Collection of Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) Data using Mobile Operating Systems

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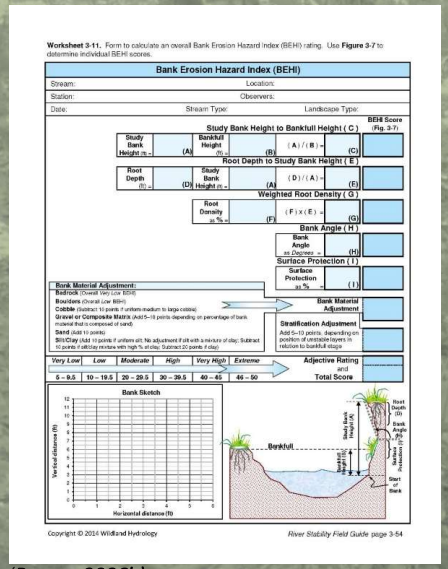
Bank Erosion Hazard Index (BEHI) and Near Bank Stress(NBS) Analysis



Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Bank Erosion Hazard Index (BEHI)

Stream: Location:
Station: Observers:
Date: Stream Type: Landscape Type:

BEHI Score (Fig. 3-7)

Study Bank Height to Bankfull Height (C)
Study Bank Height (ft) = (A) | Bankfull Height (ft) = (B) | (A) / (B) = (C)

Root Depth to Study Bank Height (E)
Root Depth (ft) = (D) | Study Bank Height (ft) = (A) | (D) / (A) = (E)

Weighted Root Density (G)
Root Density as % = (F) | (F) x (E) = (G)

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

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

Bank Material Adjustment:
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble) → Bank Material Adjustment
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 (Add 10 points if uniform silt. No adjustment if silt with a mixture of clay. Subtract 10 points if silt/clay mixture with high % of clay. Subtract 20 points if clay)
Stratification Adjustment: Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

Very Low	Low	Moderate	High	Very High	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50

Adjective Rating and Total Score

Bank Sketch

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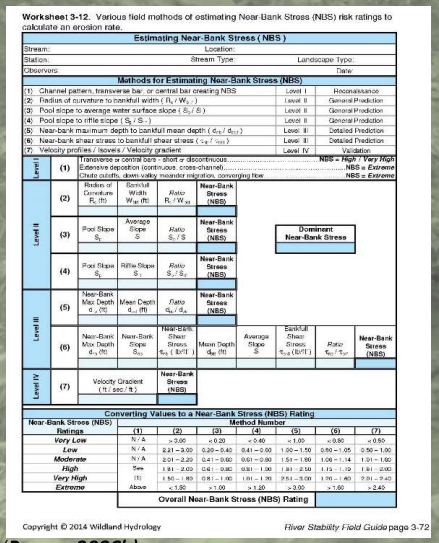
(Rosgen 2006b)



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

Estimating Near-Bank Stress (NBS)

Stream: Location:
Station: Stream Type: Landscape Type:
Observers: Date:

Methods for Estimating Near-Bank Stress (NBS)

(1)	Channel pattern, transverse bar- or central bar crossing NBS	Level I – Reconnaissance
(2)	Radius of curvature to bankfull width (R_c / W_{bkf})	Level II – General Prediction
(3)	Pool slope to average water surface slope (S_p / S)	Level II – General Prediction
(4)	Pool slope to riffle slope (S_p / S_r)	Level II – General Prediction
(5)	Near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III – Detailed Prediction
(6)	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

(1) Transverse or central bars - short 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) → Dominant Near-Bank Stress
(4) Pool Slope S_p | Riffle Slope S_r | Ratio S_p / S_r | 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	< 0.60
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.60 – 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	Tree	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	(ft)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.40	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 2.00	> 1.60	> 2.40

Overall Near-Bank Stress (NBS) Rating

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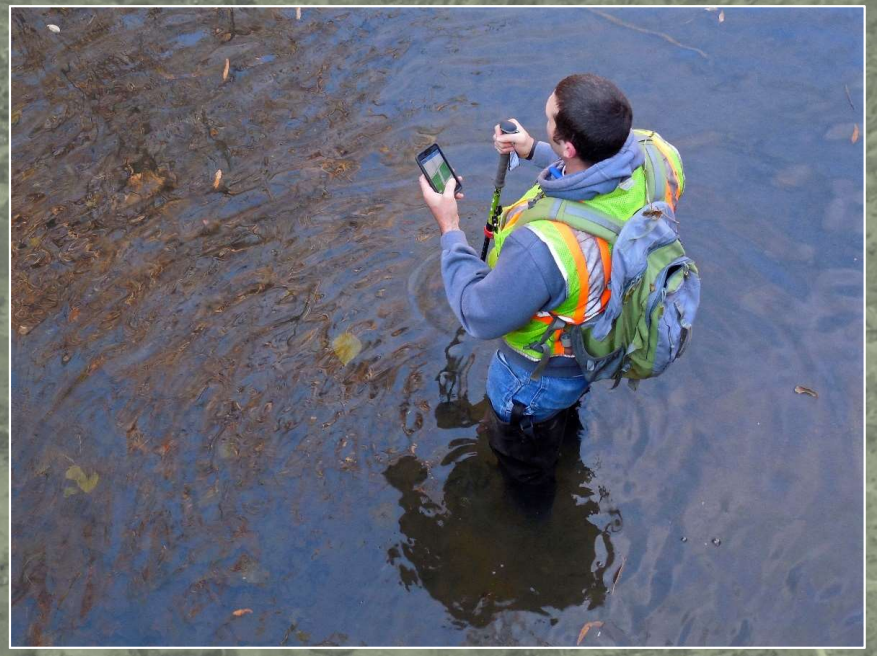
(Rosgen 2006b)

Mobile Operating Systems (MOS)

Any type of device that has cellular connectivity – Cell Phones, Tablets, etc.

- iOS (Apple)
- Android (Google)



Application (APP) Platform

ESRI APP Platforms used:

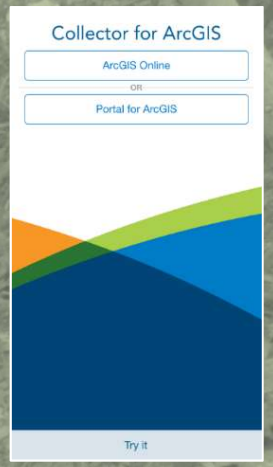
1) ArcMobile (no longer supported by ESRI, platform issues with iSO version greater than 10.2.1) (not in App store)

2) ArcCollector (supported by ESRI)

APP Platform Download:

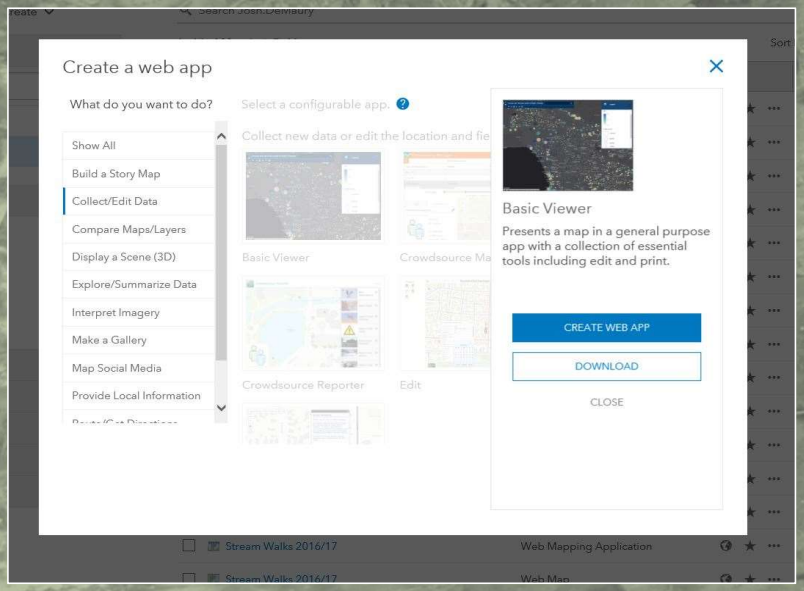
- Google Play (Android)
- Apple Store (iSO)

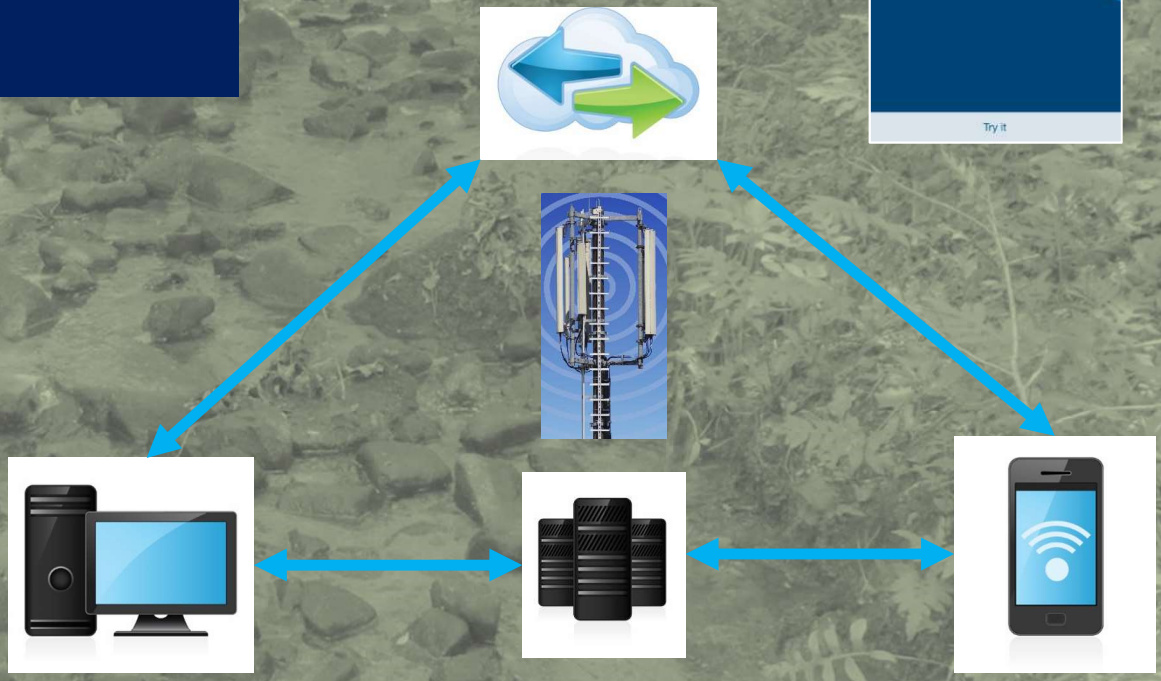
ArcGIS Online Platform



ArcGIS Online:

1) Where you create an Personalized APP (basemaps, features classes, etc.) for MOS data collection.
2) Accessed through ArcCollector by signing into your ArcGIS Online Account.
3) Data is saved directly to a SDE Geodatabase Server Connection. Can be saved directly to Cloud too.





