

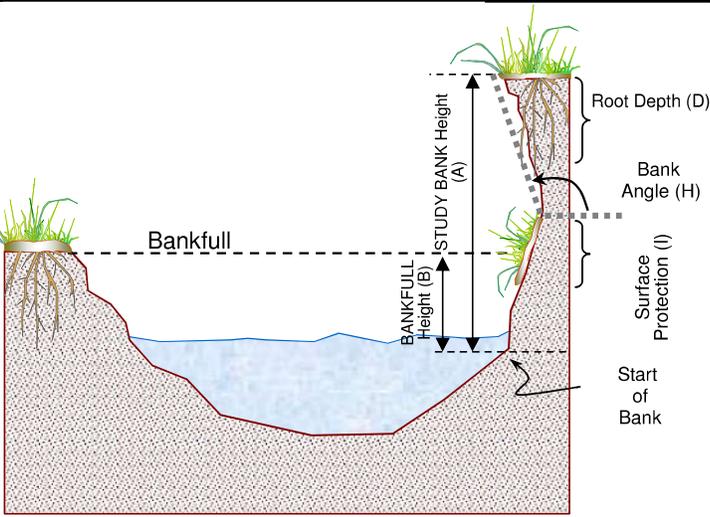
Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.

Stream: Strawberry Run		Location: BEHI #6	
Station: 70 ft		Observers: Biggs/Hepp	
Date: 4/5/18	Stream Type: G4	Valley Type: VI	

Study Bank Height / Bankfull Height (C)					BEHI Score (Fig. 3-7)
Study Bank Height (ft) =	8.50 (A)	Bankfull Height (ft) =	0.55 (B)	(A) / (B) =	15.45 (C)
					10.0
Root Depth / Study Bank Height (E)					
Root Depth (ft) =	4.00 (D)	Study Bank Height (ft) =	8.50 (A)	(D) / (A) =	0.47 (E)
					4.0
Weighted Root Density (G)					
Root Density as % =	15.00 (F)	(F) × (E) =			7.06 (G)
					9.0
Bank Angle (H)					
Bank Angle as Degrees =	120 (H)				
					9.0
Surface Protection (I)					
Surface Protection as % =	0% (I)				
					10.0

Bank Material Adjustment:	
Bedrock (Overall Very Low BEHI)	<div style="font-size: 2em; color: blue;">➔</div>
Boulders (Overall Low BEHI)	
Cobble (Subtract 10 points if uniform medium to large cobble)	
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)	
Sand (Add 10 points)	
Silt/Clay (no adjustment)	
	Bank Material Adjustment
	5
	Stratification Adjustment
	Add 5–10 points, depending on position of unstable layers in relation to bankfull stage
	5

Very Low	Low	Moderate	High	Very High	Extreme	➔	Adjective Rating and Total Score	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		52.0	

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

Estimating Near-Bank Stress (NBS)									
Stream: Strawberry Run					Location: BEHI #6				
Station: 70 ft			Stream Type: G4			Valley Type: VI			
Observers: Biggs/Hepp					Date: 4/5/18				
Methods for Estimating Near-Bank Stress (NBS)									
(1) Channel pattern, transverse bar or split channel/central bar creating NBS					Level I		Reconnaissance		
(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)					
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						Extreme			

**Dominant
Near-Bank Stress
Extreme**

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.

Stream: Strawberry Run	Location: BEHI #7
Station: 112 ft	Observers: Biggs/Hepp
Date: 4/5/18	Stream Type: G4 Valley Type: VI

Study Bank Height / Bankfull Height (C)					BEHI Score (Fig. 3-7)
Study Bank Height (ft) =	8.50 (A)	Bankfull Height (ft) =	0.55 (B)	(A) / (B) =	15.45 (C)
					10.0

Root Depth / Study Bank Height (E)					
Root Depth (ft) =	3.00 (D)	Study Bank Height (ft) =	8.50 (A)	(D) / (A) =	0.35 (E)
					5.2

