Final Report

Kansas River Basin Regional Sediment Management Section 204 Stream and River Channel Assessment

Perry Lake Watershed Report

Prepared for

U.S. Army Corps of Engineers
Kansas City District
700 Federal Building
Kansas City, Missouri 64106-2896

Kansas Water Office
901 S. Kansas Avenue
Topeka, Kansas 66612-1249

Prepared by

Gulf South Research Corporation
8081 GSRI Avenue
Baton Rouge, Louisiana 70820

August 2011

FINAL REPORT

Kansas River Basin
Regional Sediment Management
Section 204 Stream and River Channel Assessment
Perry Lake Watershed

Contract Number W912DQ-05-D-0018
Task Order No. 006

Prepared for:

U.S. Army Corps of Engineers
Kansas City District
700 Federal Building
Kansas City, Missouri 64106-2896

Kansas Water Office
901 S. Kansas Avenue
Topeka, Kansas 66612-1249

Prepared by:

Gulf South Research Corporation
8081 GSRI Avenue
Baton Rouge, Louisiana 70820

August 2011

EXECUTIVE SUMMARY

The United States (U.S.) Army Corps of Engineers (USACE), Kansas City District contracted Gulf South Research Corporation (GRSC) to complete streambank erosion and morphological assessments in the Perry Lake Watershed located approximately 52 miles northwest of Kansas City, Missouri, in portions of Brown, Atchison, and Jackson counties, Kansas. Within the Perry Lake Watershed, 50 eroding stream reaches (hot-spots) were evaluated along the Delaware River, Muddy Creek, Straight Creek, and Spring Creek. Detailed geomorphology streambank surveys were performed, and historic and current aerial photography were evaluated in preparation of this report. Aerial photography interpretation was used to predict streambank erosion rates. The field survey data were used to populate the Rosgen (2006) RIVERMorph model which produces a Bank Erodibility Hazard Index (BEHI) and Near-Bank Stress (NBS) ratings. These indices were used to estimate the erosion rates of streambanks and the reduction in erosion of streambanks by implementing best management practices (BMPs).

The 50 hot-spots surveyed in the Perry Lake Watershed comprise 28,049 linear feet of streambank. The hot-spot erosion rates varied from 0.27 to 6.41 tons per foot per year (tons/ft/yr) and the combined rate of erosion was estimated to be 79,415 tons per year (tons/yr). Based on field surveys and streambank erosion modeling, BMP scenarios were recommended for the 50 hot-spots. BMP scenarios were incorporated into the RIVERMorph stream restoration model to estimate the percent reduction of bank erosion using the Bank Assessment for Non-point Consequences of Sediment (BANCS) feature developed by Rosgen (1996 and 2006). It was estimated that, after incorporating the BMP scenarios, the total modeled erosion loss for the 50 hot-spots decreased from 79,415 to 15,336 tons/yr, a reduction of 80.6 percent. It was estimated that 61,088 cubic yards of sediment has eroded each year from the 50 hot-spots evaluated in this report.

Observations indicate that the Delaware River, Straight Creek, and Muddy Creek have been modified by channelization, thereby reducing stream channel lengths by approximately 50 percent. Figure ES-1 illustrates the channelization that has occurred on the Delaware River, relative to its historical path. Most hot-spots were located along sparsely vegetated outside bends of stream channels. The average bank height was 24 feet and the average bank angle was 34 degrees. The banks typically lacked sufficient vegetative surface protection, making

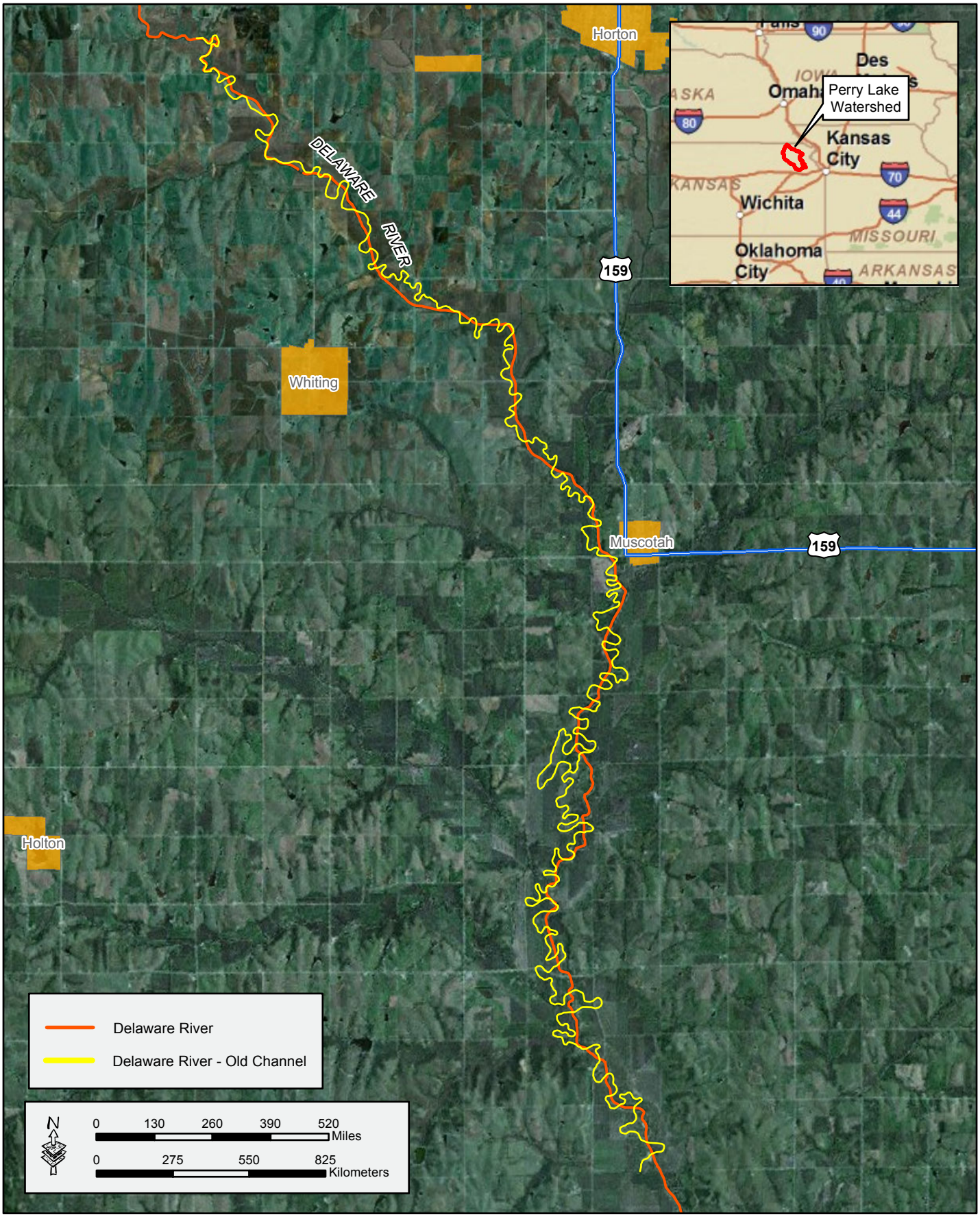


Figure ES-1: Channelization of Delaware River

GSRC

June 2011

them susceptible to erosion. Modeling results indicated that streambank stabilization BMPs would result in a reduction in streambank erosion up to 94 percent. Narrow and deep channels would require a gentle bank slope to promote the establishment and persistence of vegetation on the entire streambank.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

EXECUTIVE SUMMARY ES-1

1.0 INTRODUCTION 1-1

2.0 STUDY AREA 2-1

3.0 METHODOLOGY 3-1

3.1 Site Selection 3-1
3.2 General Site Information 3-1
3.3 Channel Dimension 3-3
3.4 Stream Restoration Software 3-3
3.4.1 Bank Erodibility Hazard Index (BEHI) 3-3
3.4.2 Near-Bank Stress (NBS) 3-4
3.5 Bank Erosion Rate 3-5
3.6 Streambank Stabilization BMPs 3-5
3.7 Evaluating BMP Effectiveness Using BANCS 3-6
3.8 BMP Recommendations for Stream Reaches 3-6
3.8.1 Rock Vanes 3-7
3.8.2 Longitudinal Peaked Stone Toe Protection (LPSTP) 3-7
3.8.3 Bank Shaping 3-7
3.9 Cost Estimates for Streambank BMPs 3-11
3.9.1 Cost-Benefit Analysis of Streambank Stabilization BMPs 3-12

4.0 RESULTS 4-1

4.1 Rates of Erosion Found at Perry Lake Watershed Hot-spots 4-1
4.2 BMP Impacts: Estimated Reduction of Sediment Erosion 4-3

5.0 CONCLUSIONS 5-1

6.0 REFERENCES 6-1

7.0 ACRONYMS AND ABBREVIATIONS 7-1

8.0 RESEARCH TEAM 8-1

LIST OF FIGURES

Figure ES-1. Channelization of the Delaware River ES-2
Figure 1-1. Location Map of the Perry Lake Watershed and the Kansas River Basin 1-2
Figure 2-1. Location of hot-spots surveyed within the Perry Lake Watershed 2-2
Figure 2-2. Channelization of Delaware River 2-3
Figure 2-3. Channelization of Straight Creek 2-4
Figure 2-4. Channelization of Muddy Creek 2-5
Figure 3-1. Flow Chart of Methods used to Assess Stream Channels and Stabilization BMPs 3-2
Figure 3-2. Structural Design of Rock Vanes 3-8
Figure 3-3. Details of Longitudinal Peaked Stone Toe Protection (LPSTP) 3-9
Figure 3-4. Details of Bank Shaping and Riparian Planting BMP 3-10

LIST OF TABLES

Table 3-1. Near-Bank Stress Rating for d_{nb}/d_{bkf} 3-5
Table 3-2. Estimated Costs to Implement Streambank Stabilization BMPs..... 3-11
Table 3-3. Stream Size and Associated BMP 3-12
Table 4-1. Existing Rates of Erosion for 50 Hot-Spots in Perry Lake Watershed 4-2
Table 4-2. Comparison of Rates of Erosion: Existing and BMP Scenario A and B..... 4-4
Table 5-1. Estimated Cost and Effectiveness of Recommended BMPs 5-2

LISTS OF PHOTOGRAPHS

Photograph 3-1. Highly erodible bank on Delaware River with steep slope and no vegetation. 3-7

LIST OF APPENDECIES

Appendix A. Hot-Spot Survey Site Information

SECTION 1.0
INTRODUCTION

1.0 INTRODUCTION

Sedimentation in the north end of Perry Lake, located in Jefferson County, Kansas, has led to a loss in water storage capacity and recreation opportunities. Authors deNoyelles and Jakubauskas (2008) estimated that 91.5 million cubic yards of sediment have accumulated in Perry Lake, resulting in a loss of more than 1,000 surface acres. Juracek and Ziegler (2007) reported that the majority of sediment being deposited in Perry Lake originates from upstream channel-bank erosion processes. The sediment yield in Perry Lake Reservoir is 1.59 acre-feet per square mile per year and represents the highest rate of sedimentation of all the reservoir basins in Kansas (Juracek 2004). Baker and deNoyelles (2008) concluded that Perry Lake's conservation pool water storage capacity has decreased by as much as 40 percent. Based on historical rates, Juracek (2006) estimated that the capacity of the conservation pools in Perry Lake to store sediments will be lost by 2021, while additional sedimentation continues to decrease the water storage capacity. Sediment deposition in Perry Lake also degrades water quality.

Streambank erosion is influenced by hydraulic and gravitational forces, surface erosion, mass failure, fluvial entrainment, freeze-thaw, dry ravel, ice scour, liquefaction and collapse, pore pressure, saturated and unsaturated failures, and soil piping (Rosgen 2001a). The process of erosion can be amplified in incised channels. Incised channels are streams that have abandoned previous floodplains due to a lowering of local base level (Rosgen 1996). Incised channels in the Perry Lake Watershed were created by channel straightening.

The United States (U.S.) Army Corps of Engineers (USACE), Kansas City District contracted Gulf South Research Corporation (GRSC) to conduct streambank erosion assessments and identify potential sediment control opportunities within the Perry Lake Watershed of the Kansas River basin (Figure 1-1). The project has been executed under Section 204 of the Water Resources Development Act of 1992, as amended by Section 2037 of the Water Resources Development Act of 2007. The Section 204 program provides for Federal cooperation and participation in the preparation of state and regional sediment management plans. For Kansas, reservoir sedimentation and public water supply management, conservation, and development strategies and recommendations are described in the Kansas Water Plan. The Kansas Water

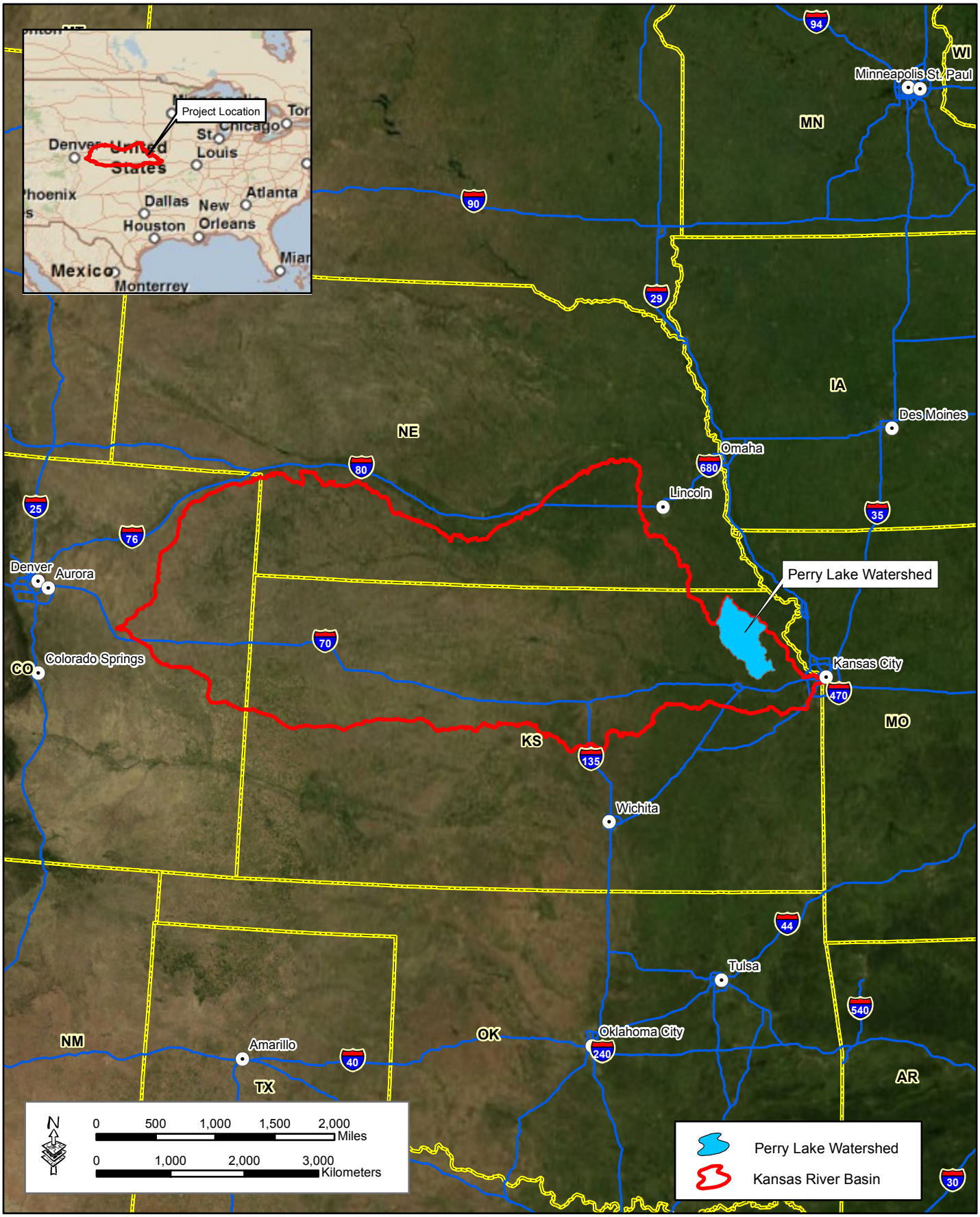


Figure 1-1: Location Map of the Perry Lake Watershed and the Kansas River Basin

GSRC

August 2011

Plan is developed and updated by the Kansas Water Office (KWO) and approved by the Kansas Water Authority (KWO 2011). This study provides information on sediment management potential and contributes to planning efforts of the KWO and other state agencies for long-term water supply sustainability.

The objectives of this project are to:

- Identify 40 to 50 streambank erosion hot-spots (areas with accelerated lateral streambank erosion) within the Perry Lake Watershed.
- Conduct streambank and riparian assessments to predict streambank erosion in the selected erosion hot-spots.
- Estimate streambank erosion rates at each streambank erosion hot-spots.
- Determine the reduction in erosion resulting from the implementation of erosion control measures.

Priority areas were selected for field assessment using Geographic Information System (GIS) data generated by KWO and Kansas Department of Health and Environment (KDHE) water quality data. Fifty streambank assessment hot-spots were selected in this study: 35 on the Delaware River, eight on Muddy Creek, five on Straight Creek, and two on Spring Creek, which is a tributary to Straight Creek. Seven of the Delaware River streambank surveys were included from previous Perry Lake Watershed studies (GSRC 2008 and GSRC 2010).

This report evaluates sediment erosion potential at selected stream sites, identifies best management practices (BMPs) for stream reaches for future erosion control projects, and estimates the volume of sediment contributed from streambank erosion. This report was prepared by GSRC and The Watershed Institute, Inc. (TWI), collectively referred to hereinafter as the Research Team.

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 2.0
STUDY AREA

2.0 STUDY AREA

The Perry Lake Watershed is located in northeastern Kansas and encompasses 1,117 square miles (sq mi). The Delaware River flows into Perry Lake near Lawrence, Kansas, and ultimately into the Kansas River. The rivers and streams throughout the watershed have been channelized extensively, as indicated by the relic channel patterns observed in historical aerial photographs. KWO identified stream erosion Priority Areas in the watershed, which are stream reaches exhibiting unstable banks. Within these Priority Areas, KWO identified streambank sections that appear to be eroding at an accelerated rate, referred to herein as a 'hot-spot.' Fifty hot-spots were evaluated along portions of the Delaware River, Muddy Creek, Straight Creek, and Spring Creek, all of which are tributaries to Perry Lake (Figure 2-1).

The Delaware River has been channelized throughout the Perry Lake Watershed. Figure 2-2 presents the location of the channel in 2008, compared to a possible historical channel location. The predicted channel location was derived by connecting meander scars and oxbows via aerial photograph interpretation. Based on the 2008 river location and the pre-modified channel location, the Delaware River has been shortened by approximately 52 percent. In addition to channel straightening, portions of the river have levees that restrict the width of the floodplain and cause further channel degradation by confining the stream flow area.

Straight Creek and Muddy Creek have also experienced significant channelization (Figures 2-3 and 2-4). Based on the aerial photograph interpretation, Straight Creek has been shortened by 52 percent and Muddy Creek has been shortened by approximately 50 percent. Significant meander cutoffs were identified and measured using aerial photographs. For some cultivated fields and land use changes, identifying pre-channelized creek locations was not feasible using aerial photography. It was assumed that the actual reduction in creek length could be greater, as not all pre-channelized creek locations were detectable through aerial photography.

