
☐ Infiltration trench	☐ VC ☐ RC ☐ WQ		
☐ Infiltration Berm/Retentive Grading	☐ VC ☐ RC ☐ WQ		
☐ Subsurface Infiltration bed	☐ VC ☐ RC ☐ WQ		
☐ Infiltration basin	☐ VC ☐ RC ☐ WQ		
☐ Pervious pavement	☐ VC ☐ RC ☐ WQ		
☐ Dry well/Seepage pit	☐ VC ☐ RC ☐ WQ		
☐ Bio-infiltration areas	☐ VC ☐ RC ☐ WQ		
☐ Rain gardens/Bio-retention	☐ VC ☐ RC ☐ WQ		
☐ Vegetated swales	☐ VC ☐ RC ☐ WQ		
☐ Constructed filters	☐ VC ☐ RC ☐ WQ		
☒ Protect Sensitive & Special Value Features	☐ VC ☐ RC ☒ WQ		
☐ Protect/Convert/Establish Riparian buffers	☐ VC ☐ RC ☐ WQ		
☒ Restoration: Buffers/ Landscape/Floodplain	☐ VC ☐ RC ☒ WQ		
☐ Disconnection from storm sewers	☐ VC ☐ RC ☐ WQ		
☐ Rooftop disconnection	☐ VC ☐ RC ☐ WQ		
☐ Vegetated roofs	☐ VC ☐ RC ☐ WQ		
☐ Runoff capture/Reuse	☐ VC ☐ RC ☐ WQ		
☐ Oil/grit separators	☐ WQ		
☒ Water quality inserts/inlets	☒ WQ		
☐ Street sweeping	☐ WQ		
☐ Other _____	☐ VC ☐ RC ☐ WQ		
☐ Other _____	☐ VC ☐ RC ☐ WQ		

6. **Off Site Discharge Analysis**

Does the project propose any off-site discharges to areas other than surface waters? ☐ **Yes** ☒ **No**

If yes, the applicant must have appropriate easement that provides the legal authority for this off-site discharge.

Applicant must provide a demonstration in both the E&S and PCSM plans that the discharge will not cause erosion, damage, or nuisance to off-site properties.

7. **Thermal Impacts Analysis**

Please explain how thermal impacts associated with this project were avoided, minimized, or mitigated. As stated in various DEP references, the use of certain techniques can avoid, minimize and mitigate the effect of thermal impacts. Following are some examples of these techniques that have been incorporated into the site development design. These include: 1) reductions in the impervious footprint of the project 2) Planting Trees

8. Identify the critical stages of implementation of the PCSM plan for which a licensed professional or designee shall be present on site: A. Wet Pond Construction B. Wetland Mitigation C. Pipe Trench Plugs in Wetland areas.

SECTION D. ANTIDEGRADATION ANALYSIS MODULE

This Section is to be completed for Special Protection Watershed Only. (HQ/EV and EV Wetlands)

PART 1 NON-DISCHARGE ALTERNATIVES EVALUATION

The applicant must consider and describe any and all non-discharge alternatives for the entire project area which are environmentally sound and will:

- **Minimize accelerated erosion and sedimentation during the earth disturbance activity**
- **Achieve no net change from pre-development to post-development volume, rate and concentration of pollutants in water quality**

E & S Plan	Official Use Only	PCSM Plan	Official Use Only
Check off the environmentally sound non-discharge Best Management Practices (BMPs) listed below to be used prior to, during, and after earth disturbance activities that have been incorporated into your E & S Plan based on your site analysis. For BMPs not checked, provide an explanation of why they were not utilized. (attach additional sheets if necessary)		Check off the environmentally sound non-discharge Best Management Practices (BMPs) listed below to be used after construction that have been incorporated into your PCSM Plan based on your site analysis. For BMPs not checked, provide an explanation of why they were not utilized. (attach additional sheets if necessary)	
Non-discharge BMPs ☐ Alternative Siting ☐ Alternative location ☐ Alternative configuration ☐ Alternative location of discharge ☐ Limited Disturbed Area ☐ Limiting Extent & Duration of Disturbance (Phasing, Sequencing) ☐ Riparian Buffers (150 ft min) ☐ Riparian Forest Buffer (150 ft min) ☐ Other _____		**Non-discharge BMPs** ☐ Alternative Siting ☐ Alternative location ☐ Alternative configuration ☐ Alternative location of discharge ☐ Low Impact Development (LID / BSD) ☐ Riparian Buffers (150 ft min) ☐ Riparian Forest Buffer (150 ft min) ☐ Infiltration ☐ Water Reuse ☐ Other _____	

Part 2 Antidegradation Best Available Combination of Technologies (ABACT)

If the net change in stormwater discharge from or after construction is not fully managed by non-discharge BMPs, the applicant must utilize ABACT BMPs to manage the difference. The Applicant must specify whether the discharge will occur during construction, post-construction or both, and identify the technologies that will be used to ensure that the discharge will be a non-degrading discharge. ABACT BMPs include but are not limited to:

E & S Plan	Official Use Only	PCSM Plan	Official Use Only
☐ **Treatment BMPs:** ☐ Sediment basin with skimmer ☐ Sediment basin ratio of 4:1 or greater (flow length to basin width) ☐ Sediment basin with 4-7 day detention ☐ Flocculants ☐ **Land disposal:** ☐ Vegetated filters ☐ Riparian buffers <150ft. ☐ Riparian Forest Buffer <150ft. ☐ Immediate stabilization ☐ **Pollution prevention:** ☐ PPC Plans ☐ Street sweeping ☐ Channels, collectors and diversions lined with permanent vegetation, rock, geotextile or other non-erosive materials ☐ **Stormwater reuse technologies:** ☐ Sediment basin water for dust control ☐ Sediment basin water for irrigation ☐ **Other** _____		☐ **Treatment BMPs:** ☐ Infiltration Practices ☐ Wet ponds ☐ Created wetland treatment systems ☐ Vegetated swales ☐ Manufactured devices ☐ Bio-retention/infiltration ☐ Green Roofs ☐ **Land disposal:** ☐ Vegetated filters ☐ Riparian Buffers <150ft. ☐ Riparian Forest Buffer <150ft. ☐ Disconnection of roof drainage ☐ Bio-retention/bio-infiltration ☐ **Pollution prevention:** ☐ Street sweeping ☐ Nutrient, pesticide, herbicide or other chemical application plan alternatives ☐ PPC Plans ☐ Non-structural Practices ☐ Land Preservation ☐ Restoration BMPs ☐ **Stormwater reuse technologies:** ☐ Cisterns ☐ Rain barrels ☐ Dry hydrant with underground storage ☐ Spray/Drip Irrigation ☐ **Other** _____	
Are the ABACT BMPs selected sufficient to minimize E & S discharges to the extent that existing or designated surface water uses are protected? ☐ Yes ☐ No. If no, and the project is located in a HQ water, proceed to Part 3.		Are the ABACT BMPs selected sufficient to achieve no net change to the extent that existing or designated surface water uses are protected? ☐ Yes ☐ No. If no, and the project is located in a HQ water, proceed to Part 3.	

Part 3 Social or Economic Justification (SEJ) (for projects in high quality waters only)

If the applicant cannot demonstrate that the net change in discharge will protect the existing quality of the receiving surface waters, for projects in HQ waters, the applicant may pursue the SEJ process for demonstrating that lowering water quality is necessary to accommodate important economic or social development in the area in which the waters are located, in accordance with Chapter 10 of the Water Quality Antidegradation Implementation Guidance Manual, DEP Document ID No. 391-0300-002.

SECTION E. CONSULTANT FOR THIS PROJECT

Last Name	First Name	MI
Sanford	Michael	G

Title	Consulting Firm
President	Sanford Surveying & Engineering P.C.

Mailing Address

4721 Atlantic Avenue

City	State	ZIP+4
Erie	PA	16506

Email	Phone	814-835-0010	Ext
msanford@sanfordsurvey.com	FAX	814-835-0057	

SECTION F. COMPLIANCE HISTORY REVIEW

Is/was the applicant(s) in violation of any permits issued by DEP or any regulated activities within the past five years?

☐ Yes ☒ No

If yes, list each permit or project that is/was in violation and provide compliance status of the activity (use additional sheets to provide information on all permits).

Permit Program or Activity:

Permit Number (if applicable):

Brief description of non-compliance:

Steps taken to achieve compliance	Date(s) Compliance Achieved

Current Compliance Status: ☐ In-Compliance ☐ In Non-Compliance

If the applicant is not in compliance with any permit requirement of DEP Regulations or regulated activity, provide a narrative description of how the applicant will achieve compliance with the permit requirement or activity, including the schedule for achieving compliance with appropriate milestones.

SECTION G. PERMIT COORDINATION

Does the applicant (owner and/or operator) have, have pending, or require any other environmental permits for this project and any additional planning requirements?

☐ Yes ☒ No If yes, list each permit or approval, permit number, and description.

Coordination Questions

1. Does the project involve any of the following: Placement of fill, excavation within or a placement of a structure located in, along, across, or projecting into a water course, floodway or body of water (including wetlands)?

   ☒ Yes ☐ No If yes, identify which authorization under Chapter 105 is applicable.

   ☒ Joint Permit ☐ General Permit ☐ Waiver

2. What is your 537 Plan status? Please note that 537 Plan approval is required prior to initiation of earth disturbance activity.

   Pending

3. Is your project associated with a Brownfield's Remediation? ☐ Yes ☒ No If yes, please indicate any coordination to date with the Environmental Cleanup Program (Act 2 or Superfund).

4. Are there any additional permits or approvals that may be required for this project? ☐ Yes ☒ No If yes, please list them.

SECTION H. CERTIFICATION

Applicant Certification

I certify under penalty of law that this application and all related attachments were prepared by me or under my direction or supervision by qualified personnel to properly gather and evaluate the information submitted. Based on my own knowledge and on inquiry of the person or persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. The responsible official's signature also verifies that the activity is eligible to participate in the NPDES permit, and that BMP's, E&S Plan, PPC Plan, PCSM Plan, and other controls are being or will be, implemented to ensure that water quality standards and effluent limits are attained. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment or both for knowing violations pursuant to Section 309(c)(4) of the Clean Water Act and, 18 Pa. C.S. §§4903-4904.

Applicant	**Co-Applicant (if applicable)**
David Cooper, Jr. Member/General Counsel	
Print Name and Title of Person Signing	Print Name and Title of Person Signing
(614) 396-3200	( )
Telephone Number of Person Signing	Telephone Number of Person Signing
Signature of Applicant	Signature of Co-Applicant
February 8, 2012	
Date Signed	Date Signed

Please note below the name, address and telephone number of the individual that should be contacted in the event additional information is required.

Name: _____

Address: _____

Telephone: ( ) _____ FAX: ( ) _____

Notarization:

Commonwealth of Pennsylvania

County of Franklin

Sworn to and Subscribed to Before Me This

8th Day of February, 2012

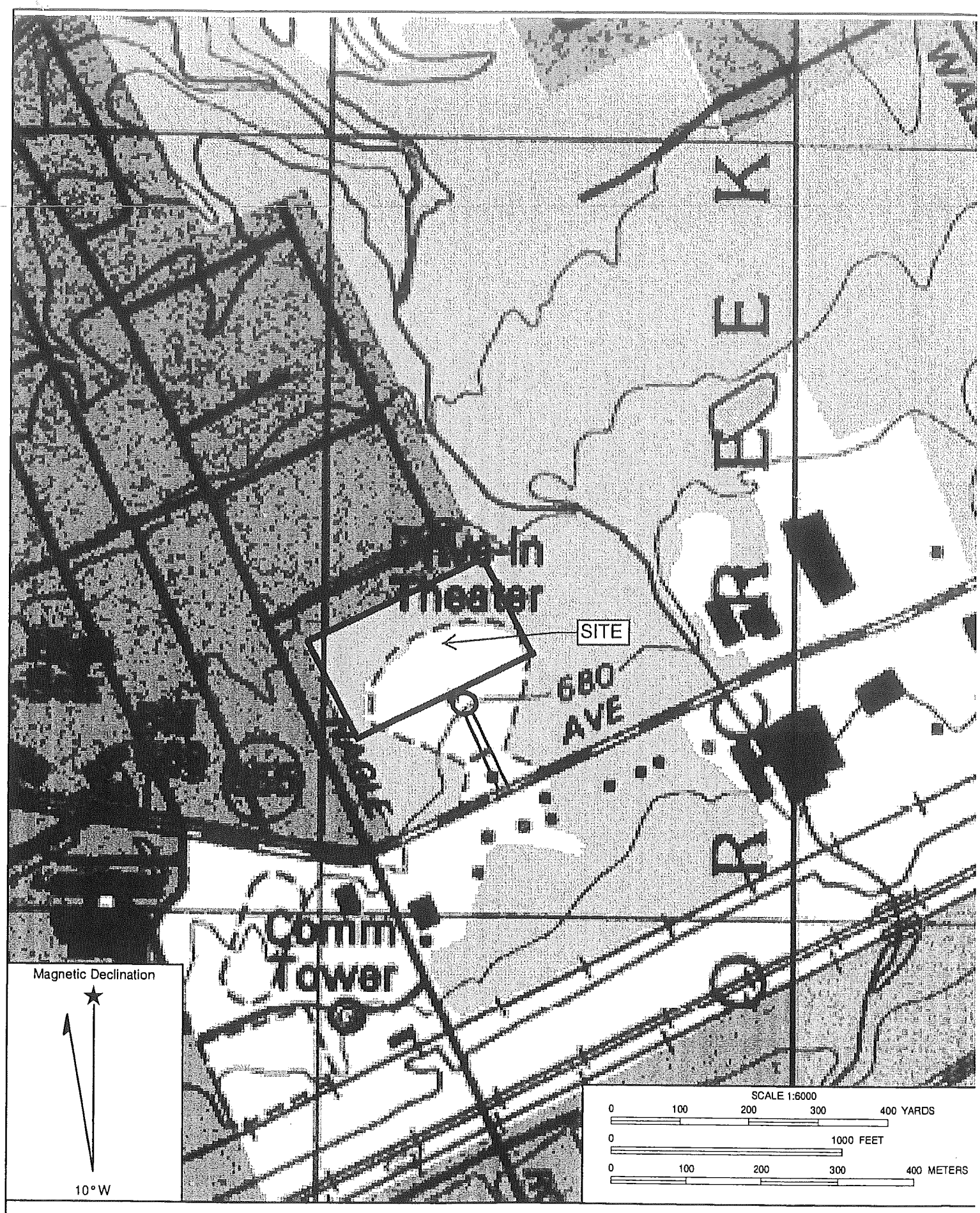
NOTARY SEAL

SHAUNTEE SLONECKER
NOTARY PUBLIC
STATE OF OHIO
Comm. Expires
March 25, 2015
Recorded in
Franklin County

Shauntee Slonecker

Notary Public

My Commission Expires: March 25, 2015



Name: ERIE NORTH
Date: 11/8/2011
Scale: 1 inch equals 500 feet

Location: 042° 09' 15.40" N 080° 00' 17.75" W NAD 27
Caption: Arneman Place

11

3930-PM-WM0035 Rev. 1/2006

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT

OFFICIAL USE ONLY
ID # PAG200250708
Date Received 6/15/07

NOTICE OF INTENT FOR COVERAGE UNDER THE GENERAL (PAG-2) NPDES PERMIT OR APPLICATION FOR AN INDIVIDUAL NPDES PERMIT FOR STORMWATER DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITIES

READ THE STEP-BY-STEP INSTRUCTIONS PROVIDED IN THIS PERMIT APPLICATION PACKAGE BEFORE COMPLETING THIS FORM.

☒ 1 acre to less than 5 acres of disturbance with a point source discharge ☐ 5 acres or larger disturbance

PLEASE PRINT OR TYPE INFORMATION IN BLACK OR BLUE INK.

CHECK APPROPRIATE BOX	GENERAL ☒	INDIVIDUAL ☐	
APPLICATION TYPE	NEW ☒	RENEWAL ☐	REVISED ☐

SECTION A. E&S PLANNING REQUIREMENTS

1. Total Project Area (Acres): 4.48 +/- Total Disturbed Area (Acres): 2.9 +/-

2. Project Name East Lake Road Alliance Church

3. Project Description

Addition of an 8910 square foot addition to existing building with approx. 42600 sf of parking.

☐ Residential Subdivision ☐ Sewerage/Water System ☐ Private Road/Residence
☒ Commercial/Industrial ☐ Public Road ☐ Government Facility
☐ Utility Facility/Transmission ☐ Recreational ☐ Remediation/Restoration

4. Please provide the latitude and longitude coordinates for the center of the project. The coordinates should be in degrees, minutes and seconds (dd mm ss.ss) Check the collection method used to determine the lat and long coordinates. See the instructions for a description of the collection methods.

Latitude: 42 ° 10 ' 31.1 " Longitude: 79 ° 59 ' 08.4 "

Collection Method: ☐ EMAP ☐ HGIS ☐ GISDR ☒ ITPMP ☐ GPS ☐ WAAS ☐ LORAN

Check the horizontal reference datum (or projection datum) employed in the collection method. EMAP and HGIS (PNDI) have known datum and do not require checking here. ☒ NAD27 ☐ NAD8 3 ☐ W GS84 (GEO84)

Enter the date of collection if the lat and long coordinates were derived from GPS, WAAS or LORAN. _____ mm _____ dd _____ yyyy

5. U.S.G.S. Quad Map Name Harborcreek, PA

6. Estimated Timetable for Major Construction Activities: (Phased projects only) NA - no phasing is proposed

Phase No. or Name	Description	Total Area	Disturbed Area	Start Date	End Date

Rev: 5/10/07

7. Existing and Previous Uses of the Land Proposed for Construction (use separate sheet if necessary):

Existing Land Uses: ☐ Agriculture ☐ Forest/Woodland ☐ Barren ☒ Urban ☐ Brownfield ☐ Other

Description: Lawn, building & parking

Previous Land Uses: ☐ Agriculture ☒ Forest/Woodland ☐ Barren ☐ Urban ☐ Brownfield ☒ Other

Description: Field woodlot

8. Potential Pollutants: (Submit the following data if soil contaminant, geology or past or present land use provides a potential for contaminated runoff from the project site) N/A ☒ Use additional sheets if necessary.

Pollutant	Concentration w/Units	Source	Sample Type	Date(s) / Number of Samples
(1)				
(2)				

Clearly indicate the source/location of the potential pollutant(s) on the Erosion and Sediment Control (E&S) Plan drawings, and describe in the E&S plan narrative what measures are proposed to manage and control discharges of these pollutants to eliminate the potential for pollution to surface waters of the Commonwealth.

9. Describe the type, source and location of any fill materials: **Be sure to read the instructions before completing this section.**

Clean Fill is uncontaminated, non-water soluble, non-decomposable, inert, solid material. The term includes soil, rock, stone, dredged material, used asphalt, and brick, block or concrete from construction and demolition activities that is separate from other waste and recognizable as such. The term does not include materials placed in or on the waters of the Commonwealth unless otherwise authorized.

Check the appropriate box

☒ All of the fill material placed on, or removed from the project site is Clean Fill, that, upon the performance of environmental due diligence, was found to have not been affected by a spill or release of a regulated substance.

☐ Some or all of the fill material placed on, or removed from, the project site is Clean Fill that has been affected by a spill or release of a regulated substance. Any person placing this fill on a property must use form FP-001 to certify the origin of the fill material and the results of analytical testing to qualify the material as clean fill. A copy of this form must be retained by the owner of the property receiving the fill (waste/spoil areas and cut/borrow areas).

10. Summary of E&S Control BMPs as detailed in the attached E&S Plan:

1. Silt fence
2. Rock construction entrance
3. Erosion Control Blanket Channel Lining

11. Stormwater Discharges to (during construction):

Waters of the Commonwealth ☒ Municipal Separate Storm Sewer ☐ Private Storm Sewer ☐

12. Receiving Water/Watershed Name:	Name of Municipal Storm Sewer Operator:	Name of Private Storm Sewer Operator:
Unnamed tributary to Sixmile Creek	NA	NA
13. Chapter 93 Receiving Water Classification:	**Secondary Water:**	**Other:**
CWF; MF	Lake Erie	NA

3930-PM-WM0035 Rev. 1/2006

SECTION B. APPLICANT INFORMATION

Applicant's Last Name	First Name	MI	Phone / FAX
Rubeis	Richard	NA	Phone 814/898-2771 FAX NA

Organization Name or Registered Fictitious Name	Phone / FAX
East Lake Road Alliance Church	Phone 814/898-2771 FAX NA

Mailing Address	City	State	ZIP + 4
4500 East Lake Road	Erie	PA	16511

Co-Applicant's Last Name	First Name	MI	Phone / FAX
NA			Phone FAX

Organization Name or Registered Fictitious Name	Phone / FAX
NA	Phone FAX

Mailing Address	City	State	ZIP + 4
NA			

SECTION C. SITE INFORMATION

Site Name
East Lake Road Alliance Church

Site Location
4500 East Lake Road

Site Location -- City	State	ZIP+4
Erie (Harborcreek Township)	PA	16511

Detailed Written Directions to Site

From US Route 5(East Lake Road) & PA Route 956 (Iroquois Avenue) intersection, proceed east on Route 5 approximately 2.44 miles to site on left (north).

County	Municipality	City	Boro	Twp
Erie	Harborcreek	☐	☐	☒
		☐	☐	☐
		☐	☐	☐

SECTION D. OTHER POLLUTANTS; PREPAREDNESS PREVENTION AND CONTINGENCY (PPC) PLAN

1. Will chemicals, solvents, other hazardous waste or materials that have the potential to cause accidental pollution during earth disturbance activities be used or stored on site? Yes ☐ No ☒ **(If yes, a PPC Plan is required)**

SECTION E. POST CONSTRUCTION STORMWATER MANAGEMENT (PCSM) PLAN
See the Attached Instructions on how to Complete This Section

All PCSM plans should be designed to maximize infiltration technology, eliminate or minimize point source discharges to surface waters, preserve the integrity of stream channels, and protect the physical, chemical and biological qualities of the receiving water. In addition to these water quality design features, all PCSM plans must comply with local water quantity or flood control requirements.

Check those that apply:

☐ The attached PCSM plan was developed to be consistent with an Act 167 Stormwater Management Plan approved by the Department after July 2001.

☐ The attached PCSM plan was developed to be consistent with existing local ordinances that satisfy the requirements of an MS4 (NPDES Permit to Discharge Stormwater Through a Municipal Separate Storm Sewer System) permit.

☒ The attached PCSM plan was developed to employ water quality design features and BMPs that will manage any net increase in stormwater runoff volume resulting from the DEP recommended 2-year/24-hour frequency storm.

1. Please include the following as part of the PCSM plan:
   a. A written narrative.
   b. Plan drawings including construction details.
   c. Identification and location of post construction stormwater management BMPs. Such BMPs should address:
      - Infiltration
      - Volume and rate control
      - Water quality treatment
   d. Operation and maintenance procedures.
   e. Supporting calculations. (Supporting calculations and measurements are not required if the disturbed areas will be revegetated or otherwise stabilized with pervious material.)