Bank Erosion Hazard Index (BEHI) and Near Bank Stress(NBS) Analysis

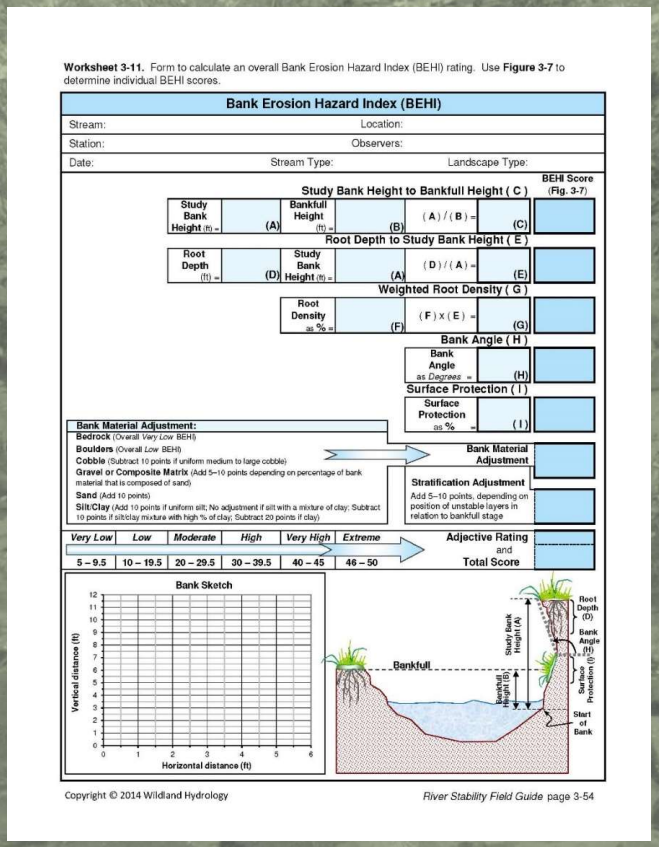
- *"Bank Assessment for Non-point source Consequences of Sediment (BANCS) model* (Rosgen, D.L. 1996, 2001a)
- *"A Practical Method of Computing Streambank Erosion Rate"* (Rosgen, D.L. 2001a)
- Empirical based streambank erosion prediction analysis that uses both qualitative and quantitative data.
- Parameters that are used for BEHI:

1) Study Bank Height
2) Bankfull Height
3) Root Depth
4) Root Density
5) Bank Angle
6) Surface Protection
7) Bank Material Adjustment

Near Bank Stress:

Seven (7) Methods of estimating NBS:

Existing conditions dictate which method is appropriate.



Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Bank Erosion Hazard Index (BEHI)

Stream: Location:

Station: Observers:

Date: Stream Type: Landscape Type:

BEHI Score (Fig. 3-7)

Study Bank Height to Bankfull Height (C)

Study Bank Height (ft) = (A) Bankfull Height (ft) = (B) (A) / (B) = (C)

Root Depth to Study Bank Height (E)

Root Depth (ft) = (D) Study Bank Height (ft) = (A) (D) / (A) = (E)

Weighted Root Density (G)

Root Density as % = (F) (F) x (E) = (G)

Bank Angle (H)

Bank Angle as Degrees = (H)

Surface Protection (I)

Surface Protection as % = (I)

Bank Material Adjustment:

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 (Add 10 points if uniform silt; No adjustment if silt with a mixture of clay; Subtract 10 points if silt/clay mixture with high % of clay; Subtract 20 points if clay)

Bank Material Adjustment

Stratification Adjustment

Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

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

Bank Sketch

Vertical distance (ft)

Horizontal distance (ft)

Bankfull

Root Depth (D)

Bank Angle (H)

Surface Protection (I)

Start of Bank

Study Bank Height (A)

Bankfull Height (B)

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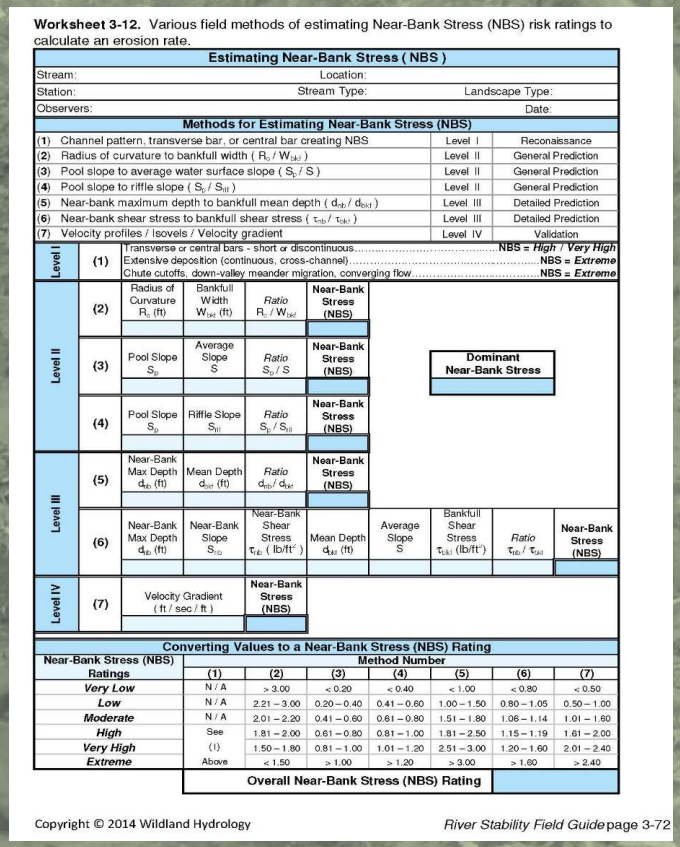

Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate an erosion rate.

Estimating Near-Bank Stress (NBS)

Stream: Location:

Station: Stream Type: Landscape Type:

Observers: Date:

Methods for Estimating Near-Bank Stress (NBS)

(1)	Channel pattern, transverse bar, or central bar creating NBS	Level I	Reconaissance
(2)	Radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General Prediction
(3)	Pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4)	Pool slope to riffle slope (S_p / S_{ff})	Level II	General Prediction
(5)	Near-bank maximum depth to bankfull mean depth (d_{mb} / d_{bkf})	Level III	Detailed Prediction
(6)	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 or central bars - short 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)	**Dominant Near-Bank Stress**
(4)	Pool Slope S_p	Riffle Slope S_{ff}	*Ratio* S_p / S_{ff}	Near-Bank Stress (NBS)	

Level III

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

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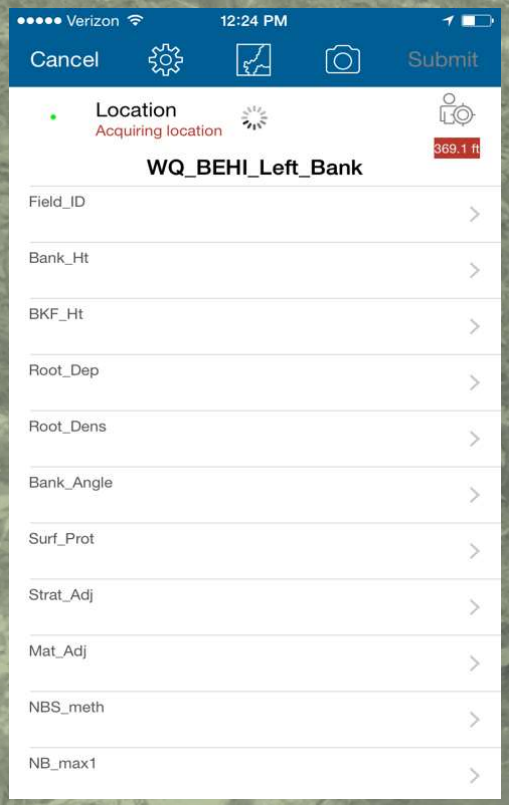
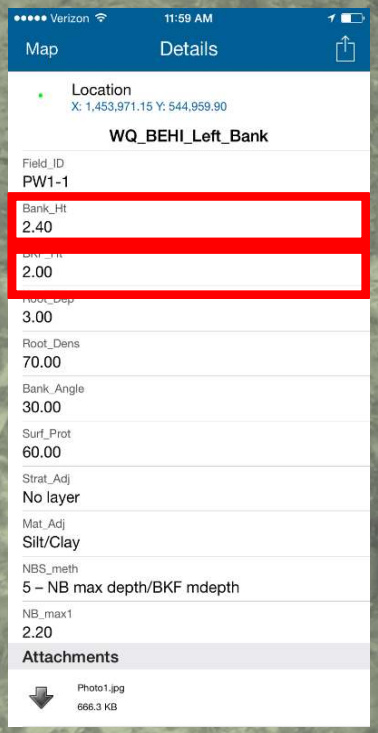
Field Data Collection