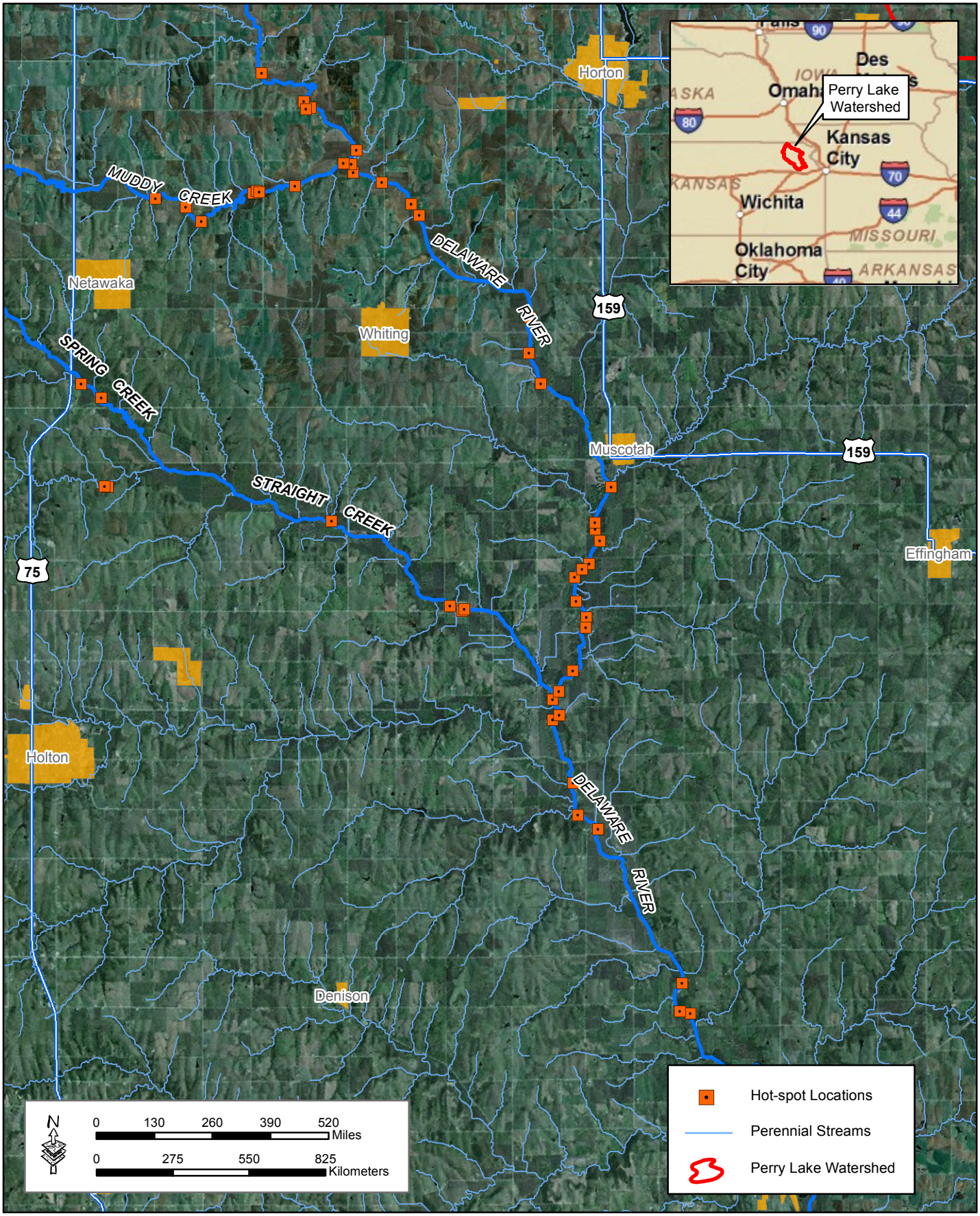


Figure 2-1: Location of Hot-spots surveyed within the Perry Lake Watershed

GSRC

June 2011

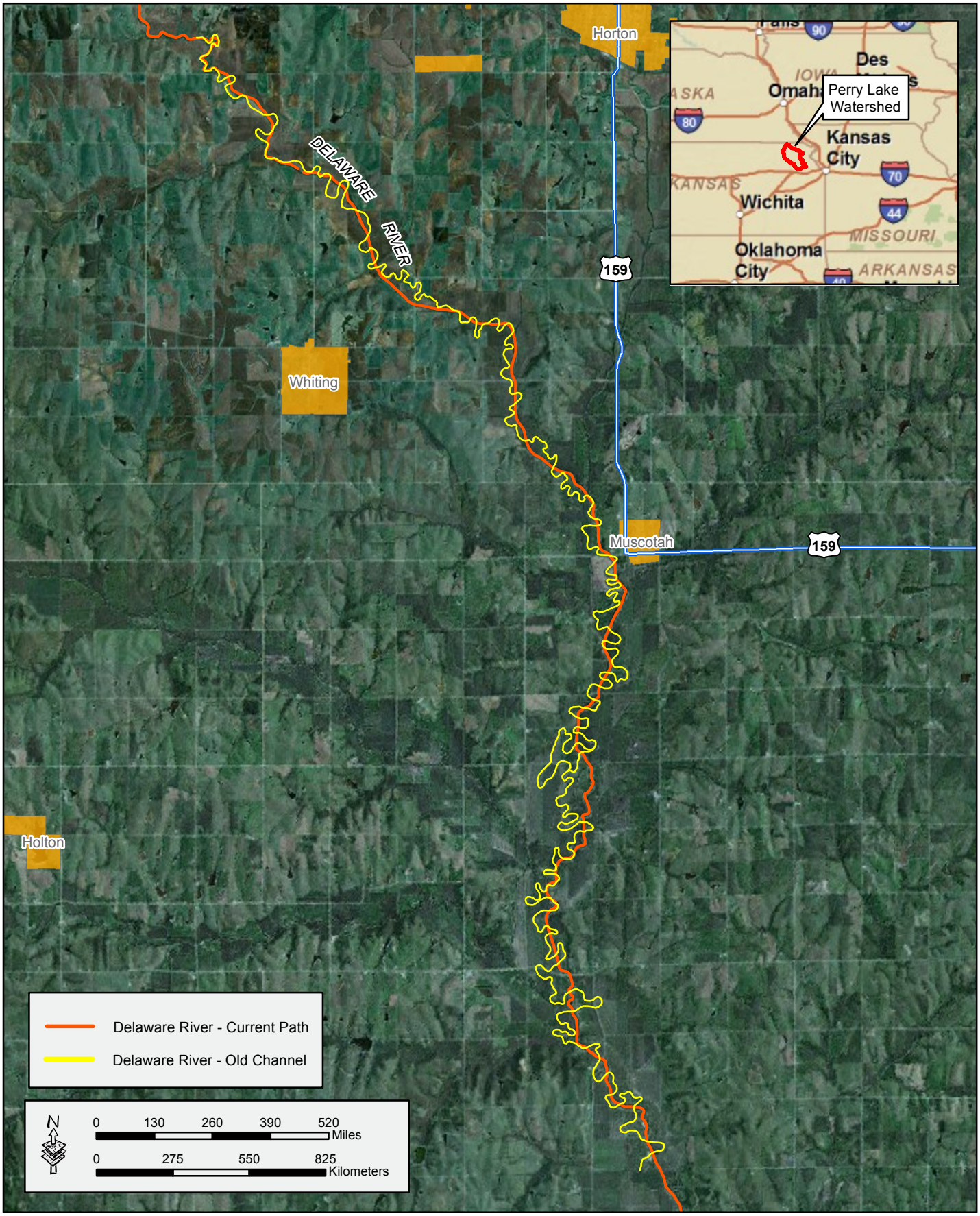


Figure 2-2: Channelization of Delaware River

GSRC

June 2011

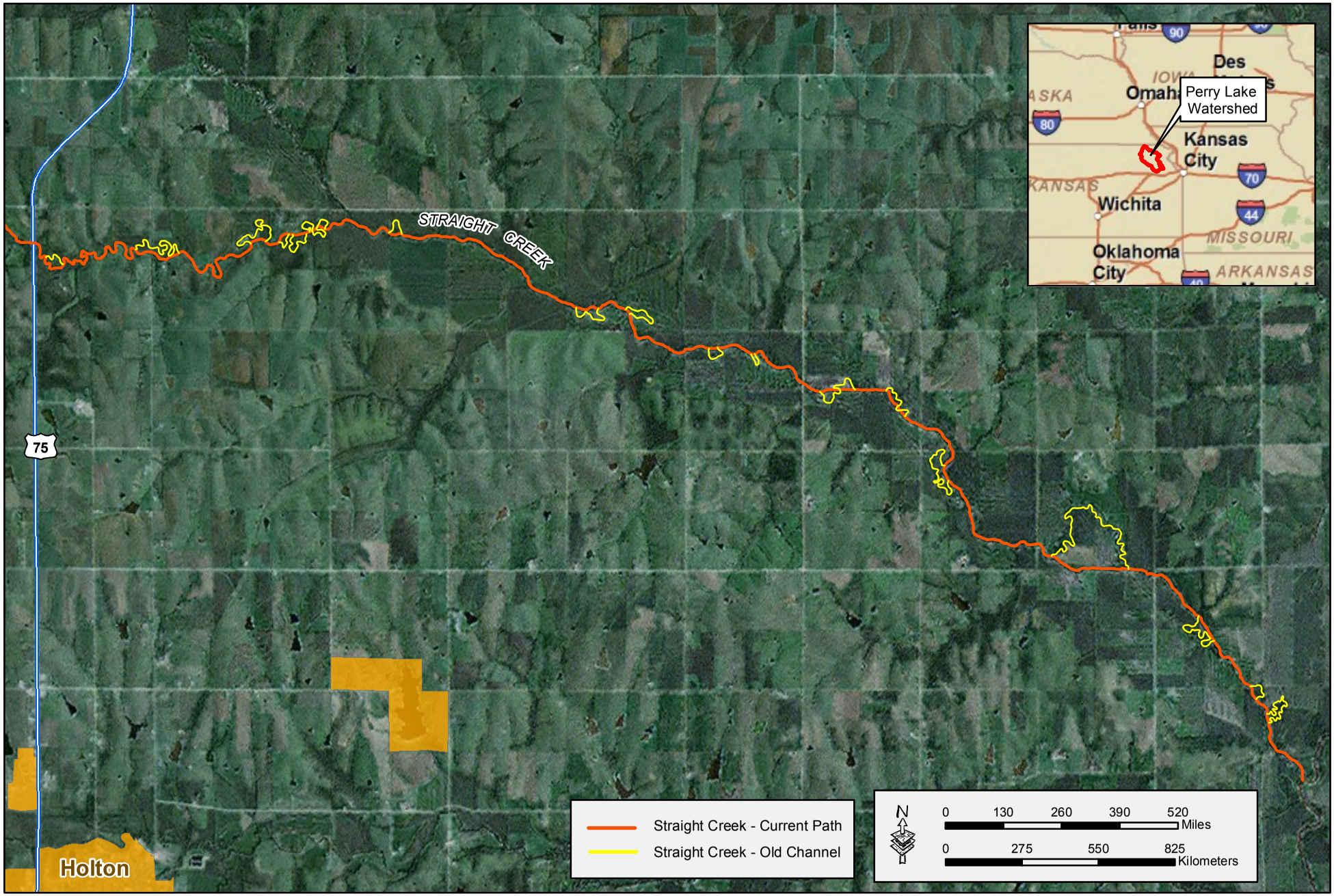


Figure 2-3: Channelization of Straight Creek

GSRC

June 2011

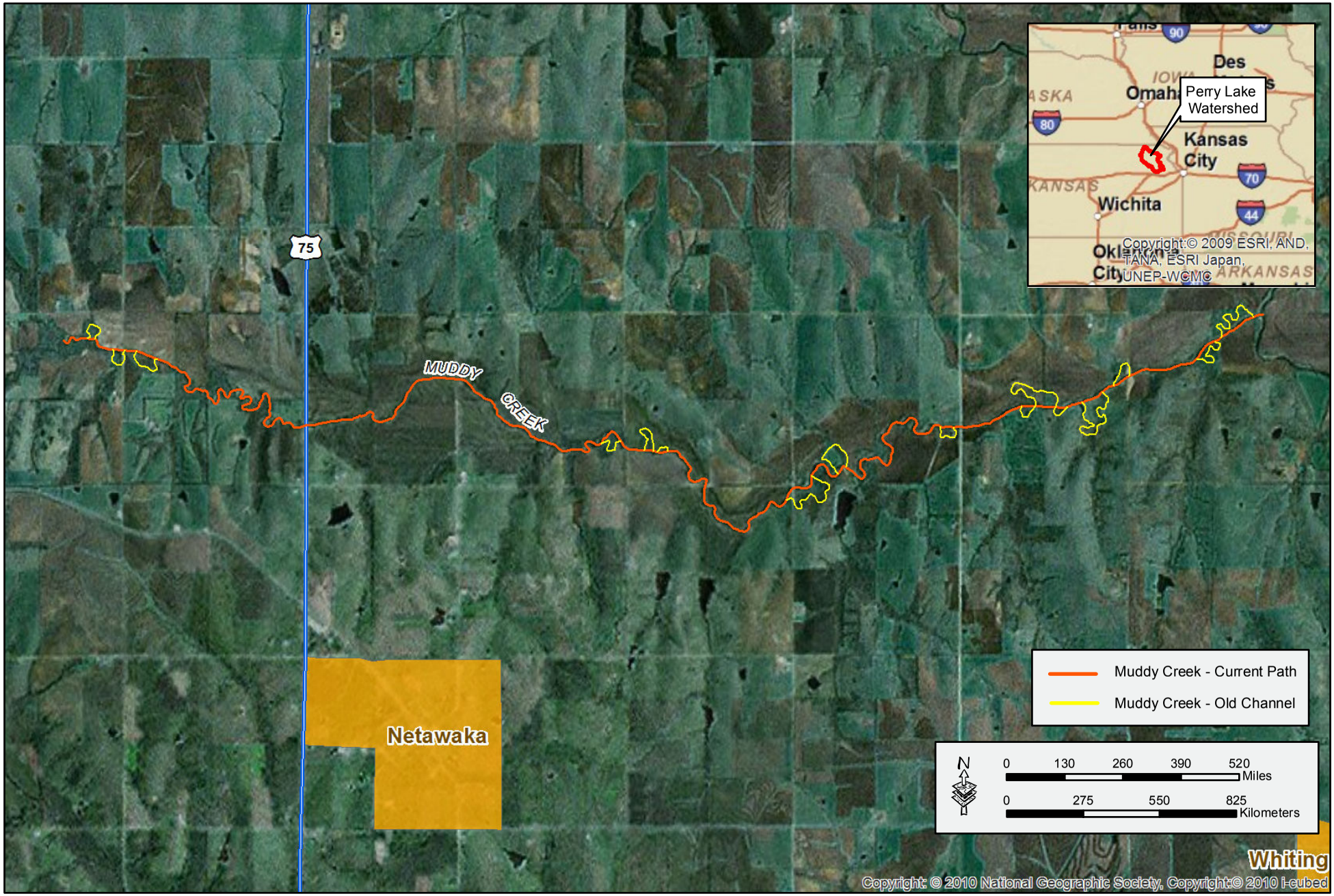


Figure 2-4: Channelization of Muddy Creek

GSRC

June 2011

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 3.0
METHODOLOGY

3.0 METHODOLOGY

Within the Perry Lake Watershed, 50 hot-spots were evaluated along Muddy Creek, Straight Creek, Spring Creek, and the Delaware River. Detailed geomorphic streambank surveys were performed at the hot-spots, and historic and current aerial photography were used to determine annual streambank erosion rates. The field survey data was used to populate the Rosgen (2006) RIVERMorph model and a Bank Erodibility Hazard Index (BEHI) and Near-Bank Stress (NBS) rating was produced for the 50 hot-spots (existing conditions). Stream stabilization BMPs were developed for each of the hot-spots and they were evaluated again in the RIVERMorph model using the Bank Assessment for Non-point Consequences of Sediment (BANCS) feature. New BEHI and NBS ratings were compared to the existing conditions to determine the effectiveness of the stabilization BMPs. A detailed narrative of methodology is provided in the following sections and depicted in Figure 3-1.

3.1 Site Selection

KWO (Kansas Water Office) identified stream erosion Priority Areas in the Perry Lake Reservoir watershed. KWO recorded the location of streambank hot-spots using aerial photographs and assigned a unique identification number (UniqueID) for each site. The KWO UniqueID system was used to identify streambanks experiencing erosion in the watershed. A total of 50 hot-spots were evaluated in the Perry Lake Watershed, including sites on Muddy Creek, Straight Creek, Spring Creek, and the Delaware River. The UniqueID system used by KWO provided a reference for erodible banks in this study; however, if a survey site was evaluated and was not on the KWO list, a UniqueID was assigned. Prior to all field work, rights of entry from landowners were obtained by personal communication or by the Delaware River Watershed Restoration and Protection Strategies (WRAPS) group.

3.2 General Site Information

General site data were collected from visual observations, such as vegetation type present on the streambank and riparian corridor, rooting density percentage of streambank vegetation, land use adjacent to the stream reach, and type of soils found in the streambed and bank.

METHODS FOR STREAM SURVEYS AND STABILIZATION BMPS

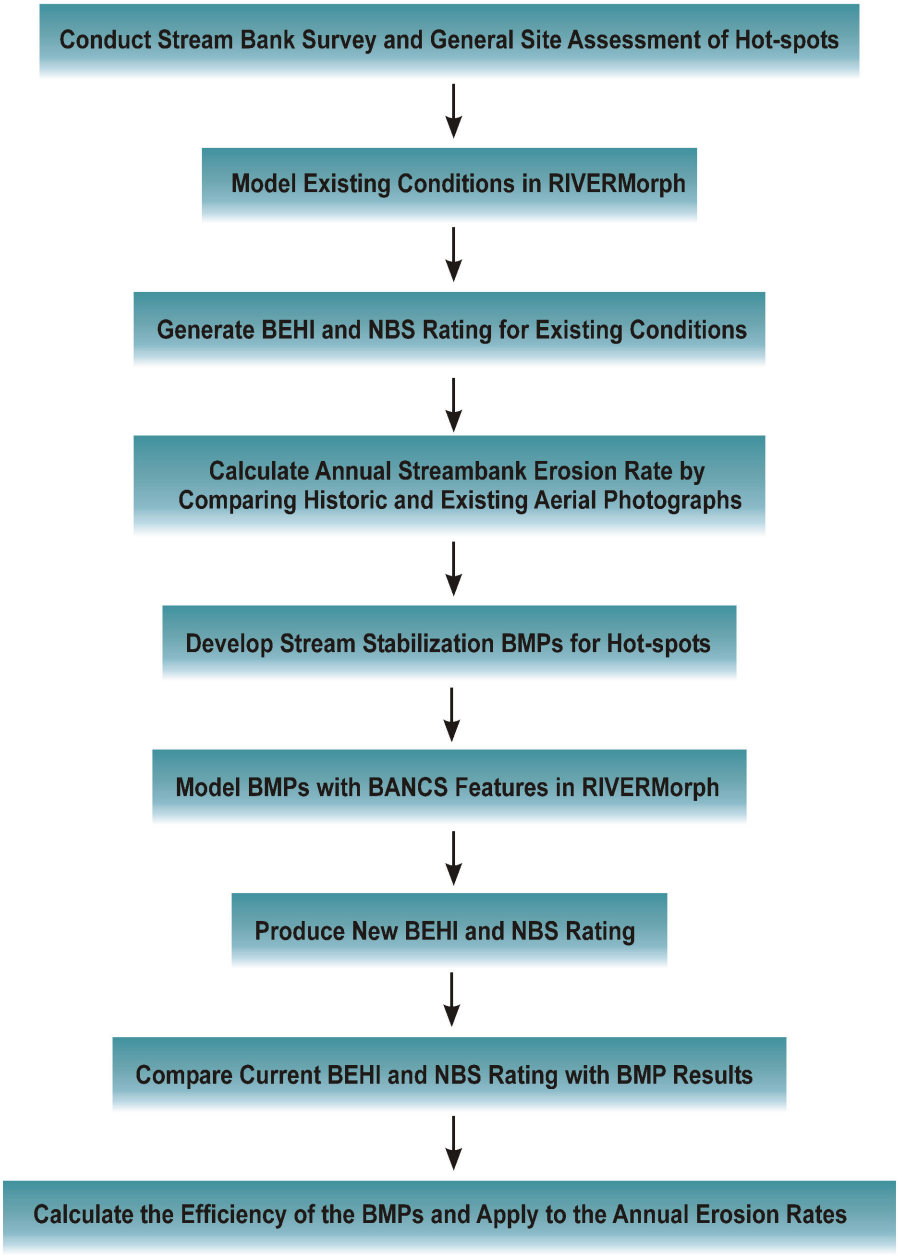


Figure 3-1: Flow Chart of Methods used to Assess Stream Channels and Stabilization BMPs

GSRC

August 2011

3.3 Channel Dimension

Using a Leica TCR407 total station with a Carlson Explorer II data collector, the eroding bank length and cross-section shape were surveyed to obtain channel dimensions. For each cross-section, a transect oriented perpendicular to the flow was surveyed by recording measurements at regular intervals to accurately depict the channel shape. In addition, physical features, such as edge of water, channel thalweg (deepest part of the streambed), terraces, vegetation root depth, bank stratigraphy, and bankfull stage indicators (i.e. bank angle, vegetation changes, and top of sediment deposits) were documented.

3.4 Stream Restoration Software

All survey data were entered into the RIVERMorph software, which is designed to analyze stream geomorphic data, calculate stream classification, and facilitate stream restoration designs. RIVERMorph was used to estimate the total annual sediment erosion volume and model the effectiveness of streambank stabilization BMPs using the BANCS (Bank Assessment for Non-point Consequences of Sediment) feature. RIVERMorph produces a number of stream stability analyses, two of which were used in this report, the BEHI (Bank Erodibility Hazard Index) and NBS (Near-Bank Stress) rating.

3.4.1 Bank Erodibility Hazard Index (BEHI)

The BEHI was used to assess streambank erosion potential (Rosgen 2001b). BEHI is a quantitative assessment of channel stability that ranks the following series of parameters in streambank resistance to erosion:

1. Ratio of streambank height to bankfull height
2. Ratio of riparian vegetation rooting depth to streambank height
3. Rooting density percentage
4. Particle size of streambed and bank soils
5. Streambank angle
6. Bank material stratigraphy and presence of soil lenses
7. Bank surface protection provided by debris, rocks, and vegetation

BEHI assessment procedures assign a numeric index rating for each parameter, the indices of which are summed to describe an overall erosion potential score. BEHI characterizes erosion

potential as low, moderate, high, very high, and extreme. BEHI assessments were performed using survey data and field observations. The BEHI data were entered into RIVERMorph, and the software calculated the BEHI variables and overall BEHI rating. Modified BEHI scores were also calculated using changes suggested by Sass (2011). Sass (2011) combined the vegetation components (rooting depth ratio and weighted root density percent) into one category (Woody Vegetation Present) since they relate to similar processes. Sass (2011) found that BEHI vegetation scores were consistent for streams in the Black Vermillion watershed. A BEHI vegetation score of 2.5 was applied if woody vegetation was present and an 8.5 if woody vegetation was absent (Sass 2011). The modification strengthened the BEHI/NBS curves for moderate and high BEHI rated sites. The RIVERMorph BEHI data were then exported into a Watershed Assessment of River Stability and Sediment Supply (WARSS) worksheet (Rosgen 2006). The BEHI Rosgen worksheets are presented in Appendix A.

3.4.2 Near-Bank Stress (NBS)

In addition to BEHI, NBS ratings were performed to assess bank stability. NBS ratings are used to identify potential disproportionate energy distribution in the near-bank region that can lead to accelerated bank erosion (Rosgen 2006). Rosgen (2006) has developed seven different options for rating NBS. These options range from a reconnaissance level assessment to a detailed prediction determination. The NBS rating can use the following methods:

1. Channel pattern, traverse bar, or split channel/central bar creating NBS/high velocity gradient
2. Ratio of radius of curvature to bankfull width
3. Ratio of pool slope to average water surface slope
4. Ratio of pool slope to riffle slope
5. Ratio of near-bank maximum depth to bankfull mean depth
6. Ratio of NBS to bankfull shear stress
7. Rates of velocity profiles/isovels/velocity gradient

To determine NBS in this study, the ratio of the near-bank maximum depth (d_{nb}) to the mean bankfull depth (d_{bkf}) was calculated. The near-bank maximum depth is the maximum depth within the one-third portion of channel cross-section nearest the study streambank (Rosgen 1996). RIVERMorph was used to calculate the d_{nb}/d_{bkf} ratio based on the surveyed cross

sections. The ratios were then rated based on the NBS ratings developed by Rosgen (2006) which are presented in Table 3-1.

Table 3-1. Near-Bank Stress Rating for d_{nb}/d_{bkf}

d_{nb}/d_{bkf} Ratio	NBS Rating
< 1.00	Very Low
1.00 - 1.50	Low
1.51 – 1.80	Moderate
1.81 – 2.50	High
2.51 – 3.00	Very High
> 3.00	Extreme

Source: Rosgen 2006

3.5 Bank Erosion Rate

Aerial photographs from 1991 were compared with aerial photographs from 2008. First, the 1991 rectified aerial photographs (U.S. Geological Survey [USGS] 1997) were used to plot the channel location in ArcMap (ESRI 2008). Next, the 1991 plotted channel position was compared with the 2008 rectified aerial photograph channel position (U.S. Department of Agriculture Farm Service Agency [USDA FSA] 2008). The surface area loss was delineated and the area calculated in ArcMap. For all 50 sites, the area eroded during the 17-year time span was used to predict an annual erosion volume loss (tons/ft/yr) and land loss (ft/yr) rate.

3.6 Streambank Stabilization BMPs

Four streambed and bank stabilization BMPs were considered for stabilizing the hot-spots, including rock vanes, longitudinal peaked stone toe protection (LPSTP), shaping the banks to a 3-foot horizontal to 1-foot vertical (3:1) slope, and planting the riparian corridor with native trees, shrubs, and grasses. The NBS was adjusted to the low rating, as defined by Rosgen (2006), to reflect the installation of rock vanes, which would help reduce water velocities in the near-bank region. The BMP implementation scenarios were divided into two periods: years 1 through 3 and years 4 through 10.

The BEHI modeling scenarios included:

- Current conditions
- BMP implementation years 1 through 3
- BMP implementation years 4 through 10

The BEHI parameters, such as rooting depth, root density percentage, and surface protection were altered to represent two typical periods of vegetation establishment (i.e., young plants versus mature plants).

3.7 Evaluating BMP Effectiveness Using BANCS

The BANCS model was used to estimate the erosion rates of the proposed BMP scenarios. The BANCS model is a feature in the Rosgen RIVERMorph BEHI assessment. To predict erosion loss reductions associated with implementing streambank stabilization BMPs, the BANCS model was utilized to determine percent reduction estimates of annual streambank erosion following BMP implementation. Rosgen (1996 and 2006) calibrated BEHI scores from streams in Colorado and in Yellowstone National Park to yield a linear relationship between NBS scores and bank erosion rates.

To use the BANCS model, BEHI and NBS ratings must be calculated from a selected stream reach. Once the rating values are calculated and entered into RIVERMorph, the streambank erosion relationship can be selected (Rosgen 2006). BANCS then predicts erosion loss based on the proposed BMPs. It should be noted that the BANCS model is only statistically valid for predicting bank erosion rates in Colorado and Yellowstone National Park streams (Rosgen 2006), as these relationships have not been validated for Kansas alluvial streams. The application of this method to streams in Kansas was chosen to provide a framework to demonstrate the potential percent reduction in erosion loss based on the implementation of BMPs. The BANCS model was used to predict the percent reduction in erosion loss when comparing current conditions and BMP implementation scenarios.

3.8 BMP Recommendations for Stream Reaches

The field surveys indicated that the bank types that were experiencing the greatest erosion rates were those along outside meander bends with narrow or non-existent riparian corridors. The banks of these reaches have steep slopes and little surface protection, and would continue to move laterally unless effective BMPs were implemented as determined by the BANCS model. The following sections describe the recommended stream stabilization BMPs suitable for unstable streambanks.

3.8.1 Rock Vanes

Rock vanes, recommended to address accelerated streambank erosion, are structures designed to reduce water velocities and redirect flow away from the near-bank region (Figure 3-2). They are effective stabilization structures for channels with low width-to-depth ratios.

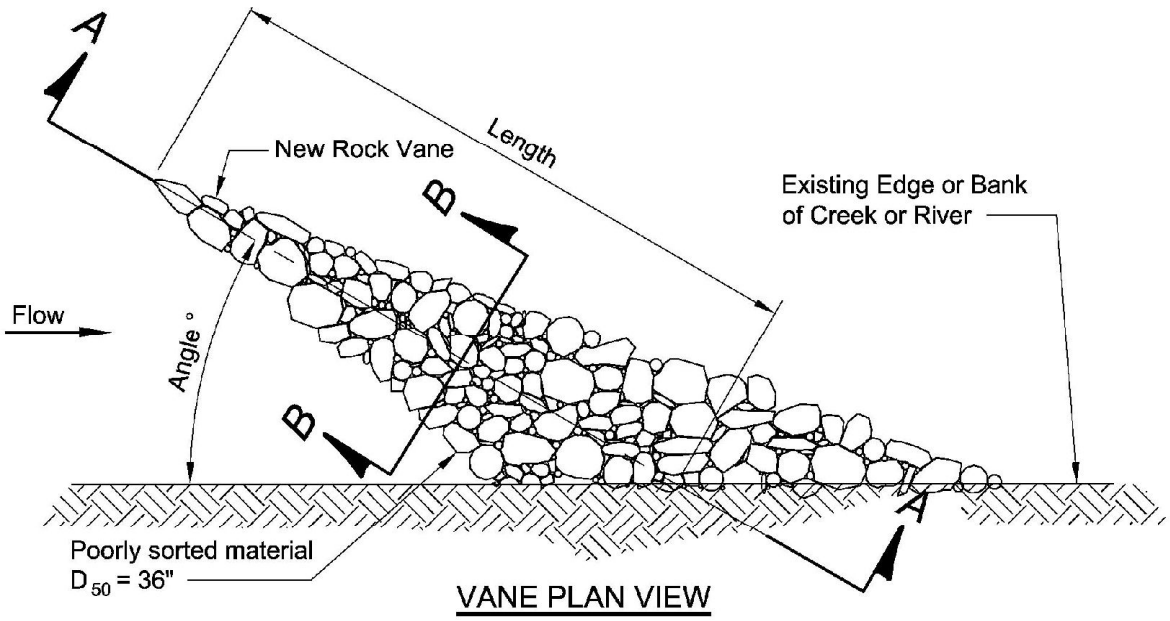
3.8.2 Longitudinal Peaked Stone Toe Protection (LPSTP)

LPSTP (Figure 3-3) has proven to increase stability on stream reaches experiencing high near-bank stress. LPSTP is a continuous stone dike placed longitudinally at, or slightly streamward of, the toe of the slope of the streambank. It reinforces the bank toe. The LPSTP does not necessarily follow the toe exactly, but can be placed to create a uniform alignment along the bend. The amount of stone required depends on depth of scour at the toe, estimated stream forces (impinging flow) on the bank, and flood stage and duration.

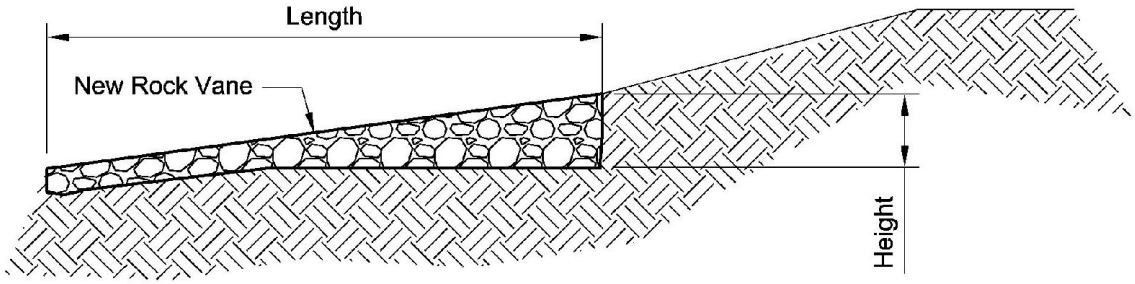
3.8.3 Bank Shaping

Bank shaping is recommended to increase streambank stability by dissipating energy during high flow events. Bank shaping is usually employed along outside river bends where relatively steep banks do not promote establishment and persistence of vegetation that would otherwise stabilize the bank (Photograph 3-1). Bank shaping involves excavation to reduce the bank angle and create a more gentle slope of 3:1 (18.4 degrees) to promote the establishment and persistence of indigenous trees and grasses. The root systems of plants stabilize the streambank, thereby reducing the potential for soil erosion during high water events. Figure 3-4 presents a diagram of bank shaping and demonstrates the change in bank slope and vegetation establishment before and after bank shaping has occurred.

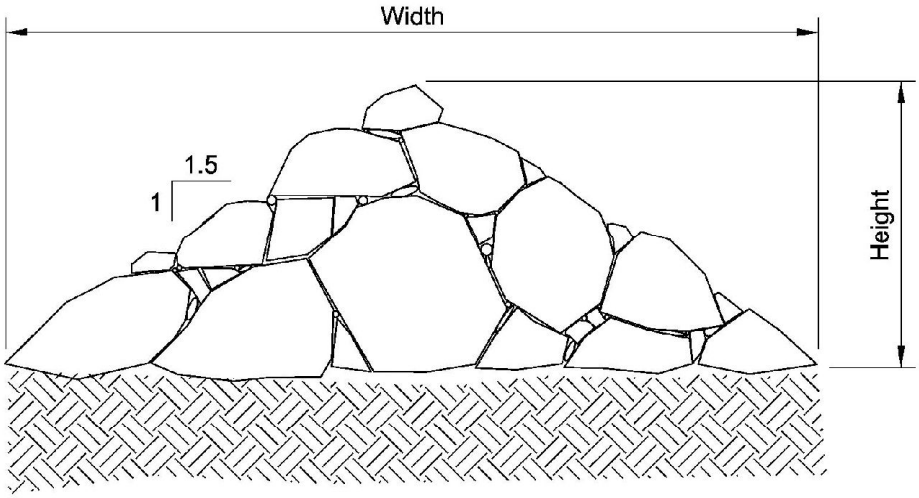
Photograph 3-1. Highly erodible bank on Delaware River with steep slope and no vegetation.