2. Explain how post construction stormwater runoff volume will be managed if BMPs will not infiltrate the total net increase in stormwater runoff volume. (Net increase volume = Post construction runoff volume minus Pre-construction runoff volume):

   ☒ N/A (check N/A only if BMPs **will** infiltrate all of the Net Change in Runoff)

3. Are there existing post construction stormwater management (PCSM) BMPs at this location/site? ☒ YES ☐ NO

   Do you plan to use or expand any of these existing PCSM BMPs? ☐ YES ☒ NO

   List the existing PCSM BMPs that will be used or expanded.

4. **SUMMARY TABLE FOR SUPPORTING CALCULATION AND MEASUREMENT DATA**
See the Instructions on how to Complete This Section

☐ Check this box if supporting calculations and measurements are NOT required in accordance with Section E.1.e on the preceding page.

Design storm frequency 2-year/24-hour Rainfall amount 2.62 inches	Pre-construction	Post Construction	Net Change
Impervious area (acres)	0.82	2.06	+1.241
Volume of stormwater runoff (acre-feet) without planned stormwater BMPs	0.3186	0.4808	+0.1622
Volume of stormwater runoff (acre-feet) with planned stormwater BMPs		0.3186	+ 0.0
Stormwater discharge rate for the design frequency storm (Cubic feet per second -cfs)	3.39	1.74	- 2.65

SUMMARY DESCRIPTION OF POST CONSTRUCTION STORMWATER BMPs

5. In the lists below, check the BMPs identified in the PCSM Plan. Indicate the function(s) of the BMP by checking **DR** for the function detention/retention; checking **IF** for infiltration/recharge; or checking **WQ** for water quality treatment. More than one function may be checked for a BMP. List the stormwater volume and area of runoff to be treated by each BMP type. If any BMP in the PCSM Plan is not listed below, describe it in the space provided after "Other".

BMP	Function(s)	(acre-feet) Volume of stormwater treated	Acres treated
☐ Wet ponds	☐ DR ☐ IF ☐ WQ		
☐ Constructed wetlands	☐ DR ☐ IF ☐ WQ		
☐ Retention basins	☐ DR ☐ IF ☐ WQ		
☒ Detention basin	☒ DR ☐ IF ☐ WQ	0.3395	4.2
☒ Underground detention	☒ DR ☒ IF ☒ WQ	0.2353	1.44
☐ Extended detention basin	☐ DR ☐ IF ☐ WQ		
☐ Water quality fore bay	☐ DR ☐ IF ☐ WQ		
☐ Infiltration trench	☐ DR ☐ IF ☐ WQ		
☐ Infiltration bed	☐ DR ☐ IF ☐ WQ		
☐ Infiltration basin	☐ DR ☐ IF ☐ WQ		
☒ Porous pavement	☒ DR ☒ IF ☐ WQ	0.2353	1.44
☐ Dry well	☐ DR ☐ IF ☐ WQ		
☐ Bio-infiltration areas	☐ DR ☐ IF ☐ WQ		
☐ Rain gardens/Bio-retention	☐ DR ☐ IF ☐ WQ		
☒ Vegetated filter swales	☐ DR ☐ IF ☒ WQ	0.3188	1.44
☐ Sand/organic filters	☐ DR ☐ IF ☐ WQ		
☐ Natural area conservation	☐ DR ☐ IF ☐ WQ		
☐ Filter/buffer strips	☐ DR ☐ IF ☐ WQ		
☐ Surfaces drain to vegetated areas	☐ DR ☐ IF ☐ WQ		
☐ Downspouts to vegetated areas	☐ DR ☐ IF ☐ WQ		
☐ Green roofs	☐ DR ☐ IF ☐ WQ		
☐ Cisterns/rain barrels	☐ DR ☐ IF ☐ WQ		
☐ Oil/grit separators	☐ DR ☐ IF ☐ WQ		
☐ Water quality inserts/inlets	☐ DR ☐ IF ☐ WQ		
☐ Street sweeping	☐ DR ☐ IF ☐ WQ		
☐ Other _____	☐ DR ☐ IF ☐ WQ		
☐ Other _____	☐ DR ☐ IF ☐ WQ		

SECTION F. CONSULTANT FOR THIS PROJECT

Last Name	First Name	MI
Patterson	John	K

Title	Consulting Firm
Project Engineer	Lake Engineering

Mailing Address
140 Meadville Street

City	State	ZIP+4
Edinboro	PA	16412-2508

Email
john@lake-eng.com

Phone 814/734-1414 Ext 02
FAX 814/734-4339

SECTION G. PERMIT COORDINATION AND COMPLIANCE REVIEW

Does the applicant (owner and/or operator) have or require any other Department permit or approval for this project?

☒ Yes ☐ No If yes, list each permit or approval, permit number, and description.

GP-4 Outfall

Compliance History Review:

Is/was applicant in violation of any permits issued by DEP? ☐ Yes ☒ No

If yes, list each permit that is/was in violation and provide compliance status of the permitted activity (use additional sheets to provide information on all permits).

Permit Program:

Permit Number:

Brief description of Non-Compliance:

Steps taken to achieve compliance and date(s) compliance achieved:

Current Compliance Status: ☐ In-Compliance ☐ In Non-Compliance

If the applicant is not in compliance with any environmental law or regulation, permit, order or schedule of compliance of the Department, provide a narrative description of how the applicant will achieve compliance including the appropriate milestones.

SECTION H. CERTIFICATION

Applicant Certification

I certify under penalty of law that this application and all related attachments were prepared by me or under my direction or supervision by qualified personnel to properly gather and evaluate the information submitted. Based on my own knowledge and on inquiry of the person or persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. The responsible official's signature also verifies that the activity is eligible to participate in the NPDES permit, and that BMP's, E&S Plan, PPC Plan, PCSM Plan, and other controls are being or will be, implemented to ensure that water quality standards and effluent limits are attained. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment or both for knowing violations pursuant to Section 309(c)(4) of the Clean Water Act and, 18 Pa. C.S. §§4903-4904.

Applicant	**Co-Applicant (if applicable)**
Richard Rubeis, Pastor	NA
Print Name and Title of Person Signing	Print Name and Title of Person Signing
(814) 898-2771	( )
Telephone Number of Person Signing	Telephone Number of Person Signing
Signature of Applicant	Signature of Co-Applicant
3/22/07	
Date Signed	Date Signed

Please note below the name, address and telephone number of the individual that should be contacted in the event additional information is required.

Name: John K Patterson, PE - Lake Engineering

Address: 140 Meadville Street, Edinboro, PA 16412

Telephone: (814) 734-1414 x 02 FAX: (814) 734-4339

Notarization:

Commonwealth of Pennsylvania

County of Erie

Sworn to and Subscribed to Before Me This

22nd Day of March, 20 07

NOTARY SEAL

Kent Kuholski

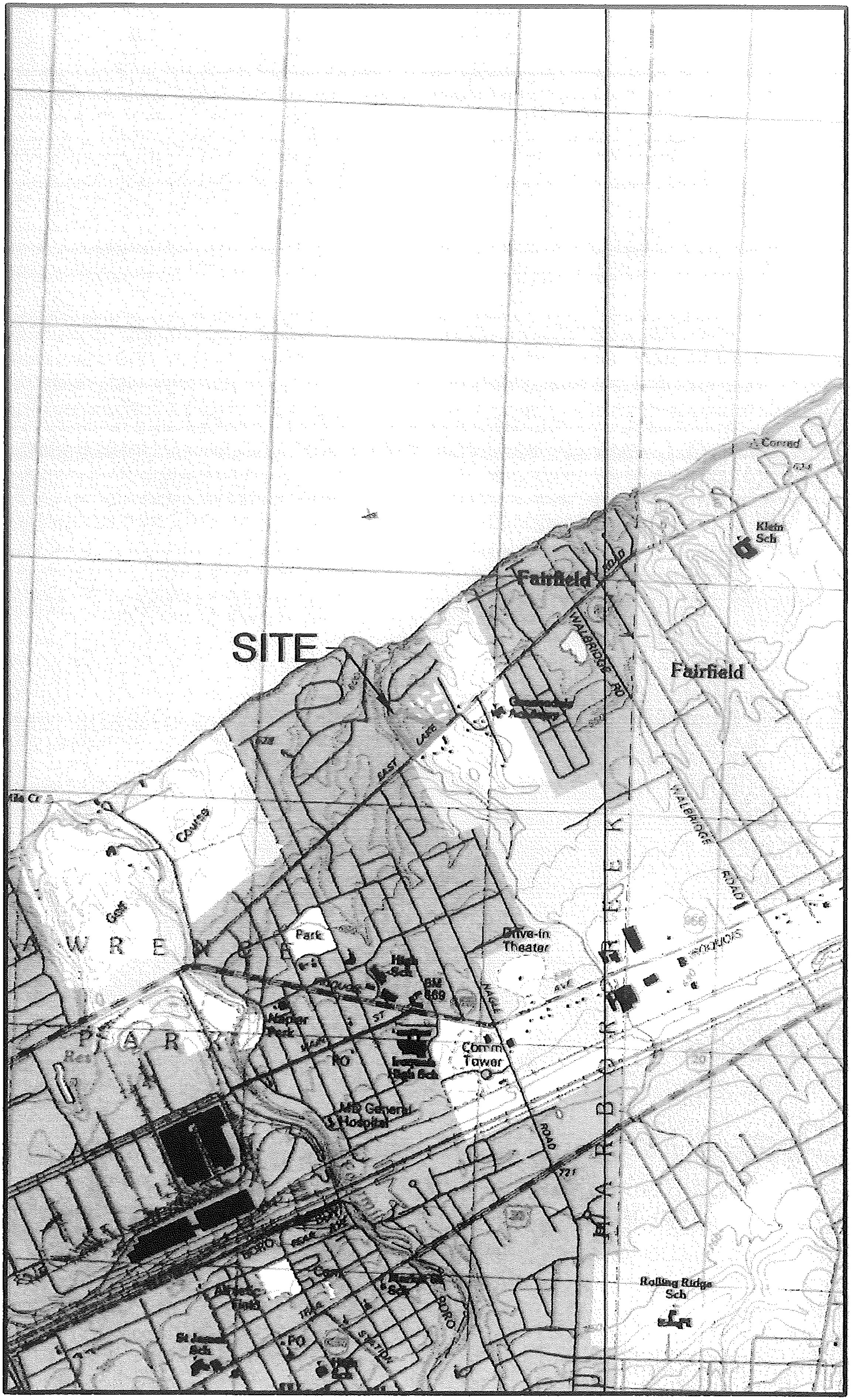
Notary Public

My Commission Expires:

NOTARIAL SEAL
KENT M KUHOLSKI
Notary Public
EDINBORO BOROUGH, ERIE COUNTY
My Commission Expires Mar 14, 2009

LOCATION MAP

(SCALE 1"=2000')



EAST LAKE ROAD
ALLIANCE CHURCH

HARBORCREEK TOWNSHIP
ERIE COUNTY

USGS QUADRANGLES
HARBORCREEK 1996
ERIE NORTH 1996

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT

OFFICIAL USE ONLY
ID # PAG 200250504
Date Received 11/12/04

NOTICE OF INTENT FOR COVERAGE UNDER THE GENERAL (PAG-2) NPDES PERMIT OR APPLICATION FOR AN INDIVIDUAL NPDES PERMIT FOR STORMWATER DISCHARGES ASSOCIATED WITH CONSTRUCTION ACTIVITIES

Read the step-by-step instructions provided in this Permit Application Package before completing this form.

☐ **1 acre to less than 5 acres of disturbance with a point source discharge** ☒ **5 acres or larger disturbance**

PLEASE PRINT OR TYPE INFORMATION IN BLACK OR BLUE INK.

CHECK APPROPRIATE BOX	GENERAL ☒	INDIVIDUAL ☐	
APPLICATION TYPE	NEW ☐	RENEWAL ☒	REVISED ☐

SECTION A. E&S PLANNING REQUIREMENTS

1. Total Project Acres: 68.90 Total Disturbed Acres: 12.99

2. Project Name

VILLAGE OF FOXWOOD - SECTION 7 & 8

3. Project Description

CONSTRUCTION OF 48 SINGLE-FAMILY RESIDENTIAL LOTS

☒ Residential Subdivision ☐ Sewerage/Water System ☐ Private Road/Residence
☐ Commercial/Industrial ☐ Public Road ☐ Government Facility
☐ Utility Facility/Transmission ☐ Recreational ☐ Remediation/Restoration

4. Please provide the latitude and longitude coordinates for the center of the project. The coordinates should be in degrees, minutes and seconds (dd mm ss.ss) Check the collection method used to determine the lat and long coordinates. See the instructions for a description of the collection methods.

Latitude: 42 °/ 07 '/ 49 " Longitude: 79 °/ 59 '/ 05 "

Collection Method: ☐ EMAP ☐ HGIS ☒ GISDR ☐ ITPMP ☐ GPS ☐ WAAS ☐ LORAN

Check the horizontal reference datum (or projection datum) employed in the collection method. EMAP and HGIS (PNDI) have known datum and do not require checking here. ☐ NAD27 ☒ NAD83 ☐ GEO84

Enter the date of collection if the lat and long coordinates were derived from GPS, WAAS or LORAN. _____ mm _____ dd _____ yyyy

5. U.S.G.S. Quad Map Name HARBORCREEK

6. Estimated Timetable for Major Construction Activities: (Phased projects only)

Phase No. or Name	Description	Total Acres	Disturbed Acres	Start Date	End Date
PHASE 1	SUBDIVISION #7	7.39	4.71	JAN 05	JUNE 07
PHASE 2	SUBDIVISION #8	8.69	8.28	JUNE 07	DEC 09

7. Existing and Previous Uses of the Land Proposed for Construction (use separate sheet if necessary):

Existing Land Uses: ☐ Agriculture ☒ Forest/Woodland ☐ Barren ☐ Urban ☐ Brownfield ☐ Other

Description: _____

Previous Land Uses: ☐ Agriculture ☒ Forest/Woodland ☐ Barren ☐ Urban ☐ Brownfield ☐ Other

Description: _____

8. Potential Pollutants: (Submit the following data if soil properties, geology or past or present land use provides a potential for contaminated runoff from the project site) N/A ☒ Use additional sheets if necessary.

Pollutant	Concentration w/Units	Source	Sample Type	Date(s) / Number of Samples
(1)				
(2)				

Clearly indicate the source/location of the potential pollutant(s) on the Erosion and Sediment Control (E&S) Plan drawings, and describe in the E&S plan narrative what measures are proposed to manage and control discharges of these pollutants to eliminate the potential for pollution to surface waters of the Commonwealth.

9. Describe the type, source and location of any fill materials: **Be sure to read the instructions before completing this section.**

Clean Fill is uncontaminated, non-water soluble, non-decomposable, inert, solid material. The term includes soil, rock, stone, dredged material, used asphalt, and brick, block or concrete from construction and demolition activities that is separate from other waste and recognizable as such. The term does not include materials placed in or on the waters of the Commonwealth unless otherwise authorized.

Check the appropriate box

☒ All of the fill material placed on, or removed from the project site is Clean Fill, that, upon the performance of environmental due diligence, was found to have not been affected by a spill or release of a regulated substance.

☐ Some or all of the fill material placed on, or removed from, the project site is Clean Fill that has been affected by a spill or release of a regulated substance. Any person placing this fill on a property must use form FP-001 to certify the origin of the fill material and the results of analytical testing to qualify the material as clean fill. A copy of this form must be retained by the owner of the property receiving the fill (waste/spoil areas and cut/borrow areas).

10. Summary of E&S Control BMPs as detailed in the attached E&S Plan:

FILTER FABRIC FENCE
GRASS-LINED SWALES
STONE & CONCRETE BLOCK INLET PROTECTION
SEDIMENT EMBANKMENT TRAPS

11. Stormwater Discharges to (during construction):

Waters of the Commonwealth ☒ Municipal Separate Storm Sewer ☒ Private Storm Sewer ☐

12. Receiving Water/Watershed Name:	Name of Municipal Storm Sewer Operator:	Name of Private Storm Sewer Operator:
UNT SIX MILE CREEK	HARBORCREEK TWP	
13. Chapter 93 Receiving Water Classification:	**Secondary Water:**	**Other:**
CWF, MF	UNT SIX MILE CREEK	

SECTION B. APPLICANT INFORMATION

Applicant's Last Name	First Name	MI	Phone	814-899-7561
SHAFER	TIM		FAX	
Organization Name or Registered Fictitious Name			Phone	
TIM SHAFER & SONS CONSTRUCTION			FAX	
Mailing Address	City		State	ZIP + 4
211 PRESTON AVE,	ERIE		PA	16511
Co-Applicant's Last Name	First Name	MI	Phone	
			FAX	
Organization Name or Registered Fictitious Name			Phone	
			FAX	
Mailing Address	City		State	ZIP + 4

SECTION C. SITE INFORMATION

Site Name

VILLAGE OF FOXWOOD

Site Location

EAST SIDE OF ROUTE 430 JUST SOUTH OF COOPER ROAD

Site Location -- City	State	ZIP+4
HARBORCREEK TWP. - ERIE	PA	

Detailed Written Directions to Site

I-90 TO EXIT 32 - NORTH ON RT.430 / STATION ROAD APPROXIMATELY 1.6 MILES. VILLAGE OF FOXWOOD IS LOCATED ON THE EAST SIDE OF RT 430.

County	Municipality	City	Boro	Twp
ERIE	HARBORCREEK	☐	☐	☒
		☐	☐	☐
		☐	☐	☐

SECTION D. OTHER POLLUTANTS; PREPAREDNESS PREVENTION AND CONTINGENCY (PPC) PLAN

1. Will chemicals, solvents, other hazardous waste or materials that have the potential to cause accidental pollution during earth disturbance activities be used or stored on site? Yes ☐ No ☒ **(If yes, a PPC Plan is required)**

SECTION E. POST CONSTRUCTION STORMWATER MANAGEMENT (PCSM) PLAN
See the Attached Instructions on how to Complete This Section

All PCSM plans should be designed to maximize infiltration technology, eliminate or minimize point source discharges to surface waters, preserve the integrity of stream channels, and protect the physical, chemical and biological qualities of the receiving water. In addition to these water quality design features, all PCSM plans must comply with local water quantity or flood control requirements.

Check those that apply:

☒ The attached PCSM plan was developed to be consistent with existing local ordinances enacted under an Act 167 Stormwater Management Plan approved by the Department after July 2001.

☐ The attached PCSM plan was developed to be consistent with existing local ordinances that satisfy the requirements of an MS4 (NPDES Permit to Discharge Stormwater Through a Municipal Separate Storm Sewer System) permit.

☐ The attached PCSM plan was developed to employ water quality design features and BMPs that will manage any net increase in stormwater runoff volume resulting from a 2-year/ 24-hour frequency storm.

1. Please include the following as part of the PCSM plan:
   a. A written narrative.
   b. Plan drawings including construction details.
   c. Identification and location of post construction stormwater management BMPs. Such BMPs should address:
      - Infiltration
      - Volume and rate control
      - Water quality treatment
   d. Operation and maintenance procedures.
   e. Supporting calculations. (Supporting calculations and measurements are not required if the disturbed areas will be revegetated or otherwise stabilized with pervious material.)

2. Explain how post construction stormwater runoff volume will be managed if BMPs will not infiltrate the total net increase in stormwater runoff volume. (Net increase volume = Post construction runoff volume minus Pre-construction runoff volume):

   ☐ N/A (check N/A only if BMPs **will** infiltrate all of the Net Change in Runoff)

   STORMWATER RUNOFF WILL BE DIRECTED TO GRASS-LINED SWALES ALONG THE REAR YARDS OF THE PPROPOSED LOTS. THESE SWALES WILL DIRECT RUNOFF TO THE EXISTING & PROPOSED STORM SEWER WHICH CONVEYS THE RUNOFF TO THE STORMWATER DETENTION POND.

3. Are there existing post construction stormwater management (PCSM) BMPs at this location/site? ☒ YES ☐ NO

   Do you plan to use or expand any of these existing PCSM BMPs? ☒ YES ☐ NO

   List the existing PCSM BMPs that will be used or expanded.

   STORMWATER MANAGAMENT POND

   EXISTING STORM SEWER FROM SECTIONS 3 & 4.

4. **SUMMARY TABLE FOR SUPPORTING CALCULATION AND MEASUREMENT DATA**
See the Instructions on how to Complete This Section

☐ Check this box if supporting calculations and measurements are NOT required in accordance with Section E.1.e on the preceding page.

Design storm frequency _____ Rainfall amount 2.62 inches	Pre-construction	Post Construction	Net Change
Impervious area (acres)	0	5.08	5.08
Volume of stormwater runoff (acre-feet) without planned stormwater BMPs	1.119	0	1.119
Volume of stormwater runoff (acre-feet) with planned stormwater BMPs		1.378	1.378
Stormwater discharge rate for the design frequency storm	10.13	6.53	-3.6

SUMMARY DESCRIPTION OF POST CONSTRUCTION STORMWATER BMPs

5. In the lists below, check the BMPs identified in the PCSM Plan. Indicate the function(s) of the BMP by checking **DR** for the function detention/retention; checking **IF** for infiltration/ recharge; or checking **WQ** for water quality treatment. More than one function may be checked for a BMP. List the stormwater volume and area of runoff to be treated by each BMP type. If any BMP in the PCSM Plan is not listed below, describe it in the space provided after "Other".

BMP	Function(s)	Volume of stormwater treated	Acres treated
☐ Wet ponds	☐ DR ☐ WQ		
☐ Constructed wetlands	☐ DR ☐ WQ		
☐ Retention basins	☐ DR		
☒ Detention basin	☒ DR		61.06
☐ Underground detention	☐ DR		
☐ Extended detention basin	☐ DR ☐ WQ		
☐ Water quality fore bay	☐ DR ☐ WQ		
☐ Infiltration trench	☐ DR ☐ IF ☐ WQ		
☐ Infiltration bed	☐ DR ☐ IF ☐ WQ		
☐ Infiltration basin	☐ DR ☐ IF ☐ WQ		
☐ Porous pavement	☐ DR ☐ IF		
☐ Dry well	☐ DR ☐ IF		
☐ Bio-infiltration areas	☐ DR ☐ IF ☐ WQ		
☐ Rain gardens/Bio-retention	☐ DR ☐ WQ		
☒ Vegetated filter swales	☒ IF ☒ WQ		3.87
☐ Sand/organic filters	☐ IF ☐ WQ		
☐ Natural area conservation	☐ DR ☐ IF ☐ WQ		
☐ Filter/buffer strips	☐ DR ☐ IF ☐ WQ		
☐ Surfaces drain to vegetated areas	☐ DR ☐ IF ☐ WQ		
☐ Downspouts to vegetated areas	☐ DR ☐ IF ☐ WQ		
☐ Green roofs	☐ DR ☐ WQ		
☐ Cisterns/rain barrels	☐ DR		
☐ Oil/grit separators	☐ WQ		
☐ Water quality inserts/inlets	☐ WQ		
☐ Street sweeping	☐ WQ		
☐ Other _____	☐ DR ☐ IF ☐ WQ		
☐ Other _____	☐ DR ☐ IF ☐ WQ		

SECTION F. CONSULTANT FOR THIS PROJECT

Last Name	First Name	MI
WELKA	JAMES	T.