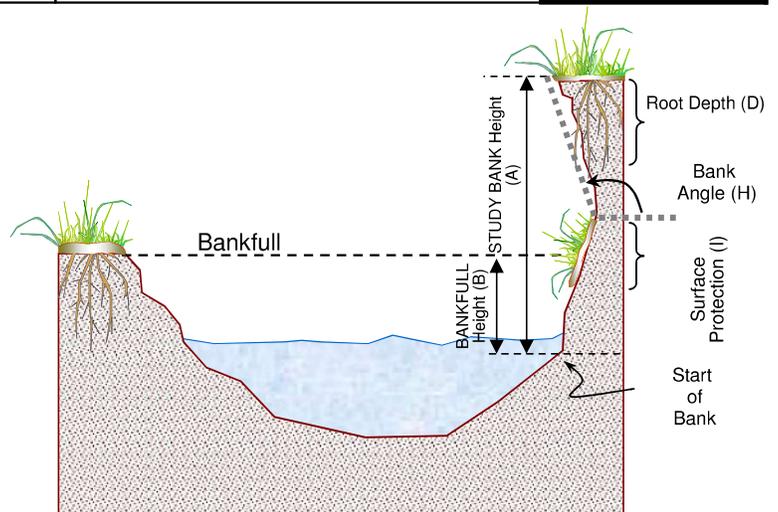
Weighted Root Density (G)					
Root Density as % =	10.00 (F)	(F) × (E) =	3.53 (G)		
					9.5

Bank Angle (H)			
Bank Angle as Degrees =	70 (H)		
			4.5

Surface Protection (I)			
Surface Protection as % =	10% (I)		
			9.0

Bank Material Adjustment:					
<ul style="list-style-type: none"> Bedrock (Overall Very Low BEHI) Boulders (Overall Low BEHI) Cobble (Subtract 10 points if uniform medium to large cobble) Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand) Sand (Add 10 points) Silt/Clay (no adjustment) 	<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <th style="text-align: left;">Bank Material Adjustment</th> <td style="width:50px; text-align: center;">5</td> </tr> <tr> <th style="text-align: left;">Stratification Adjustment</th> <td style="text-align: center;">5</td> </tr> </table> <p style="font-size: small; margin-top: 5px;">Add 5–10 points, depending on position of unstable layers in relation to bankfull stage</p>	Bank Material Adjustment	5	Stratification Adjustment	5
Bank Material Adjustment	5				
Stratification Adjustment	5				

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		48.2



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

Estimating Near-Bank Stress (NBS)									
Stream: Strawberry Run					Location: BEHI #7				
Station: 112 ft			Stream Type: G4			Valley Type: VI			
Observers: Biggs/Hepp					Date: 4/5/18				
Methods for Estimating Near-Bank Stress (NBS)									
(1) Channel pattern, transverse bar or split channel/central bar creating NBS					Level I		Reconnaissance		
(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)	<div style="border: 1px solid black; padding: 5px; text-align: center;"> Dominant Near-Bank Stress High </div>			
	(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)					
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			

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream: Strawberry Run		Location: Project Reach					
Graph Used: District of Columbia		Total Stream Length (ft): 816.0				Date: 7/17/18	
Observers: Biggs/Hepp		Valley Type: VI			Stream Type: G4		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI rating (Worksheet 3-11) (adjective)	NBS rating (Worksheet 3-12) (adjective)	Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft ³ /yr)	Erosion Rate (tons/yr/ft)
1. BEHI #1*	Extreme	High	2.4	140.0	7.5	2520.00	1.008
2. BEHI #2*	Extreme	High	2.4	141.0	7.5	2538.00	1.008
3. BEHI #3*	High	High	1.0	38.0	5.0	190.00	0.280
4. BEHI #4*	Very High	High	1.0	141.0	6.0	846.00	0.336
5. BEHI #5*	High	High	1.0	29.0	4.5	130.50	0.252
6. BEHI #6	Very High	High	1.0	43.0	5.0	215.00	0.280
7. BEHI #7	Extreme	Extreme	4.5	70.0	8.5	2677.50	2.142
8. BEHI #8*	Extreme	High	2.4	112.0	8.5	2284.80	1.142
9. BEHI #9*	Moderate	Moderate	0.3	67.0	5.0	100.50	0.084
10. BEHI #10*	Very High	Moderate	0.5	35.0	8.0	140.00	0.224
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total Erosion (ft ³ /yr)	11642.30	
Convert erosion in ft ³ /yr to yds ³ /yr {divide Total Erosion (ft ³ /yr) by 27}					Total Erosion (yds ³ /yr)	431.20	
Dry Bulk Density of the Soil is 112 lb/cf.					Total Erosion (tons/yr)	651.97	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					Total Erosion (tons/yr/ft)	0.799	

* BEHI and NBS ratings were determined using ocular estimates and field calibration technique as described in Section 3.2