VANE PLAN VIEW



VANE CROSS SECTION A-A

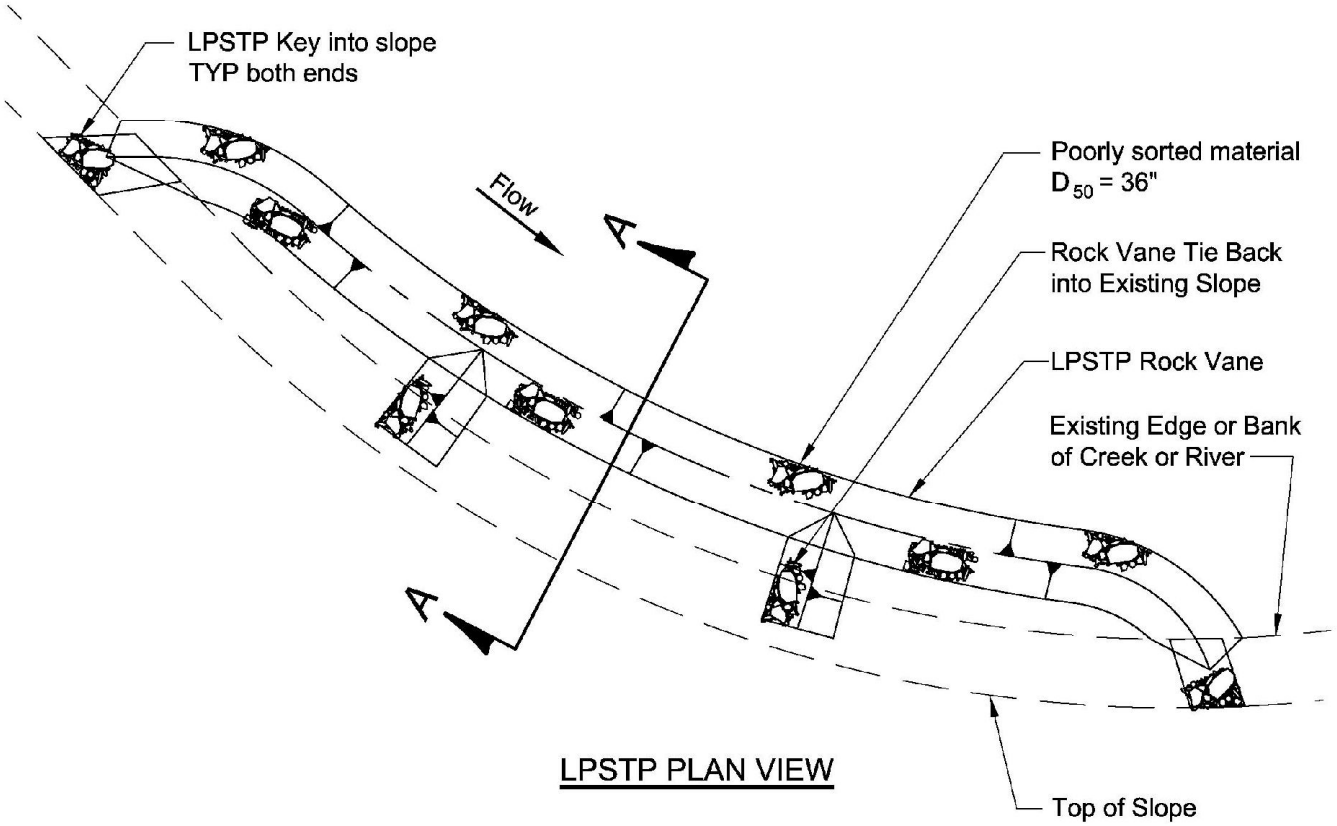


VANE CROSS SECTION B-B

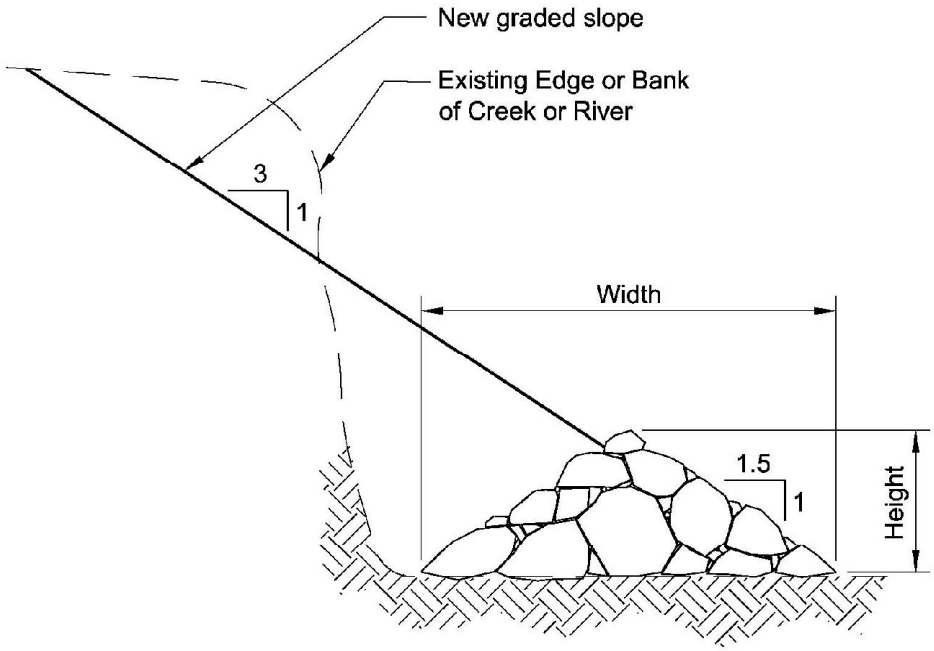
Figure 3-2: Structural Design of Rock Vanes

GSRC

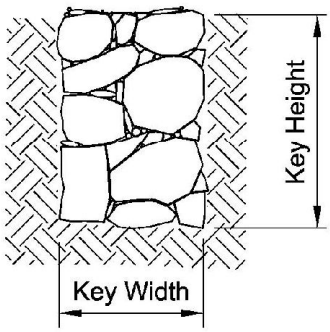
September 2011



LPSTP PLAN VIEW



LPSTP CROSS SECTION A-A



KEY SECTION VIEW

Figure 3-2: Details of Longitudinal Peaked Stone Toe Protection (LPSTP)

GSRC

September 2011

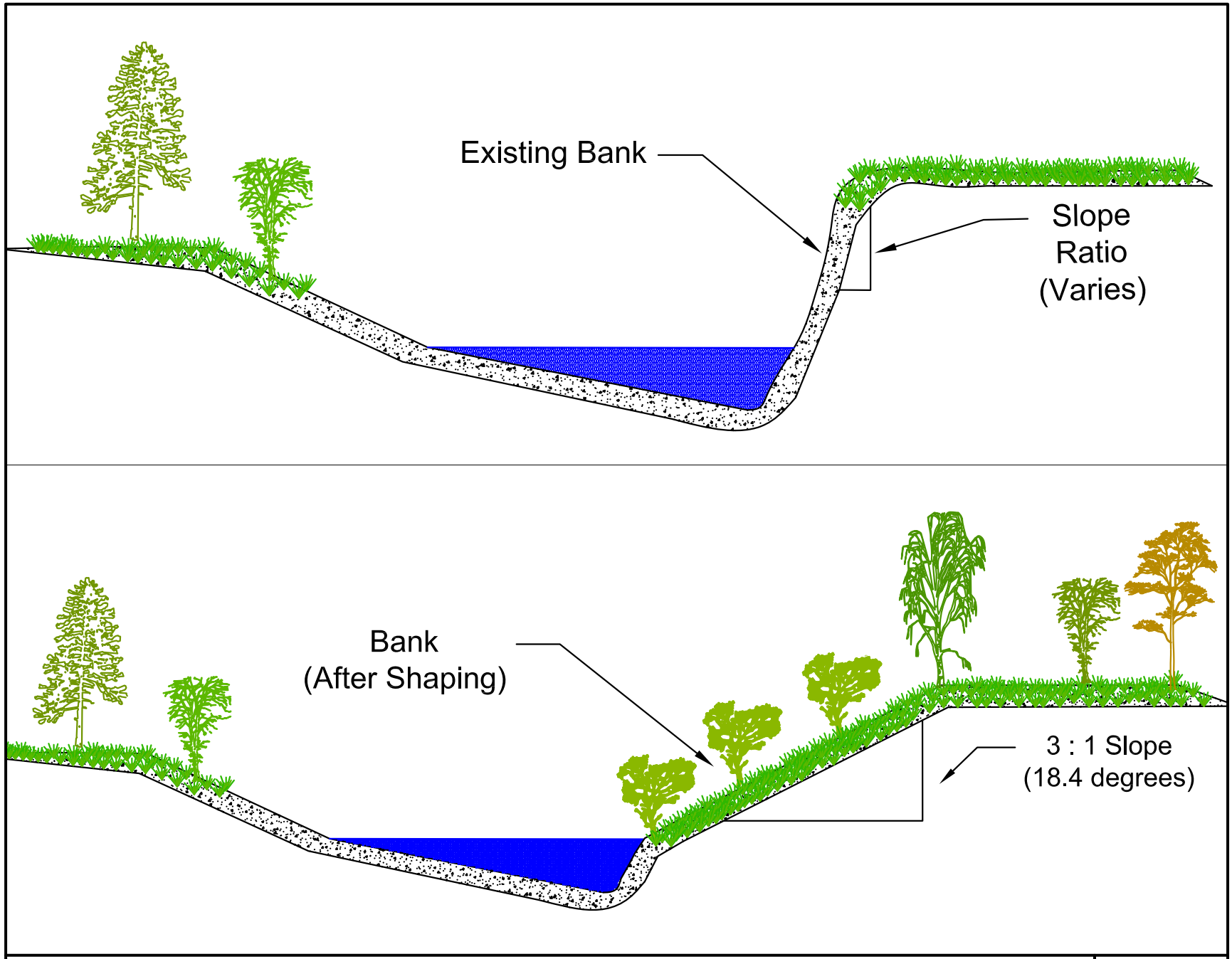


Figure 3-4: Details of Bank shaping and Riparian Planting BMP

GSRC
June 2011

3.9 Cost Estimates for Streambank BMPs

Information from previous streambank stabilization projects and U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Environmental Quality Improvement Program (EQIP) was used to estimate the costs for implementing streambank stabilization BMPs. Rock placement and bank shaping proved to be the most expensive components of stream restoration. Previous estimates developed for adjacent watersheds were shown to be as high as $97 per linear ft (TWI 2007). Large, deep rivers typically require more rock, thus requiring more funding.

Table 3-2 provides cost estimates for implementing stream stabilization BMPs. These values may vary, as specific rock quantities, soil moving, and site condition data are unknown. The cost estimates assumed that the distance to the source of materials (quarry) would be less than 30 miles (typical for the area) and that the bank material would be excavated, deposited, and graded on the adjacent land.

Table 3-2. Estimated Costs to Implement Streambank Stabilization BMPs

BMP Description	Cost Estimate (per linear foot)
1. Survey and design Rock delivery and placement As-built certification design Bank excavation and shaping	$5.00 to $10.00 $25.00 to $35.00 $5.00 to $10.00 $20.00 to $30.00
2. Vegetation (material and planting) Cover Crop Mulch Stakes to support planted woody species Bare root seedlings Grass filter strip	$5.00
3. Contingencies Unexpected site conditions requiring additional materials and construction time	$3.00 - $5.50
TOTAL	**$63.00 - $95.50**

Bank shaping by excavating steep banks to a minimum of a 3:1 slope (18.4 degrees) was recommended to rehabilitate unstable banks on the river bends. Construction of a bankfull bench would increase stream stability by dissipating energy during high flow events. Excavating streambanks to desired conditions would cost approximately $20 to $30 per linear foot. Planting

a riparian buffer consisting of live cuttings, bare root seedlings, and a native grass strip would cost approximately $5 per linear foot.

The cost to implement BMPs on smaller stream systems would typically be less than larger streams, since water depths are less and bank heights are lower. These estimates are reflective of current prices (2011), which may fluctuate based on material prices and fuel costs. For the purpose of this study, stream reaches were segregated into small, medium, and large categories. The costs to implement streambank stabilization BMPs were calculated by multiplying the length of the streambank by the estimated cost to install per linear foot. Table 3-3 presents three stream size categories and estimated cost per linear foot.

Table 3-3. Stream Size and Associated BMP

Size of Stream	Discharge Flow Rate at Bankfull (cfs)	Cost of BMP per Linear Foot
Small	1 to 2,000	$63.00
Medium	2,001 to 8,000	$80.00
Large	8,001 and greater	$95.00

Source: GSRC and U.S. Department of Agriculture, Natural Resources Conservation Service EQIP information.

3.9.1 Cost-Benefit Analysis of Streambank Stabilization BMPs

To analyze the cost-benefit of streambank stabilization BMPs, installation costs were distributed over a 10-year period. It was assumed that the BMPs would be fully functional and reduce the rate of erosion at the predicted rate over the 10-year period. For example, if the cost to install stabilization BMPs along a streambank is $100,000 and the BMP reduced the erosion rate by 100 tons/yr, the cost-benefit of the streambank stabilization BMP would be 100 tons/yr per $10,000 of BMP investment.

SECTION 4.0
RESULTS

4.0 RESULTS

This section summarizes the results of field surveys and streambank modeling. Appendix A includes additional results regarding the erosion calculations, BMP recommendations, field assessment forms, BEHI worksheets, channel and bank cross-sections, and aerial photographs depicting the lateral channel movement for each of the 50 hot-spots from 1991 to 2008, a 17-year time period.

4.1 Rates of Erosion Found at Perry Lake Watershed Hot-spots

A total of 50 hot-spots were surveyed in the Perry Lake Watershed, which is comprised of 28,049 linear feet of streambank. The hot-spot erosion rates varied from 0.27 to 6.41 tons per foot per year (tons/ft/yr) and their combined rate of erosion was estimated to be 79,415 tons per year (tons/yr). Erosion rates at nine of the hot-spots were equal to or less than 1.0 tons/ft/yr, while eight of the hot-spots were eroding at a rate greater than 4.0 tons/ft/yr. The median rate of erosion for the 50 hot-spots was 1.89 tons/ft/yr and the average was 2.43 tons/ft/yr. It was estimated that approximately 61,088 cubic yards of sediment has eroded each year from the 50 hot-spots assessed in this report.

The BEHI ratings ranged from 41.9 to 17.3, and streambank erodibility was primarily influenced by bank slope and vegetation density. In riparian corridors with gently sloping banks, the erodibility potential was low. Conversely, the erodibility potential was highest on outside meander bends with steep banks and sparse riparian vegetation.

NBS and bank erosion rates were not strongly correlated. The relative lack of correlation may be due to erosion rates being estimated over a 17-year period. As such, periods of significant erosion and changes in stream morphology may have occurred at a site years ago, long before the surveys were performed. A summary of the BEHI and NBS scores and streambank erosion loss rates is presented in Table 4-1.

Table 4-1. Existing Rates of Erosion for 50 Hot-Spots in Perry Lake Watershed

UniqueID	BEHI Score	BEHI Rating	d_{nb}/d_{bkf} Ratio	NBS Rating	Erosion Rate (ft/yr)	Erosion Rate (tons/ft/yr)	Total Erosion (tons/reach/yr)
0029	36.0	High	1.32	Low	1.54	1.83	32,756
0030	28.1	Moderate	1.49	Low	2.32	2.94	32,413
0031	31.1	High	1.50	Low	3.52	4.73	152,732
0039	25.6	Moderate	1.54	Moderate	4.12	5.30	85,358
0040	29.9	Moderate	1.32	Low	1.76	2.19	41,999
0042	34.0	High	1.94	High	3.33	4.55	32,855
0043	30.4	High	1.51	Moderate	1.22	1.57	21,544
0044	30.6	High	1.59	Moderate	4.30	5.47	108,622
0045	29.7	Moderate	1.55	Moderate	2.08	2.79	26,458
0047	28.7	Moderate	1.47	Low	3.28	3.49	17,978
0056	28.5	Moderate	1.33	Low	0.60	0.49	3,762
0057	38.2	High	1.52	Moderate	4.36	3.93	17,084
0062	38.5	High	1.53	Moderate	3.68	6.41	63,243
0065	27.8	Moderate	1.53	Moderate	2.92	3.57	29,978
0066	31.8	High	1.44	Low	3.69	4.25	56,231
0067	29.5	Moderate	1.44	Low	1.85	2.13	15,690
0068	31.8	High	1.41	Low	1.22	1.41	13,406
0069	41.9	Very High	1.46	Low	1.48	1.82	17,367
0070	37.7	High	1.98	High	2.63	3.44	56,856
0072	35.2	High	1.37	Low	1.17	1.46	11,930
0074	39.3	High	1.38	Low	1.98	2.57	27,786
0076	19.7	Low	2.00	High	0.97	1.08	9,652
0077	17.3	Low	1.51	Moderate	0.64	0.66	4,307
0080	25.3	Moderate	1.61	Moderate	2.72	3.71	26,526
0081	33.8	High	1.55	Moderate	3.60	4.87	81,034
0082	28.3	Moderate	1.41	Low	1.41	1.83	11,704
0083	36.1	High	1.55	Moderate	1.70	1.69	8,958
0084	36.6	High	2.22	High	2.23	3.76	24,404
0086	41.9	Very High	1.56	Moderate	3.27	2.93	35,745
0088	37.8	High	1.37	Low	2.38	1.51	14,529
0089	34.6	High	1.53	Moderate	1.48	0.85	9,269
0090	30.0	Moderate	1.73	Moderate	1.51	0.79	5,086
0094	39.4	High	1.53	Moderate	4.37	5.46	44,554
0096	31.8	High	1.45	Low	1.41	1.94	14,028
0112	23.3	Moderate	1.45	Low	4.26	3.69	19,331
0113	18.4	Low	1.74	Moderate	0.69	0.62	3,992
0114	32.3	High	1.48	Low	0.29	0.27	793
0115	38.0	High	1.31	Low	1.01	1.02	3,924
0116	29.3	Moderate	1.45	Low	0.66	0.72	3,087
0117	37.3	High	1.27	Low	1.09	1.00	7,221
0118	38.5	High	1.47	Low	1.84	1.14	8,315
0119	40.9	Very High	1.53	Moderate	1.07	1.38	5,305
0120	26.6	Moderate	1.42	Low	2.08	2.48	29,851
0121	31.3	High	1.29	Low	1.25	1.63	14,279
0122	28.8	Moderate	1.70	Moderate	0.47	0.58	3,286
0123	28.8	Moderate	1.27	Low	1.40	1.78	17,547
0124	21.5	Moderate	1.81	Moderate	0.73	1.17	3,233
0125	32.1	High	1.62	Moderate	2.94	3.16	21,948
0126	34.9	High	1.59	Moderate	2.30	2.43	11,027
0127	27.8	Moderate	1.53	Moderate	0.85	1.03	11,382

4.2 BMP Impacts: Estimated Reduction of Sediment Erosion

All 50 hot-spots were modeled with BMP scenarios that included bank shaping, riparian plantings, LPSTPs, and rock vanes. BANCS modeling of BMPs in Scenario A (years 1 through 3) indicates that sediment erosion would be reduced in most instances. Results from the BANCS model indicated that BMPs for Scenario A would result in a reduction in streambank erosion ranging from 0 to 85 percent. A total of nine of the hot-spots did not show any improvement resulting from the implementation of BMPs during the first 3 years. During Scenario A, the rate of erosion increased by 29 percent at one of the hot-spots (0113). Hot-spot site 0113 already exhibited a low erosion rate of 0.62 ton/ft/yr due to the presence of mature, densely populated riparian vegetation occupying the existing bank. In the long-term, BMPs would improve the stability of the streambanks; however, the existing riparian area would be destroyed in the process of reshaping the bank to reflect a 3:1 slope. The BANCS model indicated that erosion at Site 0113 increased by 29 percent due to decreases in plant rooting depth and density of the native vegetation. The nine sites that did not improve through modeling of Scenario A also had mature and densely populated vegetation on the existing bank, which would have been destroyed during reshaping of the streambank. It was estimated that the total erosion loss for the 50 hot-spots in Scenario A would decrease by 57.4 percent from 79,415 to 33,831 tons/yr, a reduction of 45,585 tons/yr.

BANCS modeling of the BMPs in Scenario B (years 4 through 10) indicated that rates of erosion decreased relative to Scenario A. Rates of erosion were reduced by 44 to 94 percent during the Scenario B model calculations. The difference between Scenario A and Scenario B was due to the characteristics of the vegetation on the streambank. For Scenario A, a root density of 25 percent and vegetative surface protection of 50 percent were used to mimic the conditions of newly planted vegetation. For Scenario B, a root density and surface protection of 75 percent were used to mimic well-established riparian vegetation. The decrease in erosion observed in Scenario B reinforces the importance of a densely vegetated riparian corridor. It is estimated that the total erosion loss for the 50 hot-spots in Scenario B decreased by 80.6 percent from 79,415 to 15,336 tons/yr, a reduction of 64,079 tons/yr. Scenario B showed an improvement of 23.2 percent in erosion rate relative to Scenario A. A comparison of the erosion rates resulting from before and after the implementation of BMPs, along with and estimates of the percent reduction of bank erosion for BMP Scenarios A and B are presented in Table 4-2.

Table 4-2. Comparison of Rates of Erosion: Existing and BMP Scenario A and B

UniqueID	Stream Bank Erosion Rate (tons/ft/yr)	Scenario A BMP Percent Reduction	BMP Rate of Erosion (yrs 1 through 3) (tons/ft/yr)	Scenario B BMP Percent Reduction	BMP Rate of Erosion (yrs 4 through 10) (tons/ft/yr)
0029	1.83	50%	0.92	50%	0.92
0030	2.94	0%	2.94	62%	1.12
0031	4.73	81%	0.90	81%	0.90
0039	5.30	53%	2.49	82%	0.95
0040	2.19	0%	2.19	62%	0.83
0042	4.55	82%	0.82	93%	0.32
0043	1.57	70%	0.47	87%	0.20
0044	5.47	70%	1.64	87%	0.71
0045	2.79	53%	1.31	82%	0.50
0047	3.49	0%	3.49	62%	1.33
0056	0.49	0%	0.49	62%	0.19
0057	3.93	70%	1.18	94%	0.24
0062	6.41	70%	1.92	89%	0.71
0065	3.57	53%	1.68	82%	0.64
0066	4.25	50%	2.13	81%	0.81
0067	2.13	0%	2.13	62%	0.81
0068	1.41	50%	0.71	81%	0.27
0069	1.82	50%	0.91	82%	0.33
0070	3.44	83%	0.58	94%	0.21
0072	1.46	50%	0.73	81%	0.28
0074	2.57	50%	1.29	81%	0.49
0076	1.08	31%	0.75	74%	0.28
0077	0.66	44%	0.37	44%	0.37
0080	3.71	50%	1.86	81%	0.70
0081	4.87	70%	1.46	87%	0.63
0082	1.83	0%	1.83	62%	0.70
0083	1.69	70%	0.51	74%	0.44
0084	3.76	85%	0.56	94%	0.23
0086	2.93	70%	0.88	87%	0.38
0088	1.51	50%	0.76	81%	0.29
0089	0.85	70%	0.26	87%	0.11
0090	0.79	82%	0.14	82%	0.14
0094	5.46	70%	1.64	87%	0.71
0096	1.94	50%	0.97	81%	0.37
0112	3.69	0%	3.69	62%	1.40
0113	0.62	-29%	0.80	51%	0.30
0114	0.27	50%	0.14	81%	0.05
0115	1.02	50%	0.51	81%	0.19
0116	0.72	0%	0.72	62%	0.27
0117	1.00	50%	0.50	81%	0.19
0118	1.14	50%	0.57	81%	0.22
0119	1.38	70%	0.41	87%	0.18
0120	2.48	62%	0.94	62%	0.94
0121	1.63	50%	0.82	81%	0.31
0122	0.58	50%	0.29	82%	0.10
0123	1.78	0%	1.78	62%	0.68
0124	1.17	76%	0.28	91%	0.11
0125	3.16	70%	0.95	87%	0.41
0126	2.43	70%	0.73	89%	0.27
0127	1.03	50%	0.52	82%	0.19

SECTION 5.0
CONCLUSIONS

5.0 CONCLUSIONS

A total of 50 hot-spots were surveyed in the Perry Lake Watershed, comprising 28,049 linear-feet of streambank. The hot-spot erosion rates varied from 0.27 to 6.41 tons/ft/yr, and their combined rate of erosion was estimated to be 79,415 tons/yr. It was estimated that the total erosion loss for the 50 hot-spots in Scenario A decreased by 57.4 percent from 79,415 to 33,831 tons/yr, a reduction of 45,584 tons/yr. It was estimated that the total modeled erosion loss for the 50 hot-spots in Scenario B decreased by 80.6 percent from 79,415 to 15,336 tons/yr, a reduction of 64,079 tons/yr, a decreased rate of erosion of 23.2 percent. It is estimated that 61,088 cubic yards of sediment is eroding each year from the 50 hot-spots assessed in this report.

The streambank erosion process was observed to be amplified in incised channels, such as those typical in the Perry Lake Watershed. Incised channels are vertically contained streams that have abandoned previous floodplains due to a lowering of local base level (Rosgen 1996). Incised channels in the Perry Lake Watershed were created by channel straightening and are more susceptible to streambank erosion processes due to higher bank heights, steeper bank angles, and shallow rooting depths of riparian vegetation. In addition, there are several levee systems along the Delaware River that restrict the access of high flow events to the floodplain. As a result, a greater volume of water is confined to a smaller cross-sectional area. This increases the stream power and erosion potential during high water events. In the Perry Lake Watershed, most channels have been straightened.

The recommended BMP approach is to stabilize the streambanks in place. Restoring the river and streams to historical streambed and bank elevations is not practical, given the adjacent land use and level of effort required. For the Perry Lake Watershed, stabilizing the bank toe with rock vanes and LPSTP measures is recommended. Also, shaping the bank slope to at least a 3:1 (18.4 degree) slope is recommended. Finally, establishing a vegetative riparian corridor on the streambank and on top-of-bank is recommended for long-term sustainability. Table 5-1 summarizes the results from the 50 hot-spots analyzed for BMP effectiveness.