Title	Consulting Firm
PRESIDENT	HENRY T. WELKA ASSOCIATES

Mailing Address

3200 WEST 32ND STREET

City	State	ZIP+4
ERIE	PA	16506

Email

Phone 8148333900 Ext

FAX 8148339550

SECTION G. PERMIT COORDINATION AND COMPLIANCE REVIEW

Does the applicant (owner and/or operator) have or require any other Department permit or approval for this project?

☐ Yes ☒ No If yes, list each permit or approval, permit number, and description.

Compliance History Review:

Is/was applicant in violation of any permits issued by DEP? ☐ Yes ☒ No

If yes, list each permit that is/was in violation and provide compliance status of the permitted activity (use additional sheets to provide information on all permits).

Permit Program:

Permit Number:

Brief description of Non-Compliance:

Steps taken to achieve compliance and date(s) compliance achieved:

Current Compliance Status: ☐ In-Compliance ☐ In Non-Compliance

If the applicant is not in compliance with any environmental law or regulation, permit, order or schedule of compliance of the Department, provide a narrative description of how the applicant will achieve compliance including the appropriate milestones.

SECTION H. CERTIFICATION

Applicant Certification

I certify under penalty of law that this application and all related attachments were prepared by me or under my direction or supervision by qualified personnel to properly gather and evaluate the information submitted. Based on my own knowledge and on inquiry of the person or persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. The responsible official's signature also verifies that the activity is eligible to participate in the NPDES permit, and that BMP's, E&S Plan, PPC Plan, PCSM Plan, and other controls are being or will be, implemented to ensure that water quality standards and effluent limits are attained. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment or both for knowing violations pursuant to Section 309(c)(4) of the Clean Water Act and, 18 Pa. C.S. §§4903-4904.

Applicant	Co-Applicant (if applicable)
TIM SHAFER	
Print Name and Title of Person Signing	Print Name and Title of Person Signing
(814) 899-7561	( )
Telephone Number of Person Signing	Telephone Number of Person Signing
Tim Shafer	
Signature of Applicant	Signature of Co-Applicant
11-3-04	
Date Signed	Date Signed

Please note below the name, address and telephone number of the individual that should be contacted in the event additional information is required.

Name: HENRY T. WEIKA & ASSOCIATES (CHARLES WEARY)

Address: 3200 WEST 32ND. ST.

Telephone: (814) 833-3900 FAX: (814) 833-9550

Notarization:

Commonwealth of Pennsylvania

County of Erie

Sworn to and Subscribed to Before Me This

3 Day of November, 2004

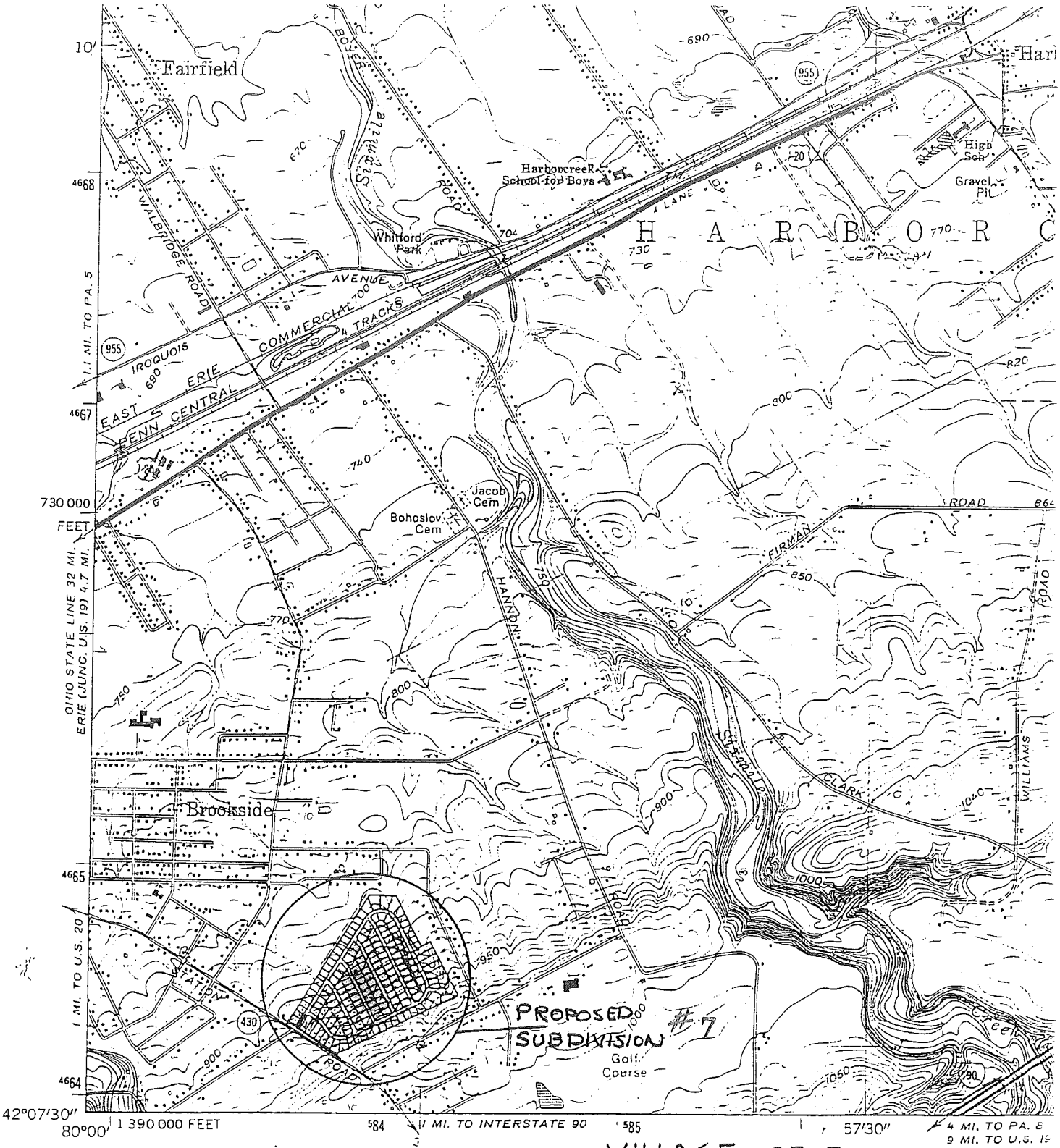
NOTARY SEAL

NOTARIAL SEAL
MARY LEE CIFELLI, NOTARY PUBLIC
ERIE, ERIE COUNTY, PENNA.
MY COMMISSION EXPIRES MARCH 19, 2005

Mary Lee Cifelli

Notary Public

My Commission Expires:



Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography from aerial photographs by photogrammetric methods
Aerial photographs taken 1956. Field check 1960

Selected hydrographic data compiled from U. S. Lake Survey Chart 33 (1959). This information is not intended for navigational purposes

SCALE 1:24 000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS LOW WATER 570.5 FEET

ROAD CLASSIFICATION

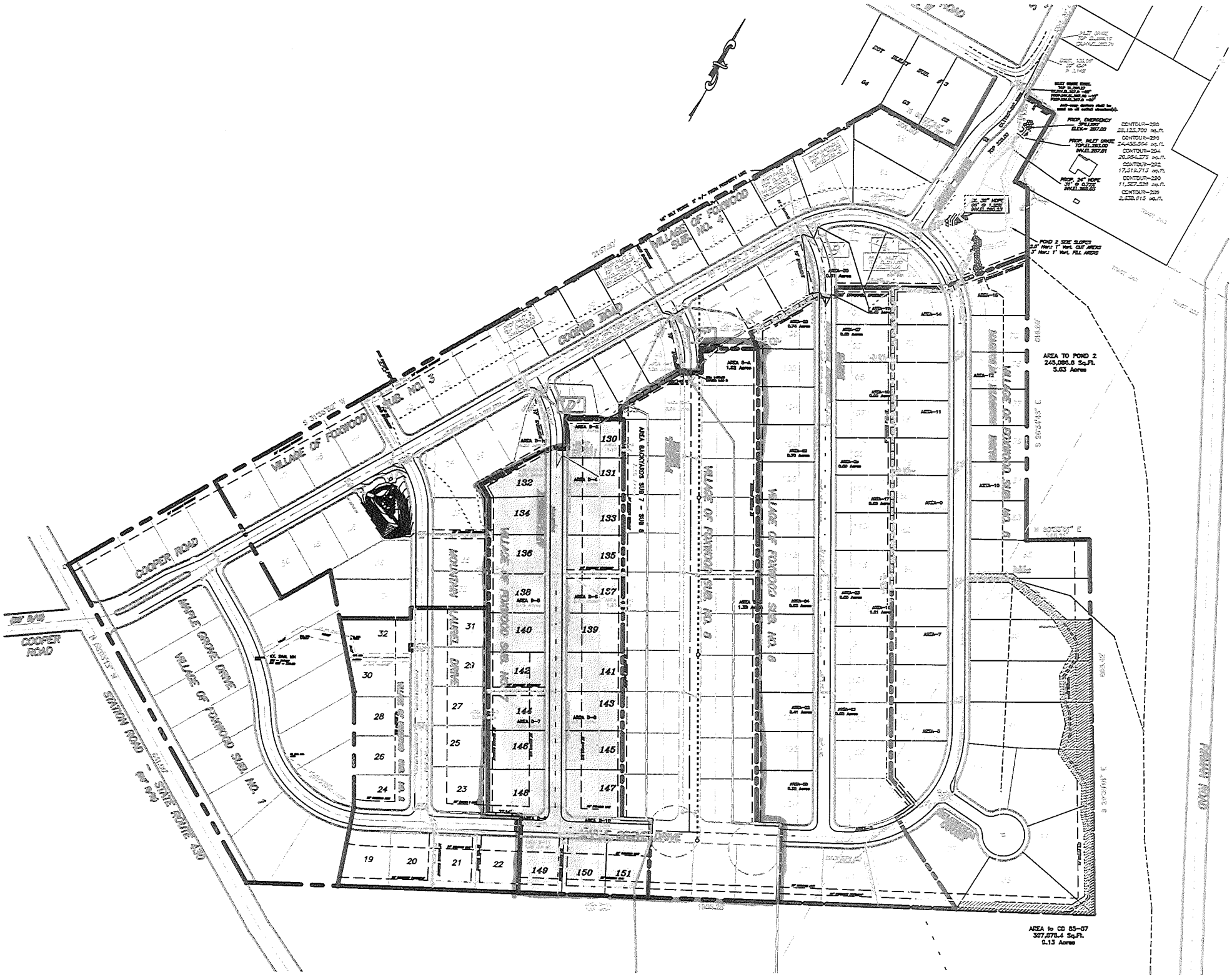
Heavy-duty ——— Light-duty - - - -
Medium-duty ——— Unimproved dirt ·····
Interstate Route U. S. Route State Route

HARBORCREEK, PA.

N4207.5—W7952.5/7.5

1960
PHOTOREVISED 1970
AMS 5068 III NW—SERIES V831

(ERIE SOUTH)
4966 II SE


COOPER ROAD
VILLAGE OF FOXWOOD SUB. NO. 3
VILLAGE OF FOXWOOD SUB. NO. 4
VILLAGE OF FOXWOOD SUB. NO. 5
VILLAGE OF FOXWOOD SUB. NO. 6
VILLAGE OF FOXWOOD SUB. NO. 7
MAPLE GROVE DRIVE
VILLAGE OF FOXWOOD SUB. NO. 1
STATION ROAD - STATE ROUTE 430
AREA TO POND 2
245,088.6 Sq.Ft.
5.63 Acres
AREA to CD 85-87
307,678.4 Sq.Ft.
7.13 Acres

Appendix D

Proposed BMP Documentation

	Default Value	Site-Specific Value	Units
Bulk Density (average of samples in stream reach)	N/A	66.6	lb/ft^3
Restoration Efficiency	50	50	%

Project Name	Tributary to Five Mile Creek											
Feature	Lat/Long		Length, ft (Bank or deposition)	Height, ft (Bank or Headcut)	BEHI Rating	NBS Rating	Predicted Rate of Bank Erosion (ft/year)	Predicted Erosion Amount (ft^3/year)	Predicted Erosion Amount (tons/year)	Predicted Erosion Rate (tons/year/ft)	Estimated TSS (tons/yr) Reduction	Comments
Feature I.D. (Bank., Headcut or Deposition I.D.)	Start Headcut Location or Start of Bank/Deposition	End For Banks or Deposition only										
LB-1	42.13754 -79.99424	42.13741 -79.99422	46.0	4.3	High	Low	0.40	79.12	2.63	0.06	1.32	
LB-2	42.13741 -79.99422	42.13735 -79.99420	27.0	0.0	--	--	--	--	--	--	--	Removed - Deposition
LB-3	42.13735 -79.99420	42.13728 -79.99423	28.0	4.7	Very High	High	1.00	131.60	4.38	0.16	2.19	
LB-4	42.13728 -79.99423	42.13707 -79.99412	88.0	3.7	High	Moderate	0.64	208.38	6.94	0.08	3.47	
LB-5	42.13707 -79.99412	42.13704 -79.99410	13.0	0.0	--	--	--	--	--	--	--	Removed - Deposition
LB-6	42.13704 -79.99410	42.13693 -79.99411	48.0	4.0	Very High	High	1.00	192.00	6.39	0.13	3.20	
LB-7	42.13693 -79.99411	42.13687 -79.99408	31.0	0.5	Moderate	High	0.80	12.40	0.41	0.01	0.21	Ocular Estimate
LB-8	42.13687 -79.99408	42.13686 -79.99407	5.0	0.0	--	--	--	--	--	--	--	Removed - Unnamed Tributary
LB-9	42.13686 -79.99407	42.13664 -79.99375	125.0	0.0	High	Moderate	0.64	0.00	0.00	0.00	0.00	Ocular Estimate
LB-10	42.13664 -79.99375	42.13658 -79.99372	23.0	4.0	Very High	Very High	1.75	161.00	5.36	0.23	2.68	
LB-11	42.13658 -79.99372	42.13653 -79.99368	22.0	3.7	High	High	1.00	81.40	2.71	0.12	1.36	Ocular Estimate
LB-12	42.13653 -79.99368	42.13653 -79.99356	37.0	3.3	High	Very Low	0.25	30.53	1.02	0.03	0.51	
LB-13	42.13653 -79.99356	42.13652 -79.99340	49.0	3.6	Moderate	Moderate	0.30	52.92	1.76	0.04	0.88	Ocular Estimate
LB-14	42.13652 -79.99340	42.13649 -79.99329	35.0	0.0	--	--	--	--	--	--	--	Removed - Deposition
LB-15	42.13649 -79.99329	42.13637 -79.99324	48.0	4.4	Extreme	Very High	3.50	739.20	24.62	0.51	12.31	Ocular Estimate
LB-16	42.13637 -79.99324	42.13628 -79.99323	36.0	10.0	Moderate	High	0.80	288.00	9.59	0.27	4.80	Ocular Estimate
LB-17	42.13628 -79.99323	42.13622 -79.99318	33.0	1.9	High	High	1.00	62.70	2.09	0.06	1.04	Ocular Estimate
LB-18	42.13622 -79.99318	42.13625 -79.99302	52.0	1.3	High	Low	0.40	27.04	0.90	0.02	0.45	Ocular Estimate
LB-19	42.13625 -79.99302	42.13623 -79.99298	15.0	2.6	High	High	1.00	39.00	1.30	0.09	0.65	Ocular Estimate
LB-20	42.13623 -79.99298	42.13617 -79.99296	28.0	3.0	Moderate	Moderate	0.30	25.20	0.84	0.03	0.42	Ocular Estimate
LB-21	42.13617 -79.99296	42.13612 -79.99293	22.0	0.0	--	--	--	--	--	--	--	Removed - Deposition
LB-22	42.13612 -79.99293	42.13609 -79.99290	14.0	1.8	Moderate	Low	0.13	3.15	0.10	0.01	0.05	Ocular Estimate
RB-1	42.13754 -79.99420	42.13744 -79.99420	37.0	2.1	High	Low	0.40	31.08	1.03	0.03	0.52	
RB-2	42.13744 -79.99420	42.13733 -79.99419	42.0	4.5	High	High	1.00	189.00	6.29	0.15	3.15	
RB-3	42.13733 -79.99419	42.13723 -79.99422	40.0	0.0	--	--	--	--	--	--	--	Removed - Deposition
RB-4	42.13723 -79.99422	42.13716 -79.99416	32.0	1.7	Very High	High	1.00	54.40	1.81	0.06	0.91	
RB-5	42.13716 -79.99416	42.13710 -79.99413	25.0	0.0	--	--	--	--	--	--	--	Removed - Deposition
RB-6	42.13710 -79.99413	42.13702 -79.99408	31.0	2.8	High	High	1.00	86.80	2.89	0.09	1.45	
RB-7	42.13702 -79.99408	42.13694 -79.99409	40.0	0.0	--	--	--	--	--	--	--	Removed - Deposition
RB-8	42.13694 -79.99409	42.13689 -79.99404	24.0	1.1	High	Moderate	0.64	16.90	0.56	0.02	0.28	
RB-9	42.13689 -79.99404	42.13684 -79.99401	28.0	0.0	--	--	--	--	--	--	--	Removed - Deposition
RB-10	42.13684 -79.99401	42.13679 -79.99393	29.0	1.8	High	Moderate	0.64	33.41	1.11	0.04	0.56	
RB-11	42.13679 -79.99393	42.13675 -79.99389	18.0	0.5	Moderate	Low	0.13	1.13	0.04	0.00	0.02	Ocular Estimate
RB-12	42.13675 -79.99389	42.13666 -79.99375	54.0	4.1	Very High	High	1.00	221.40	7.37	0.14	3.69	
RB-13	42.13666 -79.99375	42.13652 -79.99362	64.0	0.0	--	--	--	--	--	--	--	Removed - Deposition
RB-14	42.13652 -79.99362	42.13655 -79.99355	24.0	5.0	Very High	Very High	1.75	210.00	6.99	0.29	3.50	Ocular Estimate
RB-15	42.13655 -79.99355	42.13655 -79.99344	32.0	4.4	High	High	1.00	140.80	4.69	0.15	2.34	Ocular Estimate
RB-16	42.13655 -79.99344	42.13649 -79.99325	60.0	5.0	Very High	Very High	1.75	525.00	17.48	0.29	8.74	Ocular Estimate
RB-17	42.13649 -79.99325	42.13629 -79.99320	77.0	3.5	High	Moderate	0.64	172.48	5.74	0.07	2.87	Ocular Estimate
RB-18	42.13629 -79.99320	42.13623 -79.99318	29.0	2.1	High	Moderate	0.64	38.98	1.30	0.04	0.65	
RB-19	42.13623 -79.99318	42.13627 -79.99304	44.0	6.0	Very High	High	1.00	264.00	8.79	0.20	4.40	Ocular Estimate
RB-20	42.13627 -79.99304	42.13622 -79.99296	37.0	0.0	--	--	--	--	--	--	--	Removed - Deposition
RB-21	42.13622 -79.99296	42.13613 -79.99292	38.0	2.2	High	High	1.00	83.60	2.78	0.07	1.39	Ocular Estimate
RB-22	42.13613 -79.99292	42.13609 -79.99288	19.0	5.2	Very High	High	1.00	98.80	3.29	0.17	1.65	Ocular Estimate
TOTAL OF ALL GRIDS			**1649.0**	**N/A**	**N/A**	**N/A**	**N/A**	**4301.4**	**143.2**	**N/A**	**71.6**	


LB-1
RB-1
RB-2
LB-2
RB-3
LB-4
RB-4
RB-5
LB-4
RB-6
LB-5
LB-6
RB-7
LB-7
RB-9
LB-8
LB-9
RB-10
RB-11
RB-12
LB-9
RB-13
LB-10
LB-11
RB-15
RB-16
LB-12
LB-13
LB-14
LB-15
RB-17
LB-16
RB-17
RB-18
LB-17
RB-20
LB-19
RB-19
LB-18
RB-21
LB-21
RB-22
BEHI
Stable
Moderate
High
Very High
Extreme
Removed
Parcels
Stream River
Rolling Ridge Park
BEHI Ratings
0
40
80
160 Feet


LB-1
RB-1
RB-2
LB-2
RB-3
LB-4
RB-4
RB-5
LB-4
RB-6
LB-5
LB-6
RB-7
LB-7
RB-9
LB-8
LB-9
RB-10
RB-11
RB-12
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LB-10
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RB-16
LB-12
LB-13
LB-14
LB-15
RB-17
LB-16
RB-17
RB-18
LB-17
RB-20
LB-19
RB-19
LB-18
RB-21
LB-21
RB-22
NBS
No NBS
Removed
Low
Very Low
Moderate
High
Very High
Parcels
Stream River
Rolling Ridge Park
NBS Ratings
0
40
80
160 Feet

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**	**32.64**				
Reach:		**Comments:**							**High**				
Location:	LB-1	**Bank Length**	46					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
4.30	0.40	10.75	10.00	Extreme	
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
2.00	4.30	0.47	4.25	Moderate	
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
30.00	0.47	13.95	8.01	Very High	
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
45.00			3.17	Low	
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
20.00			7.22	High	
			Adjustment		Notes
Bank Materials			0.00		
			Adjustment		Notes
Bank Stratification			0.00		
		TOTAL SCORE	**32.64**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

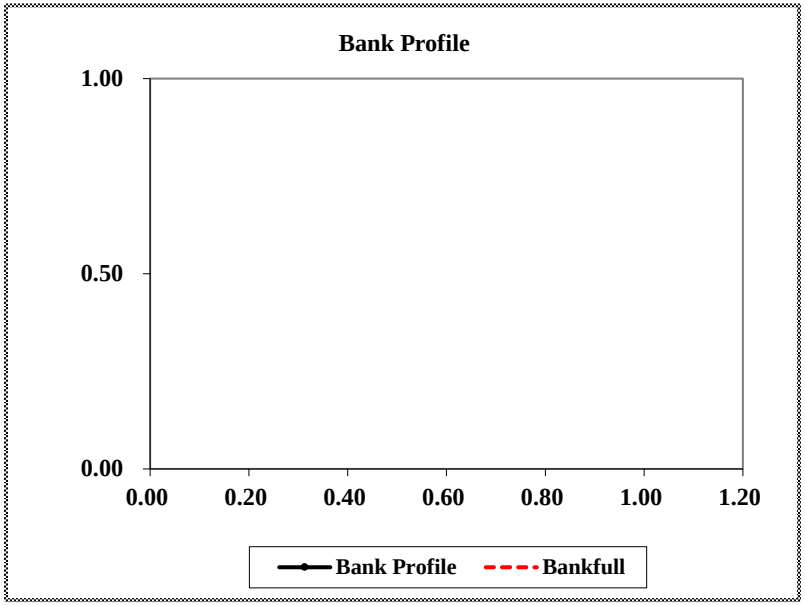
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-1** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	**1**
Dominant Near-Bank Stress	
Low	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Low**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**					
Reach:		**Comments:**											
Location:	LB-2	**Bank Length**	27					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE			