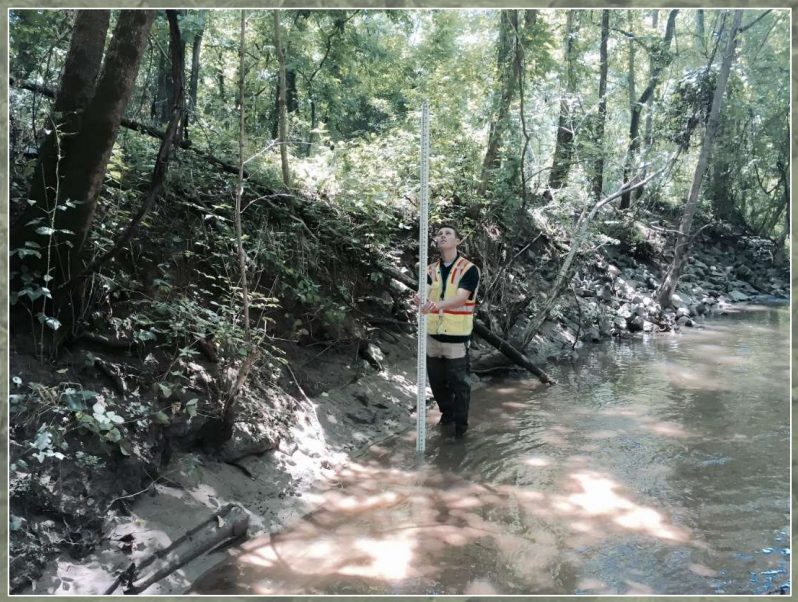


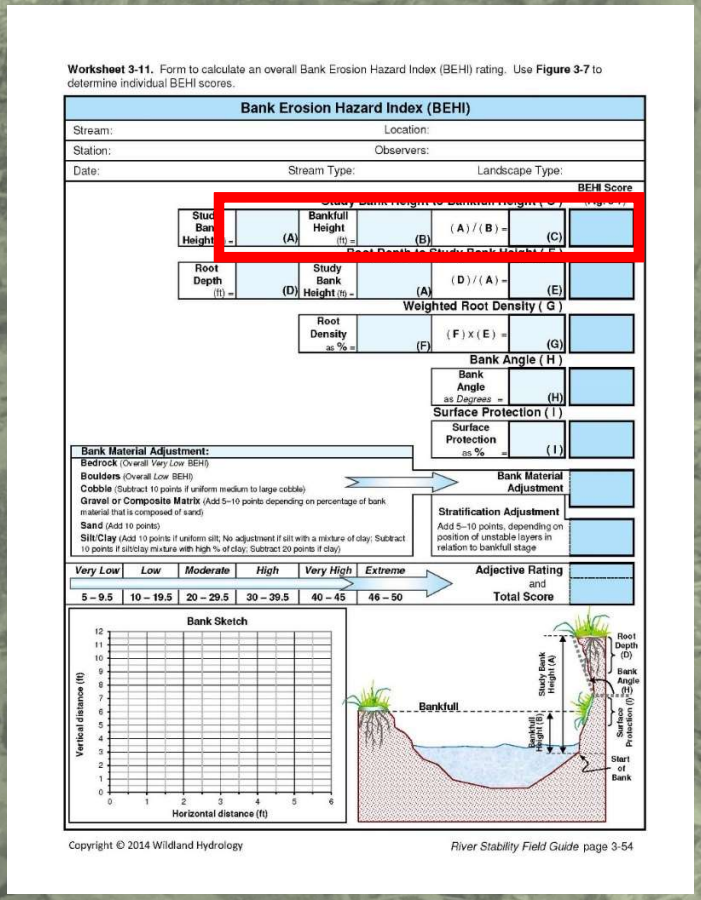
- Majority of BEHI Assessments collected are longitudinal bank surveys.
- Team of two assessors.

Bank Erosion Hazard Index (BEHI) and Near Bank Stress(NBS) Analysis

- Study Bank Height to Bankfull Height (Quantitative)
- Bankfull height typically based on regional curve.







Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Bank Erosion Hazard Index (BEHI)

Stream: Location:
Station: Observers:
Date: Stream Type: Landscape Type:

BEHI Score

Study Bank Height (A) – Bankfull Height (ft) (B) = (A)/(B) = (C)

Root Depth (ft) (D) – Study Bank Height (ft) (A) = (D)/(A) = (E)

Weighted Root Density (G)

Root Density as % (F) = (F) x (E) = (G)

Bank Angle (H)

Bank Angle as Degrees (H)

Surface Protection (I)

Surface Protection as % (I)

Bank Material Adjustment:
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 (Add 10 points if uniform silt; No adjustment if silt with a mixture of clay; Subtract 10 points if silt/clay mixture with high % of clay; Subtract 20 points if clay)

Bank Material Adjustment

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

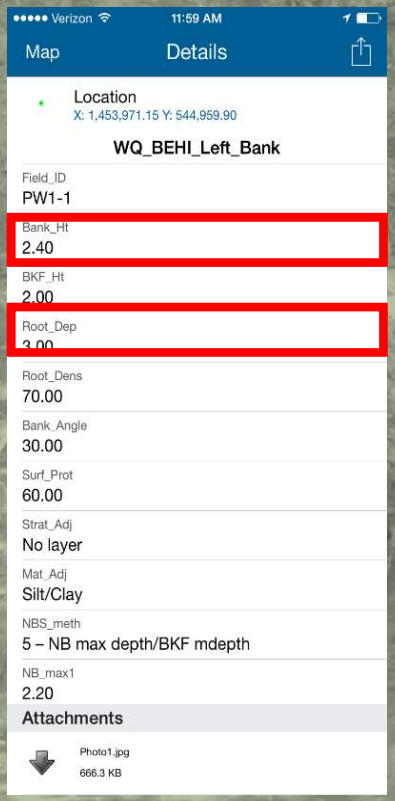
Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50

Adjective Rating and Total Score

Bank Sketch

Bank Erosion Hazard Index (BEHI) and Near Bank Stress(NBS) Analysis

- Root Depth to Study Bank Height (Quantitative)



Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Bank Erosion Hazard Index (BEHI)

Stream: Location:

Station: Observers:

Date: Stream Type: Landscape Type:

BEHI Score (Fig. 3-7)

Study Bank Height to Bankfull Height (C)

Study Bank Height (ft) = (A) | Bankfull Height (ft) = (B) | (A) / (B) = (C)

Root Depth to Study Bank Height (E)

Root Depth (ft) = (D) | Study Bank Height (ft) = (A) | (D) / (A) = (E)

Weighted Root Density (G)

Root Density as % = (F) | (F) x (E) = (G)

Bank Angle (H)

Bank Angle as *Degrees* = (H)

Surface Protection (I)

Surface Protection as % = (I)

Bank Material Adjustment:

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 (Add 10 points if uniform silt; No adjustment if silt with a mixture of clay; Subtract 10 points if silt/clay mixture with high % of clay; Subtract 20 points if clay)

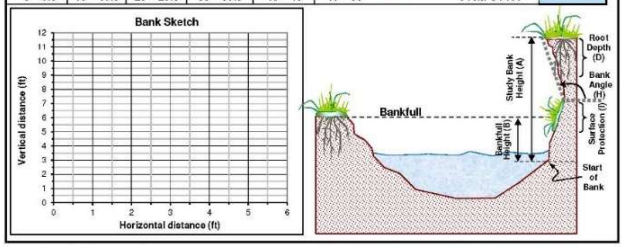
→ **Bank Material Adjustment**

Stratification Adjustment

Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

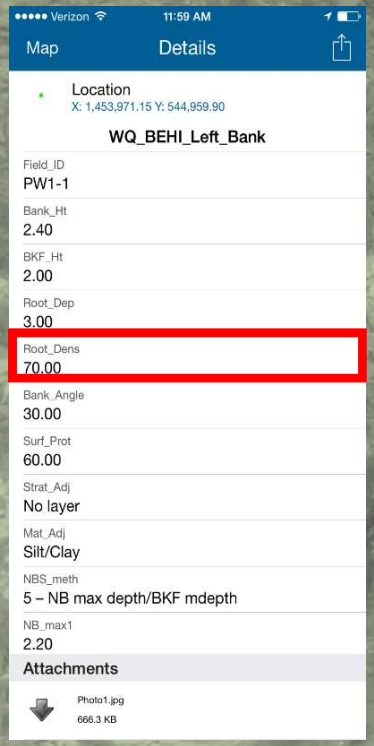
Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	Adjective Rating and Total Score
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	