Table 5-1. Estimated Cost and Effectiveness of Recommended BMPs

Survey Site Number	Name of Stream	Predicted Erosion (ton/ft/yr)	Bank Length (ft)	Years 1 through 3				Years 4 through 10			
				Percent BMP Reduction	Total Soil Reduction (tons/reach/yr)	Cost of Soil Reduction ($/ton)	Cost of Soil Reduction ($/cubic yard)	Percent BMP Reduction	Total Soil Reduction (tons/reach/yr)	Cost of Soil Reduction ($/ton)	Cost of Soil Reduction ($/cubic yard)
0029	Delaware River	1.83	1,052	50%	963	$8.74	$11.37	50%	963	$8.74	$11.37
0030	Delaware River	2.94	649	0%	0	$15,567	$20,249	62%	1,183	$4.39	$5.71
0031	Delaware River	4.73	1,900	81%	7,279	$2.09	$2.71	81%	7,279	$2.09	$2.71
0039	Delaware River	5.30	948	53%	2,663	$2.85	$3.70	82%	4,120	$1.84	$2.39
0040	Delaware River	2.19	1,130	0%	0	$27,120	$35,256	62%	1,534	$589	$766
0042	Delaware River	4.55	425	82%	1,586	$2.14	$2.79	93%	1,798	$1.89	$2.46
0043	Delaware River	1.57	805	70%	885	$7.28	$9.46	87%	1,100	$5.86	$7.61
0044	Delaware River	5.47	1,169	70%	4,476	$2.09	$2.72	87%	5,563	$1.68	$2.19
0045	Delaware River	2.79	557	53%	824	$5.41	$7.03	82%	1,274	$3.50	$4.55
0047	Delaware River	3.49	303	0%	0	$5.726	$7,444	62%	656	$291	$379
0056	Spring Creek	0.49	448	0%	0	$8,467	$11,007	62%	136	$20.74	$26.96
0057	Straight Creek	3.93	256	70%	704	$2.29	$2.98	94%	946	$1.71	$2.22
0062	Delaware River	6.41	850	70%	3,814	$1.78	$2.32	89%	4,849	$1.40	$1.82
0065	Delaware River	3.57	494	53%	935	$4.23	$5.50	82%	1,446	$2.73	$3.55
0066	Delaware River	4.25	778	50%	1,653	$3.76	$4.89	81%	2,678	$2.32	$3.02
0067	Delaware River	2.13	433	0%	0	$10,392	$13,509	62%	572	$6.06	$7.88
0068	Delaware River	1.41	561	50%	396	$11.35	$14.75	81%	641	$7.00	$9.11

Table 5-1, continued

Survey Site Number	Name of Stream	Predicted Erosion (ton/ft/yr)	Bank Length (ft)	Years 1 through 3				Years 4 through 10			
				Percent BMP Reduction	Total Soil Reduction (tons/reach/yr)	Cost of Soil Reduction ($/ton)	Cost of Soil Reduction ($/cubic yard)	Percent BMP Reduction	Total Soil Reduction (tons/reach/yr)	Cost of Soil Reduction ($/ton)	Cost of Soil Reduction ($/cubic yard)
0069	Delaware River	1.82	560	50%	510	$8.79	$11.43	82%	836	$5.36	$6.97
0070	Delaware River	3.44	971	83%	2,772	$2.80	$3.64	94%	3,140	$2.47	$3.22
0072	Delaware River	1.46	481	50%	351	$10.96	$14.25	81%	569	$6.76	$8.79
0074	Delaware River	2.57	635	50%	816	$6.23	$8.09	81%	1,322	$3.84	$5.00
0076	Delaware River	1.08	524	31%	175	$23.89	$31.06	74%	419	$10.01	$13.01
0077	Delaware River	0.66	386	44%	112	$27.55	$35.81	44%	112	$27.55	$35.81
0080	Delaware River	3.71	421	50%	781	$4.31	$5.61	81%	1,265	$2.66	$3.46
0081	Delaware River	4.87	979	70%	3,337	$2.35	$3.05	87%	4,148	$1.89	$2.45
0082	Delaware River	1.83	377	0%	0	$9,048	$11,762	62%	428	$7.05	$9.17
0083	Muddy Creek	1.69	311	70%	368	$5.33	$6.92	74%	389	$4.28	$5.57
0084	Muddy Creek	3.76	382	85%	1,221	$2.50	$3.25	94%	1,350	$2.26	$2.94
0086	Muddy Creek	2.93	718	70%	1,473	$3.07	$3.99	87%	1,830	$2.47	$3.21
0088	Muddy Creek	1.51	565	50%	427	$8.34	$10.85	81%	691	$5.15	$6.70
0089	Muddy Creek	0.85	643	70%	383	$10.59	$13.76	87%	475	$8.52	$11.08
0090	Muddy Creek	0.79	381	82%	247	$9.73	$12.64	82%	247	$9.73	$12.64
0094	Delaware River	5.46	480	70%	1,835	$2.09	$2.72	87%	2,280	$1.68	$2.19
0096	Delaware River	1.94	425	50%	412	$8.25	$10.72	81%	668	$5.09	$6.62

Table 5-1, continued

Survey Site Number	Name of Stream	Predicted Erosion (ton/ft/yr)	Bank Length (ft)	Years 1 through 3				Years 4 through 10			
				Percent BMP Reduction	Total Soil Reduction (tons/reach/yr)	Cost of Soil Reduction ($/ton)	Cost of Soil Reduction ($/cubic yard)	Percent BMP Reduction	Total Soil Reduction (tons/reach/yr)	Cost of Soil Reduction ($/ton)	Cost of Soil Reduction ($/cubic yard)
0112	Straight Creek	3.69	308	0%	0	$5,821	$7,567	62%	705	$2.75	$3.58
0113	Straight Creek	0.62	378	-29%	(68)	$7,144	$9,287	51%	120	$19.92	$25.90
0114	Straight Creek	0.27	173	50%	23	$46.67	$60.67	81%	38	$28.81	$37.45
0115	Muddy creek	1.02	226	50%	115	$12.35	$16.06	81%	187	$7.63	$9.91
0116	Muddy Creek	0.72	254	0%	0	$4,800	$6,240	62%	113	$14.11	$18.35
0117	Straight Creek	1.00	426	50%	213	$12.60	$16.38	81%	345	$7.78	$10.11
0118	Spring Creek	1.14	428	50%	244	$11.05	$14.37	81%	395	$6.82	$8.87
0119	Delaware River	1.38	226	70%	218	$8.28	$10.77	87%	271	$6.66	$8.66
0120	Delaware River	2.48	707	62%	1,087	$5.20	$6.76	62%	1,087	$5.20	$6.76
0121	Delaware River	1.63	515	50%	420	$9.82	$12.76	81%	680	$6.06	$7.78
0122	Delaware River	0.58	335	50%	97	$27.59	$35.86	82%	159	$16.82	$21.87
0123	Delaware River	1.78	586	0%	0	$13,920	$18,096	62%	647	$7.25	$9.42
0124	Delaware River	1.17	162	76%	144	$9.00	$11.70	91%	172	$7.51	$9.77
0125	Delaware River	3.16	409	70%	905	$3.62	$4.70	87%	1,124	$2.91	$3.78
0126	Delaware River	2.43	267	70%	454	$4.70	$6.11	89%	577	$3.70	$4.81
0127	Delaware River	1.03	652	50%	336	$15.53	$20.19	82%	551	$9.47	$12.31

SECTION 6.0
REFERENCES

6.0 REFERENCES

Baker, D. and deNoyelles, F. 2008. "Can Reservoir Management Reduce Sediment Deposition? *Sedimentation in Our Reservoirs: Causes and Solutions*," Kansas State University, June 2008. Contribution No. 08-250-S from the Kansas Agricultural Experiment Station.

deNoyelles, F. and Jakubauskas, M. 2008. *Current State, Trend, and Spatial Variability of Sediment in Kansas Reservoirs. Sedimentation in Our Reservoirs: Causes and Solutions*, Kansas State University, June 2008. Contribution No. 08-250-S from the Kansas Agricultural Experiment Station.

ESRI. 1999-2008. ArcMap™ Software Version 9.3 Redlands, California.

Gulf South Research Corporation. 2008. *Kansas River Basin Stream and River Channel Assessment Project.* October. Available on-line at: http://www.kwo.org/Reports%20%26%20Publications/Reports%20and%20Publications.htm#Stream Riparian

Gulf South Research Corporation. 2010. *Kansas River Basin Regional Sediment Management Section 204 Stream and River Channel Assessment*. March. Available on-line at: http://www.kwo.org/Reports%20%26%20Publications/Reports%20and%20Publications.htm#Stream Riparian

Juracek, K.E. 2004. *Sedimentation and occurrence and trends of selected chemical constituents in bottom sediment of 10 small reservoirs, eastern Kansas*. USGS Scientific Investigations Report 2004-5228.

Juracek, K.E. 2006. *Sedimentation an occurrence and trends of selected chemical constituents in bottom sediment, Empire Lake, Cherokee County, Kansas 1005-2005*. USGS Scientific Investigations Report 2006-5307.

Juracek, K.E. and Ziegler, A.C. 2007*. Estimation of sediment sources using selected chemical tracers in the Perry Lake and Lake Wabaunsee Basins, northeast Kansas*. USGS Scientific Investigations Report 2007-5020.

Kansas Water Office (KWO) 2011. *Kansas Water Plan*. Available on the Kansas Water Office website, last accessed June 26, 2011: http://www.kwo.org/Kansas%20Water%20Plan/Kansas%20Water%20Plan.htm.

RIVERMorph, LLC. 2006. RIVERMorph Stream Restoration Software. Louisville, Kentucky.

Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology Books. Pagosa Springs, Colorado.

Rosgen, D.L. 2001a. *A practical method of computing streambank erosion rate*. Proceedings of the Seventh Federal Interagency Sedimentation Conference, Vol. 2, pp. II - 9-15, March 25-29, 2001, Reno, NV.

Rosgen, D.L. 2001b. *A stream channel stability assessment methodology*. Proceedings of the Seventh Federal Interagency Sedimentation Conference, Vol. 2, pp. II - 18-26, March 25-29, 2001, Reno, NV.

Rosgen, D.L. 2006. *Watershed Assessment of River Stability and Sediment Supply (WARSS)*. Wildland Hydrology Books. Fort Collins, Colorado.

Sass, C.K. 2011. *Evaluation and Development of Predictive Streambank Erosion Curves for Northeast Kansas Using Rosgen's "BANCS" Methodology*. Dissertation: Kansas State University. Manhattan, Kansas.

U.S. Geological Survey. 1997. Compressed Digital Orthophotos. Reston, VA. Accessed on-line at: http://www.kansasgis.org/.

U.S. Department of Agriculture Farm Service Agency Aerial Photography Field Office. 2008. National Agriculture Imagery Program, Ellsworth, McPherson, and Saline County, Kansas. Salt Lake City, UT. Accessed on-line at: http://www.kansasgis.org

SECTION 7.0
ACRONYMS AND ABBREVIATIONS

7.0 ACRONYMS AND ABBREVIATIONS

BANCS	Bank Assessment for Non-point Consequences of Sediment
BEHI	Bank Erodibility Hazard Index
BHR	Bank Height Ratio
BMP	Best Management Practice
Csf	Cubic Feet per Second
EQIP	Environmental Quality Improvement Program
d_{nb}	Near bank Maximum Depth
d_{bkf}	Mean Bankfull Depth
EQIP	Environmental Quality Improvement Program
FSA	Farm Service Agency
GIS	Geographic Information System
GPS	Global Positioning System
GRSC	Gulf South Research Corporation
HUC	Hydrologic Unit Code
KDHE	Kansas Department of Health and Environment
KWO	Kansas Water Office
LPSTP	Longitudinal Peaked Stone Toe Protection
MWR	Meander Width Ratio
NBS	Near-Bank Stress
NRCS	Natural Resources Conservation Service
SWIMS	Surface Waters Information Management System
TWI	The Watershed Institute, Inc.
UniqueID	Unique Identification
U.S.	United States
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WARSS	Watershed Assessment of River Stability and Sediment Supply
WRAPS	Watershed Restoration and Protection Strategies

THIS PAGE IS INTENTIONALLY LEFT BLANK

SECTION 8.0
RESEARCH TEAM

8.0 RESEARCH TEAM

Name	Discipline-Expertise	Organization	Experience	Role In Preparing Report
Steve Kolian	Environmental and aquatic science	Gulf South Research Corporation	14 years of environmental studies which includes 7 years of watershed modeling.	Project manager, report preparation, field survey
Brock Emmert	Fluvial geomorphology	The Watershed Institute	12 years of geomorphology and riparian restoration	Field survey, report preparation, GIS
Chris Mammoliti	Fisheries and wildlife biology	The Watershed Institute	26 years of stream ecology and habitat assessments	Field survey
Chris Ingram	Environmental studies	Gulf South Research Corporation	33 years of environmental studies	QA/QC, peer review
Dennis Peters	Environmental studies	Gulf South Research Corporation	33 years of environmental studies	QA/QC, peer review
Dr. Eric Webb	Environmental studies	Gulf South Research Corporation	15 years of environmental studies	QA/QC, peer review
Steve Oivanki	Geology/Environmental Studies	Gulf South Research Corporation	20 years of environmental studies	QA/QC, peer review
Ryan McCurdy	Surveyor	The Watershed Institute	8 years of surveying	Field survey

THIS PAGE IS INTENTIONALLY LEFT BLANK

APPENDIX A
HOT-SPOT SURVEY SITE INFORMATION

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0029

A-1. Delaware Hot-Spot UniqueID: 0029

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0029	36.0	High	1.32	1.83

Description of Survey Site: There are wooded riparian corridors on both banks. Banks consists of silt, sands, loose gravels, and a weathered shale outcrop. On the upper portion of the site overland flow has created some gully erosion.

Length of Bank (feet): 1,052

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	50%
Reduction of Rate of Erosion (tons/foot/year):	0.92	0.92
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$84,160	$84,160
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	963	963
***Cost of Soil Reduction Per Ton:**	**$8.74**	**$8.74**
***Cost of Soil Reduction Per Cubic Yard:**	**$11.37**	**$11.37**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 29-Dec-10
14 Digit HUC: 102701030400030
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0029
County: Jefferson County
Legal Description: NW 1/4 Sec 2 T8S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	X
	Crop field			Rangeland	
	Timber				
Adjacent Landuse:	Pasture	X		Urban	
	Timber	X		Residential	
	Cropland			Industrial	

Channel Width:	Top of Bank to Top of Bank	182.4	Feet
	Edge of Water to Edge of Water	63.0	Feet
Water Depth:	Thalweg	1.4	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 24.7 Feet (Measure)
Root Depth of Riparian Vegetation: 14.5 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 31 degrees.
	Vertical			Active seeps observed in bank.
	1H:1V			
	2H:1V	X		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		1052	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.54 Average Feet / year

Comments on Erosion: Wooded riparian area begins about 300 feet downstream from start of assessment.

View or the right bank.

View upstream from cross section.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0029**	Location:	**Jefferson County**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **12/29/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	24.7 (A)	Bankfull Height (ft) =	13.2 (B)	(A) / (B) =	1.9 (C)	7.3
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	14.5 (D)	Study Bank Height (ft) =	24.7 (A)	(D) / (A) =	0.6 (E)	3.5
Weighted Root Density (G)						
		Root Density as % =	45 (F)	(F) x (E) =	26.4 (G)	6.4
Bank Angle (H)						
				Bank Angle as *Degrees* =	40 (H)	2.9
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

Bank Material Adjustment:

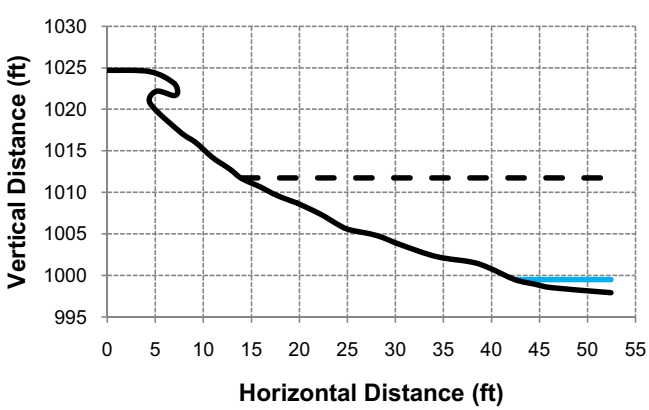
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

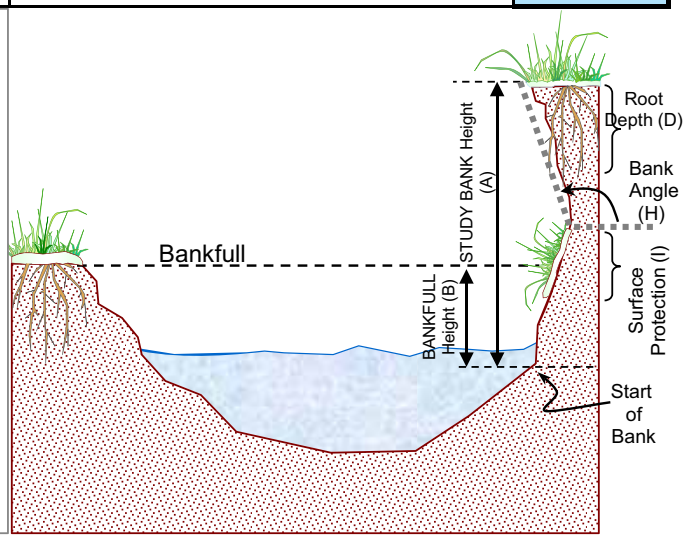
Bank Material Adjustment 2

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

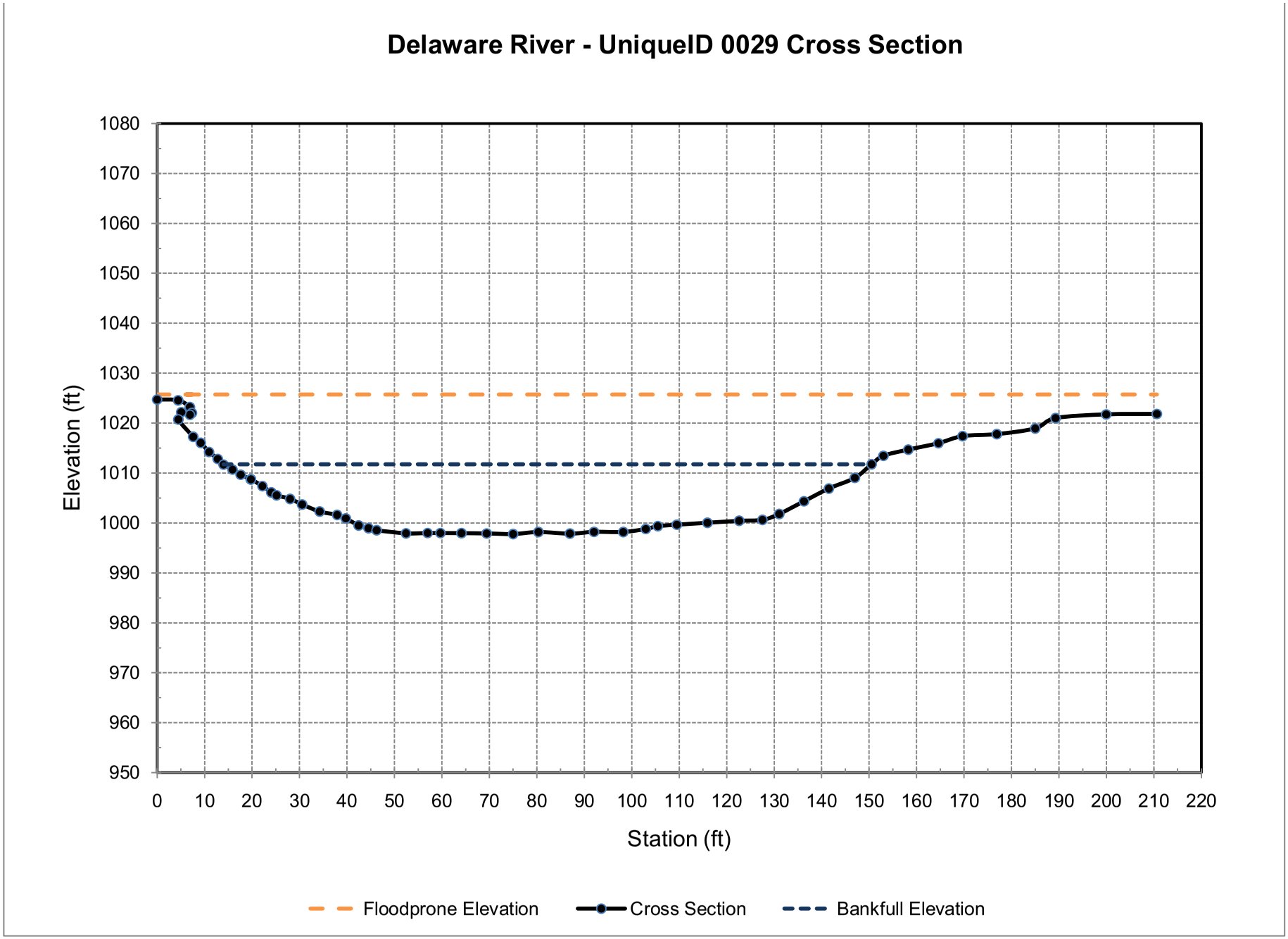
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		36.0

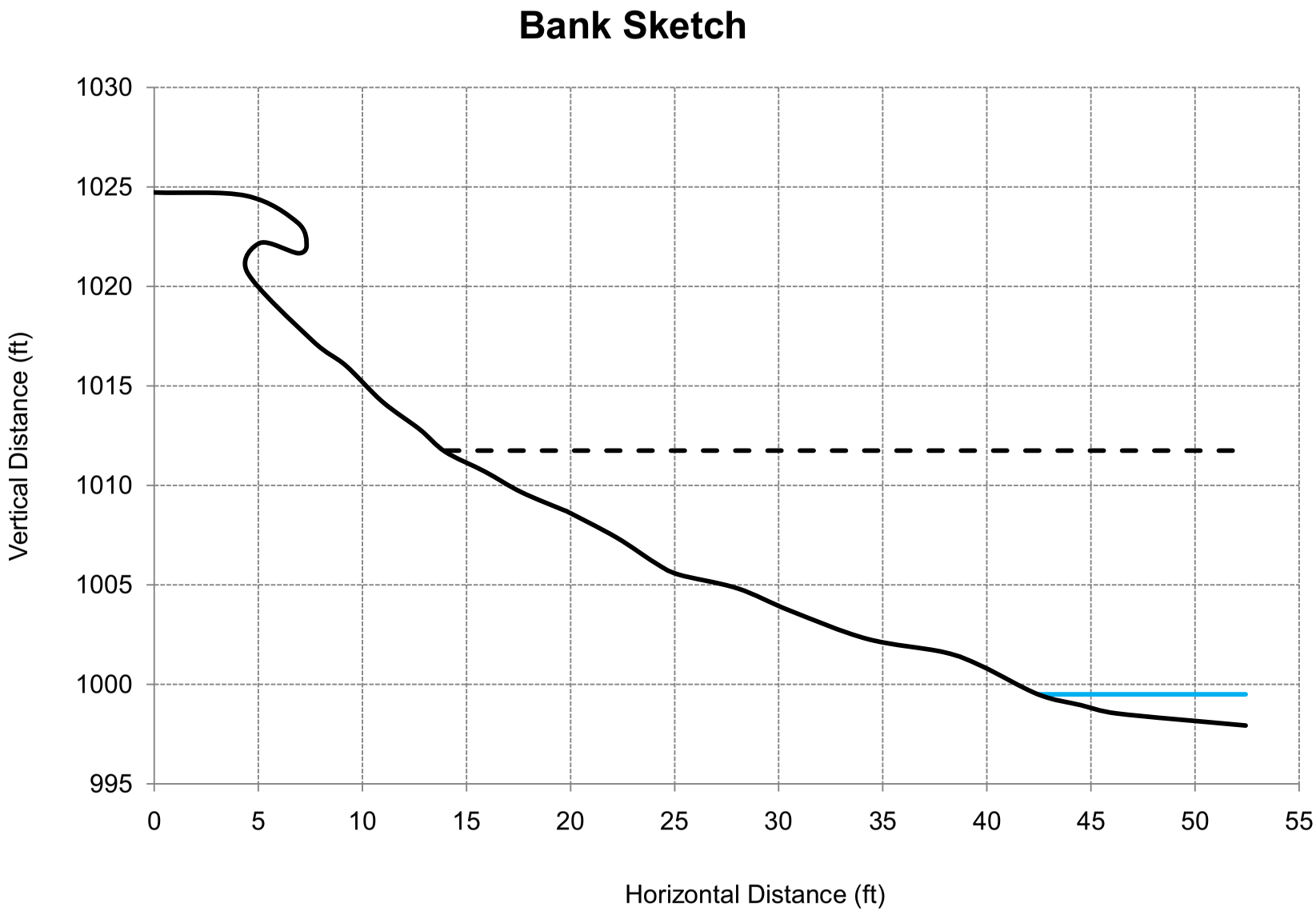
Bank Sketch





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0029 Cross Section
Elevation (ft)
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
Station (ft)
Floodprone Elevation
Cross Section
Bankfull Elevation


Bank Sketch
1030
1025
1020
1015
1010
1005
1000
995
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
50
55
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0030

A-2. Delaware Hot-Spot UniqueID: 0030

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0030	28.1	Moderate	1.49	2.94

Description of Survey Site: This site has a wooded ripariran cooridor on both banks. Banks consist of silt loam and sand.

Length of Bank (feet): 649

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	0%	62%
Reduction of Rate of Erosion (tons/foot/year):	0.00	1.82
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$51,920	$51,920
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	0	1183
***Cost of Soil Reduction Per Ton:**	**$15,576**	**$4.39**
***Cost of Soil Reduction Per Cubic Yard:**	**$20,249**	**$5.71**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume 1 cubic yard weighs 1.3 tons. For year 1 through 3, modeling results did not produce an erosion reduction; therefore 3 years of BMP installation costs were added to calculate the cost-benefits associated with year 1 through 3.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 29-Dec-10
14 Digit HUC: 10270103040030
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0030
County: Jefferson County
Legal Description: NE 1/4 Sec 3 T8S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	70	Feet	Pasture	
	Crop field			Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	181.9	Feet
	Edge of Water to Edge of Water	51.6	Feet
Water Depth:	Thalweg	3.2	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 26.3 Feet (Measure)
Root Depth of Riparian Vegetation: 16.6 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 38 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		649	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 2.32 Average Feet / year

Comments on Erosion:

View of the right bank.