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

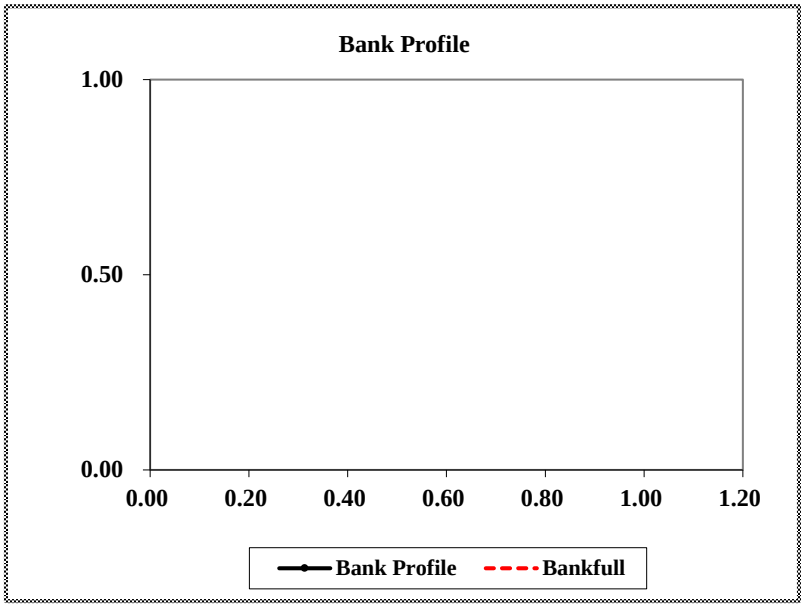
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Removed due to deposition

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-2** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**)	Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	
Dominant Near-Bank Stress	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating						

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**40.86**		
Reach:		**Comments:**								**Very High**		
Location:	LB-3	**Bank Length**	28					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
4.70	0.40	11.75	10.00	Extreme	
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
2.30	4.70	0.49	4.01	Moderate	
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
60.00	0.49	29.36	5.95	Moderate	
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
120.00			10.00	Extreme	
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
30.00			5.90	Moderate	
			Adjustment		Notes
Bank Materials			0.00		
			Adjustment		Notes
Bank Stratification			5.00		
		TOTAL SCORE	**40.86**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

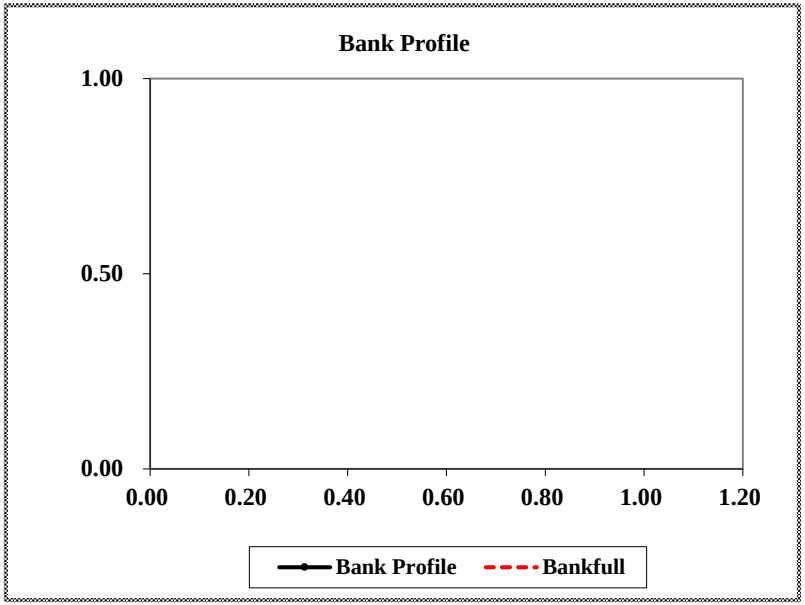
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-3** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**)	Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2) Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3) Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4) Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	**1**
Dominant Near-Bank Stress	
High	

Level III

(5) Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6) Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV

(7) Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**	**32.58**				
Reach:		**Comments:**							**High**				
Location:	LB-4	**Bank Length**	88					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio

Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
3.70	0.40	9.25	10.00	Extreme	

Root Depth / Bank Height Ratio

Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
1.80	3.70	0.49	4.04	Moderate	

Weighted Root Density

Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
15.00	0.49	7.30	8.74	Very High	

Bank Angle

Bank Angle (°)			Index	Bank Erosion Potental	Notes
60.00			3.90	Low	

Surface Protection

Surface Protection (%)			Index	Bank Erosion Potental	Notes
30.00			5.90	Moderate	

	Adjustment		Notes
Bank Materials	0.00		
	Adjustment		Notes
Bank Stratification	0.00		
TOTAL SCORE	**32.58**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

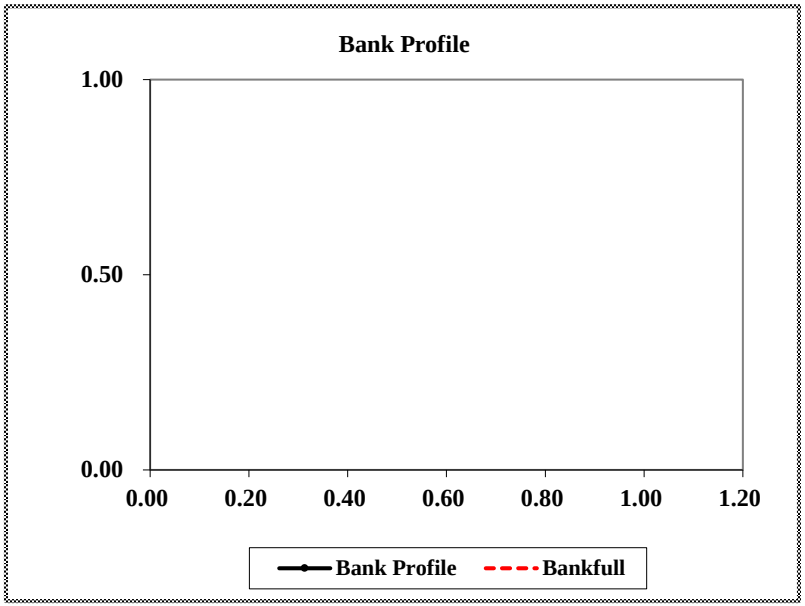
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-4** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Moderate	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Moderate**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**					
Reach:		**Comments:**											
Location:	LB-5	**Bank Length**	13					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE			

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

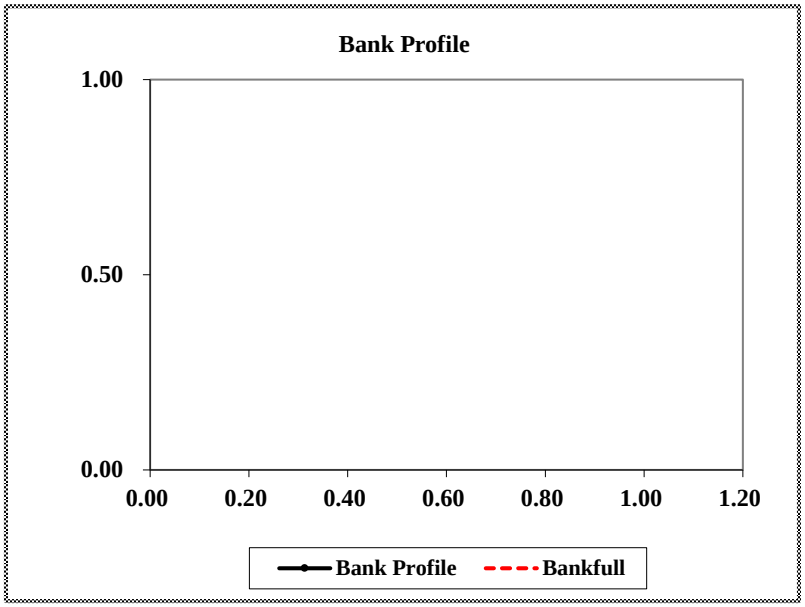
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Removed due to deposition

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-5** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**)	Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	
Dominant Near-Bank Stress	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating						

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**	**42.90**				
Reach:		**Comments:**							**Very High**				
Location:	LB-6	**Bank Length**	48					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio

Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
4.00	0.40	10.00	10.00	Extreme	

Root Depth / Bank Height Ratio

Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
2.00	4.00	0.50	3.90	Low	

Weighted Root Density

Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
10.00	0.50	5.00	9.00	Very High	

Bank Angle

Bank Angle (°)		Index	Bank Erosion Potental	Notes
120.00		10.00	Extreme	

Surface Protection

Surface Protection (%)		Index	Bank Erosion Potental	Notes
5.00		10.00	Extreme	

	Adjustment		Notes
Bank Materials	0.00		
	Adjustment		Notes
Bank Stratification	0.00		
TOTAL SCORE	**42.90**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

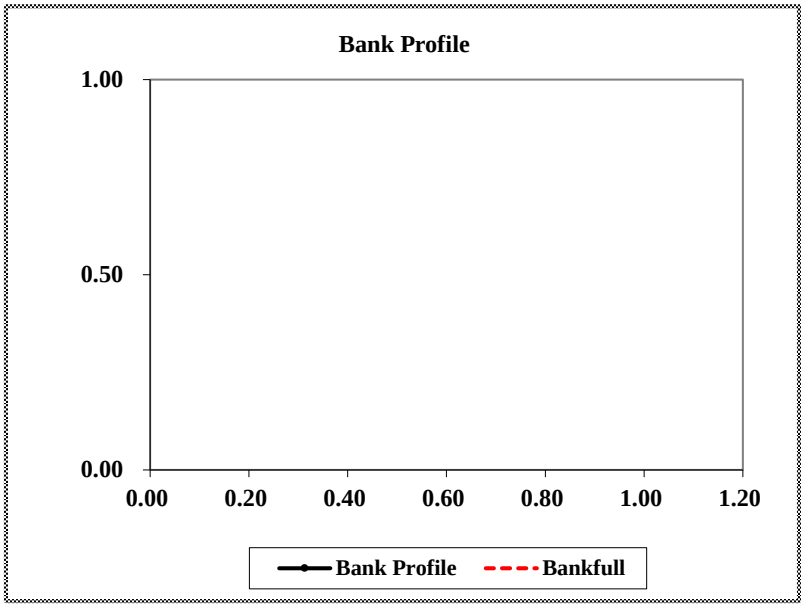
Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile

Horizontal Distance	Vertical Height	Notes

Bankfull

Horizontal Distance	Vertical Height	Notes



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-6** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	**High**

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**Moderate**			
Location:	LB-7	**Bank Length**	31					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
0.50					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Moderate**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

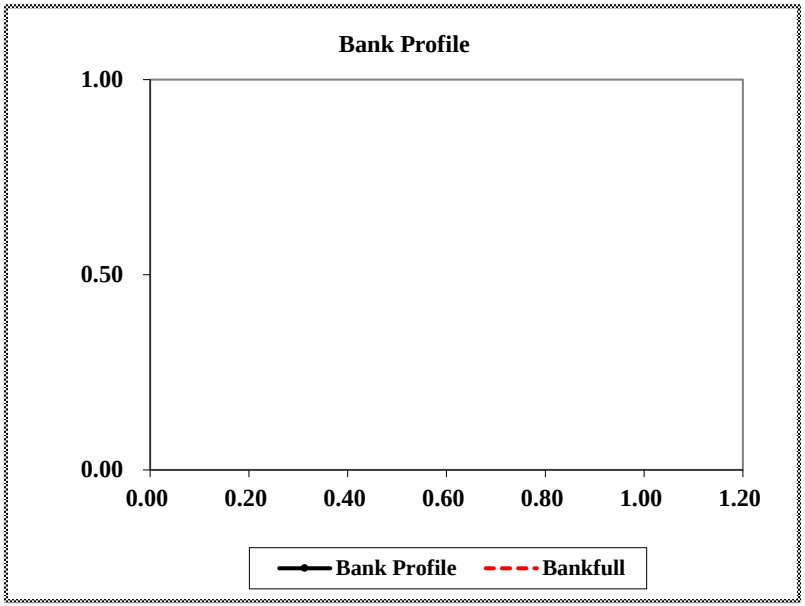
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - Moderate

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-7** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High
Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2) Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3) Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4) Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	**1**
Dominant Near-Bank Stress	
High	

Level III

(5) Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6) Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV

(7) Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**					
Reach:		**Comments:**											
Location:	LB-8	**Bank Length**	5					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE			

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

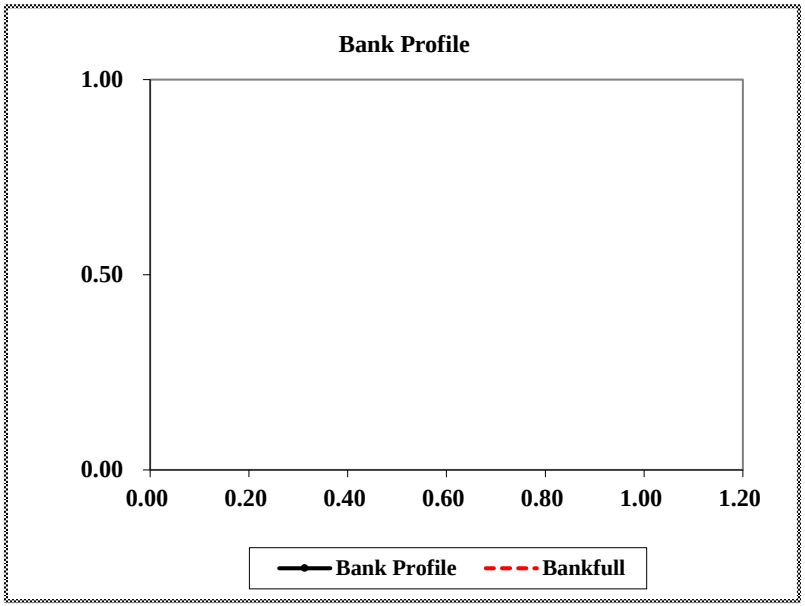
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Removed - Unnamed Tributary

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-8** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**)	Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	
Dominant Near-Bank Stress	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating						

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**High**			
Location:	LB-9	**Bank Length**	125					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**High**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

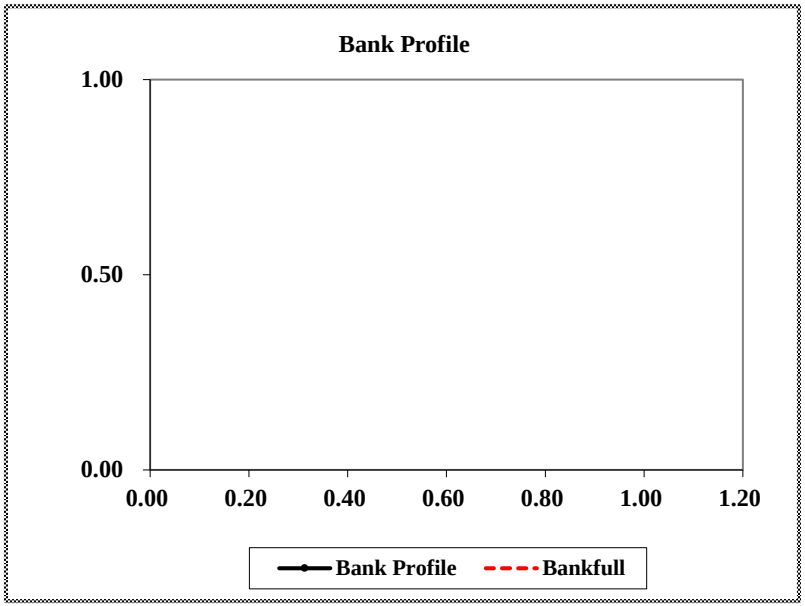
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Occular estimate - High

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-9** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Moderate	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Moderate**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**	**43.66**				
Reach:		**Comments:**							**Very High**				
Location:	LB-10	**Bank Length**	23					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio

Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
4.00	0.40	10.00	10.00	Extreme	

Root Depth / Bank Height Ratio

Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
1.30	4.00	0.33	5.65	Moderate	

Weighted Root Density

Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
40.00	0.33	13.00	8.11	Very High	

Bank Angle

Bank Angle (°)			Index	Bank Erosion Potental	Notes
80.00			5.90	Moderate	

Surface Protection

Surface Protection (%)			Index	Bank Erosion Potental	Notes
10.00			9.00	Very High	

	Adjustment		Notes
Bank Materials	0.00		
	Adjustment		Notes
Bank Stratification	5.00		
TOTAL SCORE	**43.66**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

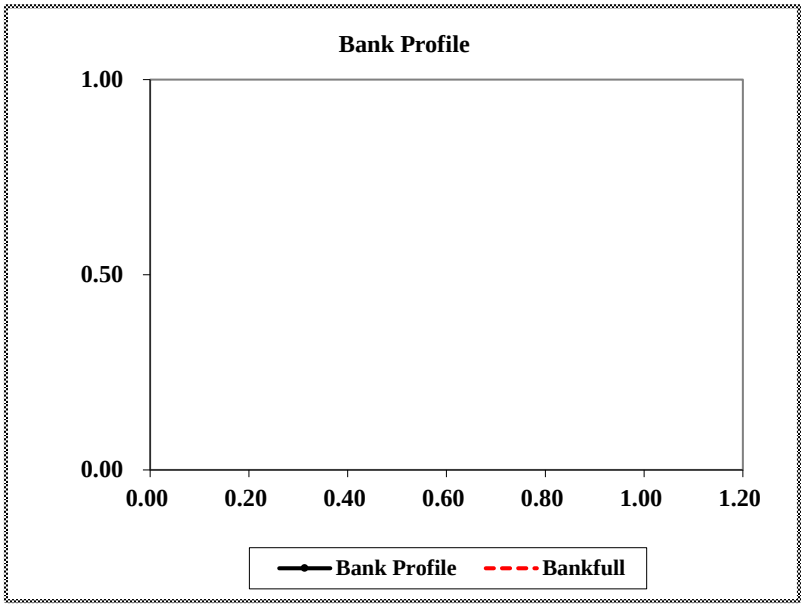
Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile

Horizontal Distance	Vertical Height	Notes

Bankfull

Horizontal Distance	Vertical Height	Notes



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-10** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Very High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Very High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**High**			
Location:	LB-11	**Bank Length**	22					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
3.70					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	3.70				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**High**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

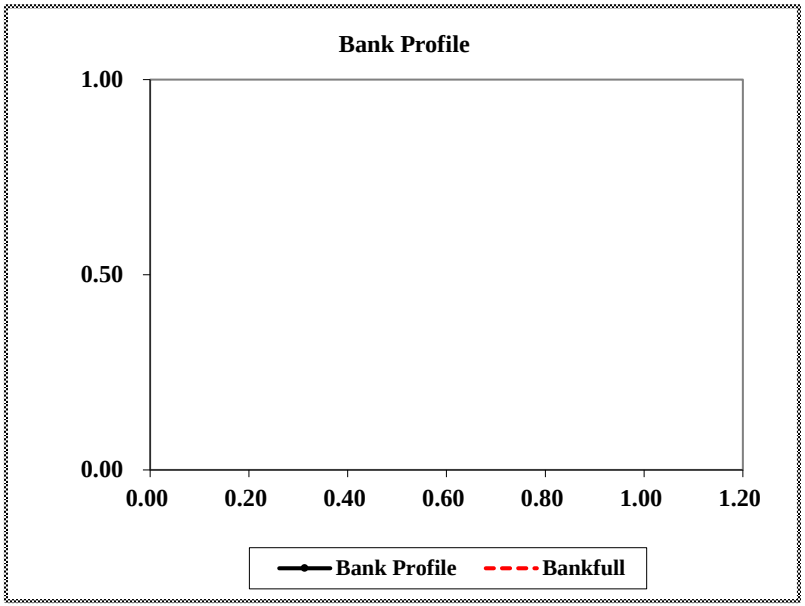
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Occular estimate - High

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-11** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**	**36.45**				
Reach:		**Comments:**							**High**				
Location:	LB-12	**Bank Length**	37					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
3.30	0.40	8.25	10.00	Extreme	
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
0.80	3.30	0.24	6.65	High	
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
20.00	0.24	4.85	10.00	Extreme	
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
60.00			3.90	Low	
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
30.00			5.90	Moderate	
			Adjustment		Notes
Bank Materials			0.00		
			Adjustment		Notes
Bank Stratification			0.00		
		TOTAL SCORE	**36.45**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

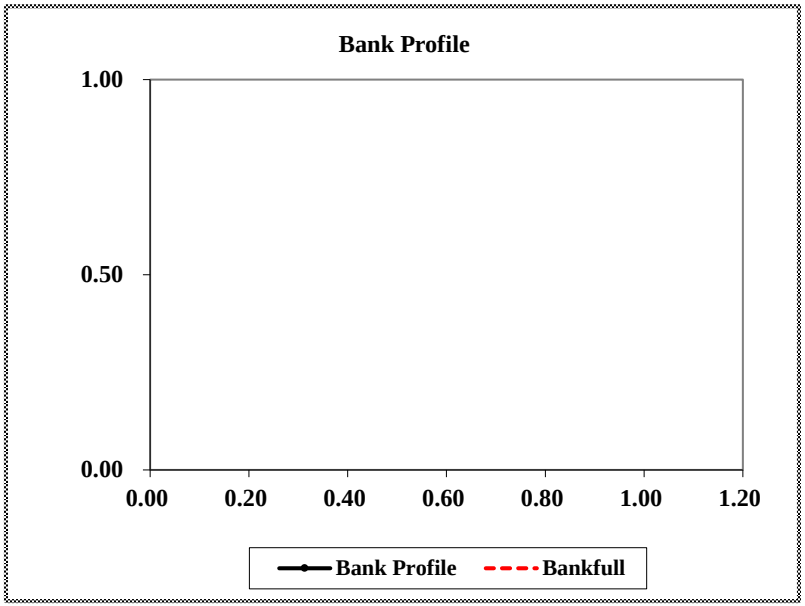
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-12** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Very Low	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Very Low**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**Moderate**			
Location:	LB-13	**Bank Length**	49					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
3.60					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	3.60				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Moderate**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