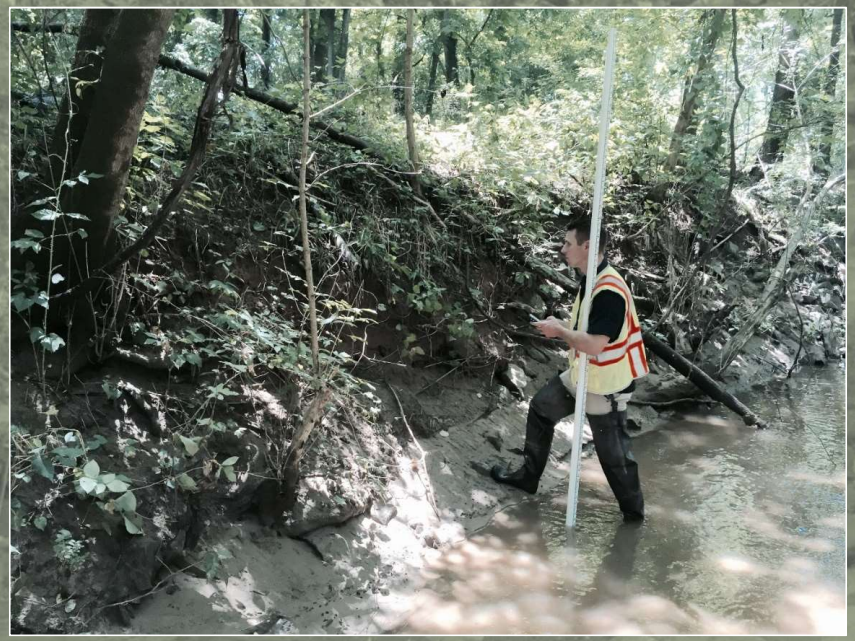
Bank Sketch

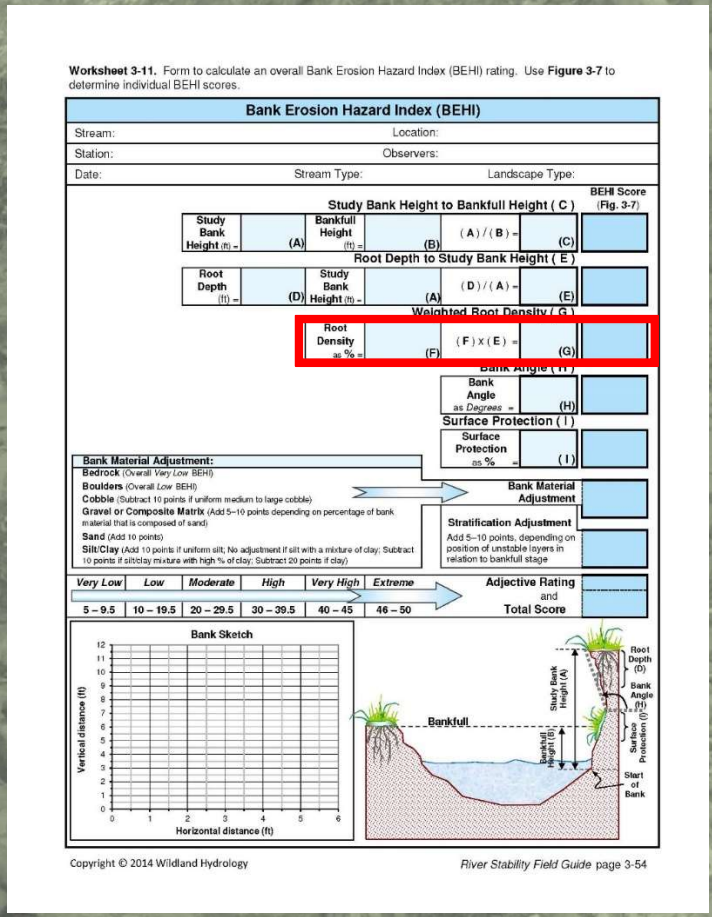


Bank Erosion Hazard Index (BEHI) and Near Bank Stress(NBS) Analysis

- Weighted Root Density (Qualitative)







Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Bank Erosion Hazard Index (BEHI)

Stream: Location:

Station: Observers:

Date: Stream Type: Landscape Type:

BEHI Score (Fig. 3-7)

Study Bank Height to Bankfull Height (C)

Study Bank Height (ft) = (A) | Bankfull Height (ft) = (B) | (A) / (B) = (C)

Root Depth to Study Bank Height (E)

Root Depth (ft) = (D) | Study Bank Height (ft) = (A) | (D) / (A) = (E)

Weighted Root Density (G)

Root Density as % = (F) | (F) x (E) = (G)

Bank Angle (H)

Bank Angle as Degrees = (H)

Surface Protection (I)

Surface Protection as % = (I)

Bank Material Adjustment:

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 (Add 10 points if uniform silt; No adjustment if silt with a mixture of clay; Subtract 10 points if silt/clay mixture with high % of clay; Subtract 20 points if clay)

Bank Material Adjustment

Stratification Adjustment

Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

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

Bank Sketch

Vertical distance (ft)

Horizontal distance (ft)

Bankfull

Study Bank Height (A)

Root Depth (D)

Bank Angle (H)

Surface Protection (I)

Bankfull Height (B)

Start of Bank

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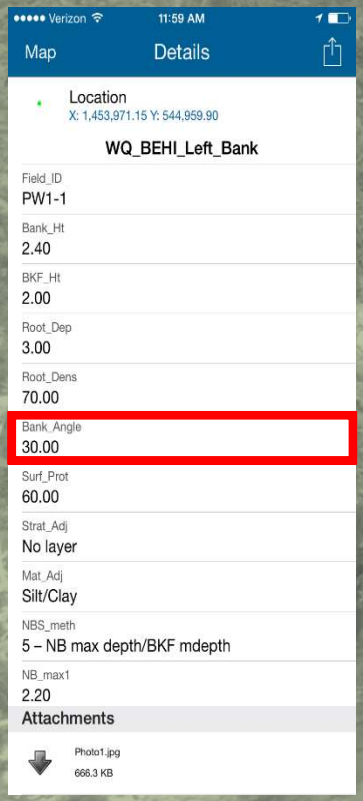
Bank Erosion Hazard Index (BEHI) and Near Bank Stress(NBS) Analysis

- Bank Angle (Quantitative – Slope steepness)
- Measured with protractor.



Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Bank Erosion Hazard Index (BEHI)

Stream: Location:
Station: Observers:
Date: Stream Type: Landscape Type:

BEHI Score (Fig. 3-7)

Study Bank Height to Bankfull Height (C)
Study Bank Height (ft) = (A) Bankfull Height (ft) = (B) (A) / (B) = (C)

Root Depth to Study Bank Height (E)
Root Depth (ft) = (D) Study Bank Height (ft) = (A) (D) / (A) = (E)

Weighted Root Density (G)
Root Density as % = (F) (F) x (E) = (G)

Bank Angle as Degrees = (H)

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

Bank Material Adjustment:
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 (Add 10 points if uniform silt; No adjustment if silt with a mixture of clay; Subtract 10 points if silt/clay mixture with high % of clay; Subtract 20 points if clay)

Bank Material Adjustment

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

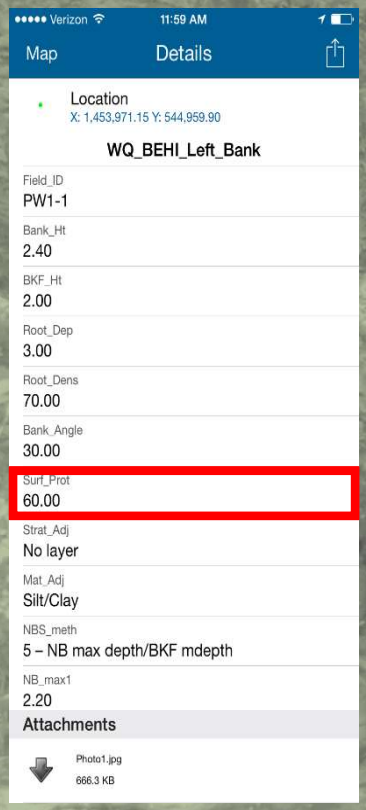
Very Low	Low	Moderate	High	Very High	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50

Adjective Rating and Total Score

Bank Sketch
Vertical distance (ft)
Horizontal distance (ft)
Bankfull
Root Depth (D)
Bank Angle (H)
Surface Protection (I)
Study Bank Height (A)
Bankfull Height (B)
Start of Bank

Bank Erosion Hazard Index (BEHI) and Near Bank Stress(NBS) Analysis

- Surface Protection (Qualitative)



Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Bank Erosion Hazard Index (BEHI)

Stream: Location:

Station: Observers:

Date: Stream Type: Landscape Type:

BEHI Score (Fig. 3-7)

Study Bank Height to Bankfull Height (C)

Study Bank Height (ft) = (A) Bankfull Height (ft) = (B) (A) / (B) = (C)

Root Depth to Study Bank Height (E)

Root Depth (ft) = (D) Study Bank Height (ft) = (A) (D) / (A) = (E)

Weighted Root Density (G)

Root Density as % = (F) (F) x (E) = (G)

Bank Angle (H)

Bank Angle as Degrees = (H)

Surface Protection (I)

Surface Protection (I)

Bank Material Adjustment:

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 (Add 10 points if uniform silt; No adjustment if silt with a mixture of clay; Subtract 10 points if silt/clay mixture with high % of clay; Subtract 20 points if clay)

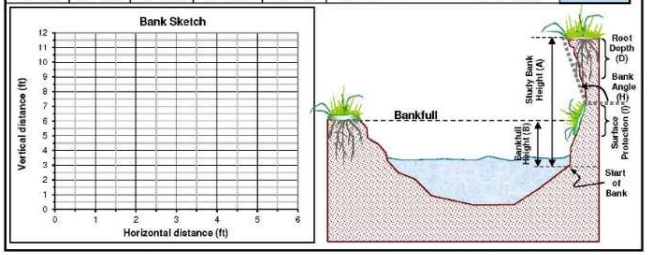
Bank Material Adjustment

Stratification Adjustment

Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

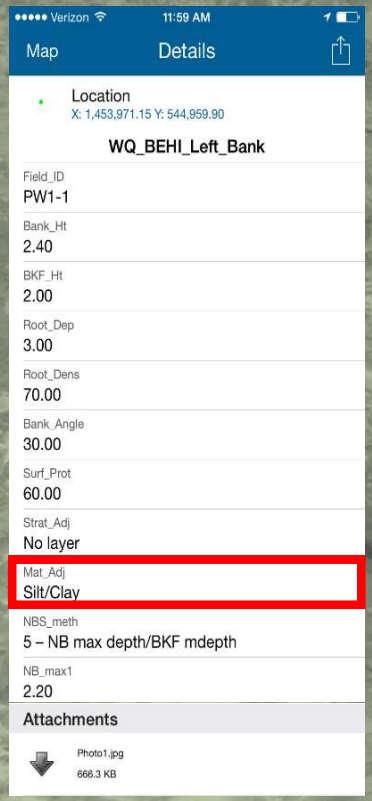
Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	Adjective Rating and Total Score
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	