View upstream from cross section.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0030**	Location:	**Jefferson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**12/29/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	26.3 (A)	Bankfull Height (ft) =	19.9 (B)	(A) / (B) =	1.3 (C)	4.8
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	16.6 (D)	Study Bank Height (ft) =	26.3 (A)	(D) / (A) =	0.6 (E)	3.3
Weighted Root Density (G)						
		Root Density as % =	50 (F)	(F) x (E) =	31.6 (G)	5.8
Bank Angle (H)						
				Bank Angle as *Degrees* =	48 (H)	3.3
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

Bank Material Adjustment:

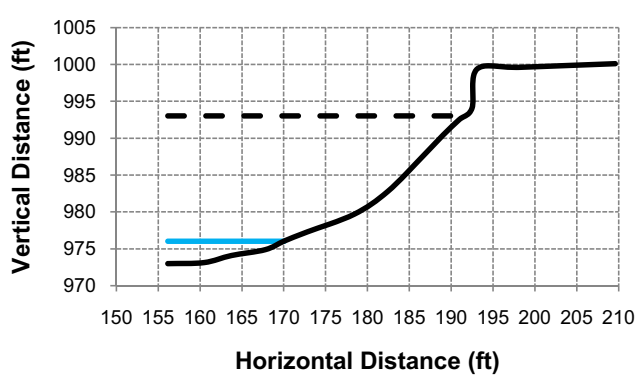
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

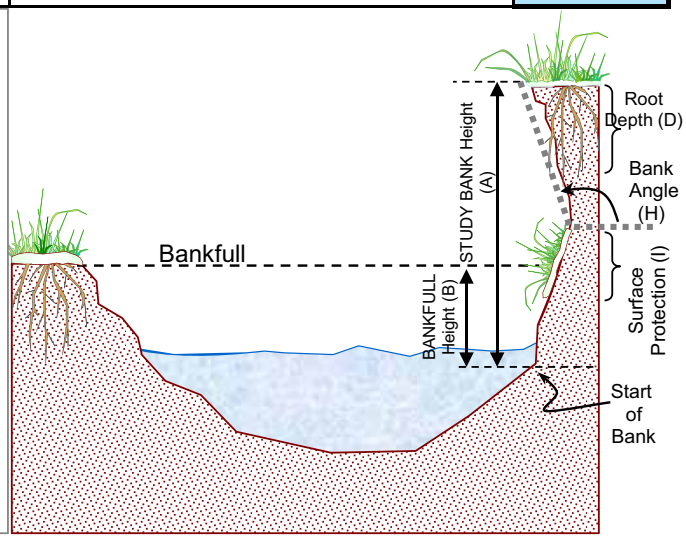
Bank Material Adjustment 2

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

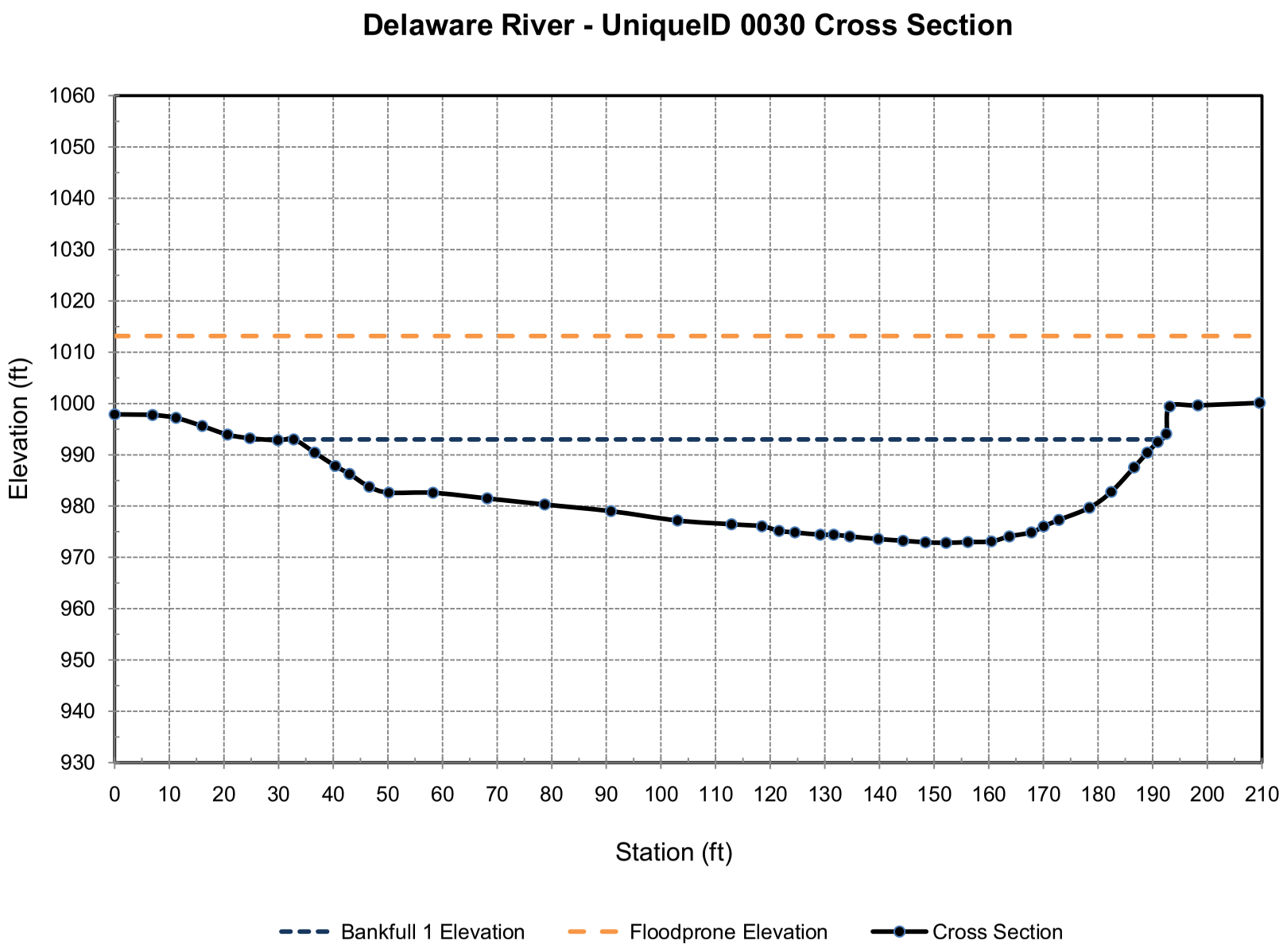
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		28.1

Bank Sketch

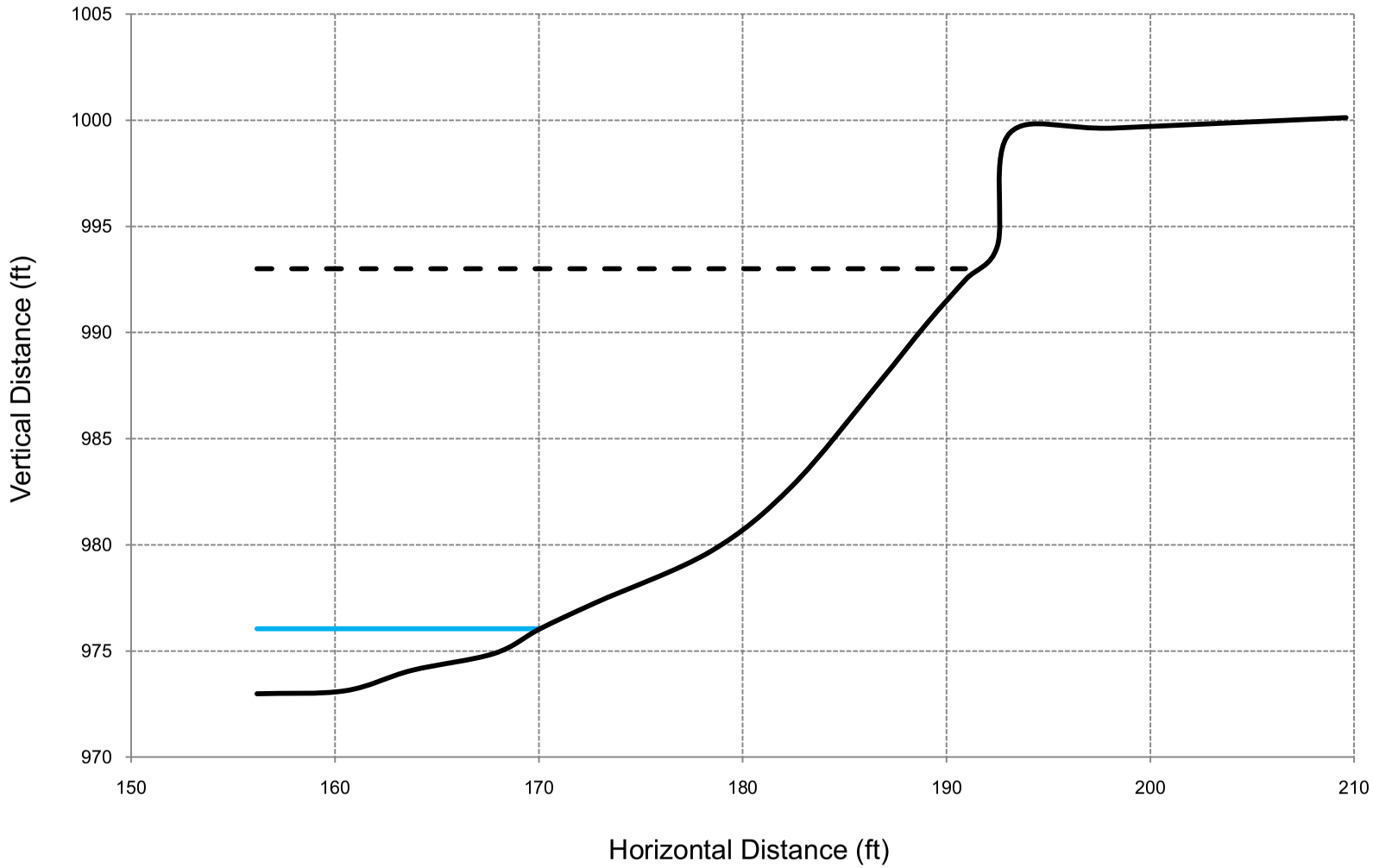




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0030 Cross Section
Elevation (ft)
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Station (ft)
Bankfull 1 Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1005
1000
995
990
985
980
975
970
Vertical Distance (ft)
150
160
170
180
190
200
210
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0031

A-3. Delaware Hot-Spot UniqueID: 0031

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0031	31.1	High	1.50	4.73

Description of Survey Site: This site has a narrow wooded riparian buffer. There are two differnent vegetation types, the first is a narrow band of trees and the second is Johnson grass with other forbs mixed in. Banks are dominsted by silt loam material.

Length of Bank (feet): 1,900

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	81%	81%
Reduction of Rate of Erosion (tons/foot/year):	3.83	3.83
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$152,000	$152,000
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	7279	7279
***Cost of Soil Reduction Per Ton:**	**$2.09**	**$2.09**
***Cost of Soil Reduction Per Cubic Yard:**	**$2.71**	**$2.71**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 29-Dec-10
14 Digit HUC: 10270103040020
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0031
County: Jefferson County
Legal Description: SE 1/4 Sec 34 T7S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	203.3	Feet
	Edge of Water to Edge of Water	52.7	Feet
Water Depth:	Thalweg	3.9	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 27.9 Feet (Measure)
Root Depth of Riparian Vegetation: 9.3 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 33 degrees.
	Vertical			Active seeps observed in bank.
	1H:1V	X		
	2H:1V			

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		1900	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 3.52 Average Feet / year

Comments on Erosion: There is one small area of wooded riparian vegetation in middle of meander bend.

View upstream.

View of bank toe erosion.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0031**	Location:	**Jefferson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **12/29/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	27.9 (A)	Bankfull Height (ft) =	19.1 (B)	(A) / (B) =	1.5 (C)	5.7
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	9.3 (D)	Study Bank Height (ft) =	27.9 (A)	(D) / (A) =	0.3 (E)	5.6
Weighted Root Density (G)						
		Root Density as % =	40 (F)	(F) x (E) =	13.3 (G)	8.1
Bank Angle (H)						
				Bank Angle as *Degrees* =	36 (H)	2.7
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

Bank Material Adjustment:

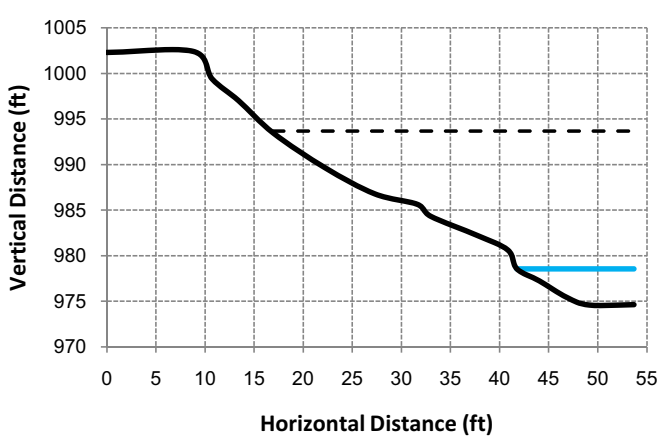
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

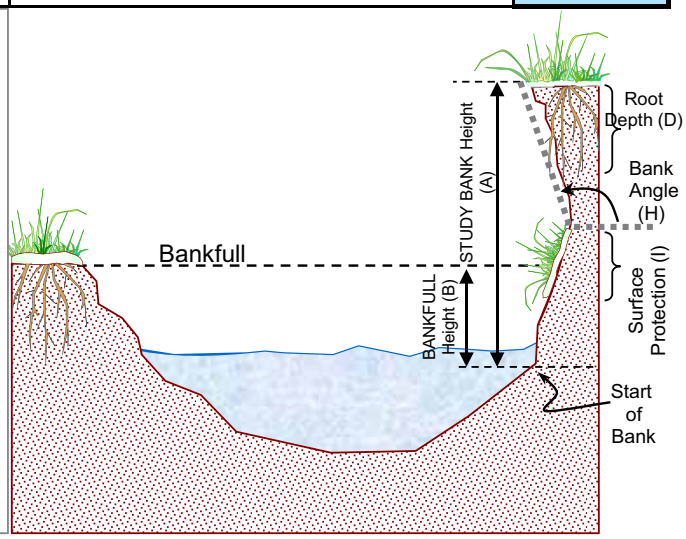
Bank Material Adjustment 0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

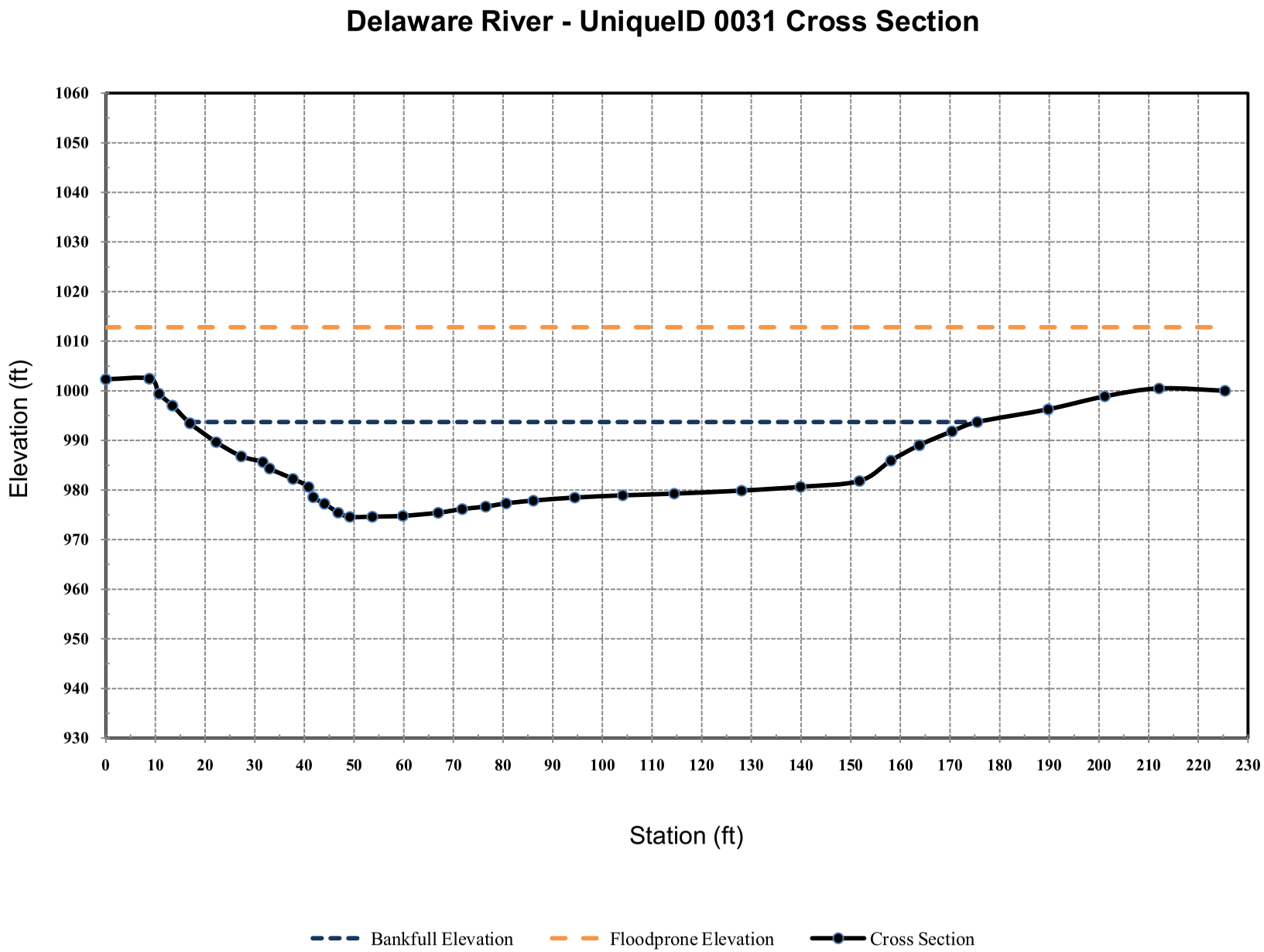
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		31.1

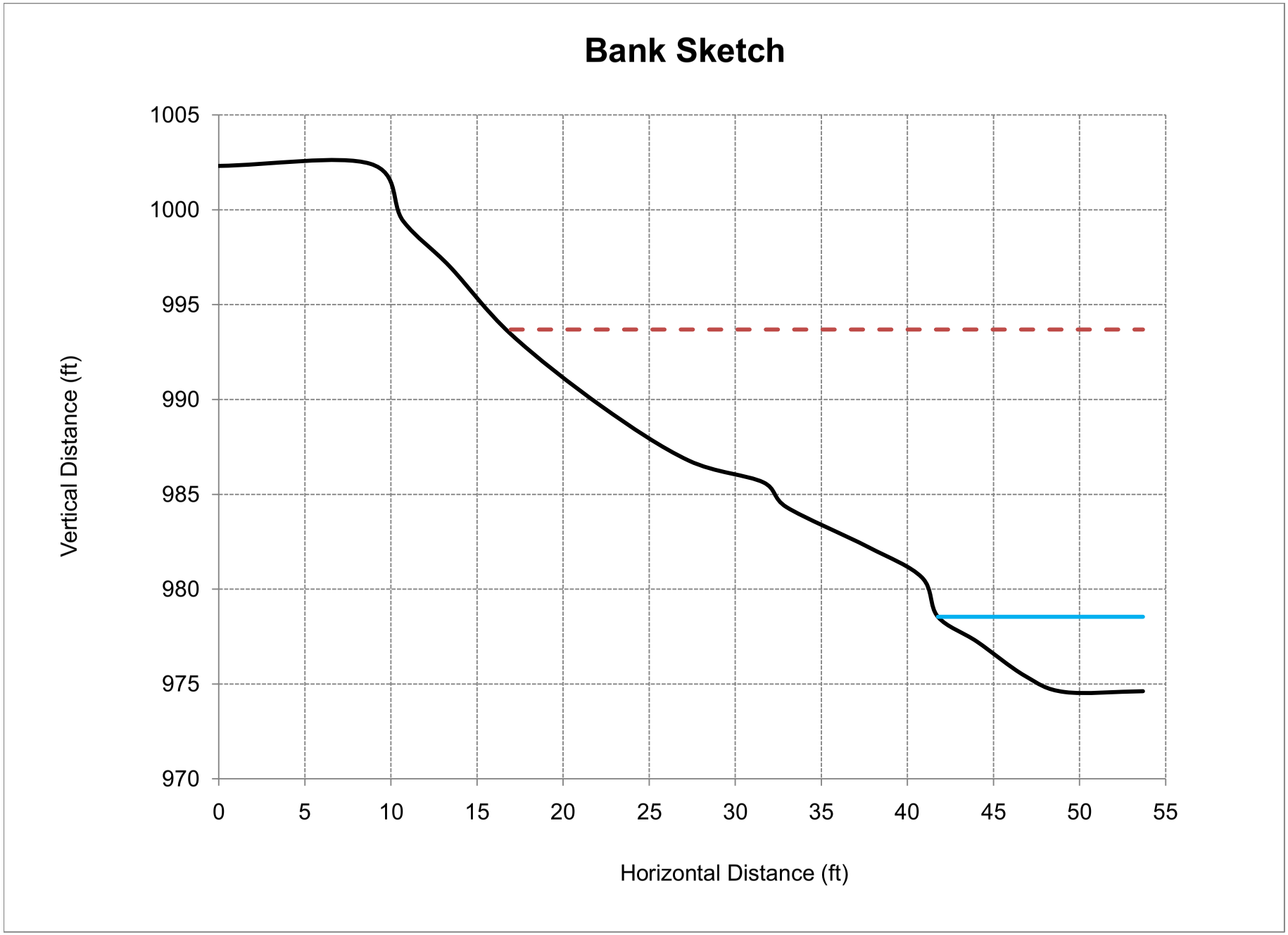
Bank Sketch





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0031 Cross Section
Elevation (ft)
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1005
1000
995
990
985
980
975
970
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
50
55
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0039

A-4. Delaware Hot-Spot UniqueID: 0039

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0039	25.6	Moderate	1.54	5.30

Description of Survey Site: This site has a narrow wooded ripaian cooridor. There are multiple seeps in the lower half of the site. Banks are silty clay material.

Length of Bank (feet): 948

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	53%	82%
Reduction of Rate of Erosion (tons/foot/year):	2.81	4.35
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$75,840	$75,840
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	2663	4120
***Cost of Soil Reduction Per Ton:**	**$2.85**	**$1.84**
***Cost of Soil Reduction Per Cubic Yard:**	**$3.70**	**$2.39**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 19-Nov-10
14 Digit HUC: 10270103040030
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0039
County: Atchison County
Legal Description: NW 1/4 Sec16 T7S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	30	Feet	Pasture	
	Crop field			Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	240.8	Feet
	Edge of Water to Edge of Water	64.3	Feet
Water Depth:	Thalweg	2.6	Feet

Livestock access to Riparian Area **Yes** _____ **No** X
If yes, what is the duration in months per year? _____

Debris or Channel Blockages **Yes** _____ **No** X

Buildings or Structures Threatened **Yes** _____ **No** X
If yes, what is their distance from the streambank? _____ Feet

Bank Erosion Inventory

Average Bank Height: 26.7 Feet (Measure)
Root Depth of Riparian Vegetation: 20.1 Feet

Bank Slope:	Undercut		Comments: Average Bank Angle is 32 degrees.
	Vertical		Active seeps observed in bank.
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		948	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 4.12 Average Feet / year

Comments on Erosion:

View across channel at cross section

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0039**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/19/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	26.7 (A)	Bankfull Height (ft) =	16.7 (B)	(A) / (B) =	1.6 (C)	6.0
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	20.1 (D)	Study Bank Height (ft) =	26.7 (A)	(D) / (A) =	0.8 (E)	2.7
Weighted Root Density (G)						
		Root Density as % =	10 (F)	(F) x (E) =	7.5 (G)	8.7
Bank Angle (H)						
				Bank Angle as *Degrees* =	36 (H)	2.7
Surface Protection (I)						
				Surface Protection as % =	35 (I)	5.5

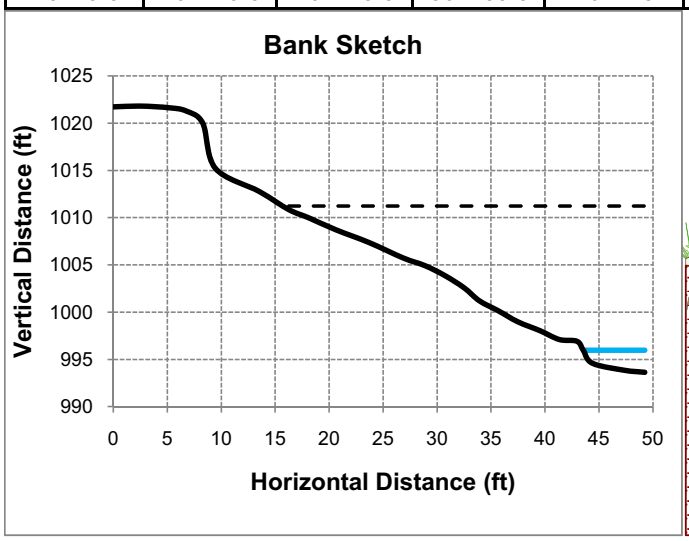
Bank Material Adjustment:

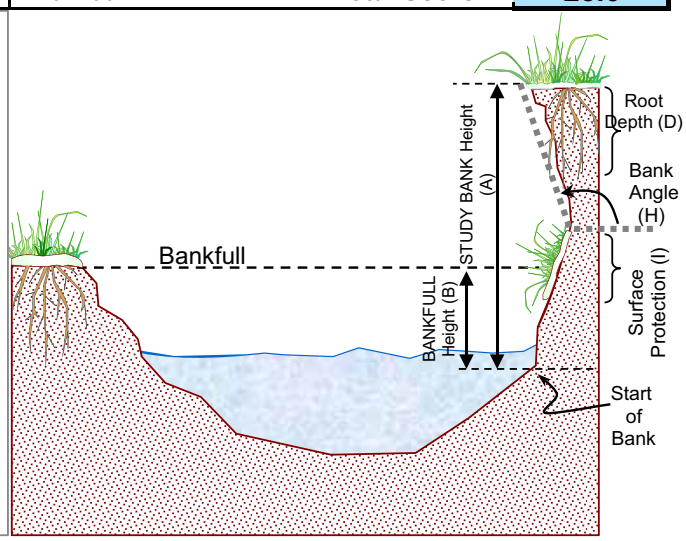
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

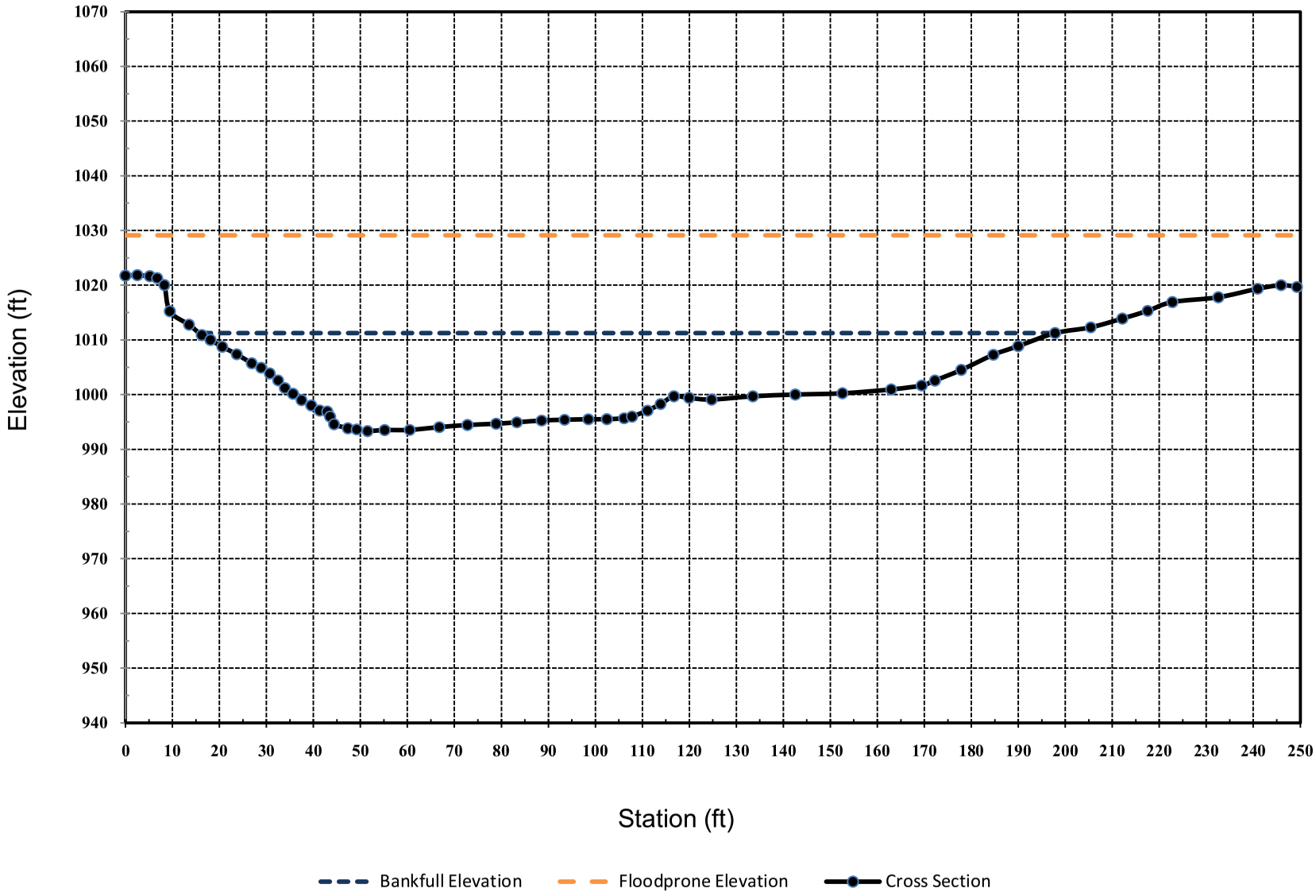
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		25.6