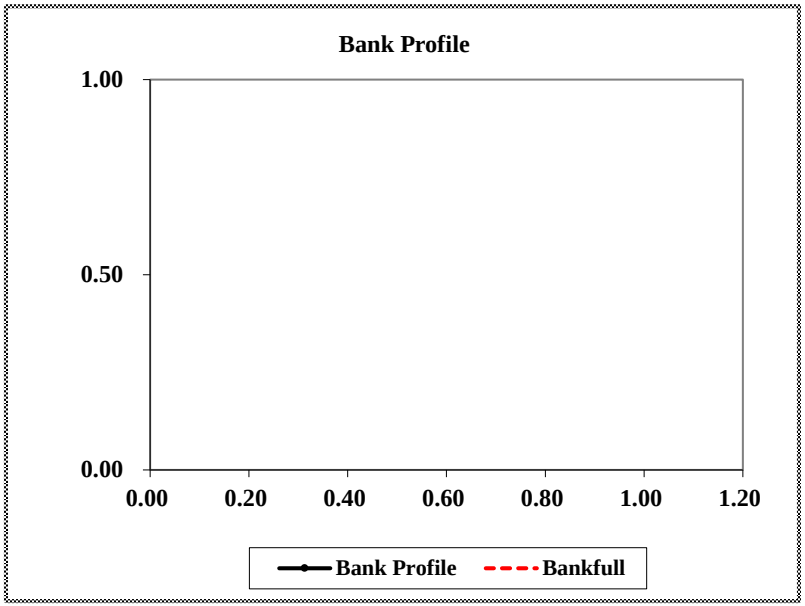
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Occular estimate - Moderate

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-13** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Moderate	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Moderate**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**					
Reach:		**Comments:**											
Location:	LB-14	**Bank Length**	35					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE			

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

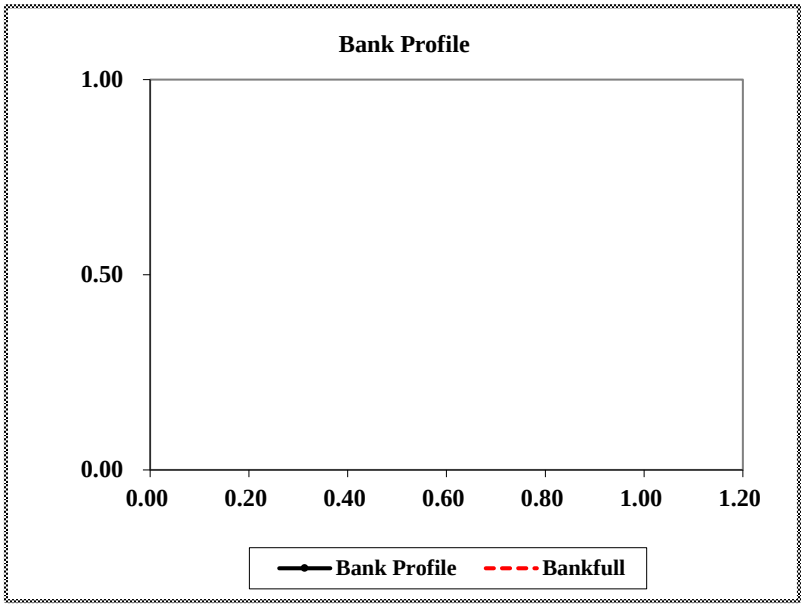
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Removed due to deposition

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-14** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**)	Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method

Dominant Near-Bank Stress

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40

Overall Near-Bank Stress (NBS) rating

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**Extreme**			
Location:	LB-15	**Bank Length**	48					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
4.40					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	4.40				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Extreme**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

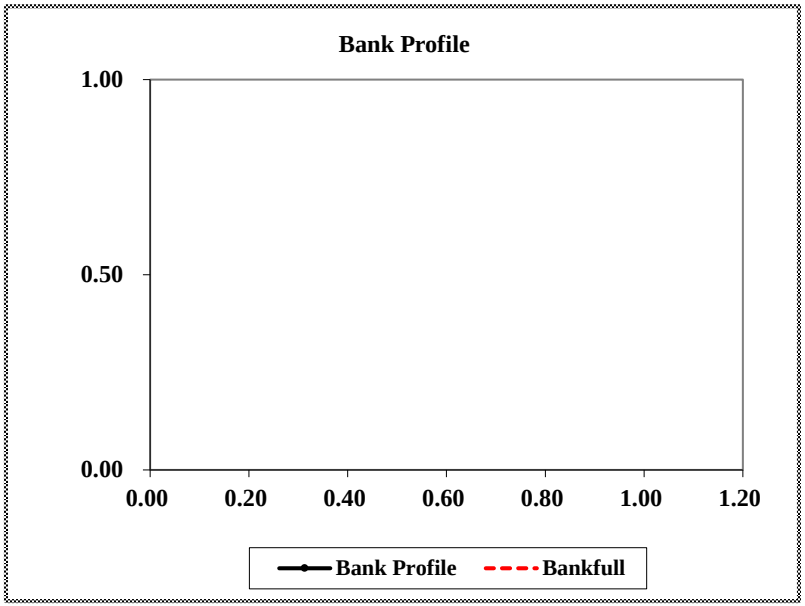
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Occular estimate - Extreme

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-15** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**)	Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High
Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Very High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Very High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**Moderate**			
Location:	LB-16	**Bank Length**	36					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
10.00					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	10.00				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Moderate**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

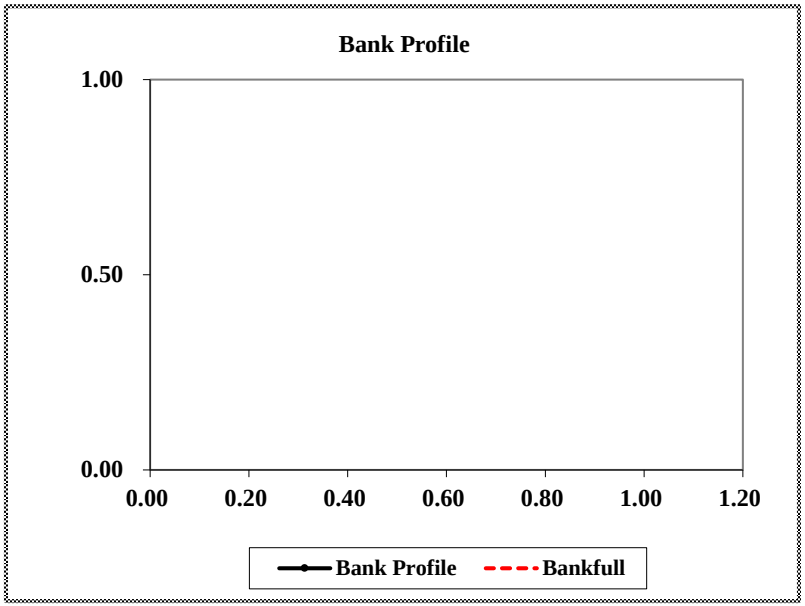
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - Moderate

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-16** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	**1**
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**High**			
Location:	LB-17	**Bank Length**	33					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
1.90					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	1.90				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**High**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

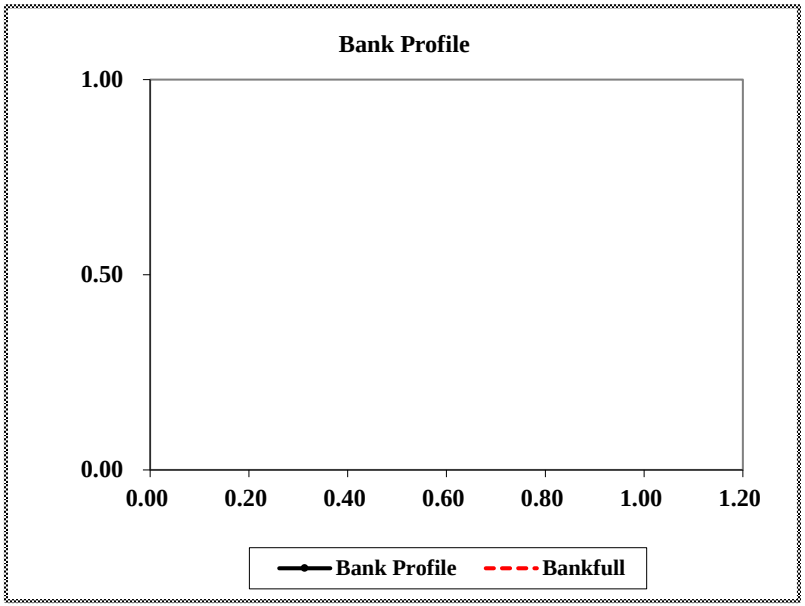
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Occular estimate - High

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-17** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**High**			
Location:	LB-18	**Bank Length**	52					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
1.30					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	1.30				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Moderate**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

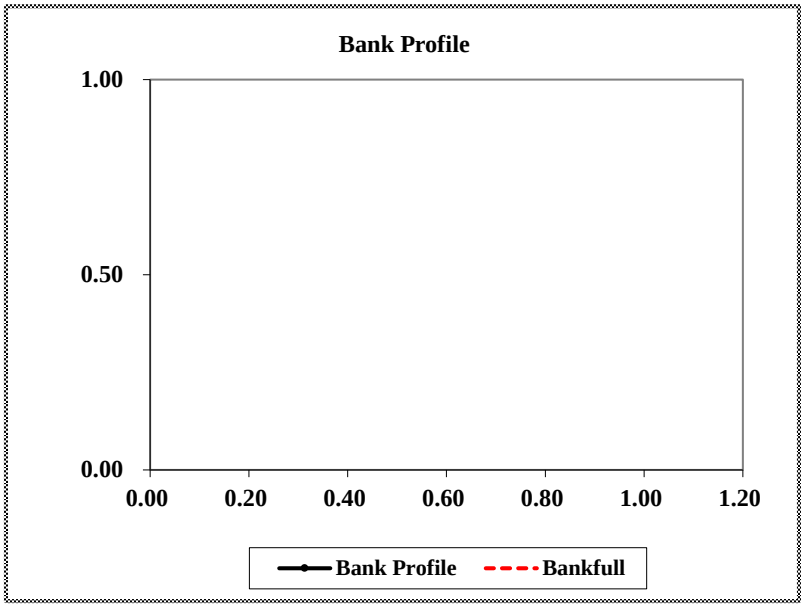
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - Moderate

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-18** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	**1**
Dominant Near-Bank Stress	
Low	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Low**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**High**			
Location:	LB-19	**Bank Length**	15					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
2.60					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	2.60				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**High**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

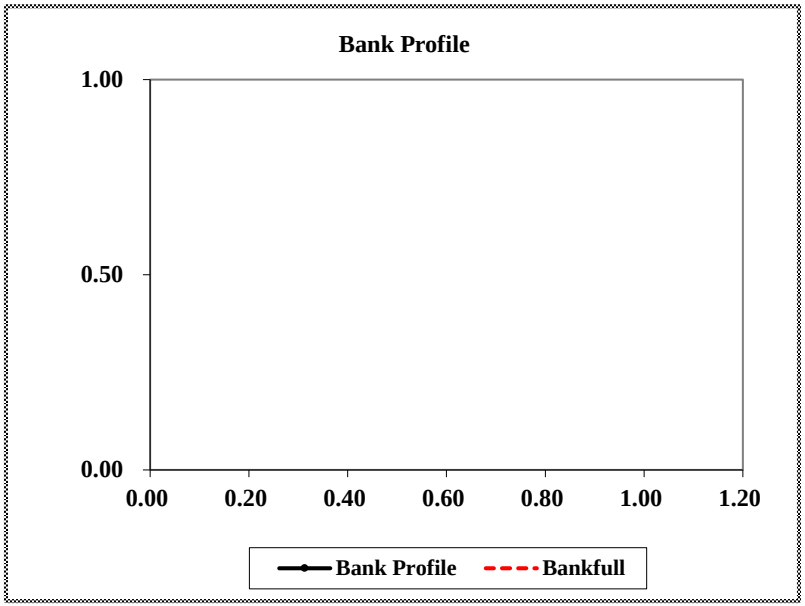
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - High

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-19** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High
Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**Moderate**			
Location:	LB-20	**Bank Length**	28					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
3.00					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	3.00				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Moderate**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

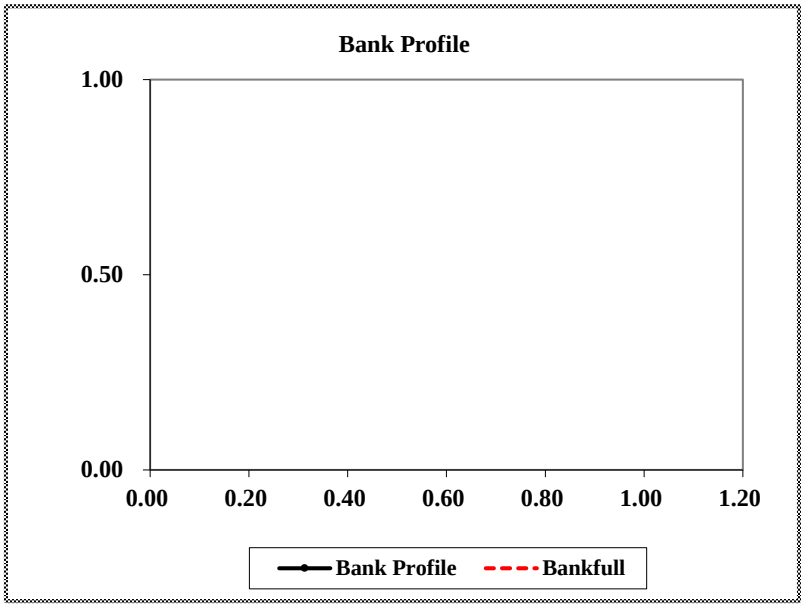
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - Moderate

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-20** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Moderate	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Moderate**	

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-20** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**)	Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High
Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Moderate	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Moderate**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**					
Reach:		**Comments:**											
Location:	LB-21	**Bank Length**	22					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE			

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

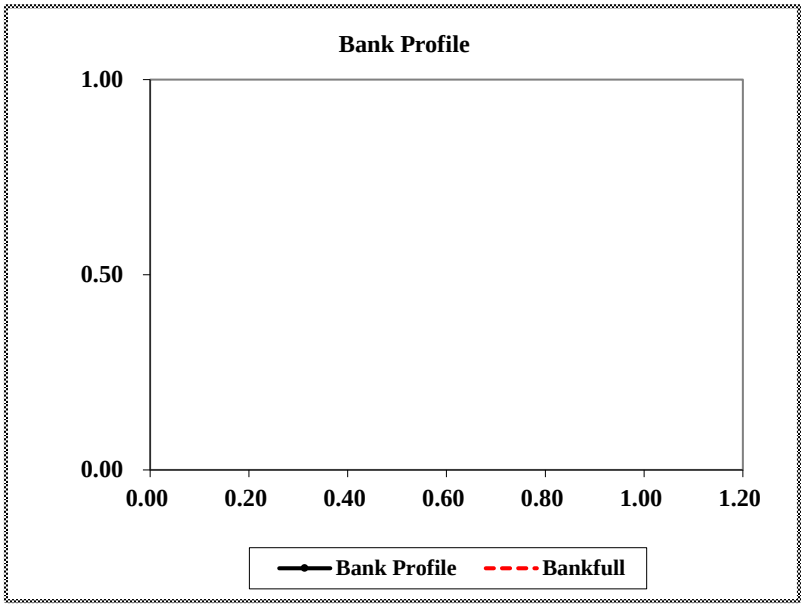
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Removed due to deposition

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: Tributary to Five Mile Creek Location: **Rolling Ridge Park**

Station: **LB-21** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	
Dominant Near-Bank Stress	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating						

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**Moderate**			
Location:	LB-22	**Bank Length**	14					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
1.80					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	1.80				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Moderate**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

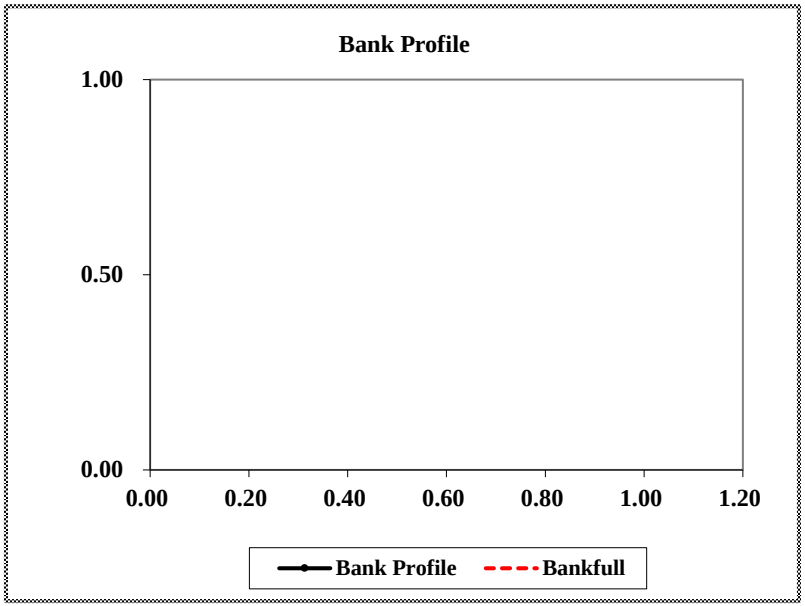
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Occular estimate - Moderate

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **LB-22** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Low	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Low**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**30.25**			
Reach:		**Comments:**								**High**			
Location:	RB-1	**Bank Length**	37					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio

Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
2.10	0.40	5.25	10.00	Extreme	

Root Depth / Bank Height Ratio

Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
1.00	2.10	0.48	4.14	Moderate	

Weighted Root Density

Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
20.00	0.48	9.52	8.50	Very High	

Bank Angle

Bank Angle (°)			Index	Bank Erosion Potental	Notes
70.00			4.90	Moderate	

Surface Protection

Surface Protection (%)			Index	Bank Erosion Potental	Notes
70.00			2.71	Low	

	Adjustment		Notes
Bank Materials	0.00		
	Adjustment		Notes
Bank Stratification	0.00		
TOTAL SCORE	**30.25**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

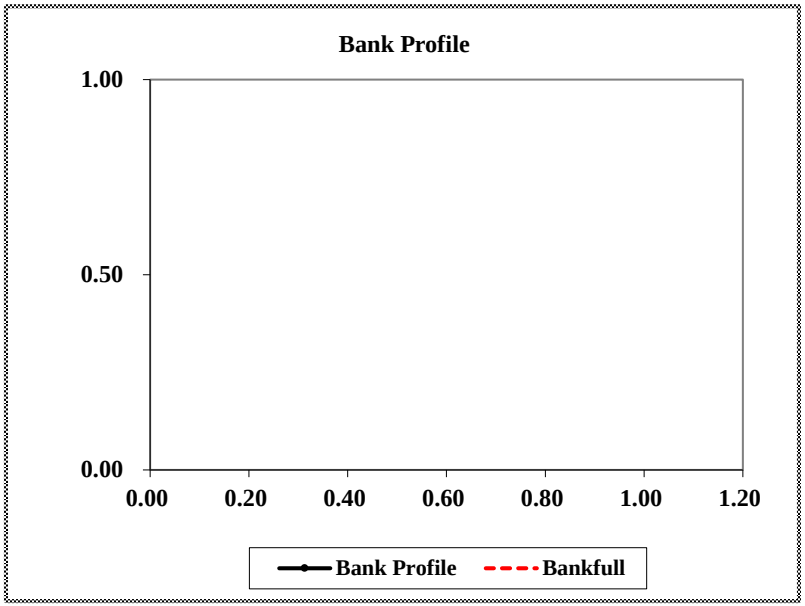
Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**

Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-1** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Low	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Low**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**36.20**			
Reach:		**Comments:**								**High**			
Location:	RB-2	**Bank Length**	42					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio

Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
4.50	0.40	11.25	10.00	Extreme	

Root Depth / Bank Height Ratio

Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
2.50	4.50	0.56	3.63	Low	

Weighted Root Density

Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
30.00	0.56	16.67	7.67	High	

Bank Angle

Bank Angle (°)			Index	Bank Erosion Potental	Notes
80.00			5.90	Moderate	

Surface Protection

Surface Protection (%)			Index	Bank Erosion Potental	Notes
10.00			9.00	Very High	

	Adjustment		Notes
Bank Materials	0.00		
	Adjustment		Notes
Bank Stratification	0.00		
TOTAL SCORE	**36.20**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

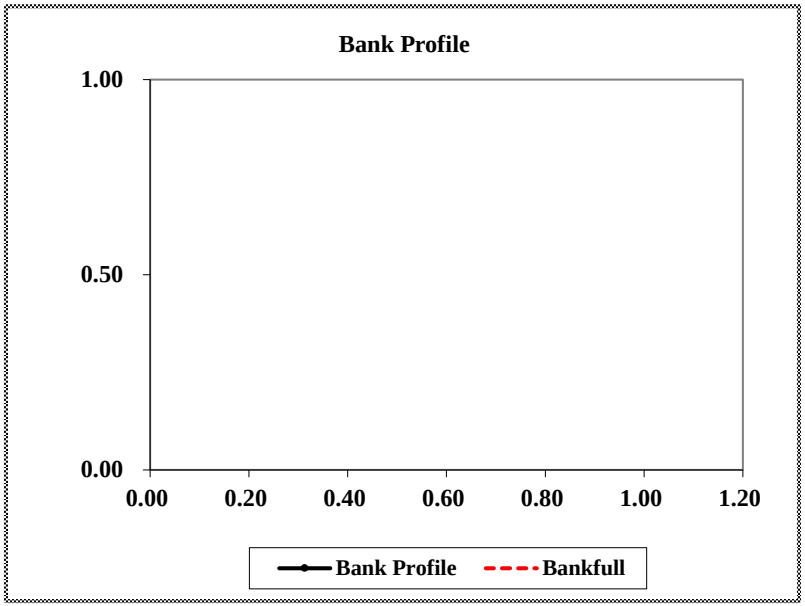
Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile

Horizontal Distance	Vertical Height	Notes

Bankfull

Horizontal Distance	Vertical Height	Notes



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-2** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**					
Reach:		**Comments:**											
Location:	RB-3	**Bank Length**	40					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE			

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

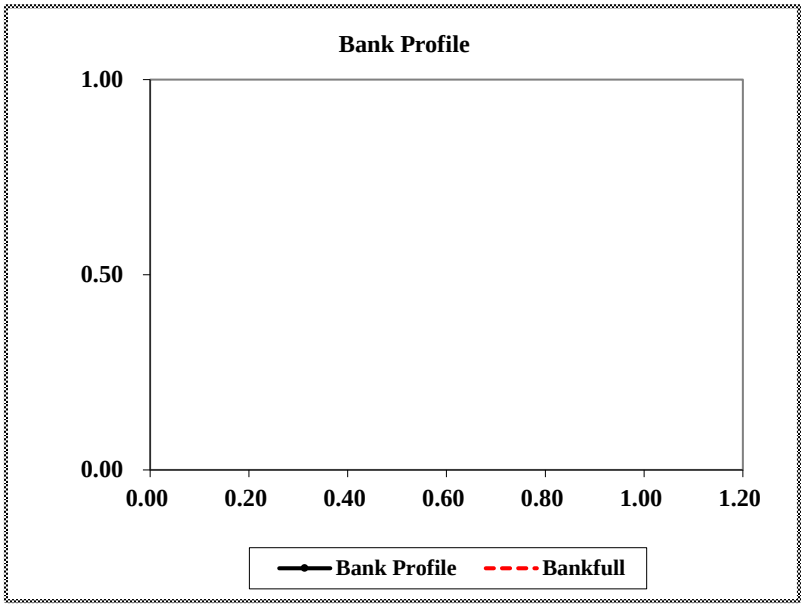
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Removed due to deposition