Bank Sketch



Bank Erosion Hazard Index (BEHI) and Near Bank Stress(NBS) Analysis

- Bank Material Adjustment (Qualitative)



Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Bank Erosion Hazard Index (BEHI)

Stream: Location:
Station: Observers:
Date: Stream Type: Landscape Type:

BEHI Score (Fig. 3-7)

Study Bank Height to Bankfull Height (C)
Study Bank Height (ft) = (A) / Bankfull Height (ft) = (B) (A) / (B) = (C)

Root Depth to Study Bank Height (E)
Root Depth (ft) = (D) / Study Bank Height (ft) = (A) (D) / (A) = (E)

Weighted Root Density (G)
Root Density as % = (F) (F) x (E) = (G)

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

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

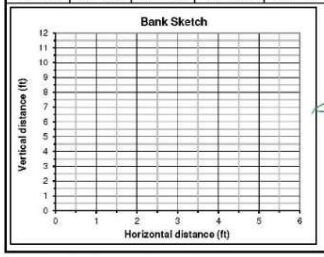
Bank Material Adjustment:
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (Add 10 points if uniform silt; No adjustment if silt with a mixture of clay; Subtract 10 points if silt/clay mixture with high % of clay; Subtract 20 points if clay)

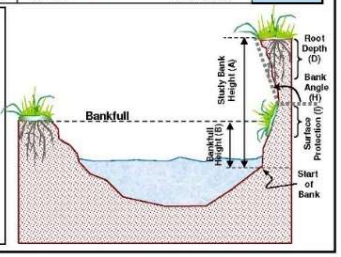
Bank Material Adjustment

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50

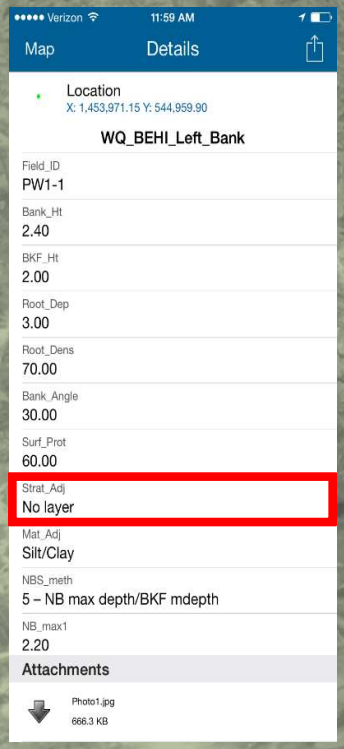
Adjective Rating and Total Score

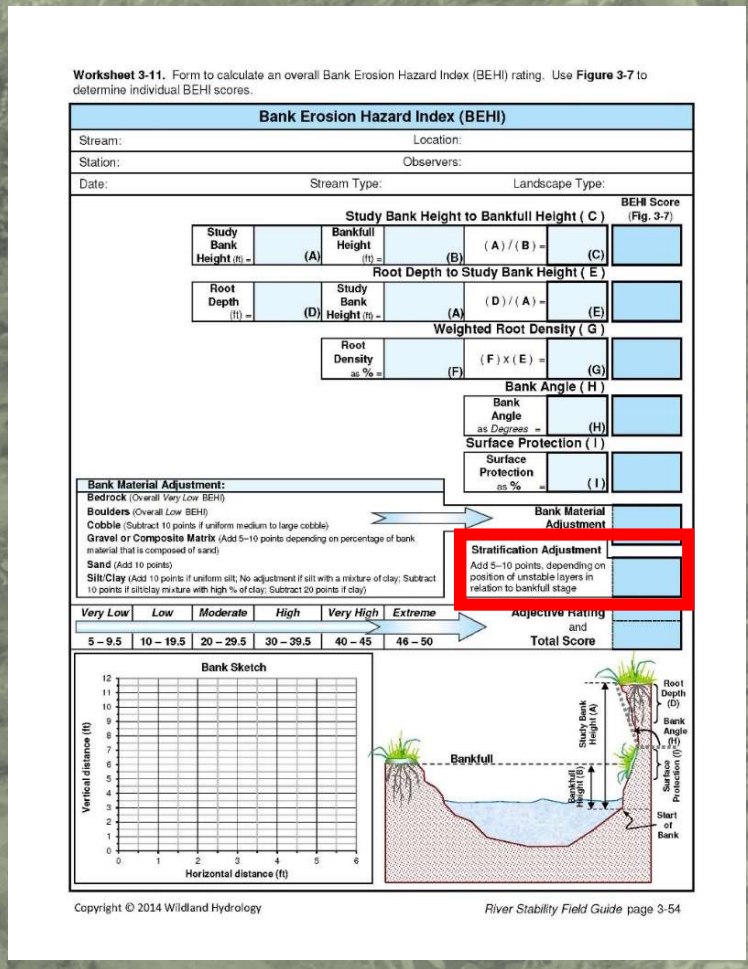




Bank Erosion Hazard Index (BEHI) and Near Bank Stress(NBS) Analysis

- Stratification Adjustment (Qualitative)





Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Bank Erosion Hazard Index (BEHI)

Stream: Location:

Station: Observers:

Date: Stream Type: Landscape Type:

BEHI Score (Fig. 3-7)

Study Bank Height to Bankfull Height (C)

Study Bank Height (ft) = (A) Bankfull Height (ft) = (B) (A) / (B) = (C)

Root Depth to Study Bank Height (E)

Root Depth (ft) = (D) Study Bank Height (ft) = (A) (D) / (A) = (E)

Weighted Root Density (G)

Root Density as % = (F) (F) x (E) = (G)

Bank Angle (H)

Bank Angle as *Degrees* = (H)

Surface Protection (I)

Surface Protection as % = (I)

Bank Material Adjustment:

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 (Add 10 points if uniform silt; No adjustment if silt with a mixture of clay; Subtract 10 points if silt/clay mixture with high % of clay; Subtract 20 points if clay)

Bank Material Adjustment

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

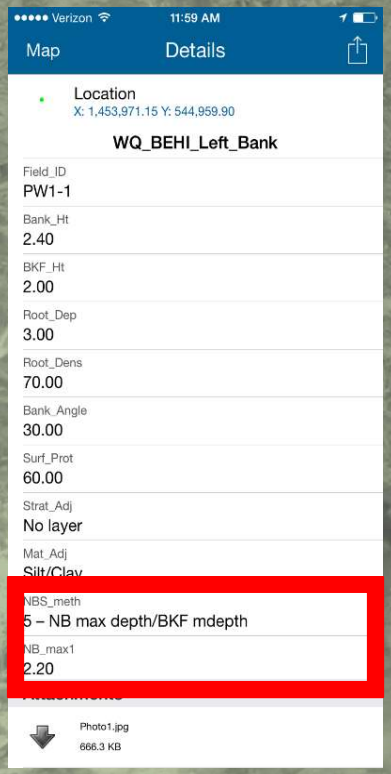
Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50

Adjective Rating and Total Score

Bank Sketch

Bank Erosion Hazard Index (BEHI) and Near Bank Stress(NBS) Analysis

- **Near Bank Stress**
  - Seven (7) Methods



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

Estimating Near-Bank Stress (NBS)

Stream: Location:

Station: Stream Type: Landscape Type:

Observers: Date:

Methods for Estimating Near-Bank Stress (NBS)

(1)	Channel pattern, transverse bar, or central bar creating NBS	Level I	Reconaissance
(2)	Radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General Prediction
(3)	Pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4)	Pool slope to riffle slope (S_p / S_{rif})	Level II	General Prediction
(5)	Near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed Prediction
(6)	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 or central bars - short 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)**

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)**

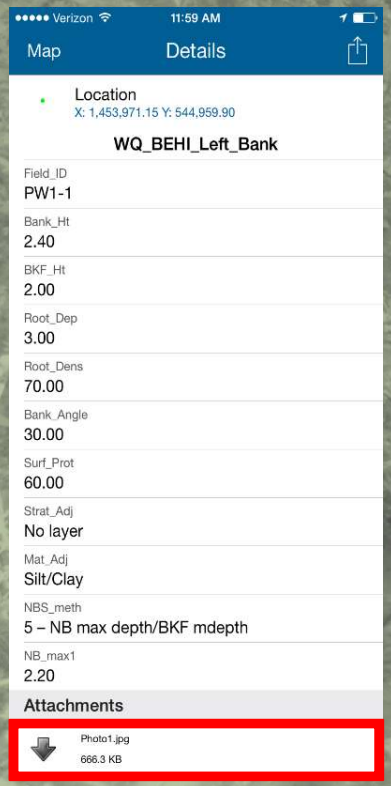
Converting Values to a Near-Bank Stress (NBS) Rating

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 (BEHI) and Near Bank Stress(NBS) Analysis

- **Photographic Documentation**
- Spatially associated with assessment point.



Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Bank Erosion Hazard Index (BEHI)

Stream: Location:

Station: Observers:

Date: Stream Type: Landscape Type:

BEHI Score (Fig. 3-7)

Study Bank Height to Bankfull Height (C)

Study Bank Height (ft) = (A) Bankfull Height (ft) = (B) (A) / (B) = (C)

Root Depth to Study Bank Height (E)

Root Depth (ft) = (D) Study Bank Height (ft) = (A) (D) / (A) = (E)

Weighted Root Density (G)

Root Density as % = (F) (F) x (E) = (G)

Bank Angle (H)

Bank Angle as *Degrees* = (H)

Surface Protection (I)

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Bank Material Adjustment:

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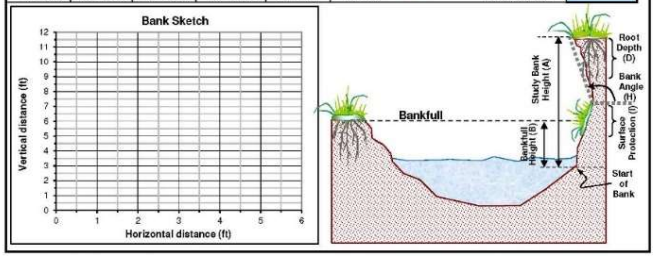
Bank Material Adjustment

Stratification Adjustment

Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

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

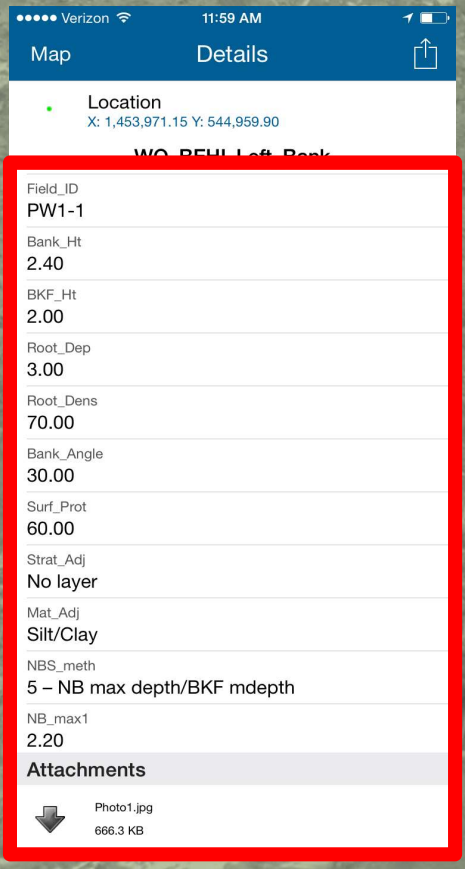
Bank Sketch

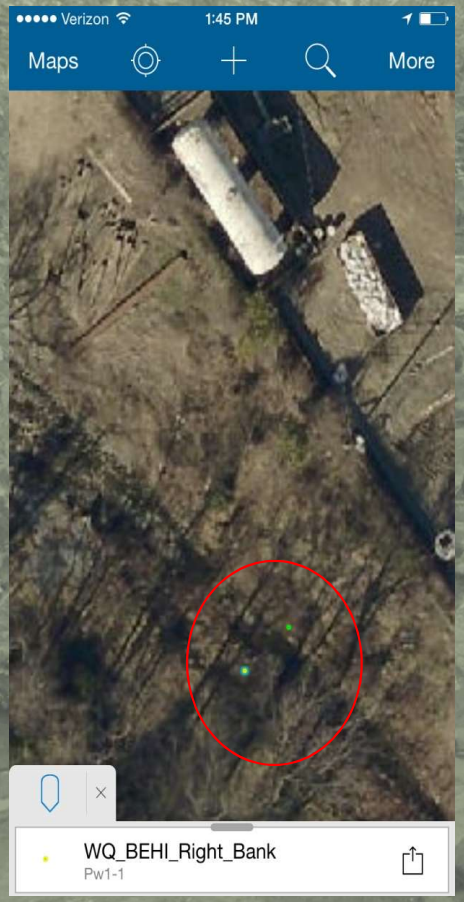


River Stability Field Guide page 3-54

SDE Geodatabase

- Saves data directly to the assigned Feature Class that can be instantly accessed through ArcDesktop.



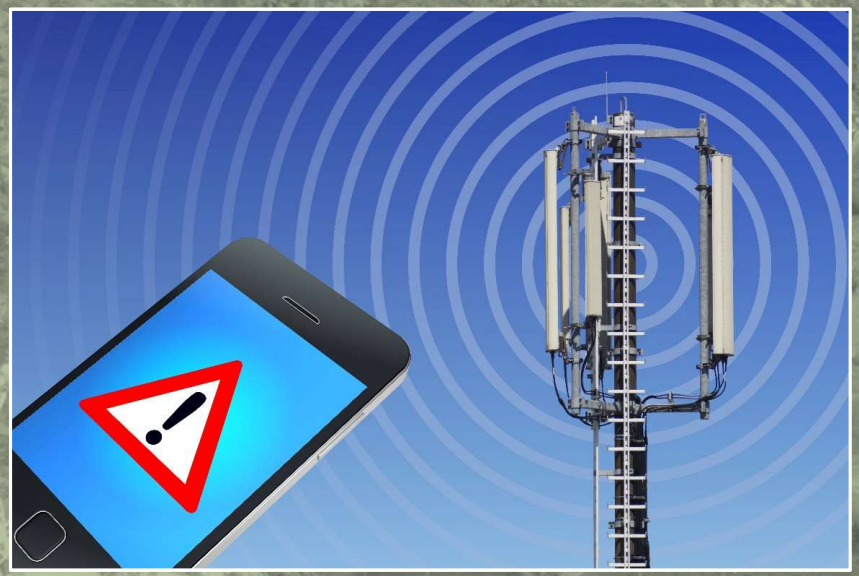


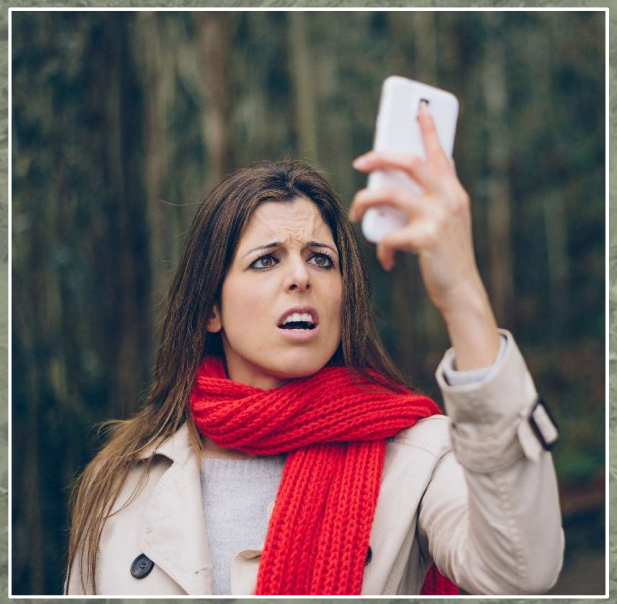
edms_gis.SDE.WQ_BEHI_Left_Bank

Field_ID	Bank_Angle	Surf_Prot	Root_Dens	Root_Dep	Bank_Ht	BKF_Ht	Strat_Adj	Mat_Adj	NBS_meth	NBS	NB_max1
PW21-8	75	75	75	3	3	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Low	2.2
PW21-9	30	80	75	3	2	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Low	2.2
PW1-1	30	60	70	3	2.4	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Low	2.2
PW1-2	60	75	70	3	8	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Low	2.4
PW1-3	60	30	75	3	2.4	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Moderate	2.75
PW1-4	30	75	75	3	2.4	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Low	2.25
PW1-5	40	45	45	1.5	2.4	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Low	1.75
PW21-1	30	80	75	3	3	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Low	2.1
PW21-2	45	50	60	3	3.5	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Low	2.4
PW21-3	80	10	30	2	4	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Low	2.5
PW21-4	70	50	60	3	3.5	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Low	2.3
PW21-5	60	80	75	3	4	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Moderate	2.6
PW21-6	20	75	75	3	3	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Low	2
PW21-7	70	40	30	2	3	2	No layer	Silt/Clay	5 – NB max depth/BKF mdepth	Moderate	2.6

No Cell Service? Connectivity Issues?

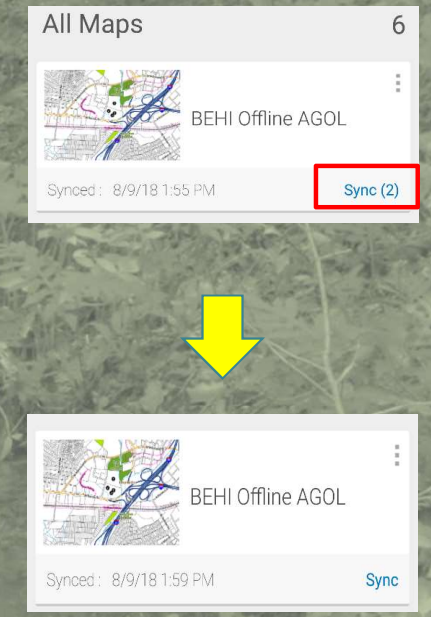
No problem!





ArcCollector allows for the ability to directly save collected data to the MOS

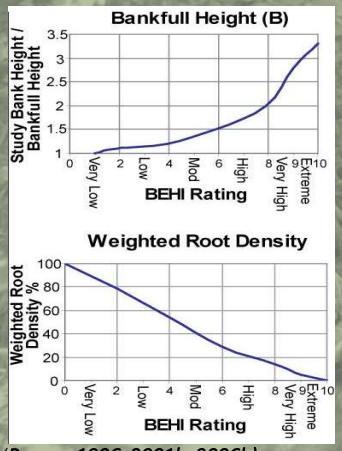
- If you know you are working in a remote area, ArcCollector allows for the ability to directly save collected data to MOS
- Select work area.
- Select map detail.
- Saves a base map that can be used multiple times.
- After you are finished collecting, sync data to the SDE Geodatabase or to the Cloud.