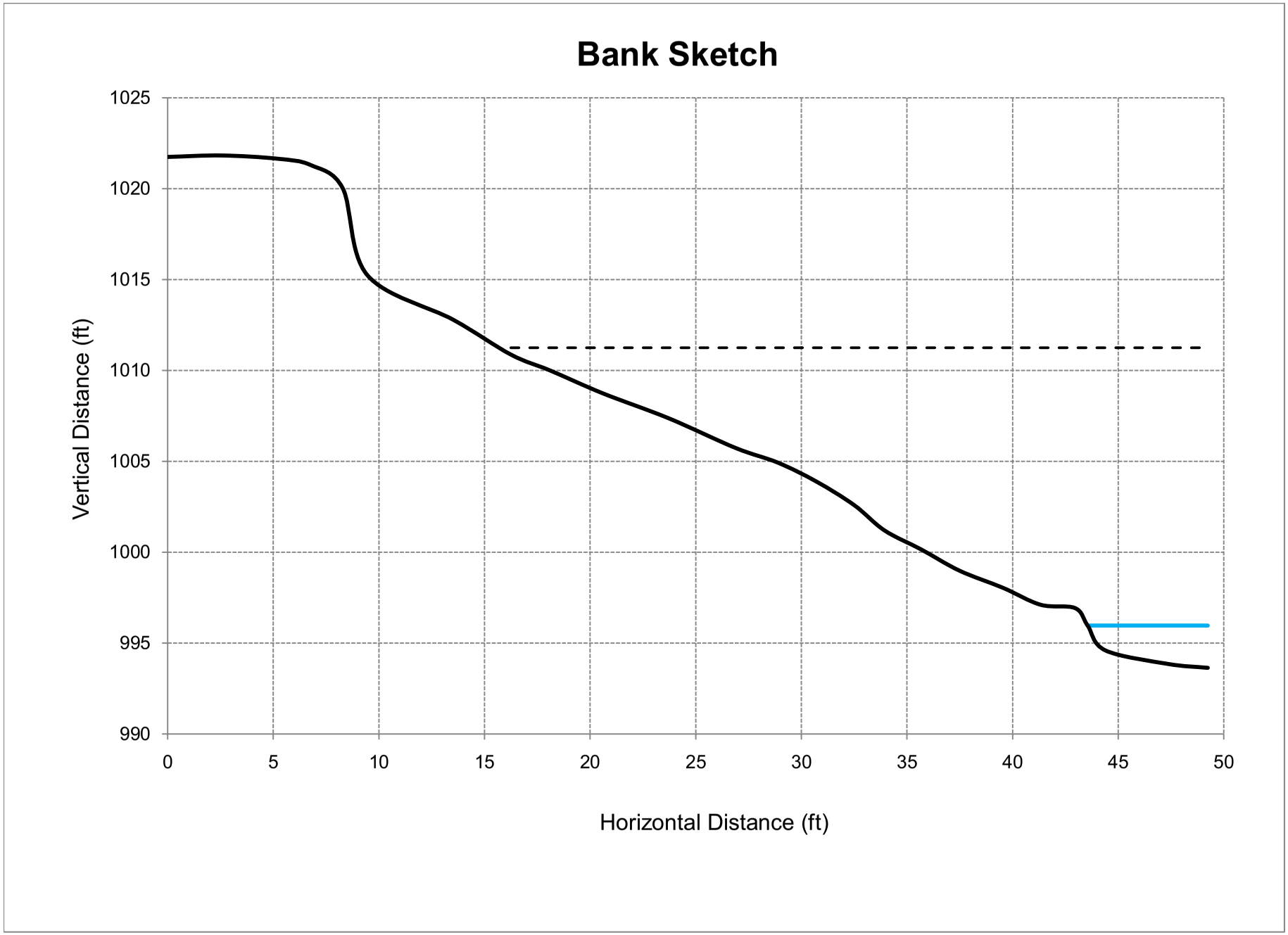




Copyright © 2006 Wildland Hydrology

Delaware River - UniqueID 0039 Cross Section




Bank Sketch
Vertical Distance (ft)
1025
1020
1015
1010
1005
1000
995
990
0
5
10
15
20
25
30
35
40
45
50
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0040

A-5. Delaware Hot-Spot UniqueID: 0040

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0040	29.9	Moderate	1.32	2.19

Description of Survey Site: This site has no riparian cooridor. There are major "blow-outs" on the lower end. Bank material is predomiatly silty clay.

Length of Bank (feet): 1,130

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	0%	62%
Reduction of Rate of Erosion (tons/foot/year):	0.00	1.36
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$90,400	$90,400
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	0	1534
***Cost of Soil Reduction Per Ton:**	**$27,120**	**$5.89**
***Cost of Soil Reduction Per Cubic Yard:**	**$35,256**	**$7.66**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume 1 cubic yard weighs 1.3 tons. For year 1 through 3, modeling results did not produce an erosion reduction; therefore 3 years of BMP installation costs were added to calculate the cost-benefits associated with year 1 through 3.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 19-Nov-10
14 Digit HUC: 10270103040030
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0040
County: Atchison County
Legal Description: NE 1/4 Sec 17 T7S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	X
	Crop field			Rangeland	
	Timber				
Adjacent Landuse:	Pasture	X		Urban	
	Timber			Residential	
	Cropland			Industrial	

Channel Width:	Top of Bank to Top of Bank	268.7	Feet
	Edge of Water to Edge of Water	74.7	Feet
Water Depth:	Thalweg	2.3	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 25.8 Feet (Measure)
Root Depth of Riparian Vegetation: 18.6 Feet

Bank Slope:	Undercut		Comments:	Average Bank angle is 31 degrees.
	Vertical			Active seeps in bank observed.
	1H:1V	X		
	2H:1V			

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		1,130	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.76 Average Feet / year

Comments on Erosion:

View of the left bank.

View looking upstream.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0040**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/19/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	25.8 (A)	Bankfull Height (ft) =	13.2 (B)	(A) / (B) =	2.0 (C)	7.7
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	18.6 (D)	Study Bank Height (ft) =	25.8 (A)	(D) / (A) =	0.7 (E)	2.8
Weighted Root Density (G)						
		Root Density as % =	30 (F)	(F) x (E) =	21.6 (G)	7.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	50 (H)	3.4
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

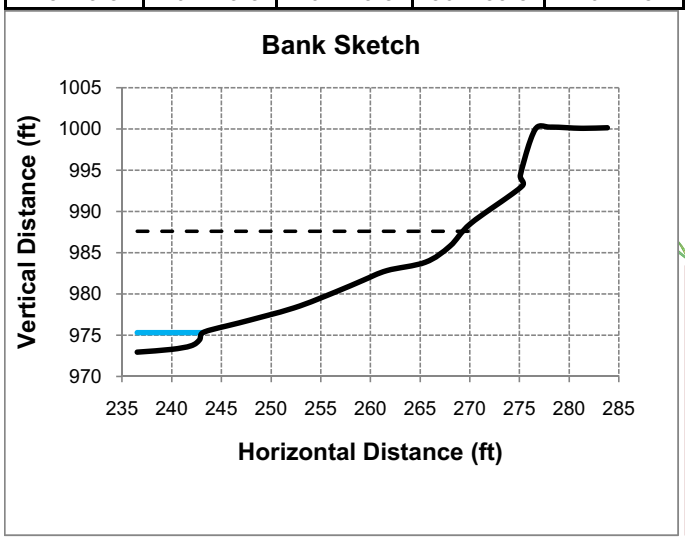
Bank Material Adjustment:

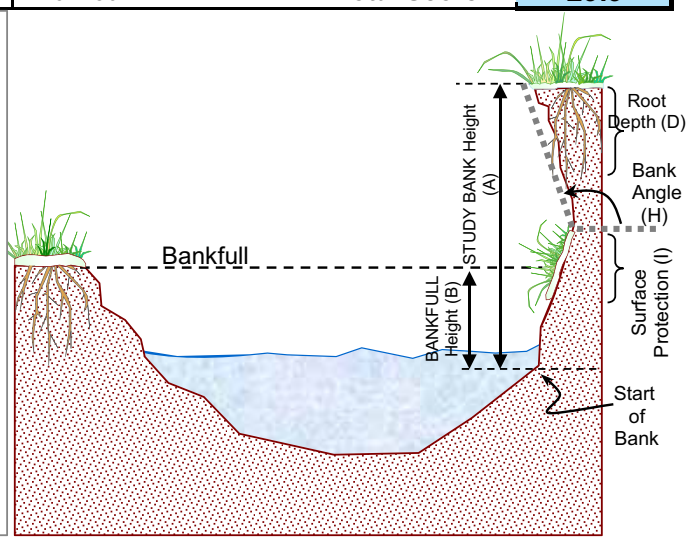
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0

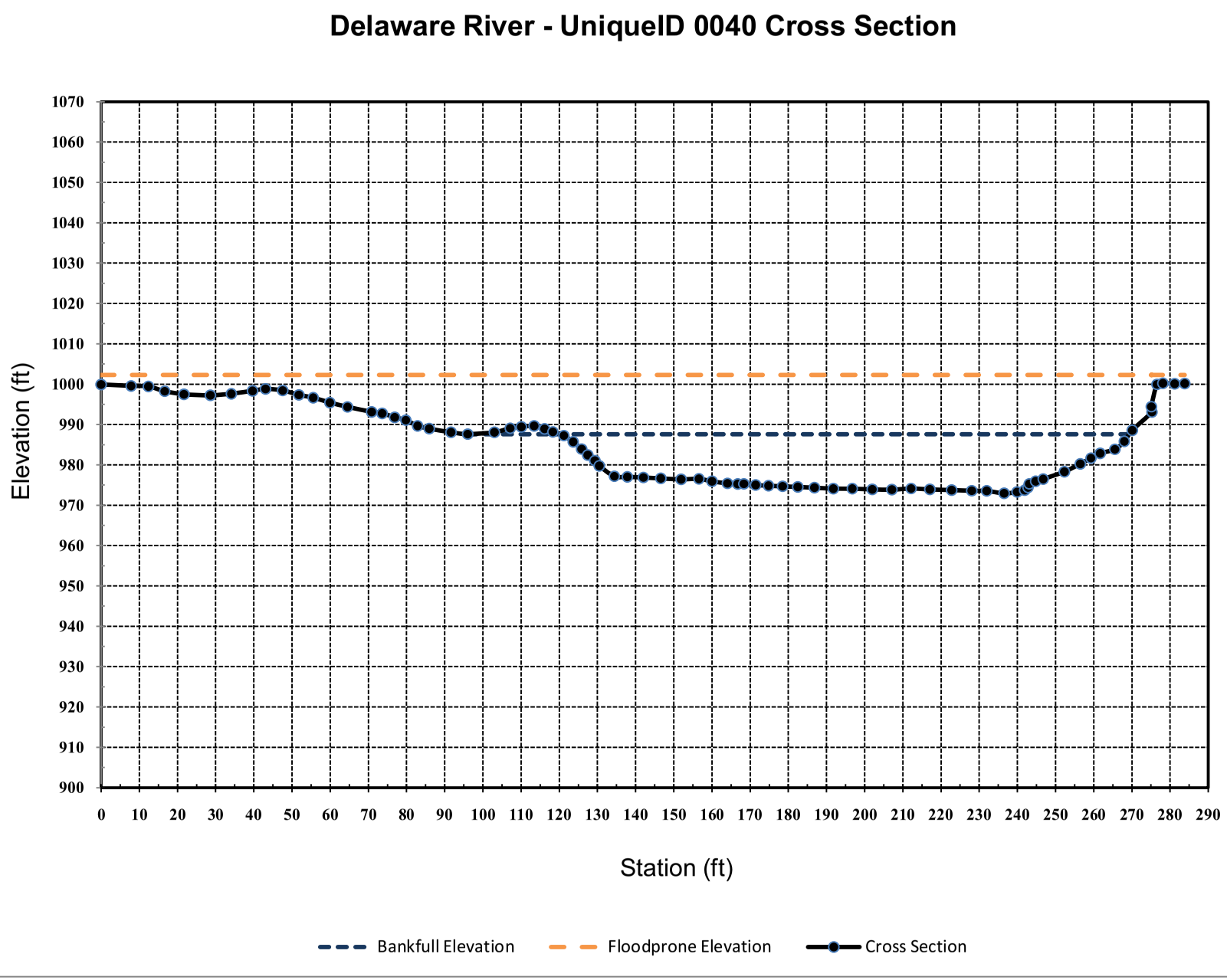
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

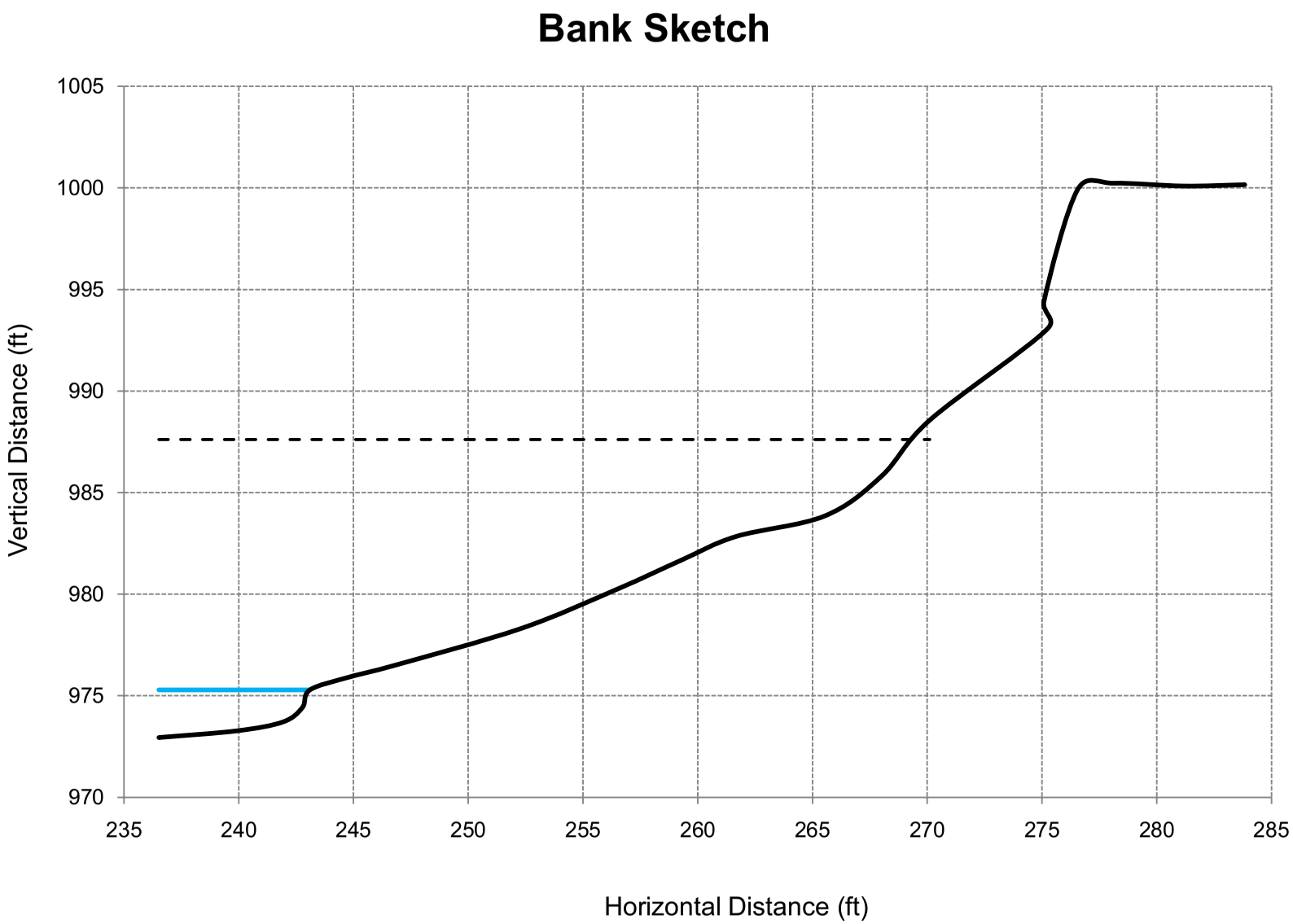
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		29.9





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0040 Cross Section
Elevation (ft)
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
920
910
900
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1005
1000
995
990
985
980
975
970
Vertical Distance (ft)
235
240
245
250
255
260
265
270
275
280
285
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0042

A-6 Delaware Hot-Spot UniqueID: 0042

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0042	34.0	High	1.94	4.55

Description of Survey Site: The riparian corridor consists of samplings, grasses, and forbs. There is a levee about 250 feet east of eroding bank.

Length of Bank (feet): 425

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	82%	93%
Reduction of Rate of Erosion (tons/foot/year):	3.73	4.23
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$34,000	$34,000
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	1586	1798
***Cost of Soil Reduction Per Ton:**	**$2.14**	**$1.89**
***Cost of Soil Reduction Per Cubic Yard:**	**$2.79**	**$2.46**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 10-Jul-08
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0042
County: Atchison County
Legal Description: SE 1/4 Sec. 8 T7S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	300	Feet	Pasture	X
	Crop field			Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	247.4	Feet
	Edge of Water to Edge of Water	53.8	Feet
Water Depth:	Thalweg	3.2	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 28.4 Feet (Measure)
Root Depth of Riparian Vegetation: 2.6 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 27 degrees. There is a grass buffer between the bank and levee. The average width is 300 feet. There are quite a few trees in the buffer.
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	

Eroding Bank Length: 625 Feet

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 3.33 Average Feet / year

Comments on Erosion:

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0042**	Location:	**Atchison County**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **07/10/08**	Stream Type: **-**	Valley Type:	**VIII**

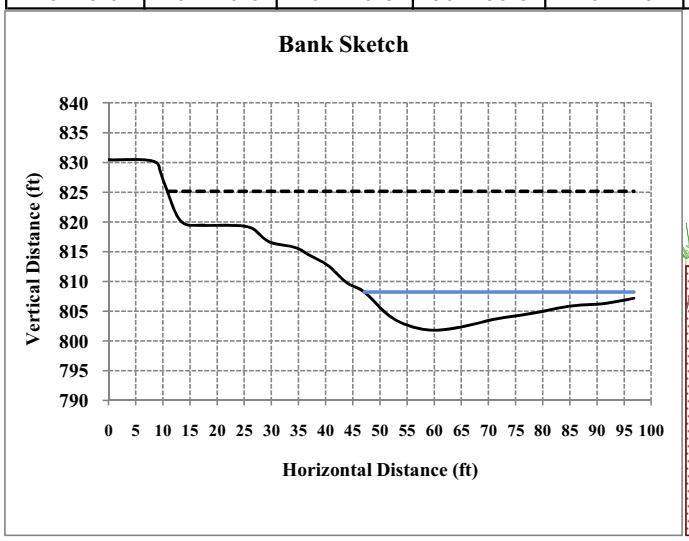
						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	28.4 (A)	Bankfull Height (ft) =	23.3 (B)	(A) / (B) =	1.2 (C)	4.1
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	2.6 (D)	Study Bank Height (ft) =	28.4 (A)	(D) / (A) =	0.1 (E)	8.6
Weighted Root Density (G)						
		Root Density as % =	10 (F)	(F) x (E) =	0.9 (G)	10
Bank Angle (H)						
				Bank Angle as *Degrees* =	27 (H)	2.3
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9

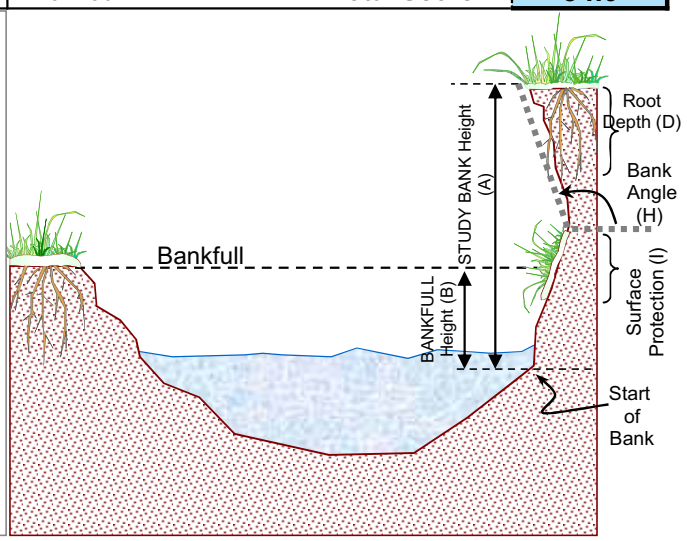
Bank Material Adjustment:

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 (no adjustment)

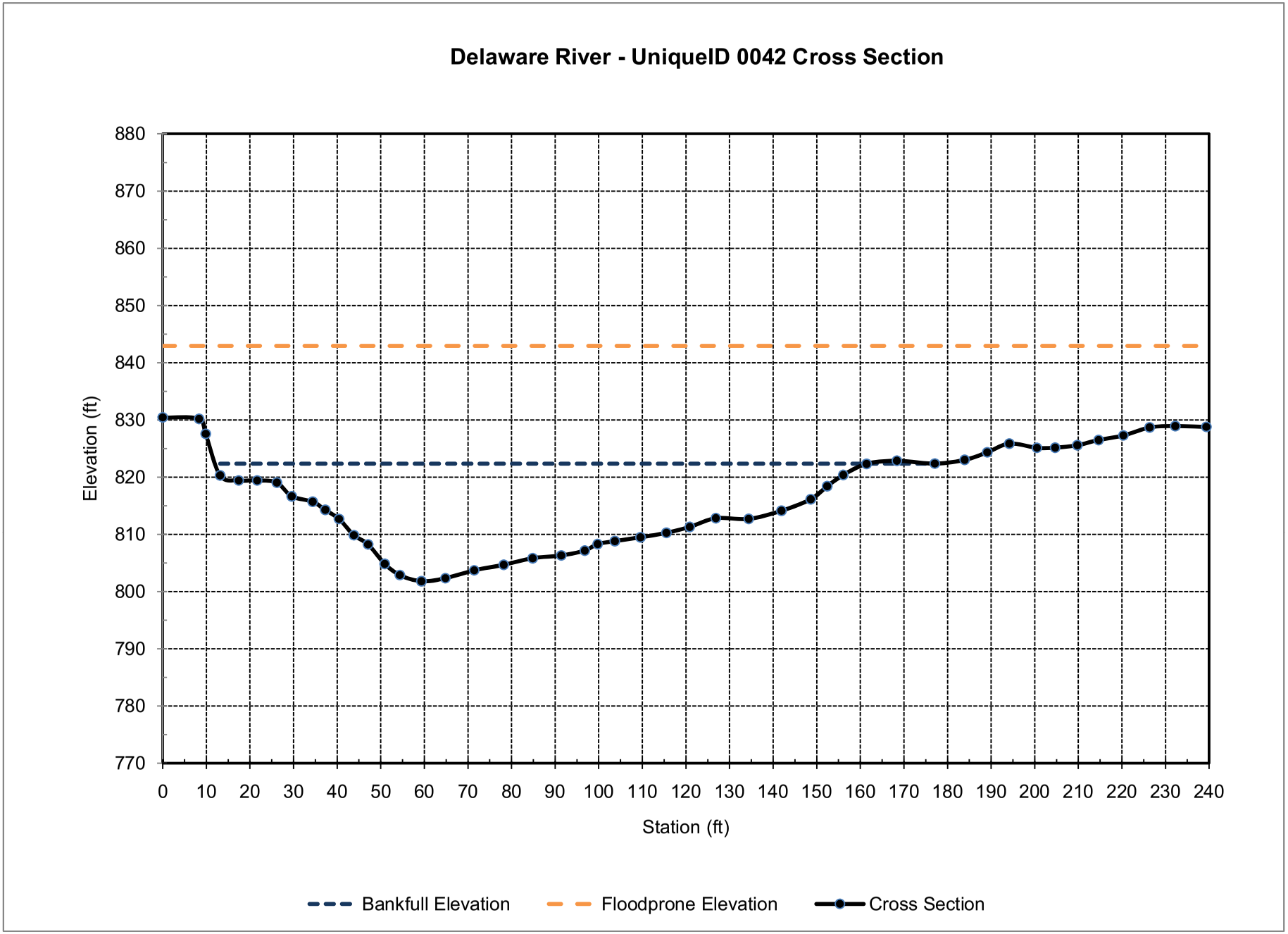
Bank Material Adjustment	0
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		34.0

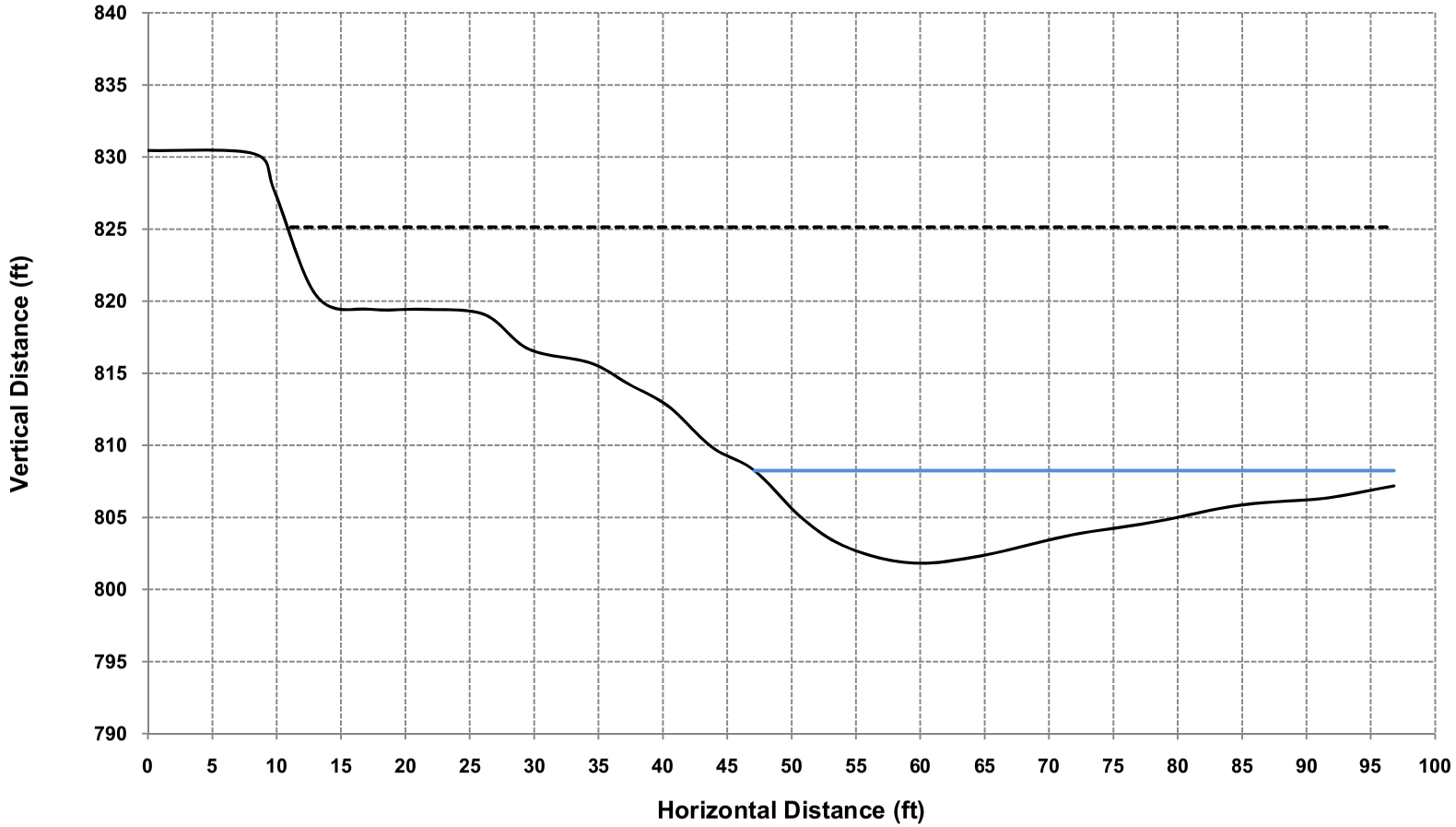




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0042 Cross Section
Elevation (ft)
880
870
860
850
840
830
820
810
800
790
780
770
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


840
835
830
825
820
815
810
805
800
795
790
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0043

A-7. Delaware Hot-Spot UniqueID: 0043

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0043	30.4	High	1.51	1.57

Description of Survey Site: This site has a narrow riparian cooridor. Its bank materials consist of silt loam on top half and sandy loam on the bottom half.