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-3** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method **Dominant Near-Bank Stress**

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40

Overall Near-Bank Stress (NBS) rating

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**	**40.09**				
Reach:		**Comments:**							**Very High**				
Location:	RB-4	**Bank Length**	32					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio

Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
1.70	0.40	4.25	10.00	Extreme	

Root Depth / Bank Height Ratio

Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
0.80	1.70	0.47	4.19	Moderate	

Weighted Root Density

Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
10.00	0.47	4.71	10.00	Extreme	

Bank Angle

Bank Angle (°)			Index	Bank Erosion Potental	Notes
80.00			5.90	Moderate	

Surface Protection

Surface Protection (%)			Index	Bank Erosion Potental	Notes
5.00			10.00	Extreme	

	Adjustment		Notes
Bank Materials	0.00		
	Adjustment		Notes
Bank Stratification	0.00		
TOTAL SCORE	**40.09**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

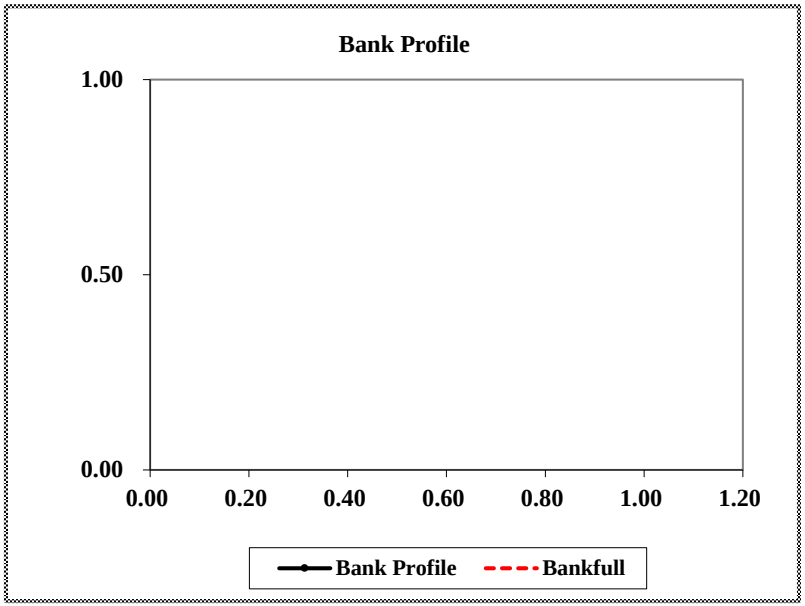
Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile

Horizontal Distance	Vertical Height	Notes

Bankfull

Horizontal Distance	Vertical Height	Notes



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-4** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**					
Reach:		**Comments:**											
Location:	RB-5	**Bank Length**	25					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE			

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

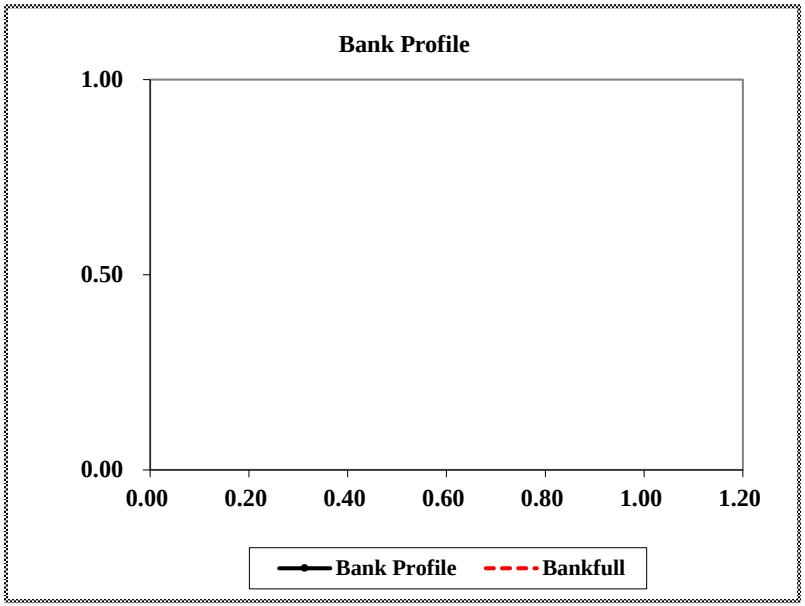
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Removed due to deposition

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-5** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	
Dominant Near-Bank Stress	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40

Overall Near-Bank Stress (NBS) rating

BANK EROSION HAZARD INDEX

	Tributary to Five Mile Creek	Observer(s):	IT RS	Data:	IT	QA/QC:	RS	Total Score:	38.99				
Reach:		Comments:							High				
Location:	RB-6	Bank Length	31					Total Score Values:	Very Low	Low	Moderate	High	Very High	Extreme
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
2.80	0.40	7.00	10.00	Extreme	
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
1.00	2.80	0.36	5.33	Moderate	
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
20.00	0.36	7.14	8.76	Very High	
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
80.00			5.90	Moderate	
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
10.00			9.00	Very High	
			Adjustment		Notes
Bank Materials			0.00		
			Adjustment		Notes
Bank Stratification			0.00		
		TOTAL SCORE	**38.99**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables	Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
	Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
		Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

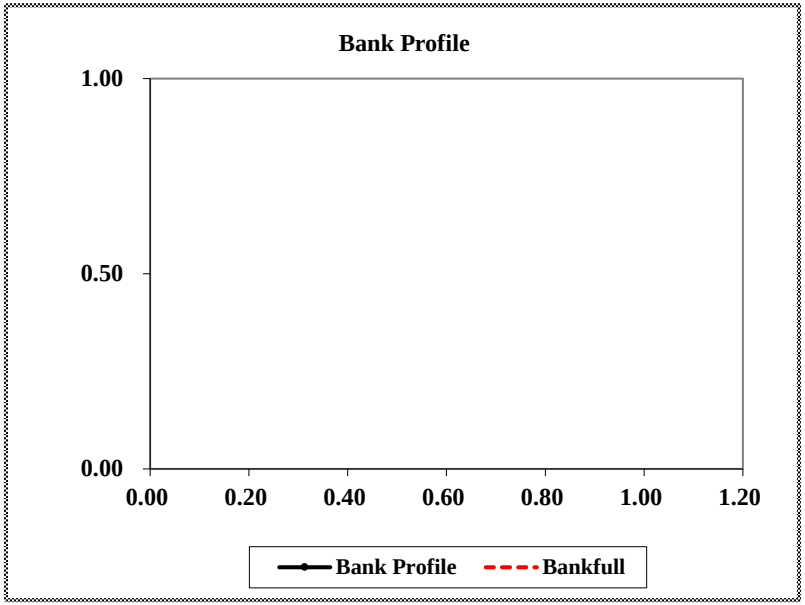
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	Vertical Height	Notes
Bankfull		
Horizontal Distance	Vertical Height	Notes



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-6** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**					
Reach:		**Comments:**											
Location:	RB-7	**Bank Length**	40					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE			

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

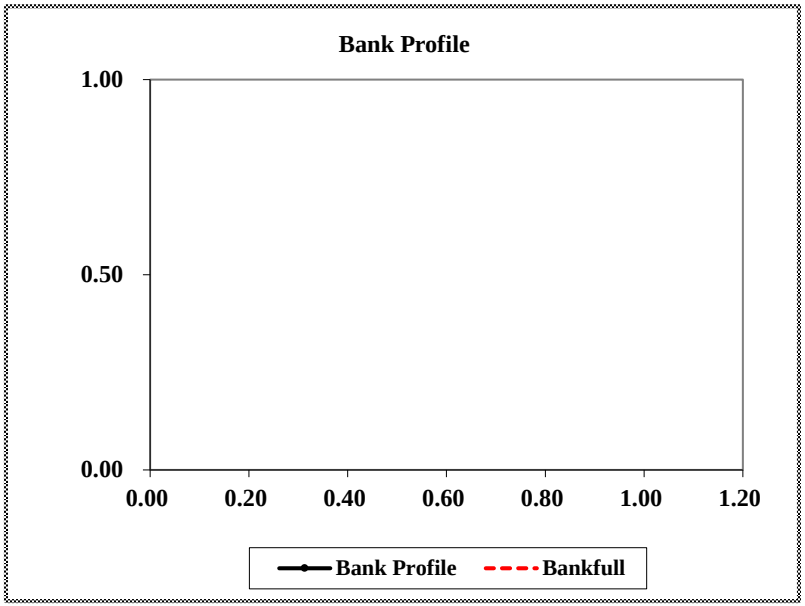
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Removed due to deposition

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-7** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2) Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3) Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4) Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method | **Dominant Near-Bank Stress**

Level III

(5) Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6) Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV

(7) Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40

Overall Near-Bank Stress (NBS) rating

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**	**35.85**				
Reach:		**Comments:**							**High**				
Location:	RB-8	**Bank Length**	24					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio

Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
1.10	0.40	2.75	8.93	Very High	

Root Depth / Bank Height Ratio

Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
0.60	1.10	0.55	3.68	Low	

Weighted Root Density

Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
20.00	0.55	10.91	8.34	Very High	

Bank Angle

Bank Angle (°)			Index	Bank Erosion Potental	Notes
80.00			5.90	Moderate	

Surface Protection

Surface Protection (%)			Index	Bank Erosion Potental	Notes
10.00			9.00	Very High	

	Adjustment		Notes
Bank Materials	0.00		
	Adjustment		Notes
Bank Stratification	0.00		
TOTAL SCORE	**35.85**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

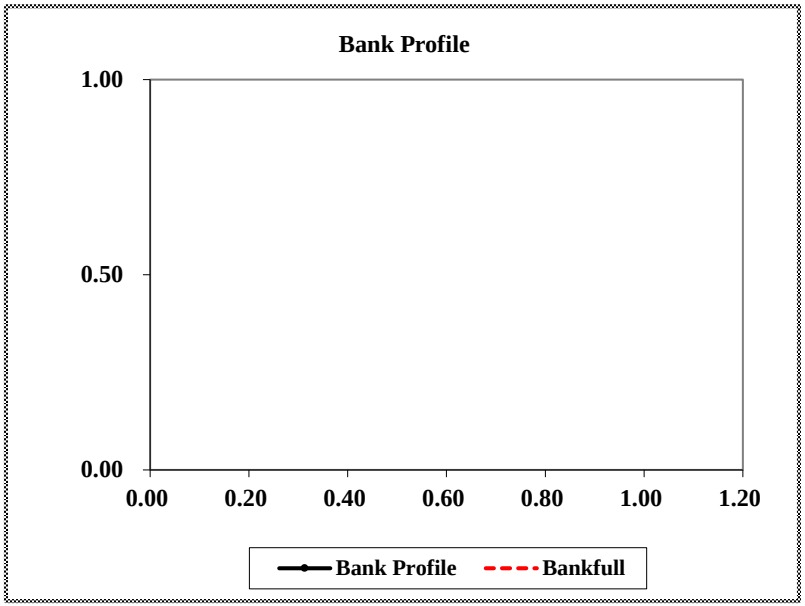
Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile

Horizontal Distance	Vertical Height	Notes

Bankfull

Horizontal Distance	Vertical Height	Notes



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-8** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Moderate	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Moderate**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**					
Reach:		**Comments:**											
Location:	RB-9	**Bank Length**	28					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE			

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

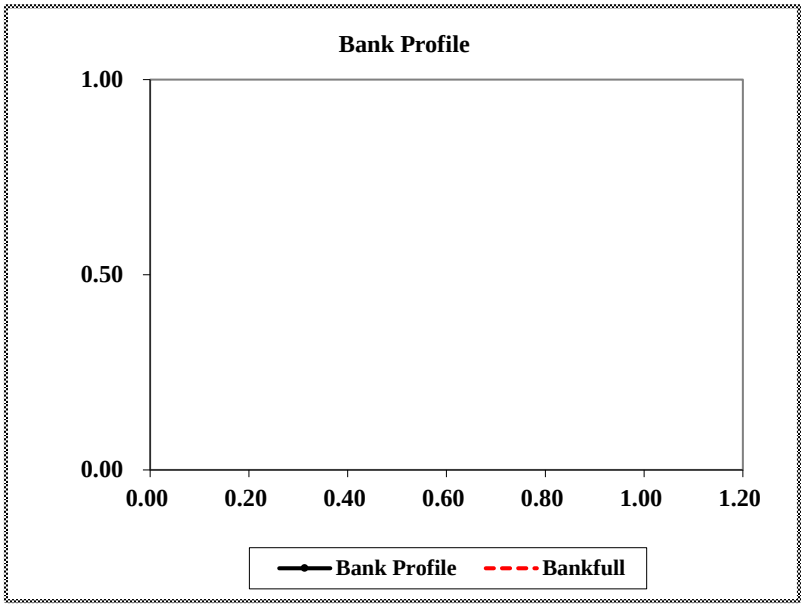
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Removed due to deposition

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-9** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	
Dominant Near-Bank Stress	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating						

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**	**37.47**				
Reach:		**Comments:**							**High**				
Location:	RB-10	**Bank Length**	29					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio

Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
1.80	0.40	4.50	10.00	Extreme	

Root Depth / Bank Height Ratio

Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
1.00	1.80	0.56	3.63	Low	

Weighted Root Density

Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
10.00	0.56	5.56	8.94	Very High	

Bank Angle

Bank Angle (°)			Index	Bank Erosion Potental	Notes
80.00			5.90	Moderate	

Surface Protection

Surface Protection (%)			Index	Bank Erosion Potental	Notes
10.00			9.00	Very High	

	Adjustment		Notes
Bank Materials	0.00		
	Adjustment		Notes
Bank Stratification	0.00		
TOTAL SCORE	**37.47**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

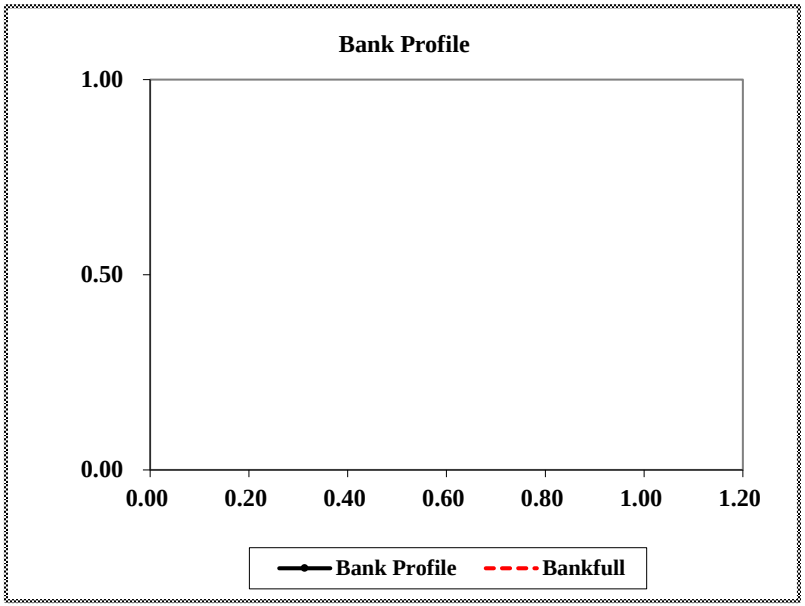
Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**

Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-10** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High
Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	**Moderate**

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Moderate**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**Moderate**			
Location:	RB-11	**Bank Length**	18					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
0.50					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	0.50				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Moderate**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

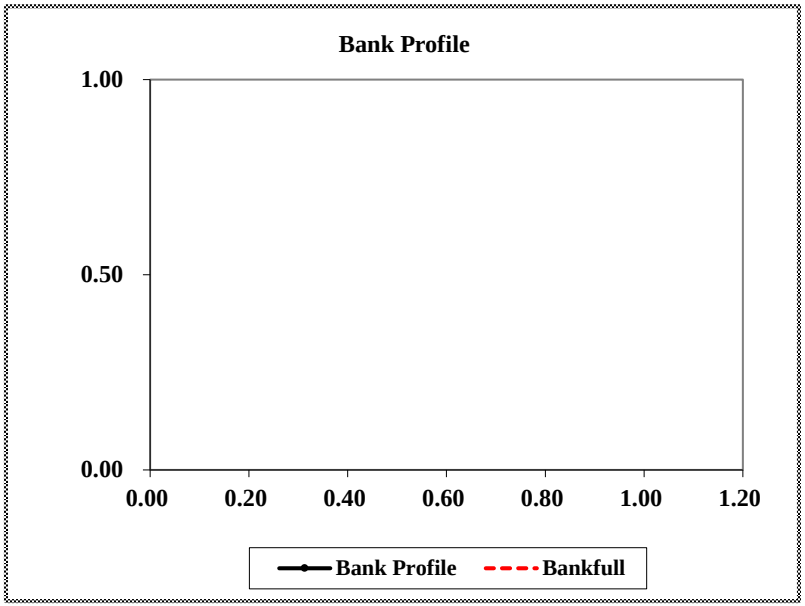
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - Moderate

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-11** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Low	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Low**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**	**42.19**				
Reach:		**Comments:**							**Very High**				
Location:	RB-12	**Bank Length**	54					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio

Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
4.10	0.40	10.25	10.00	Extreme	

Root Depth / Bank Height Ratio

Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
0.80	4.10	0.20	7.29	High	

Weighted Root Density

Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
25.00	0.20	4.88	10.00	Extreme	

Bank Angle

Bank Angle (°)			Index	Bank Erosion Potental	Notes
80.00			5.90	Moderate	

Surface Protection

Surface Protection (%)			Index	Bank Erosion Potental	Notes
10.00			9.00	Very High	

	Adjustment		Notes
Bank Materials	0.00		
	Adjustment		Notes
Bank Stratification	0.00		
TOTAL SCORE	**42.19**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

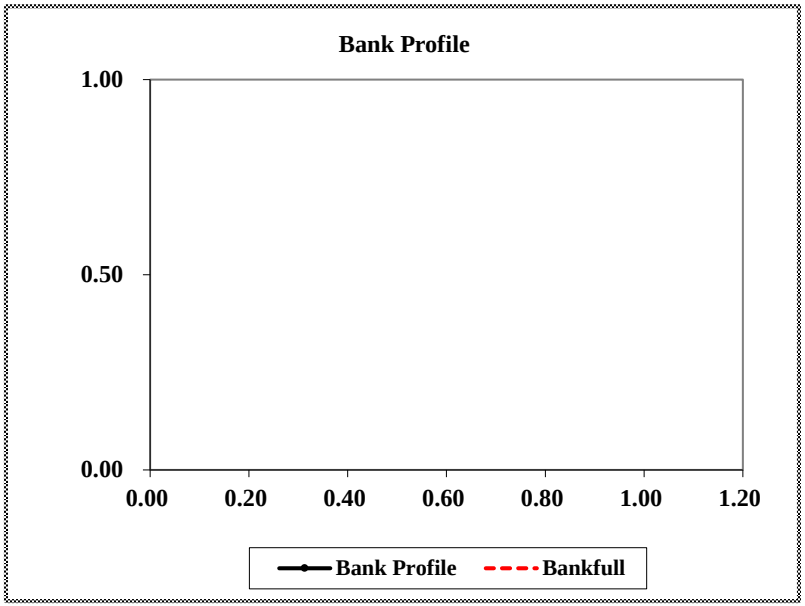
Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile

Horizontal Distance	Vertical Height	Notes

Bankfull

Horizontal Distance	Vertical Height	Notes



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-12** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**					
Reach:		**Comments:**											
Location:	RB-13	**Bank Length**	64					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE			

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

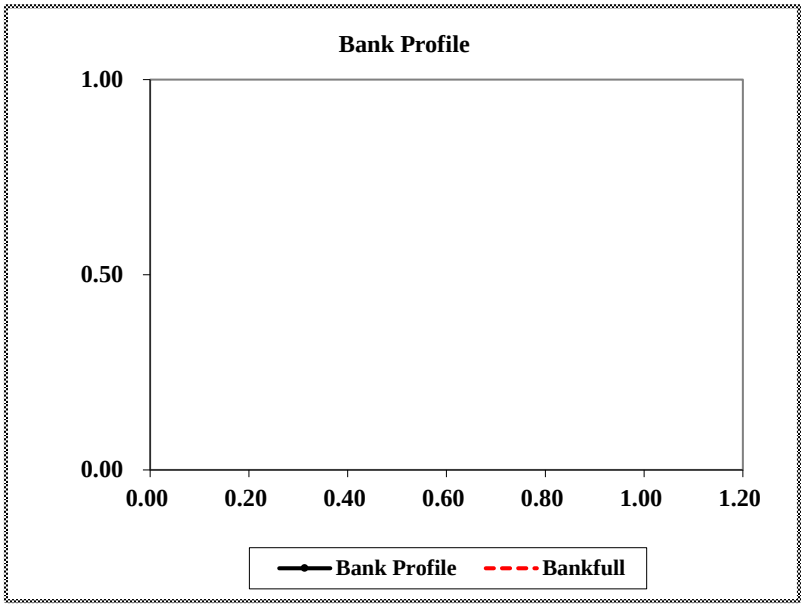
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Removed due to deposition

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-13** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2) Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3) Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4) Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method | **Dominant Near-Bank Stress**

Level III

(5) Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6) Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV

(7) Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40

Overall Near-Bank Stress (NBS) rating

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**Very High**			
Location:	RB-14	**Bank Length**	24					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
5.00					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	5.00				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Very High**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

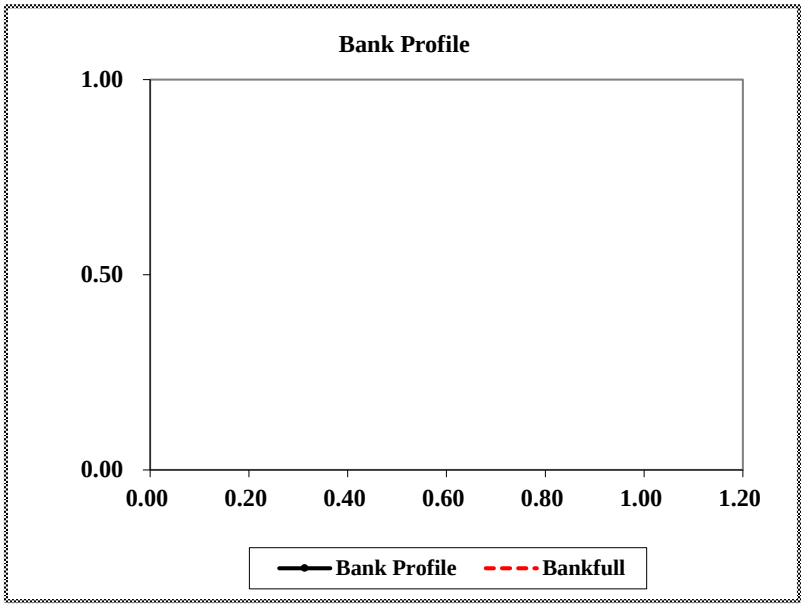
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - Very High

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-14** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Very High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Very High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**High**			
Location:	RB-15	**Bank Length**	32					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio

Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
4.40					

Root Depth / Bank Height Ratio

Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	4.40				

Weighted Root Density

Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes

Bank Angle

Bank Angle (°)		Index	Bank Erosion Potental	Notes

Surface Protection

Surface Protection (%)		Index	Bank Erosion Potental	Notes

	Adjustment		Notes
Bank Materials			
	Adjustment		Notes
Bank Stratification			
TOTAL SCORE	**High**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

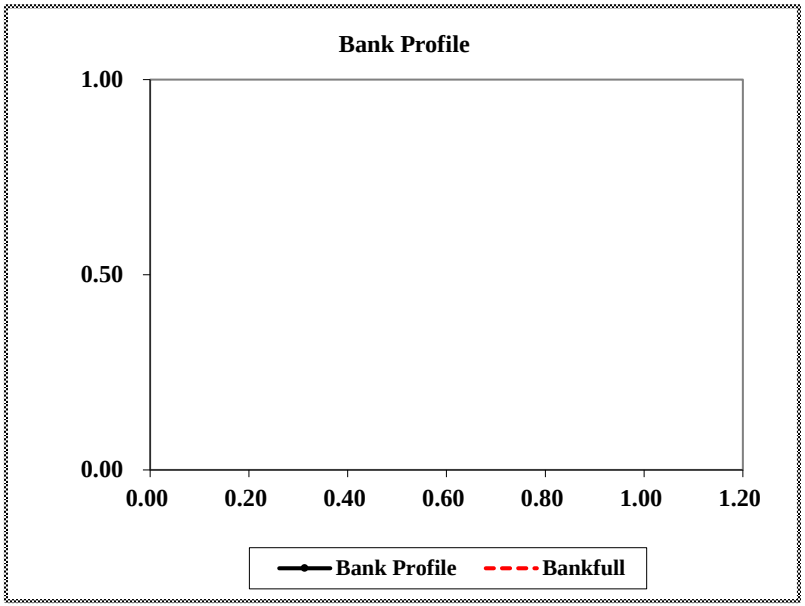
Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile

Horizontal Distance	Vertical Height	Notes

Bankfull

Horizontal Distance	Vertical Height	Notes



Ocular estimate - High

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-15** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High
Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	**1**
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**Very High**			
Location:	RB-16	**Bank Length**	60					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
5.00					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	5.00				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Very High**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

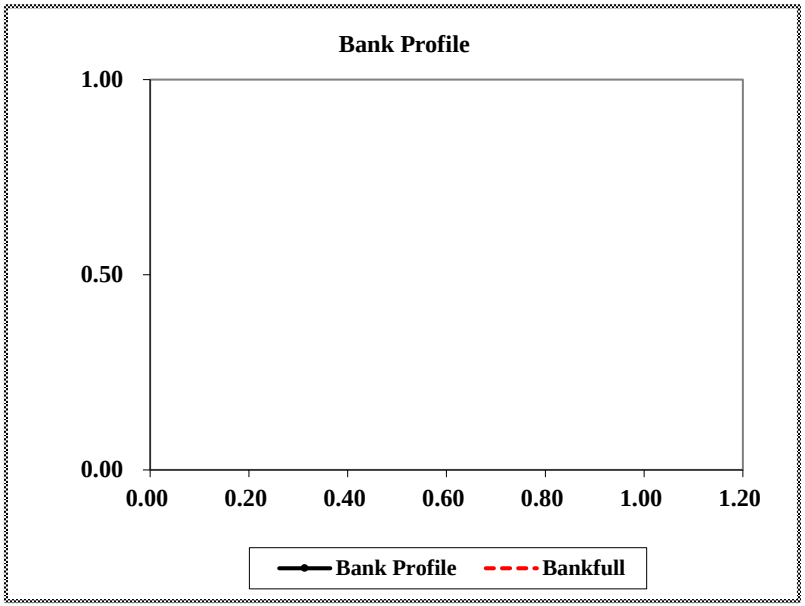
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - Very High

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-16** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2) Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3) Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4) Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	**1**
Dominant Near-Bank Stress	
Very High	

Level III

(5) Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6) Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV

(7) Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Very High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**High**			
Location:	RB-17	**Bank Length**	77					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
3.50					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	3.50				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**High**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

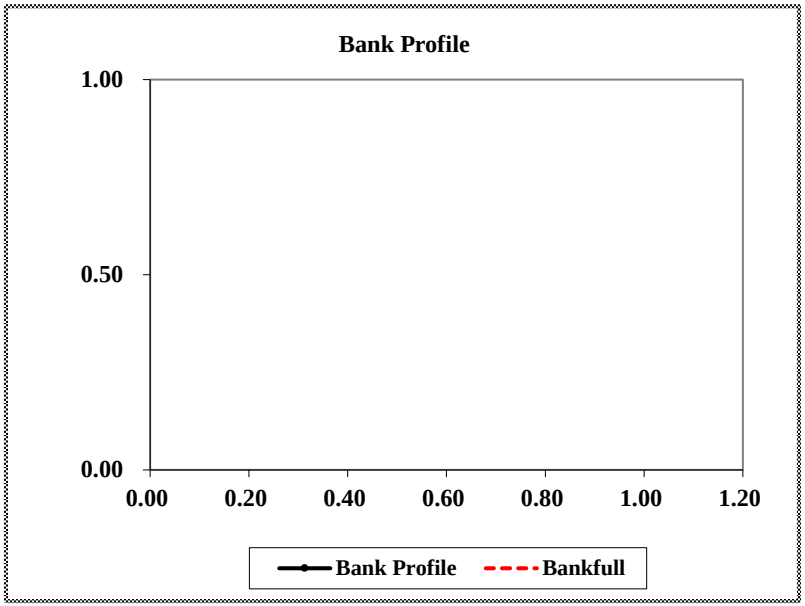
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - High

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-17** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……..NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Moderate	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Moderate**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**	**33.29**				
Reach:		**Comments:**							**High**				
Location:	RB-18	**Bank Length**	29					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio

Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
2.10	0.40	5.25	10.00	Extreme	

Root Depth / Bank Height Ratio

Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
1.00	2.10	0.48	4.14	Moderate	

Weighted Root Density

Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
40.00	0.48	19.05	7.35	High	

Bank Angle

Bank Angle (°)			Index	Bank Erosion Potental	Notes
80.00			5.90	Moderate	

Surface Protection

Surface Protection (%)			Index	Bank Erosion Potental	Notes
30.00			5.90	Moderate	

	Adjustment		Notes
Bank Materials	0.00		
	Adjustment		Notes
Bank Stratification	0.00		
TOTAL SCORE	**33.29**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

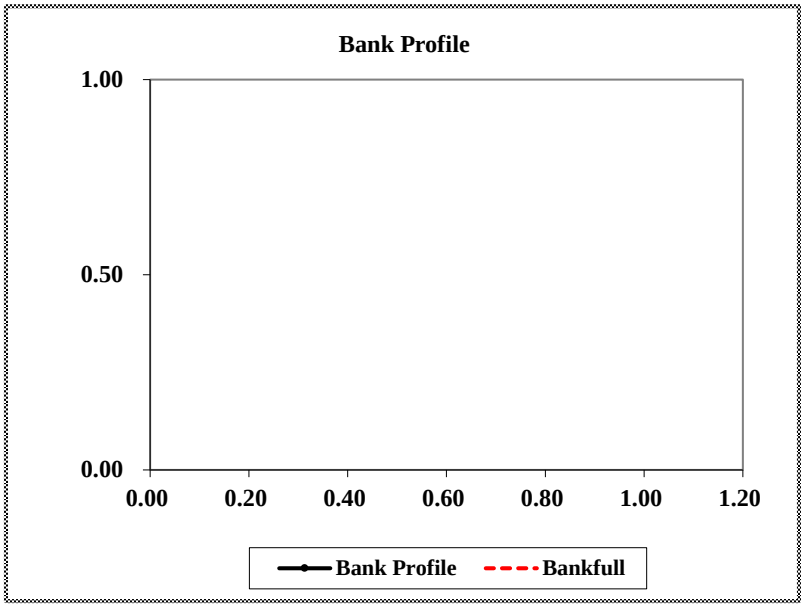
Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**

Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-18** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**)	Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
Moderate	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**Moderate**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**Very High**			
Location:	RB-19	**Bank Length**	44					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
6.00					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	6.00				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Very High**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

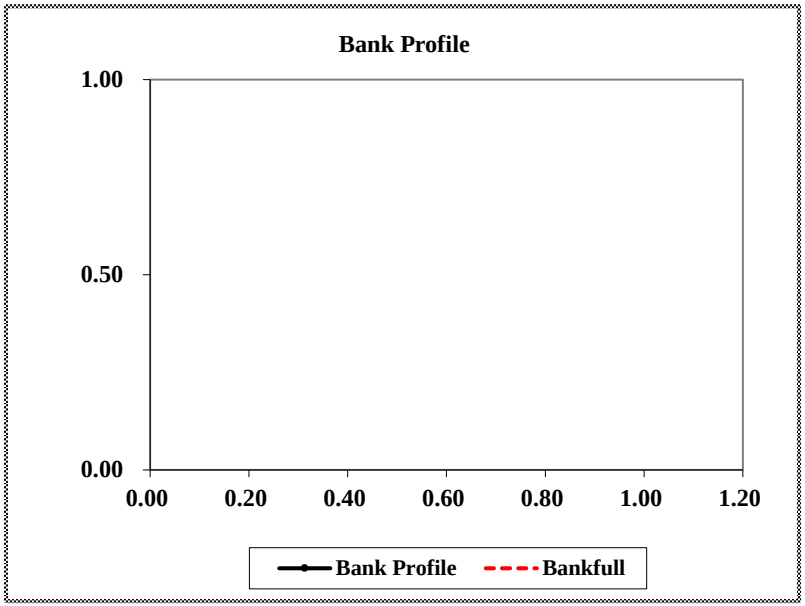
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - Very High

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-19** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**					
Reach:		**Comments:**											
Location:	RB-20	**Bank Length**	37					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE			

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

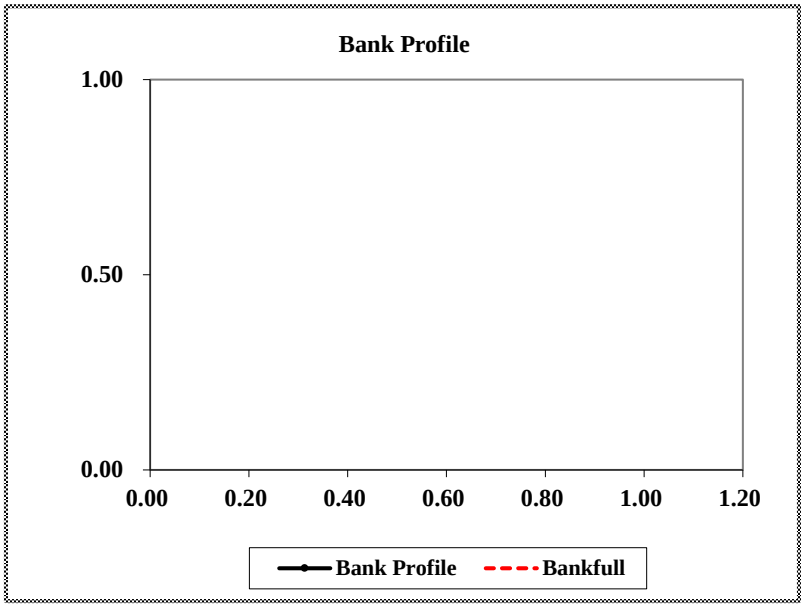
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Removed due to deposition

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-20** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**)	Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	
Dominant Near-Bank Stress	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating						

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**High**			
Location:	RB-21	**Bank Length**	38					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables

Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
2.20					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	2.20				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**High**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

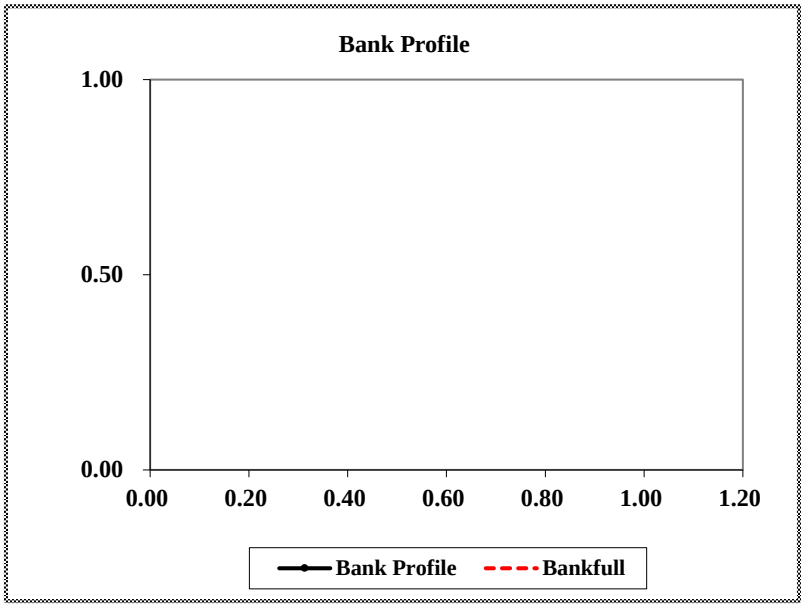
Adjustments

Bank Material	
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - High

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-21** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

BANK EROSION HAZARD INDEX

Stream:	Tributary to Five Mile Creek	**Observer(s):**	IT RS	**Data:**	IT	**QA/QC:**	RS	**Total Score:**		**NA**			
Reach:		**Comments:**								**Very High**			
Location:	RB-22	**Bank Length**	19					**Total Score Values:**	**Very Low**	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
Date:	5/24/2022								5-10	10-20	20-30	30-40	40-45	45-50

Erodibility Variables					
Bank Height / Bankfull Height Ratio					
Bank Height	Bankfull Height	Value	Index	Bank Erosion Potental	Notes
5.20					
Root Depth / Bank Height Ratio					
Root Depth	Bank Height	Value	Index	Bank Erosion Potental	Notes
	5.20				
Weighted Root Density					
Root Density (%)	Root Depth / Bank Height	Value	Index	Bank Erosion Potental	Notes
Bank Angle					
Bank Angle (°)			Index	Bank Erosion Potental	Notes
Surface Protection					
Surface Protection (%)			Index	Bank Erosion Potental	Notes
			Adjustment		Notes
Bank Materials					
			Adjustment		Notes
Bank Stratification					
		TOTAL SCORE	**Very High**		

Bank Erosion Potential

		Very Low	Low	Moderate	High	Very High	Extreme
Erodibility Variables							
Bank Height / Bankfull Height	Value	1.00-1.10	1.11-1.19	1.20-1.50	1.60-2.00	2.10-2.80	>2.80
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Root Depth / Bank Height	Value	1.00-0.90	0.89-0.50	0.49-0.30	0.29-0.15	0.14-0.05	<0.05
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Weighted Root Density	Value	100-80	79-55	54-30	29-15	14-5	<5
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Bank Angle	Value	0-20	21-60	61-80	81-90	91-119	>119
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10
Surface Protection	Value	100-80	79-55	54-30	29-15	14-10	<10
	Index	1.0-1.9	2.0-3.9	4.0-5.9	6.0-7.9	8.0-9.0	10

Adjustments

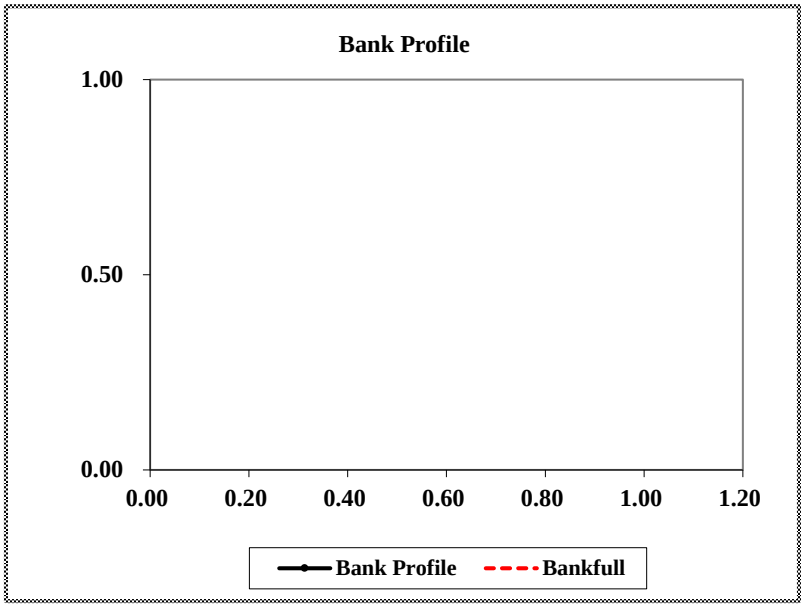
Bedrock	Bedrock banks have a very low erosion potential.
Boulders	Boulder banks have a low erosion potential.
Cobble	Substract 10 points. No adjustment if sand/gravel compose greater than 50% of bank.
Clay/Silt Loam	Add 5 points.
Gravel	Add 5-10 points depending on percentage of bank material composed of sand.
Sand	Add 10 points.
Silt / Clay	No adjustment.

Bank Material

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage.

Bank Profile		
Horizontal Distance	**Vertical Height**	**Notes**
Bankfull		
Horizontal Distance	**Vertical Height**	**Notes**



Ocular estimate - Very High

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: **Tributary to Five Mile Creek** Location: **Rolling Ridge Park**

Station: **RB-22** Stream Type: Valley Type:

Observers: **IT RS** Date: **5/24/2022**

Methods for Estimating Near-Bank Stress (NBS)

(**1**) Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(**2**) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(**3**) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(**4**) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(**5**) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(**6**) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(**7**) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I **(1)**

Transverse and/or central bars-short and/or discontinuous…… ……..NBS = High / Very High

Extensive deposition (continuous, cross-channel)…… ……...NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow…… ……..NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Method	1
Dominant Near-Bank Stress	
High	

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV **(7)**

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating					**High**	

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 1

Date: 5/24/2022

Photographer: INT

Description: LB-1

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 2

Date: 5/24/2022

Photographer: INT

Description: LB-2, Deposition

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 3

Date: 5/24/2022

Photographer: INT

Description: LB-3

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 4

Date: 5/24/2022

Photographer: INT

Description: LB-4

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 5

Date: 5/24/2022

Photographer: INT

Description: LB-6

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 6

Date: 5/24/2022

Photographer: INT

Description: LB-7

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 7

Date: 5/24/2022

Photographer: INT

Description: LB-8, Unnamed Tributary

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 8

Date: 5/24/2022

Photographer: INT

Description: LB-9

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 9

Date: 5/24/2022

Photographer: INT

Description: LB-10

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 10

Date: 5/24/2022

Photographer: INT

Description: LB-11

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 11

Date: 5/24/2022

Photographer: INT

Description: LB-212, Deposition

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 12

Date: 5/24/2022

Photographer: INT

Description: LB-13

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 13

Date: 5/24/2022

Photographer: INT

Description: LB-14, Deposition

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 14

Date: 5/24/2022

Photographer: INT

Description: LB-15

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 15

Date: 5/24/2022

Photographer: INT

Description: LB-16

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 16

Date: 5/24/2022

Photographer: INT

Description: LB-17

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 17

Date: 5/24/2022

Photographer: INT

Description: LB-19

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 18

Date: 5/24/2022

Photographer: INT

Description: LB-20

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 19

Date: 5/24/2022

Photographer: INT

Description: LB-21, Deposition

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 20

Date: 5/24/2022

Photographer: INT

Description: LB-22

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 21

Date: 5/24/2022

Photographer: INT

Description: RB-1

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 22

Date: 5/24/2022

Photographer: INT

Description: RB-2

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 23

Date: 5/24/2022

Photographer: INT

Description: RB-3, Deposition

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 24

Date: 5/24/2022

Photographer: INT

Description: RB-4

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 25

Date: 5/24/2022

Photographer: INT

Description: RB-5, Deposition, confluence of piped Five Mile Creek and tributary

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 26

Date: 5/24/2022

Photographer: INT

Description: RB-6

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 27

Date: 5/24/2022

Photographer: INT

Description: RB-7, Deposition

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 28

Date: 5/24/2022

Photographer: INT

Description: RB-8

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 29

Date: 5/24/2022

Photographer: INT

Description: RB-9, Deposition

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 30

Date: 5/24/2022

Photographer: INT

Description: RB-11

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 31

Date: 5/24/2022

Photographer: INT

Description: RB-12

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 32

Date: 5/24/2022

Photographer: INT

Description: RB-13, Deposition

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 33

Date: 5/24/2022

Photographer: INT

Description: RB-14

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 34

Date: 5/24/2022

Photographer: INT

Description: RB-15

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 35

Date: 5/24/2022

Photographer: INT

Description: RB-16

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 36

Date: 5/24/2022

Photographer: INT

Description: RB-17

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 37

Date: 5/24/2022

Photographer: INT

Description: RB-18

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 38

Date: 5/24/2022

Photographer: INT

Description: RB-19

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 39

Date: 5/24/2022

Photographer: INT

Description: RB-20, Deposition

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 40

Date: 5/24/2022

Photographer: INT

Description: RB-21

Client: Harborcreek Township, PA

Site: Rolling Ridge Park

Project #: 7526210007

Photo: 41

Date: 5/24/2022

Photographer: INT

Description: RB-22

Note: No photos for LB-5, LB-18, or RB-10

Geotechnical Data Report

Rolling Ridge Park Stream Restoration
Erie, Pennsylvania
June 6, 2022
Terracon Project No. JD215067C

Prepared for:
Wood Environment & Infrastructure Solutions Inc.
Chantilly, Virginia

Prepared by:
Terracon Consultants, Inc.
Ashburn, Virginia

June 6, 2022

Wood Environment & Infrastructure Solutions Inc.
14424 Albemarle Point Place, Suite 115
Chantilly, Virginia 20151

Attn: Ms. Lynne Mowery, PE, CFM
P: (703) 488-3773
E: lynne.mowery@woodplc.com

Re: Geotechnical Data Report
Rolling Ridge Park Stream Restoration
3901 Brierwood Drive
Erie, Pennsylvania
Terracon Project No. JD215067C

Dear Ms. Mowery:

We have completed the Geotechnical Data Report services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. PJD225108 dated March 16, 2022. This data report presents the findings of the subsurface exploration for the above referenced project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Dylan Nixon, PE
Senior Staff Engineer

Rebecca Smith-Zakowicz, PG, PE
Principal

REPORT TOPICS

Note: This report was originally delivered in a web-based format. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Data Report

Rolling Ridge Park Stream Restoration

Erie, Pennsylvania

Terracon Project No. JD215067C

June 6, 2022

INTRODUCTION

This report presents the results of our subsurface exploration services performed for the proposed stream restoration to be located at Rolling Ridge Park in Erie, Pennsylvania.

The geotechnical engineering Scope of Services for this project included the collection of 3 hand auger samples to depths ranging from approximately 3 to 4 feet below existing site grades.