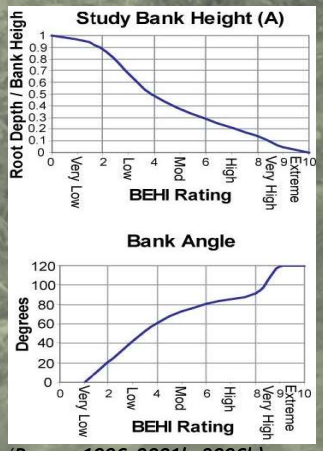
Python Scripts

- Once data is in the SDE Geodatabase Feature Class, Pre-logic Python script code(s) are computed within the Attribute Table Field Calculator to automatically calculate ratios and populate specific columns with a rating score.
- Model (Model Builder) to automatically populate each criterion and score appropriately.

AB	CD	EF	RDH_Score	RD_Score	SP_Score	BA_Score	MatAdj_Sco	Strat_Sco	EF_Score	Total_Scor	BEHI_Cat	NBS_meth	NBS	NB_max1	NBS_Score
1	75	1	1	3	3	5	0	0	1	13	Low	5 – NB max depth/BKF mdepth	Low	2.2	1.271676
1.5	112.5	1	0	0	1	3	0	0	1	5	Very Low	5 – NB max depth/BKF mdepth	Low	2.2	1.271676
1.25	87.5	1.2	0	1	3	3	0	0	3	10	Low	5 – NB max depth/BKF mdepth	Low	2.2	1.383648
0.375	26.25	4	5	7	3	3	0	0	10	28	Moderate	5 – NB max depth/BKF mdepth	Low	2.4	1.509434
1.25	93.75	1.2	0	1	5	3	0	0	3	12	Low	5 – NB max depth/BKF mdepth	Moderate	2.75	1.72956
1.25	93.75	1.2	0	1	3	3	0	0	3	10	Low	5 – NB max depth/BKF mdepth	Low	2.25	1.415094
0.625	28.125	1.2	3	7	5	3	0	0	3	21	Moderate	5 – NB max depth/BKF mdepth	Low	1.75	1.100629
1	75	1.5	1	3	1	3	0	0	5	13	Low	5 – NB max depth/BKF mdepth	Low	2.1	1.213873
0.857143	51.428571	1.75	3	5	5	3	0	0	7	23	Moderate	5 – NB max depth/BKF mdepth	Low	2.4	1.387283
0.5	15	2	3	7	8.5	5	0	0	7	30.5	High	5 – NB max depth/BKF mdepth	Low	2.5	1.445087
0.857143	51.428571	1.75	3	5	5	5	0	0	7	25	Moderate	5 – NB max depth/BKF mdepth	Low	2.3	1.32948
0.75	56.25	2	3	3	1	3	0	0	7	17	Low	5 – NB max depth/BKF mdepth	Moderate	2.6	1.50289
1	75	1.5	1	3	3	1	0	0	5	13	Low	5 – NB max depth/BKF mdepth	Low	2	1.156069
0.666667	20	1.5	3	7	5	5	0	0	5	25	Moderate	5 – NB max depth/BKF mdepth	Moderate	2.6	1.50289

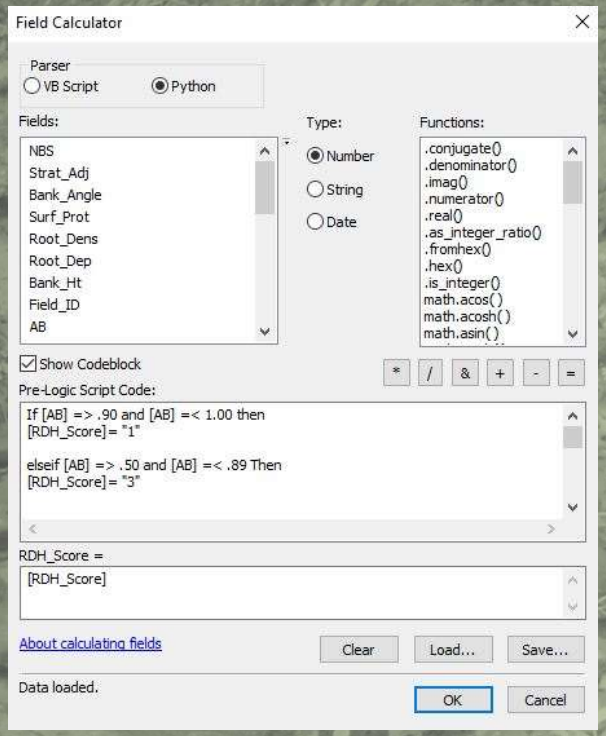


(Rosgen 1996, 2001b, 2006b)



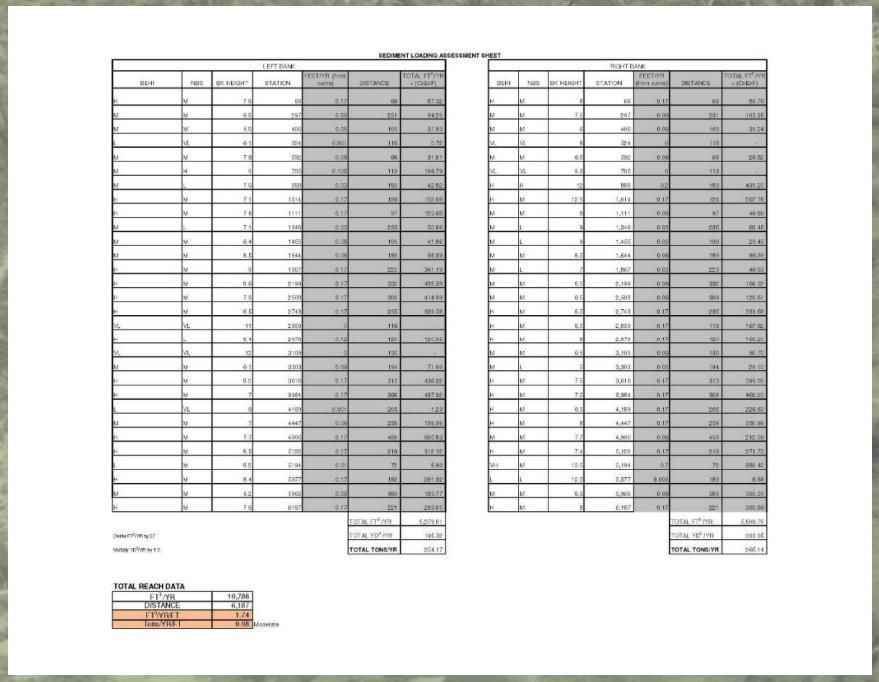
(Rosgen 1996, 2001b, 2006b)

(Rosgen 1996, 2001b, 2006b)



Postprocessed Estimated Sediment Loading Data Uses

- Spatial Analysis for Watershed Planning.
- CIP Projects estimation of streambank erosion reduction.
- Grant funding (Clean Water Management Trust Fund).
- Mecklenburg County Stream Restoration Ranking System (SRRS) Performance Standard.



SEDIMENT LOADING ASSESSMENT SHEET

LEFT BANK						
BEHI	NBS	BK HEIGHT	STATION	FT³/YR (from curve)	DISTANCE	TOTAL FT³/YR = (Col.F)
H	M	7.5	66	0.17	66	97.02
M	M	6.5	597	0.00	531	94.51
M	M	5.5	400	0.00	195	37.67
L	VL	6.1	924	0.000	116	0.70
M	M	7.8	592	0.00	68	81.41
M	H	9	705	0.105	113	106.79
M	L	7.5	888	0.00	183	42.82
H	M	7.1	1,014	0.17	126	152.46
H	M	7.5	1,111	0.17	97	183.48
M	L	7.1	1,348	0.00	235	53.48
M	M	6.4	1,455	0.00	106	41.88
M	M	6.5	1,644	0.00	189	96.89
H	M	9	1,867	0.17	223	241.13
H	M	6.6	2,199	0.17	332	485.88
H	M	7.5	2,509	0.17	309	414.68
H	M	6.5	2,743	0.17	235	389.28
VL	VL	11	2,859	0	116	-
L	L	6.4	2,979	0.10	120	120.48
VL	VL	10	3,109	0	130	-
M	M	6.1	3,303	0.00	194	71.48
H	M	6.5	3,616	0.17	313	439.68
H	M	7	3,984	0.17	368	497.60
L	VL	8	4,189	0.000	205	1.23
M	M	7	4,447	0.00	259	199.88
H	M	7.7	4,906	0.17	459	680.82
H	M	6.6	5,123	0.17	216	316.10
L	M	6.5	5,194	0.01	71	5.84
H	M	6.4	5,377	0.17	183	261.82
M	M	5.5	5,565	0.00	189	189.77
H	M	7.5	5,767	0.17	201	293.65
					TOTAL FT³/YR	5,273.61
					TOTAL YD³/YR	195.28
					TOTAL TONS/YR	254.17