Length of Bank (feet): 805

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	87%
Reduction of Rate of Erosion (tons/foot/year):	1.10	1.37
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$64,400	$64,400
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	885	1100
***Cost of Soil Reduction Per Ton:**	**$7.28**	**$5.86**
***Cost of Soil Reduction Per Cubic Yard:**	**$9.46**	**$7.61**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 11-Nov-10
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0043
County: Atchison County
Legal Description: NW 1/4 Sec5 T7S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type: Perennial X Comments
Intermittent
Ephemeral

Riparian Condition: Width 0 Feet Pasture
Crop field X Rangeland
Timber

Adjacent Landuse: Pasture Urban
Timber Residential
Cropland X Industrial

Channel Width: Top of Bank to Top of Bank 245.5 Feet
Edge of Water to Edge of Water 56.3 Feet
Water Depth: Thalweg 1.3 Feet

Livestock access to Riparian Area **Yes** **No** X
If yes, what is the duration in months per year?

Debris or Channel Blockages **Yes** **No** X

Buildings or Structures Threatened **Yes** **No** X
If yes, what is their distance from the streambank? Feet

Bank Erosion Inventory

Average Bank Height: 27 Feet (Measure)
Root Depth of Riparian Vegetation: 14.2 Feet

Bank Slope: Undercut Comments: Average bank angle is 28 degrees.
Vertical
1H:1V
2H:1V X

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		805	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.22 Average Feet / year

Comments on Erosion: There are a few mature trees on top-of-bank.

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0043**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/11/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	26.8 (A)	Bankfull Height (ft) =	18.4 (B)	(A) / (B) =	1.5 (C)	5.7
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	14.2 (D)	Study Bank Height (ft) =	26.8 (A)	(D) / (A) =	0.5 (E)	3.8
Weighted Root Density (G)						
		Root Density as % =	30 (F)	(F) x (E) =	15.9 (G)	7.8
Bank Angle (H)						
				Bank Angle as *Degrees* =	25 (H)	2.2
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

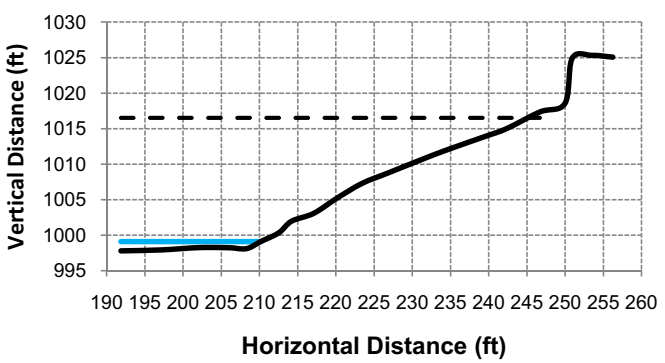
Bank Material Adjustment:

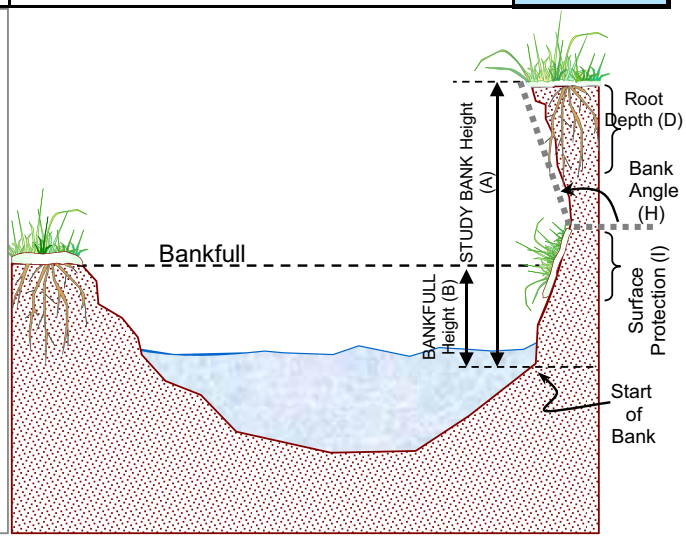
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment	2
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	0

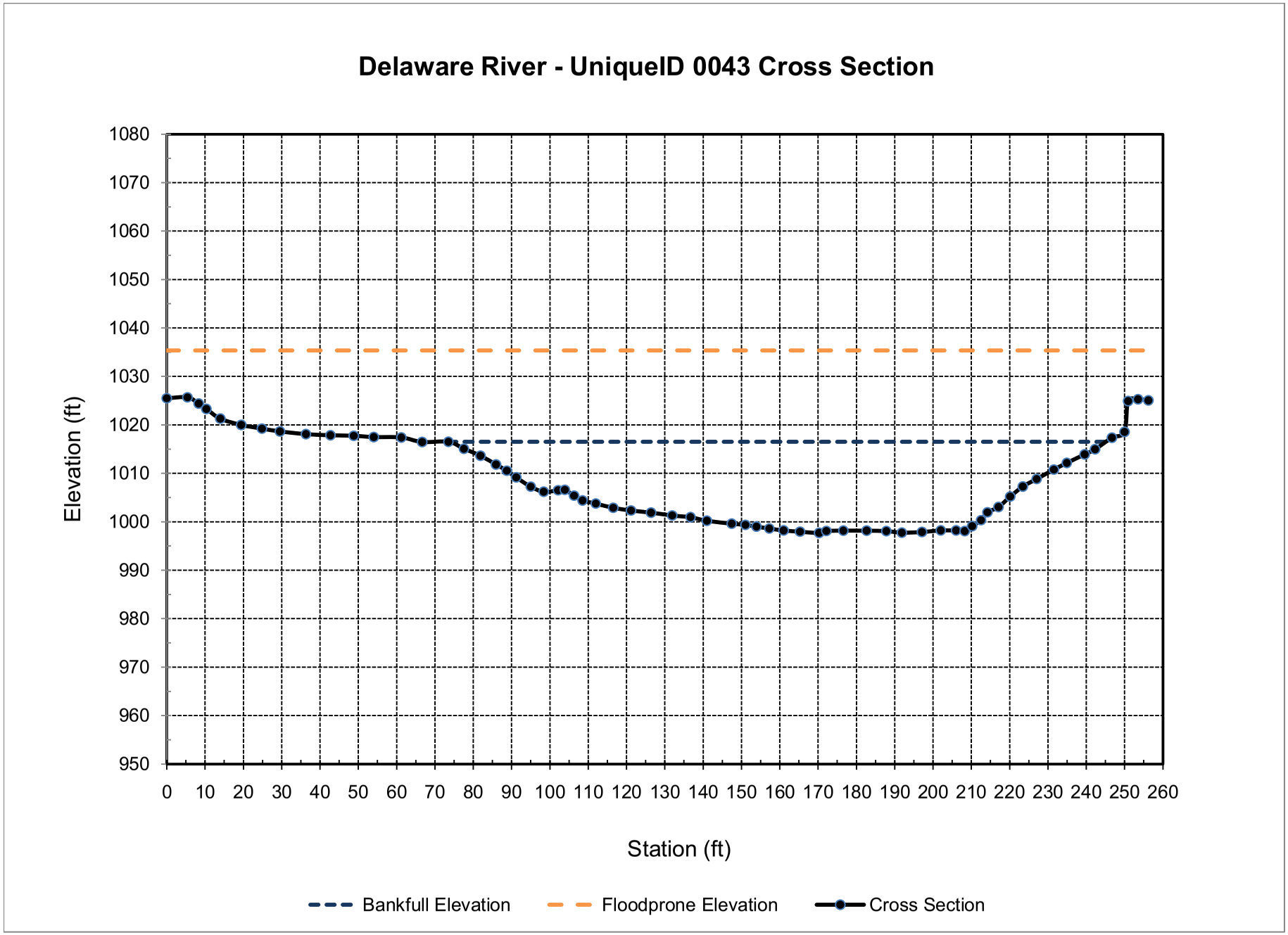
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		30.4

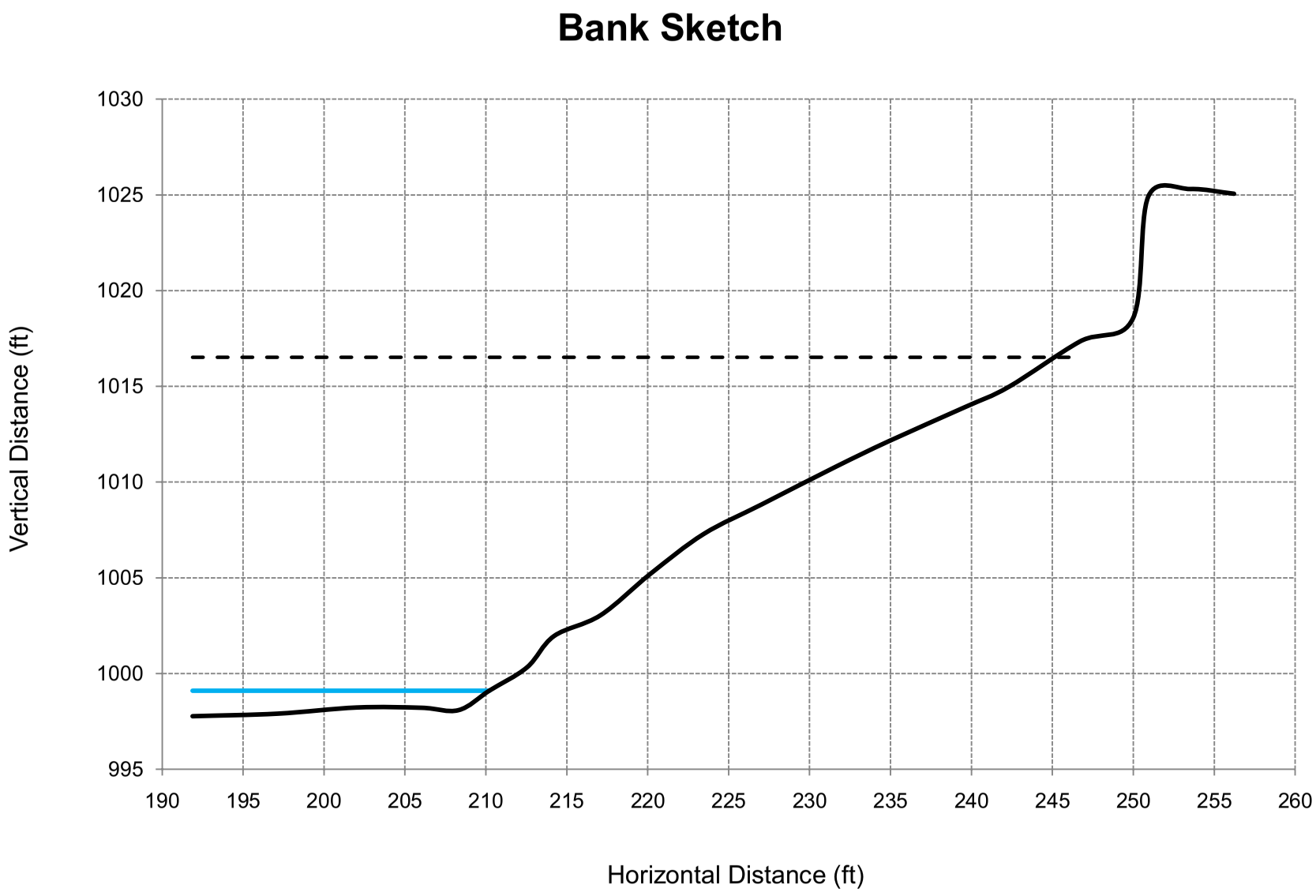
Bank Sketch





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0043 Cross Section
Elevation (ft)
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
Vertical Distance (ft)
1030
1025
1020
1015
1010
1005
1000
995
190
195
200
205
210
215
220
225
230
235
240
245
250
255
260
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0044

A-8 Delaware Hot-Spot UniqueID: 0044

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0044	30.6	High	1.59	5.47

Description of Survey Site: This site has a wooded riparian cooridor. The river is undercutting the tree roots and mature trees are falling into the channel area.

Length of Bank (feet): 1,169

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	87%
Reduction of Rate of Erosion (tons/foot/year):	3.83	4.76
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$93,520	$93,520
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	4476	5563
***Cost of Soil Reduction Per Ton:**	**$2.09**	**$1.68**
***Cost of Soil Reduction Per Cubic Yard:**	**$2.72**	**$2.19**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 11-Nov-10
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0044
County: Atchison County238.26
Legal Description: NW 1/4 Sec 5 T7S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0-350	Feet	Pasture	X
	Crop field			Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber	X		Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	238.3	Feet
	Edge of Water to Edge of Water	41.3	Feet
Water Depth:	Thalweg	2.0	Feet

Livestock access to Riparian Area **Yes** _____ **No** X
If yes, what is the duration in months per year? _____

Debris or Channel Blockages **Yes** _____ **No** X

Buildings or Structures Threatened **Yes** _____ **No** X
If yes, what is their distance from the streambank? _____ Feet

Bank Erosion Inventory

Average Bank Height: 26.4 Feet (Measure)
Root Depth of Riparian Vegetation: 11.8 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 27 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		1,169	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 4.3 Average Feet / year

Comments on Erosion: The wooded riparian corridor exceed 350 feet wide towards the lower end of site.

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0044**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/11/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	26.4 (A)	Bankfull Height (ft) =	17.4 (B)	(A) / (B) =	1.5 (C)	5.6
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	11.8 (D)	Study Bank Height (ft) =	26.4 (A)	(D) / (A) =	0.4 (E)	4.4
Weighted Root Density (G)						
		Root Density as % =	30 (F)	(F) x (E) =	13.4 (G)	8.1
Bank Angle (H)						
				Bank Angle as *Degrees* =	51 (H)	3.5
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

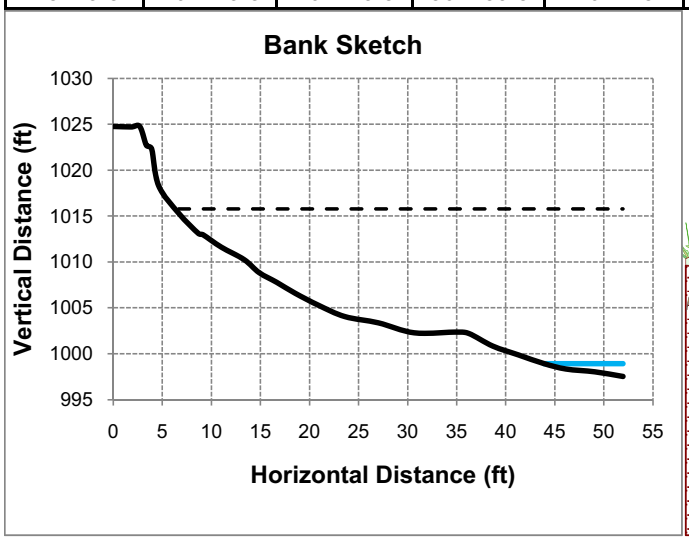
Bank Material Adjustment:

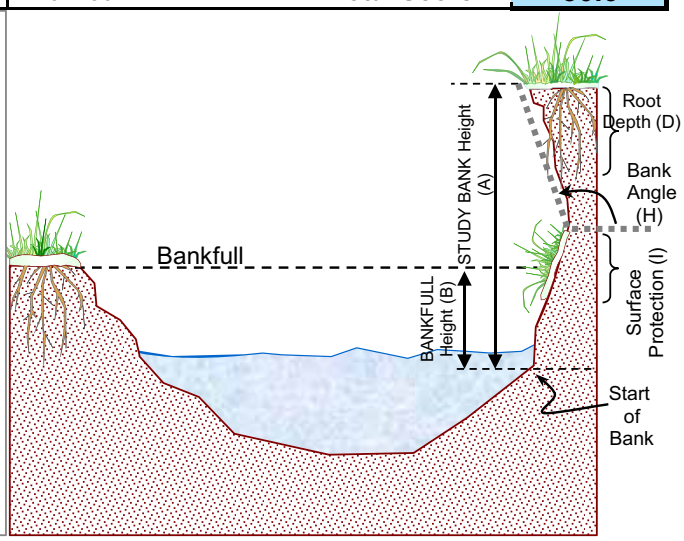
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0

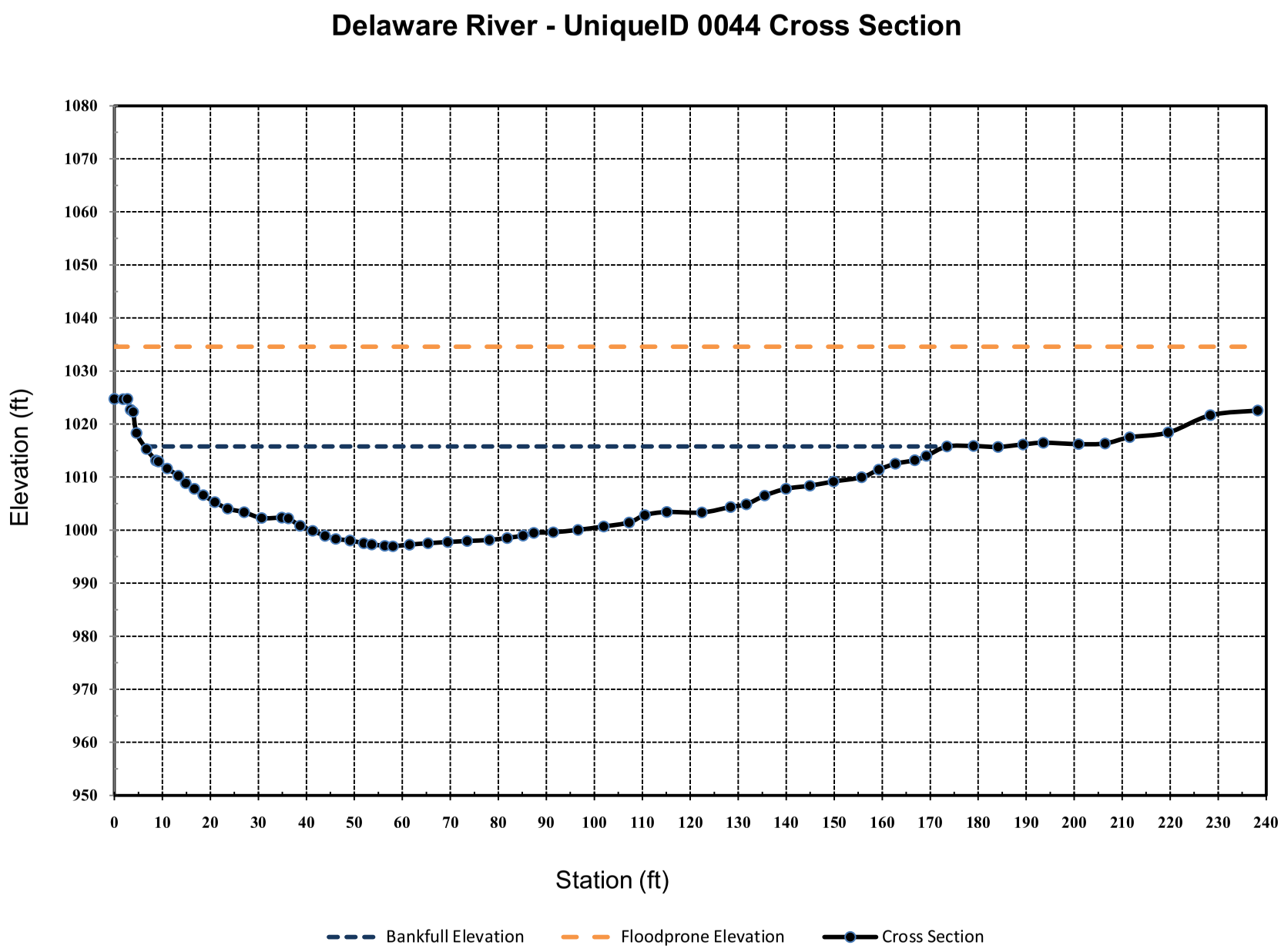
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

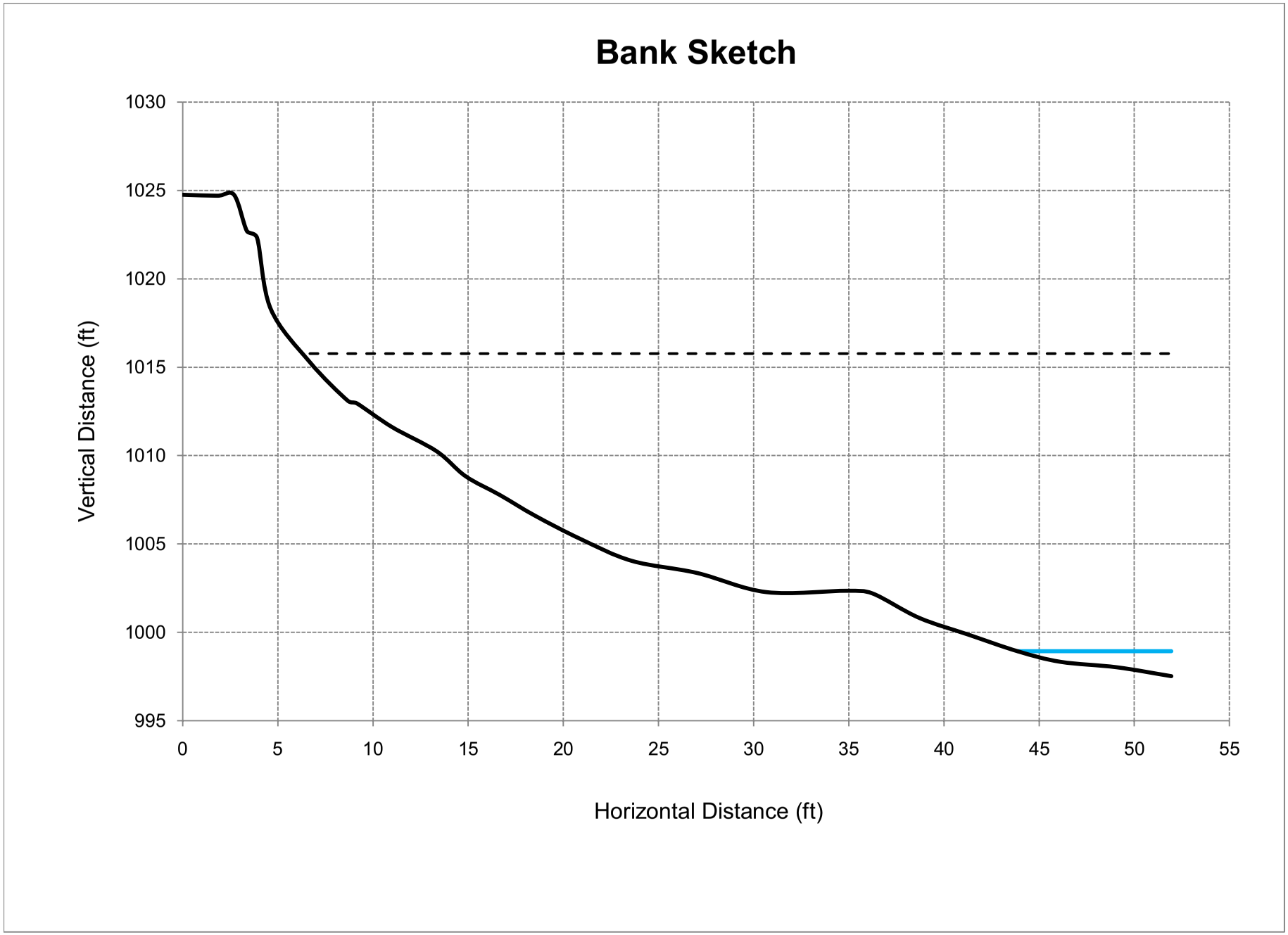
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		30.6





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0044 Cross Section
Elevation (ft)
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1030
1025
1020
1015
1010
1005
1000
995
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
50
55
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0045

A-9 Delaware Hot-Spot UniqueID: 0045

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0045	29.7	Moderate	1.55	2.79

Description of Survey Site: This site has no riparian cooridor. Banks are wet but no visable seeps. Banks consist of silty clay and silty sands.

Length of Bank (feet): 557

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	53%	82%
Reduction of Rate of Erosion (tons/foot/year):	1.48	2.29
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$44,560	$44,560
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	824	1274
***Cost of Soil Reduction Per Ton:**	**$5.41**	**$3.50**
***Cost of Soil Reduction Per Cubic Yard:**	**$7.03**	**$4.55**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 19-Nov-10
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Afilliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0045
County: Atchison County
Legal Description: SW 1/4 Sec 32 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Cropfield	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	219.6	Feet
	Edge of Water to Edge of Water	55.6	Feet
Water Depth:	Thalweg	3.3	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 27.9 Feet (Measure)
Root Depth of Riparian Vegetation: 10.7 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 36 degrees.
	Vertical			
	1H:1V	X		
	2H:1V			

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	

Eroding Bank Length: 557 Feet

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 2.08 Average Feet / year

Comments on Erosion:

View of the right bank.