Maps showing the site and hand auger locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located at Rolling Ridge Park in Erie, Pennsylvania. Latitude: 42.136525°, Longitude: -79.993038° (approximate) See **Site Location**
Current Ground Cover	Moderate to dense vegetation, steep stream banks
Existing Topography (from Google Earth)	The approximate elevation (EL) at the site ranges from EL 828 to EL 799. The elevation is in mean sea level.
Geology	Our experience near the vicinity of the proposed development and readily available geologic maps indicates subsurface conditions consist of soils derived from the weathering of Girard shale and siltstone of the Devonian geologic period. Based on our subsurface investigation, the sediments and strata correspond favorably to the geologic publications.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	■ Emails and conversations with Wood ranging from January 31, 2022 to April 26, 2022 ■ Recommendations for Crediting Outfall and Gully Stabilizations Projects in the Chesapeake Bay Watershed prepared by the Water Quality Goal Implementation Team dated October 15, 2019
Project Description	The project includes stream restoration (in accordance with the Prevented Sediment Protocol for Urban Stream Restoration dated February 27, 2020) along the stream that flows through Rolling Ridge Park.

BULK DENSITY TEST RESULTS

A total of 3 soil samples were collected along the northeastern and southwestern streambanks along the existing stream using a 3-inch x 6-inch in-situ soil core sampling device, fitted with a drive hammer and plastic liner. Samples were collected by driving the coring cylinder into the ground and removing an intact, uncompacted cylindrical soil core. The plastic liner and core were then removed from the sampler, labeled, and capped. Soil cores were then cut to produce a perpendicular surface at the end of the plastic sleeve, and soil was ejected from the sleeve and placed into an oven drying tray. The samples were dried at 105 C° overnight (16 hours) and/or until no further weight change was recorded. Bulk density was calculated as the samples weight in pounds (lbs) divided by the sample size in cubic feet (cf), reported as lbs/cf.

Test was performed in accordance with the USDA-NRCS Bulk Density Soil Cores method was described in the Kellogg Soil Survey Laboratory Methods Manual, Soil Survey Investigation Report No. 42, Version 5.0, Issued 2014, pp. 138-140.

A summary of the bulk density test results is presented below:

Sample ID	Bulk Density (lbs/cf)	Sample Location
BD-1	58.4	Streambank
BD-2	87.5	Streambank
BD-3	54.1	Streambank

EQUILIBRIUM BED SLOPE

Based on the requirements outlined in the Recommendations for Crediting Outfall and Gully Stabilization Projects in the Chesapeake Bay Watershed prepared by the Water Quality Goal Implementation Team dated October 15, 2019, it is our recommendation that the bed slope equation for “Cohesive Bed” is utilized in design. The results of our grain size analysis with

hydrometer testing showed the majority of the particle sizes in the samples tested were <0.1 mm in size.

Table 3. Equilibrium Bed Slope Equations	
Cohesive Bed	$S_{eq} = 0.0028A^{-0.33}$
Sand and Fine Gravel (0.1-5mm particle size)	$S_{eq} = 0.06 / (y * 62.43)$
Beds Coarser than Sand (>5mm particle size)	Average of 4 Equations Details can be found in 2.1.3 of Appendix A.
S_{eq} is equilibrium slope (m/m or ft/ft), A is drainage area (km^2), and y is mean flow depth (ft). When estimating the critical shear stress, a 10-year recurrence interval can be used for the design discharge, and intermediate suspended sediment concentration (1,000 to 2,000 ppm) can be assumed.	

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Hand-Auger Borings	Boring Depth (feet)	Planned Location
3	3-4	Rolling Ridge Park stream

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provided the boring layout.

Subsurface Exploration Procedures: We advanced the borings using hand augers. One composite sample was obtained in the upper 3 to 4 feet of each hand auger boring. For safety purposes, all hand auger borings were backfilled with auger cuttings after their completion.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests to understand the engineering properties of the various soil strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D798 Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

The laboratory testing program often included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plan
Exploration Plan

Note: All attachments are one page unless noted above.

SITE LOCATION

Rolling Ridge Park Stream Restoration ■ Erie, Pennsylvania
June 6, 2022 ■ Terracon Project No. JD215067C

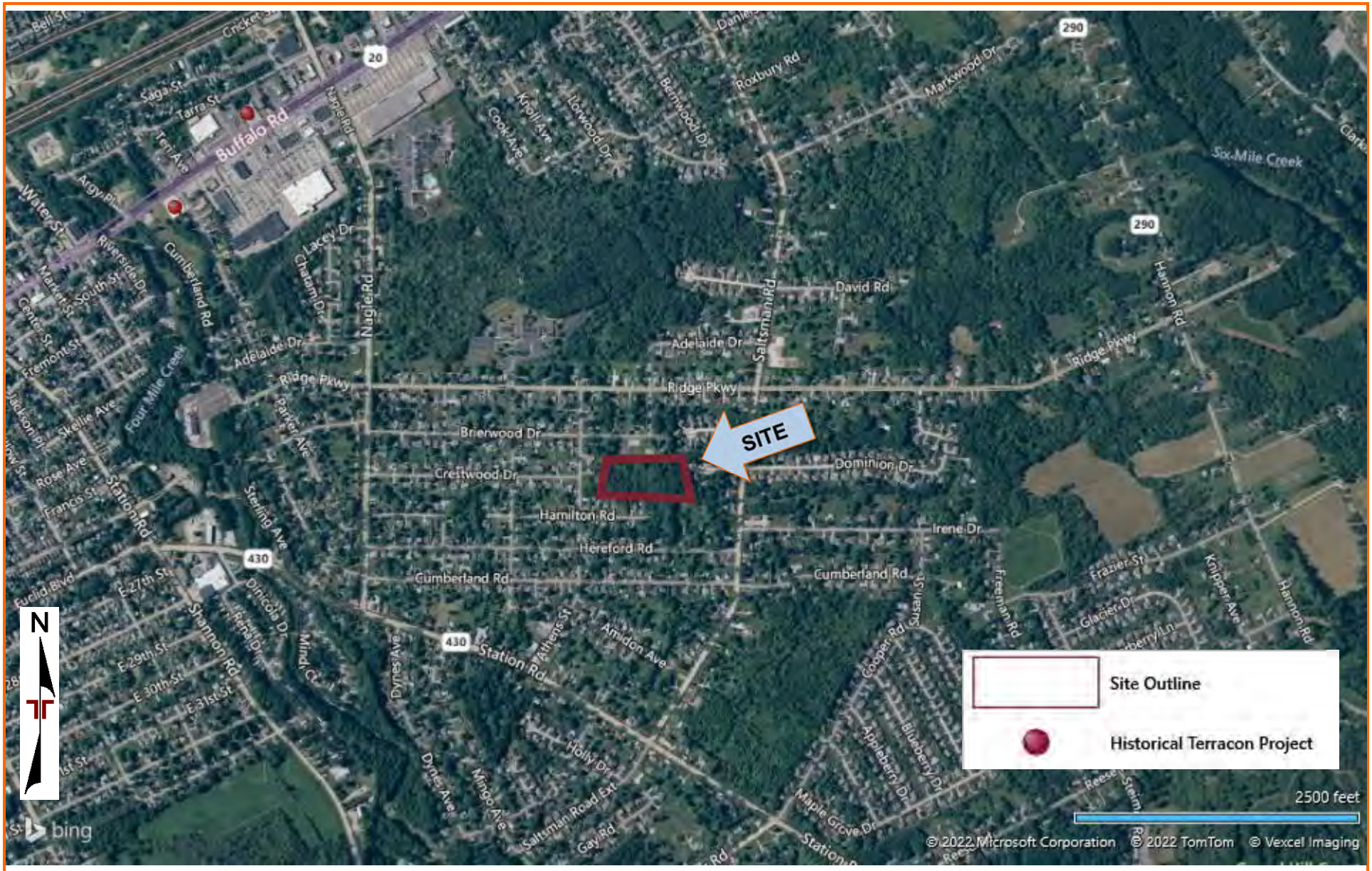


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

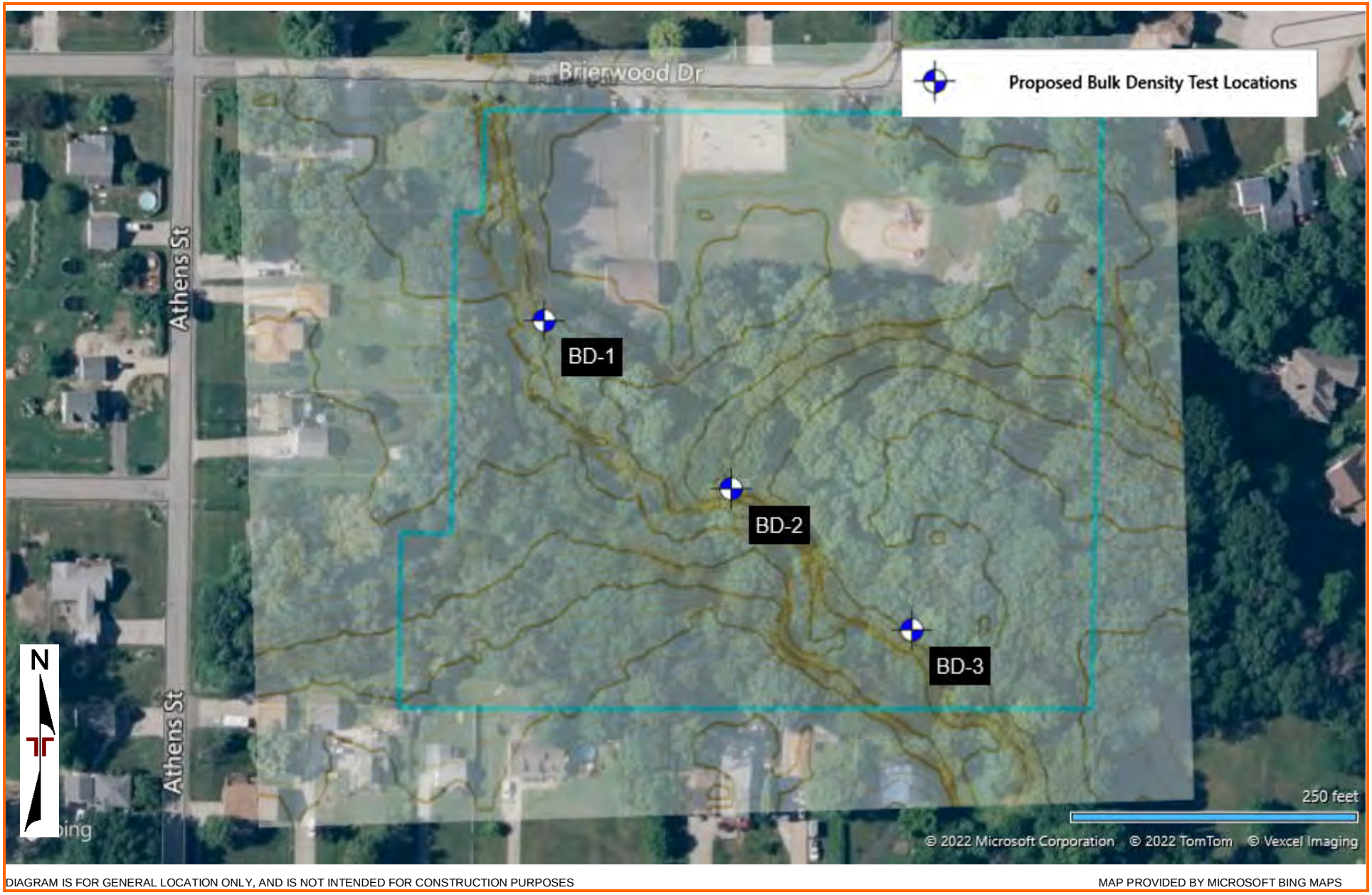


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

SUMMARY OF LABORATORY RESULTS

BORING ID	Depth	USCS Classification and Soil Description	AASHTO Class.	Munsell Color	Liquid Limit	Plastic Limit	Plasticity Index	% <#200 Sieve	% Gravel	% Sand	% Silt	% Clay	Water Content (%)	Optimum Moisture Content (%)	Maximum Dry Density, (pcf)*
B-1	0 - 3	SILT with SAND(ML)	A-4 (5)		34	27	7	76.8	0.1	23.1	63.8	13.0	32		
B-2	0 - 3	SILTY, CLAYEY SAND with	A-4 (0)		23	18	5	39.1	16.5	44.4	29.4	9.8	18		
		GRAVEL(SC-SM)													
B-3	0 - 4	CLAYEY SAND(SC)	A-6 (2)		28	17	11	47.3	7.7	45.0	31.7	15.6	16		

*Per IDOT Matls. IM 309, Single-Point Method.
**Soil of Glacial Origin

PROJECT: Rolling Ridge Park Stream Restoration

SITE: 3901 Brierwood Dr
Erie, PA

Terracon
19955 Highland Vista Dr Ste 170
Ashburn, VA
PH. 703-726-8030 FAX.

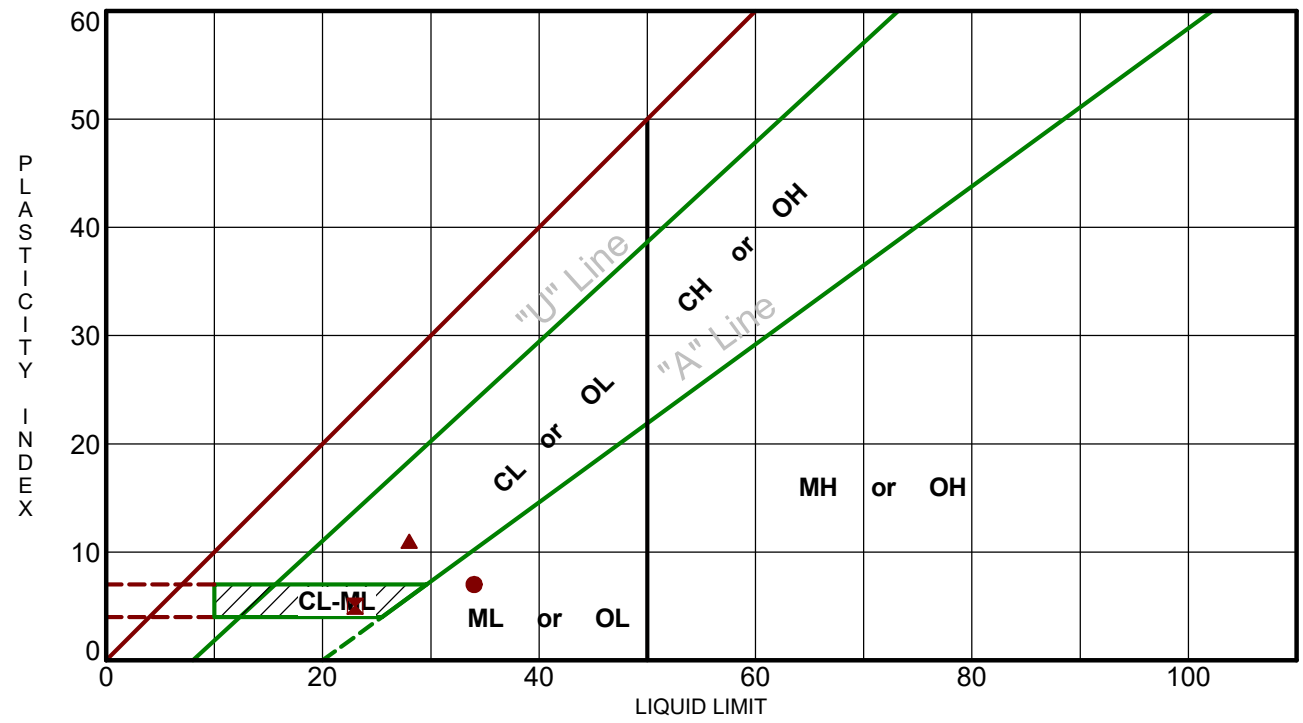
PROJECT NUMBER: JD215067C

CLIENT: Wood Partners LLC
Chantilly, VA

EXHIBIT: B-1

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth	LL	PL	PI	Fines	AASHTO	Description
● B-1	0 - 3	34	27	7	76.8	A-4 (5)	SILT with SAND (ML)
⊠ B-2	0 - 3	23	18	5	39.1	A-4 (0)	SILTY, CLAYEY SAND with GRAVEL (SC-SM)
▲ B-3	0 - 4	28	17	11	47.3	A-6 (2)	CLAYEY SAND (SC)

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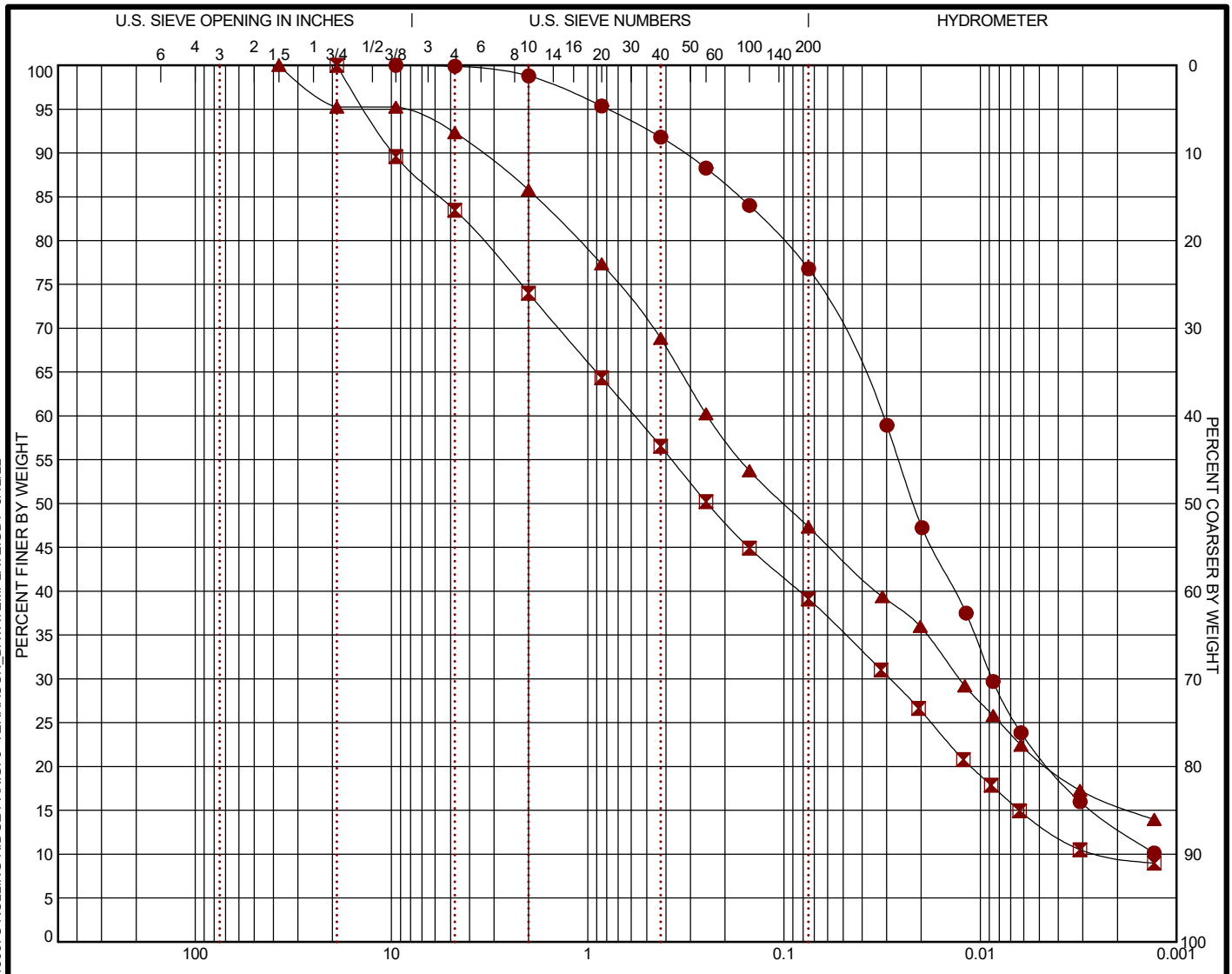
EXHIBIT: B-1

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**B-1**	**0 - 3**	**0.0**	**0.1**	**23.1**	**55.4**		**21.4**	**ML**
⊠	**B-2**	**0 - 3**	**0.0**	**16.5**	**44.4**	**25.6**		**13.5**	**SC-SM**
▲	**B-3**	**0 - 4**	**0.0**	**7.7**	**45.0**	**26.5**		**20.8**	**SC**

	GRAIN SIZE		
	●	⊠	▲
D_{60}	**0.032**	**0.578**	**0.245**
D_{30}	**0.009**	**0.029**	**0.013**
D_{10}		**0.002**	
	COEFFICIENTS		
C_C		**0.63**	
C_U		**251.21**	

●		⊠		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
3/8"	**100.0**	**3/4"**	**100.0**	**1 1/2"**	**100.0**
#4	**99.89**	**3/8"**	**89.57**	**3/4"**	**95.23**
#10	**98.79**	**#4**	**83.47**	**3/8"**	**95.23**
#20	**95.36**	**#10**	**74.0**	**#4**	**92.32**
#40	**91.81**	**#20**	**64.34**	**#10**	**85.77**
#60	**88.28**	**#40**	**56.53**	**#20**	**77.35**
#100	**84.01**	**#60**	**50.22**	**#40**	**68.84**
#200	**76.79**	**#100**	**44.91**	**#60**	**60.24**
		#200	**39.12**	**#100**	**53.74**
				#200	**47.33**

SOIL DESCRIPTION

- ● SILT with SAND (ML)
- ⊠ SILTY, CLAYEY SAND with GRAVEL (SC-SM)
- ▲ CLAYEY SAND (SC)

REMARKS

- ●
- ⊠
- ▲

PROJECT: Rolling Ridge Park Stream Restoration

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PROJECT NUMBER: JD215067C

CLIENT: Wood Partners LLC
Chantilly, VA

EXHIBIT: B-1

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 JD215067C ROLLING RIDGE PAR.GPJ TERRACON_DATATEMPLATE.GDT 5/12/22

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

SAMPLING	WATER LEVEL	FIELD TESTS
 Grab Sample	**Water Initially Encountered** **Water Level After a Specified Period of Time** **Water Level After a Specified Period of Time** **Cave In Encountered** Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	**N** Standard Penetration Test Resistance (Blows/Ft.) **(HP)** Hand Penetrometer **(T)** Torvane **(DCP)** Dynamic Cone Penetrometer **UC** Unconfined Compressive Strength **(PID)** Photo-Ionization Detector **(OVA)** Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]		GW	Well-graded gravel [F]
			$Cu < 4$ and/or [$Cc<1$ or $Cc>3.0$] [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F, G, H]
			Fines classify as CL or CH		GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]		SW	Well-graded sand [I]
			$Cu < 6$ and/or [$Cc<1$ or $Cc>3.0$] [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G, H, I]
			Fines classify as CL or CH		SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A"		CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K, L, M]
			PI plots below "A" line		MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.