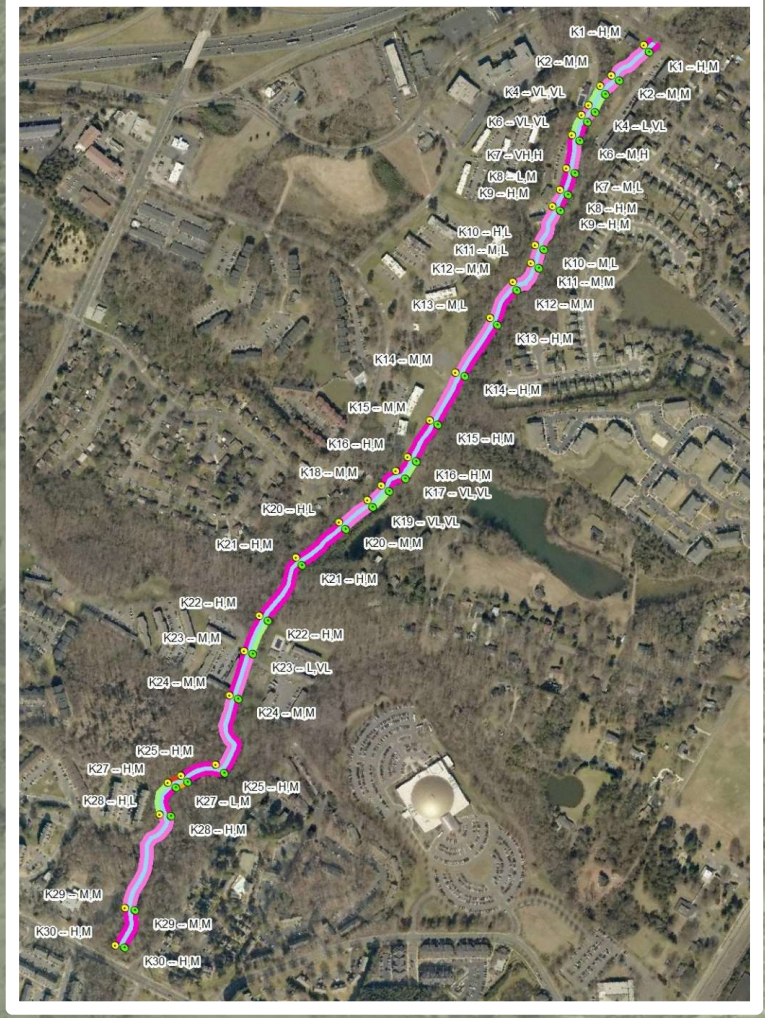
Divide FT³/YR by 27

Multiply YD³/YR by 1.3

RIGHT BANK						
BEHI	NBS	BK HEIGHT	STATION	FT³/YR (from curve)	DISTANCE	TOTAL FT³/YR = (Col.F)
H	M	8	66	0.17	66	89.76
M	M	7.5	597	0.00	531	103.95
M	M	6	400	0.00	195	39.24
VL	VL	8	924	0	116	-
M	M	8.5	592	0.00	68	28.82
VL	VL	9.5	705	0	113	-
H	H	12	888	0.2	183	423.00
H	M	12.5	1,014	0.17	126	587.70
M	M	9	1,111	0.00	97	46.56
M	L	9	1,348	0.00	235	68.46
M	L	9	1,455	0.00	106	23.42
M	M	8.5	1,644	0.00	189	96.39
M	L	7	1,867	0.00	223	46.83
M	M	8.5	2,199	0.00	332	169.32
M	M	8.5	2,509	0.00	309	131.93
H	M	8.5	2,743	0.17	235	339.68
H	M	8.5	2,859	0.17	116	167.56
H	M	8	2,979	0.17	120	169.80
M	M	9.5	3,109	0.00	130	50.70
M	L	7	3,303	0.00	194	59.10
H	M	7.5	3,616	0.17	313	399.05
H	M	7.5	3,984	0.17	368	469.20
H	M	8.5	4,189	0.17	205	226.82
H	M	8	4,447	0.17	259	230.38
M	M	7.7	4,906	0.00	459	212.00
H	M	7.4	5,123	0.17	216	571.72
VH	M	15.5	5,194	0.7	71	660.42
L	L	12.5	5,377	0.000	183	8.66
M	M	8.5	5,565	0.00	189	300.30
H	M	8	5,767	0.17	201	300.99
					TOTAL FT³/YR	5,606.75
					TOTAL YD³/YR	265.95
					TOTAL TONS/YR	345.14

TOTAL REACH DATA

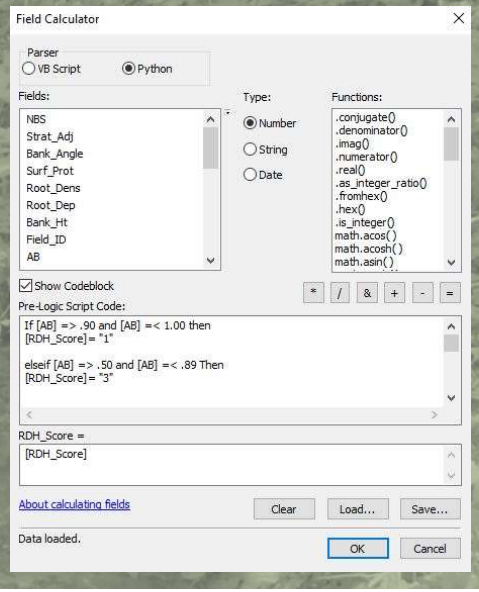
FT³/YR	10,786
DISTANCE	6,187
FT³/YR/FT	1.74
Tons/YR/FT	0.08 Moderate



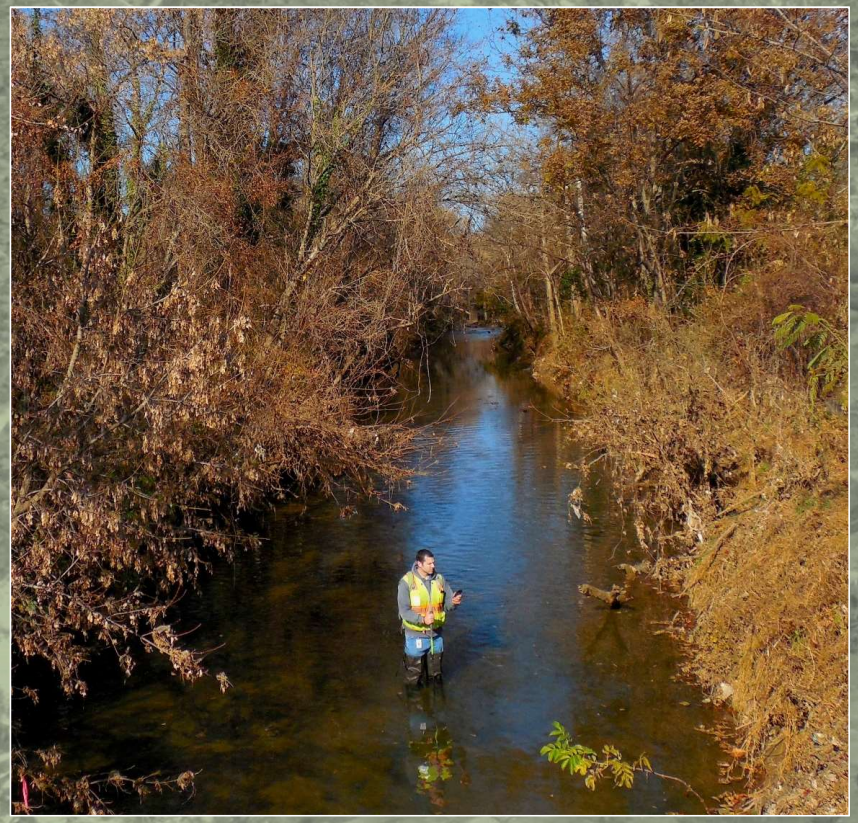
In Closing -- App & Geodatabase Benefits

- Not necessary to have paper data sheets or hip chains needed for longitudinal BEHI Surveys.
- Not necessary to have costly GPS equipment or software required for postprocessing data.
- Collected data is simultaneously put into tabular format. No transferring data from data sheets.
- Data is stored in a single database with spatial locations. Helps with CIP and Watershed Planning and collaboration work with Charlotte Water needed for sanitary sewer asset protection.
- Help with potential Future Charlotte/Mecklenburg Erosion Rating Curve (Validation).

AB	CD	EF	RDH_Score	RD_Score	SP_Score	BA_Score	MatAdj_Sco	Strat_Sco	EF_Score	Total_Scor	BEHI_Cat	NBS_meth	NBS	NB_max1	NBS_Score
1	75	1	1	3	3	5	0	0	1	13	Low	5 – NB max depth/BKF mdepth	Low	2.2	1.271676
1.5	112.5	1	0	0	1	3	0	0	1	5	Very Low	5 – NB max depth/BKF mdepth	Low	2.2	1.271676
1.25	87.5	1.2	0	1	3	3	0	0	3	10	Low	5 – NB max depth/BKF mdepth	Low	2.2	1.383648
0.375	26.25	4	5	7	3	3	0	0	10	28	Moderate	5 – NB max depth/BKF mdepth	Low	2.4	1.509434
1.25	93.75	1.2	0	1	5	3	0	0	3	12	Low	5 – NB max depth/BKF mdepth	Moderate	2.75	1.72956
1.25	93.75	1.2	0	1	3	3	0	0	3	10	Low	5 – NB max depth/BKF mdepth	Low	2.25	1.415094
0.625	28.125	1.2	3	7	5	3	0	0	3	21	Moderate	5 – NB max depth/BKF mdepth	Low	1.75	1.100629
1	75	1.5	1	3	1	3	0	0	5	13	Low	5 – NB max depth/BKF mdepth	Low	2.1	1.213873
0.857143	51.428571	1.75	3	5	5	3	0	0	7	23	Moderate	5 – NB max depth/BKF mdepth	Low	2.4	1.387283
0.5	15	2	3	7	8.5	5	0	0	7	30.5	High	5 – NB max depth/BKF mdepth	Low	2.5	1.445087
0.857143	51.428571	1.75	3	5	5	5	0	0	7	25	Moderate	5 – NB max depth/BKF mdepth	Low	2.3	1.32948
0.75	56.25	2	3	3	1	3	0	0	7	17	Low	5 – NB max depth/BKF mdepth	Moderate	2.6	1.50289
1	75	1.5	1	3	3	1	0	0	5	13	Low	5 – NB max depth/BKF mdepth	Low	2	1.156069
0.666667	20	1.5	3	7	5	5	0	0	5	25	Moderate	5 – NB max depth/BKF mdepth	Moderate	2.6	1.50289



QUESTIONS?



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