View upstream.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0045**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/19/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	27.9 (A)	Bankfull Height (ft) =	15.9 (B)	(A) / (B) =	1.8 (C)	6.7
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	10.7 (D)	Study Bank Height (ft) =	27.9 (A)	(D) / (A) =	0.4 (E)	5.1
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	7.7 (G)	8.7
Bank Angle (H)						
				Bank Angle as *Degrees* =	35 (H)	2.7
Surface Protection (I)						
				Surface Protection as % =	25 (I)	6.5

Bank Material Adjustment:

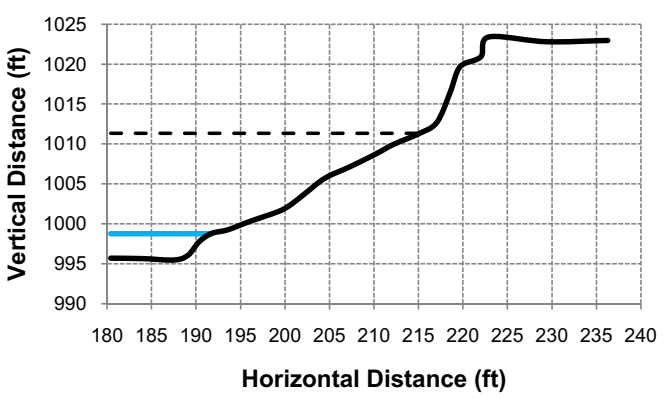
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

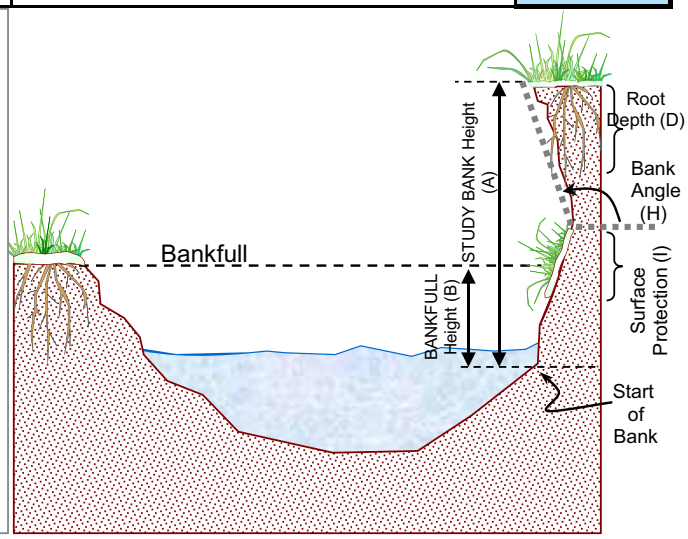
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

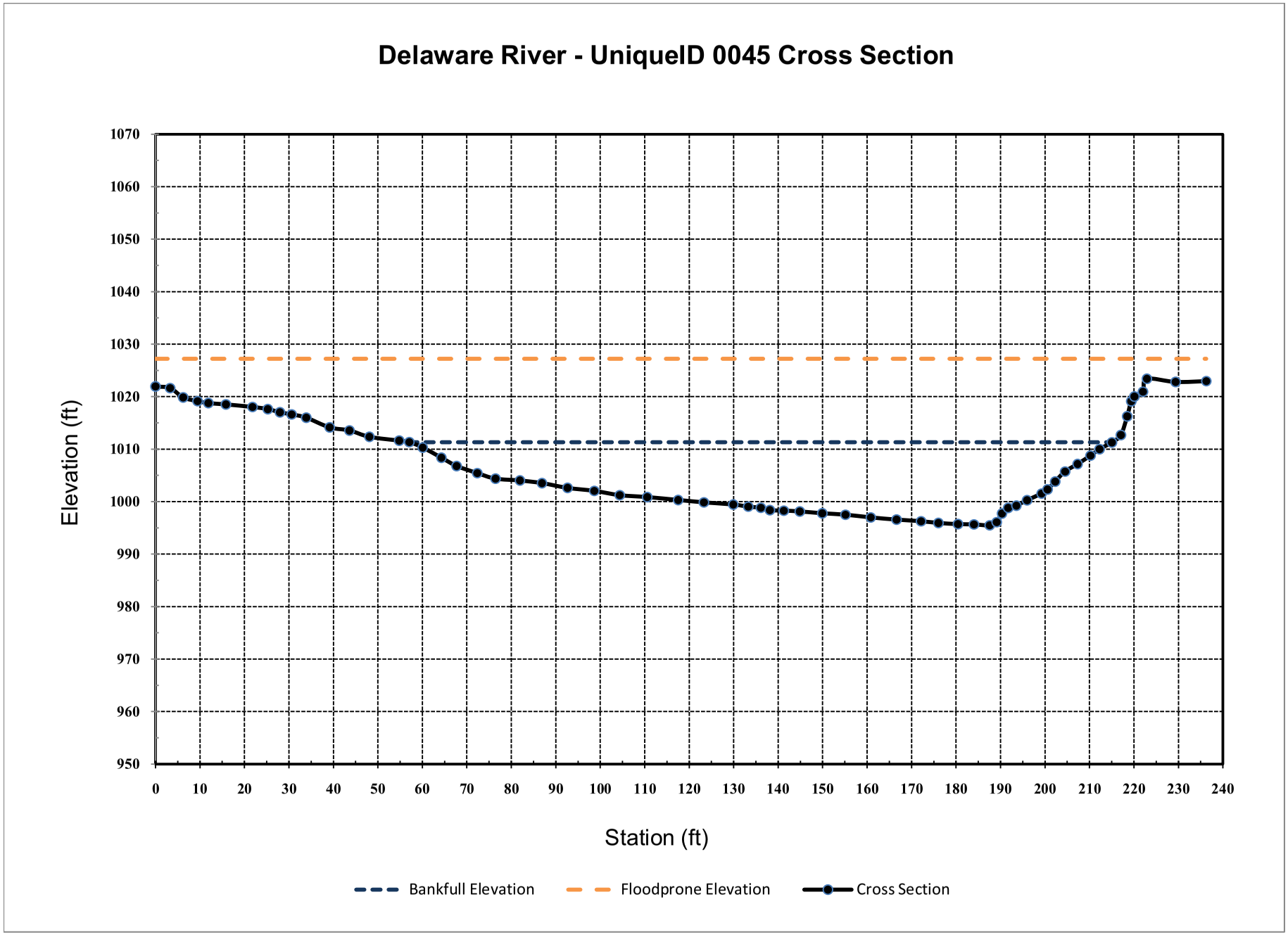
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		29.7

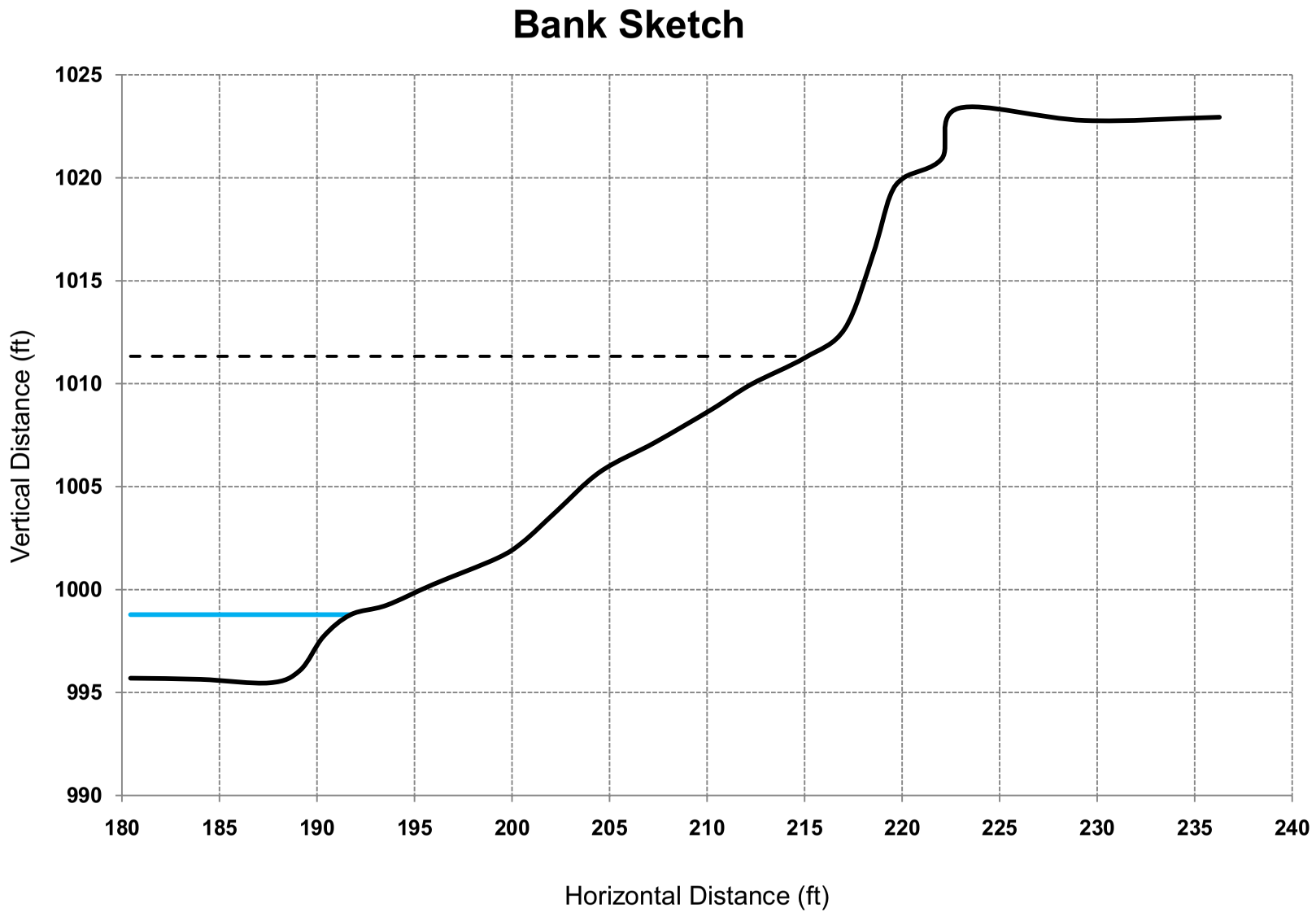
Bank Sketch





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0045 Cross Section
Elevation (ft)
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
Vertical Distance (ft)
1025
1020
1015
1010
1005
1000
995
990
180
185
190
195
200
205
210
215
220
225
230
235
240
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0047

A-10. Delaware Hot-Spot UniqueID: 0047

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0047	28.7	Moderate	1.47	3.49

Description of Survey Site: This site has a narrow wooded cooridor. There is a gully on the downstream end. Banks consist of silt loam, sand and silty clay.

Length of Bank (feet): 303

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	0%	62%
Reduction of Rate of Erosion (tons/foot/year):	0.00	2.16
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$19,089	$19,089
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	0	656
***Cost of Soil Reduction Per Ton:**	**$5,727**	**$2.91**
***Cost of Soil Reduction Per Cubic Yard:**	**$7,445**	**$3.79**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume 1 cubic yard weighs 1.3 tons. For year 1 through 3, modeling results did not produce an erosion reduction; therefore 3 years of BMP installation costs were added to calculate the cost-benefits associated with year 1 through 3.

Field Assessment Form

Site Location

Stream Name:	Straight Creek	**Date:**	9-Nov-10
14 Digit HUC:	10270103030030		
Person(s) Filling out Form:	Emmert, McCurdy, Kolian		
Affiliation(s):	Gulf South Research Corporation, Watershed Institute, Inc.		

Location: Site Number: 47
County: Jackson County
Legal Description: NE 1/4 Sec 16 T6S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	167.2	Feet
	Edge of Water to Edge of Water	20.8	Feet
Water Depth:	Thalweg	1.1	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height:	22.0	Feet (Measure)
Root Depth of Riparian Vegetation:	22.0	Feet

Bank Slope:	Undercut		Comments: Average Bank Angle is 37 degrees
	Vertical		Most of the streambank is vegetated
	1H:1V		with scattered trees on top-of-bank.
	2H:1V	X	

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		303	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 3.28 Average Feet / year

Comments on Erosion:

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Straight Creek - UniqueID 0047**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/09/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	22.1 (A)	Bankfull Height (ft) =	7.8 (B)	(A) / (B) =	2.8 (C)	10.0
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	22.1 (D)	Study Bank Height (ft) =	22.1 (A)	(D) / (A) =	1.0 (E)	1.0
Weighted Root Density (G)						
		Root Density as % =	30 (F)	(F) x (E) =	30 (G)	5.9
Bank Angle (H)						
				Bank Angle as *Degrees* =	31 (H)	2.5
Surface Protection (I)						
				Surface Protection as % =	50 (I)	4.3

Bank Material Adjustment:

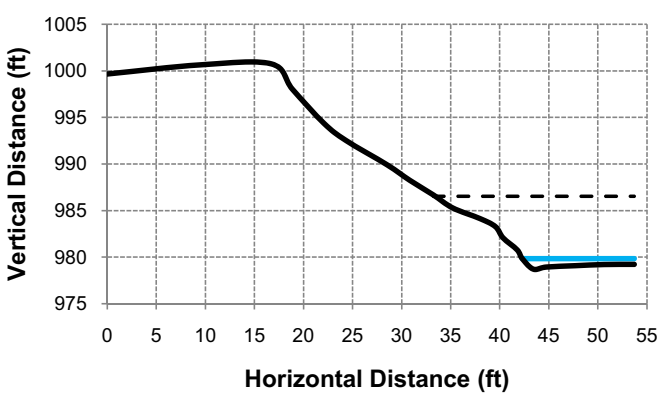
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

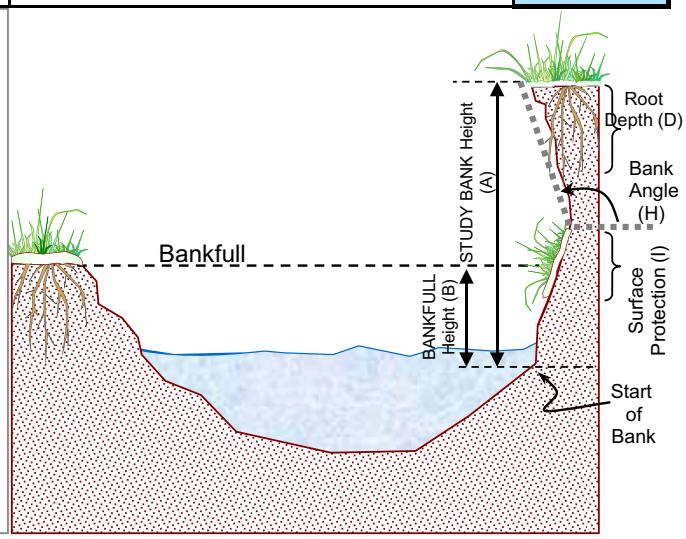
Bank Material Adjustment 5.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

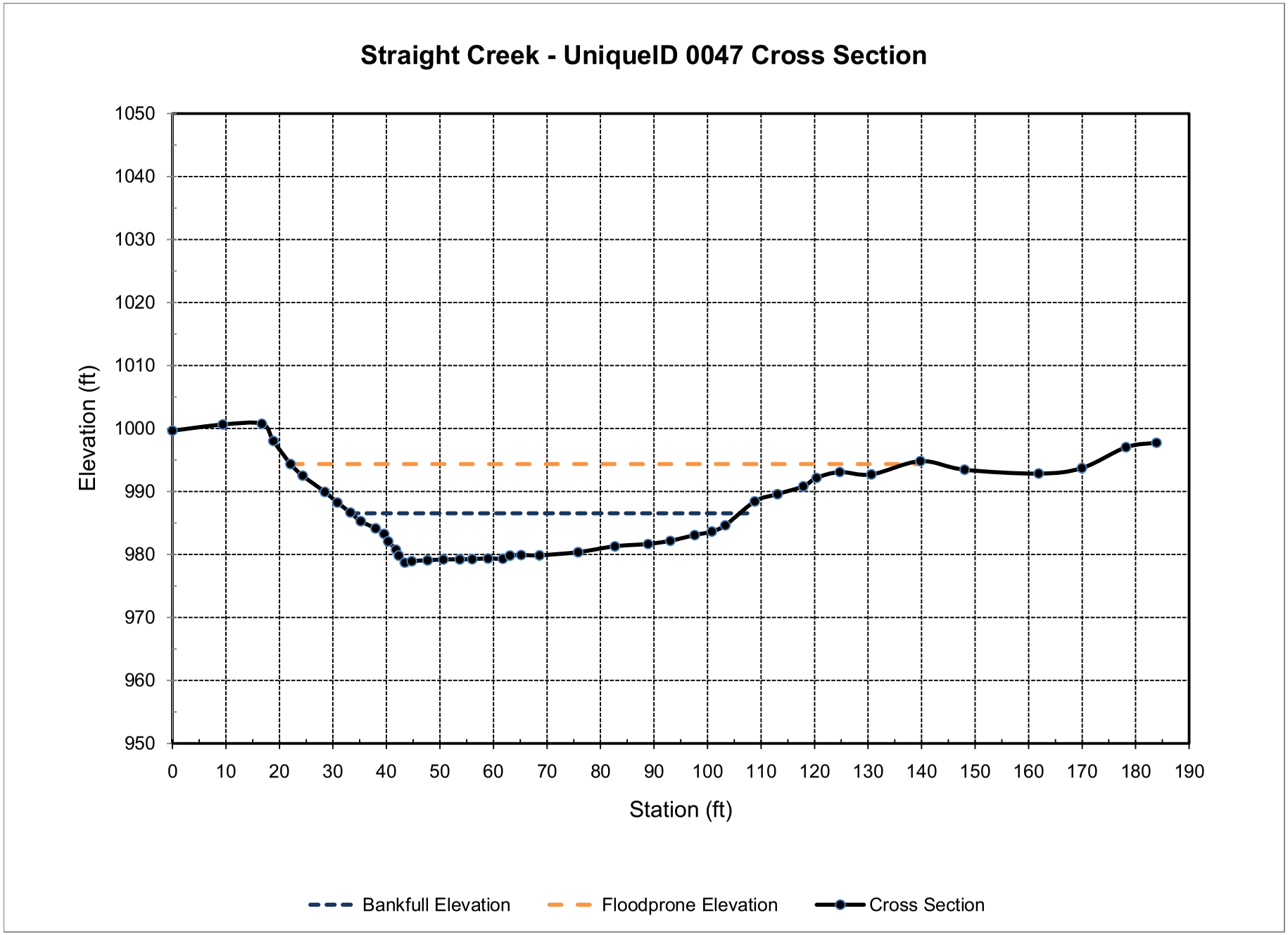
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		28.7

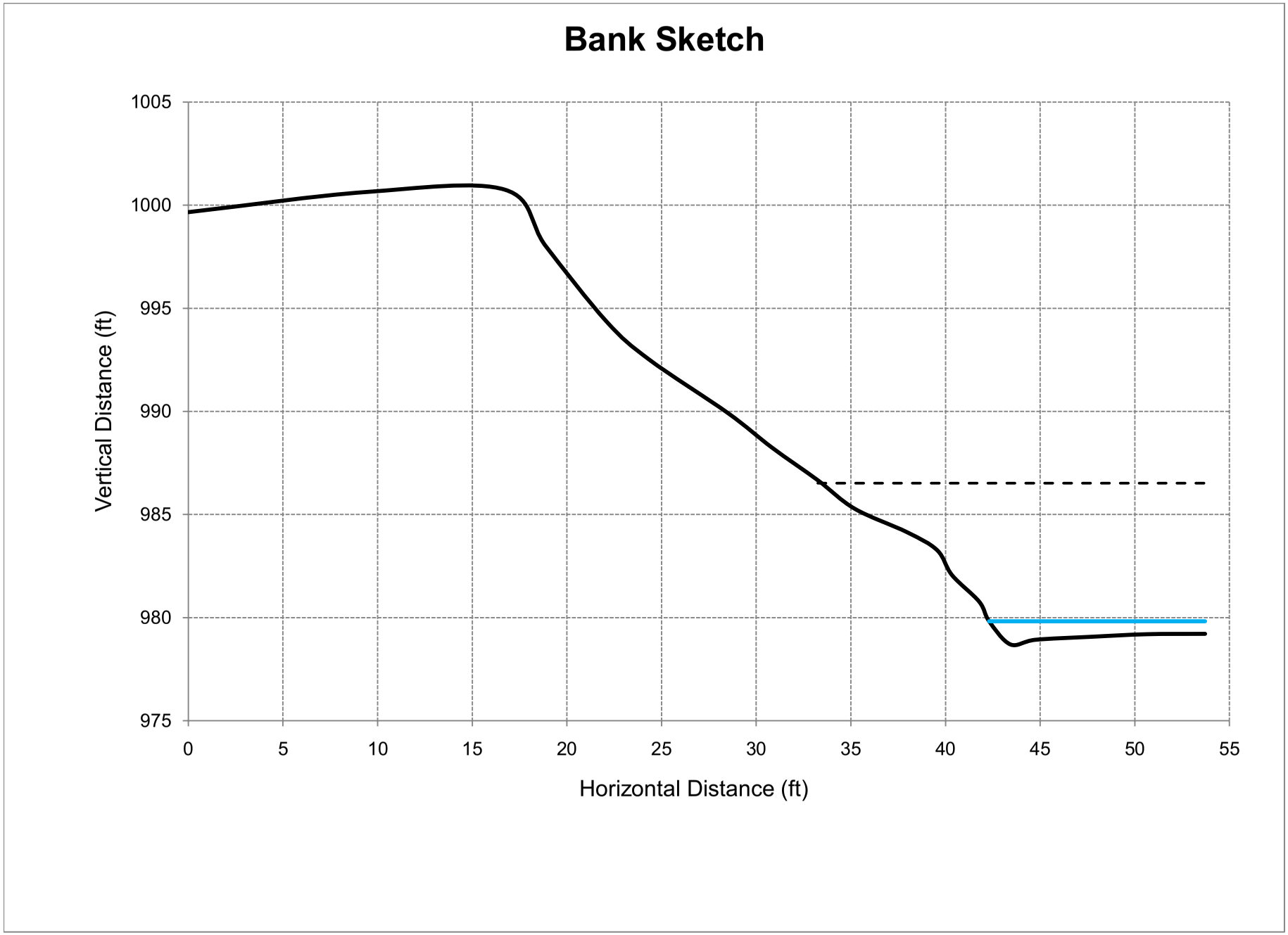
Bank Sketch





Copyright © 2006 Wildland Hydrology


Straight Creek - UniqueID 0047 Cross Section
Elevation (ft)
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1005
1000
995
990
985
980
975
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
50
55
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0056

A-11 Delaware Hot-Spot UniqueID: 0056

Location of Stream Segment: Spring Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0056	28.5	Moderate	1.33	0.49

Description of Survey Site: This site has a narrow wooded repaian cooridor. Bank are silty clay with some sands.

Length of Bank (feet): 448

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	0%	62%
Reduction of Rate of Erosion (tons/foot/year):	0.00	0.30
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$28,224	$28,224
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	0	136
***Cost of Soil Reduction Per Ton:**	**$8,467**	**$20.74**
***Cost of Soil Reduction Per Cubic Yard:**	**$11,007**	**$26.96**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume 1 cubic yard weighs 1.3 tons. For year 1 through 3, modeling results did not produce an erosion reduction; therefore 3 years of BMP installation costs were added to calculate the cost-benefits associated with year 1 through 3.

Field Assessment Form

Site Location

Stream Name: Spring Creek **Date:** 11-Nov-10
14 Digit HUC: 10270103030010
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0056
County: Jackson County
Legal Description: SE 1/4 Sec 34 T5S R15E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	35	Feet	Pasture	
	Crop field			Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber	X		Residential	
	Cropland			Industrial	

Channel Width:	Top of Bank to Top of Bank	119.7	Feet
	Edge of Water to Edge of Water	26.3	Feet
Water Depth:	Thalweg	0.9	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 17.1 Feet (Measure)
Root Depth of Riparian Vegetation: 9.6 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 40 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		448	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 0.6 Average Feet / year

Comments on Erosion:

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Spring Creek- UniqueID 0056**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/11/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	17.1 (A)	Bankfull Height (ft) =	7.4 (B)	(A) / (B) =	2.3 (C)	8.3
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	9.6 (D)	Study Bank Height (ft) =	17.1 (A)	(D) / (A) =	0.6 (E)	3.6
Weighted Root Density (G)						
		Root Density as % =	30 (F)	(F) x (E) =	16.8 (G)	7.7
Bank Angle (H)						
				Bank Angle as *Degrees* =	42 (H)	3.0
Surface Protection (I)						
				Surface Protection as % =	30 (I)	5.9

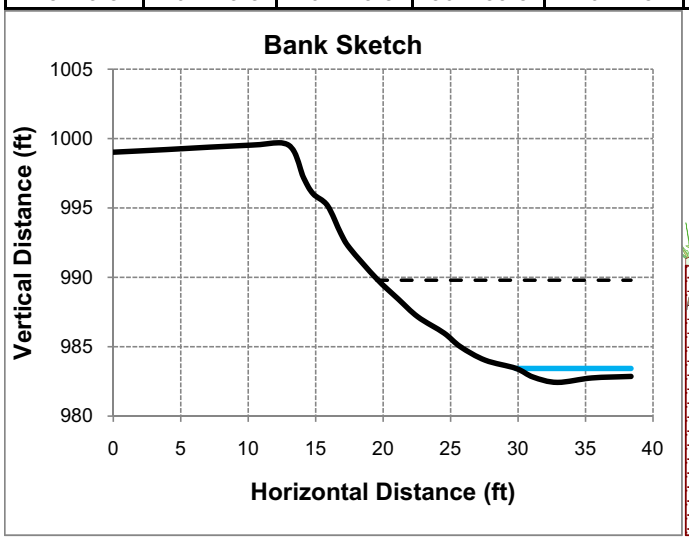
Bank Material Adjustment:

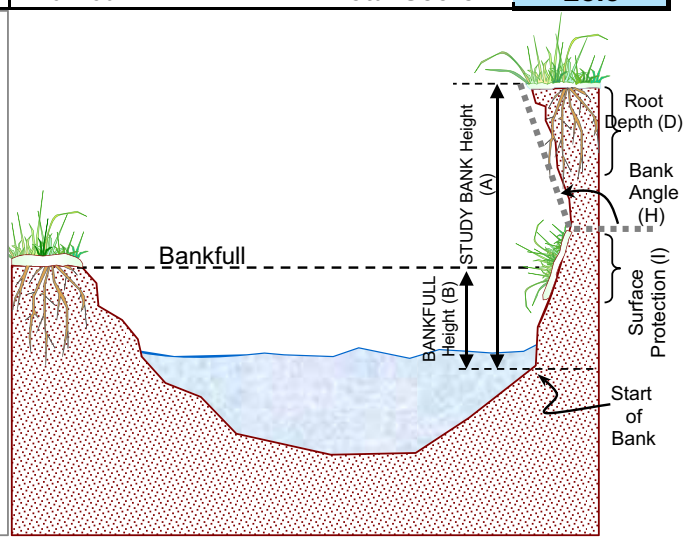
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0.0

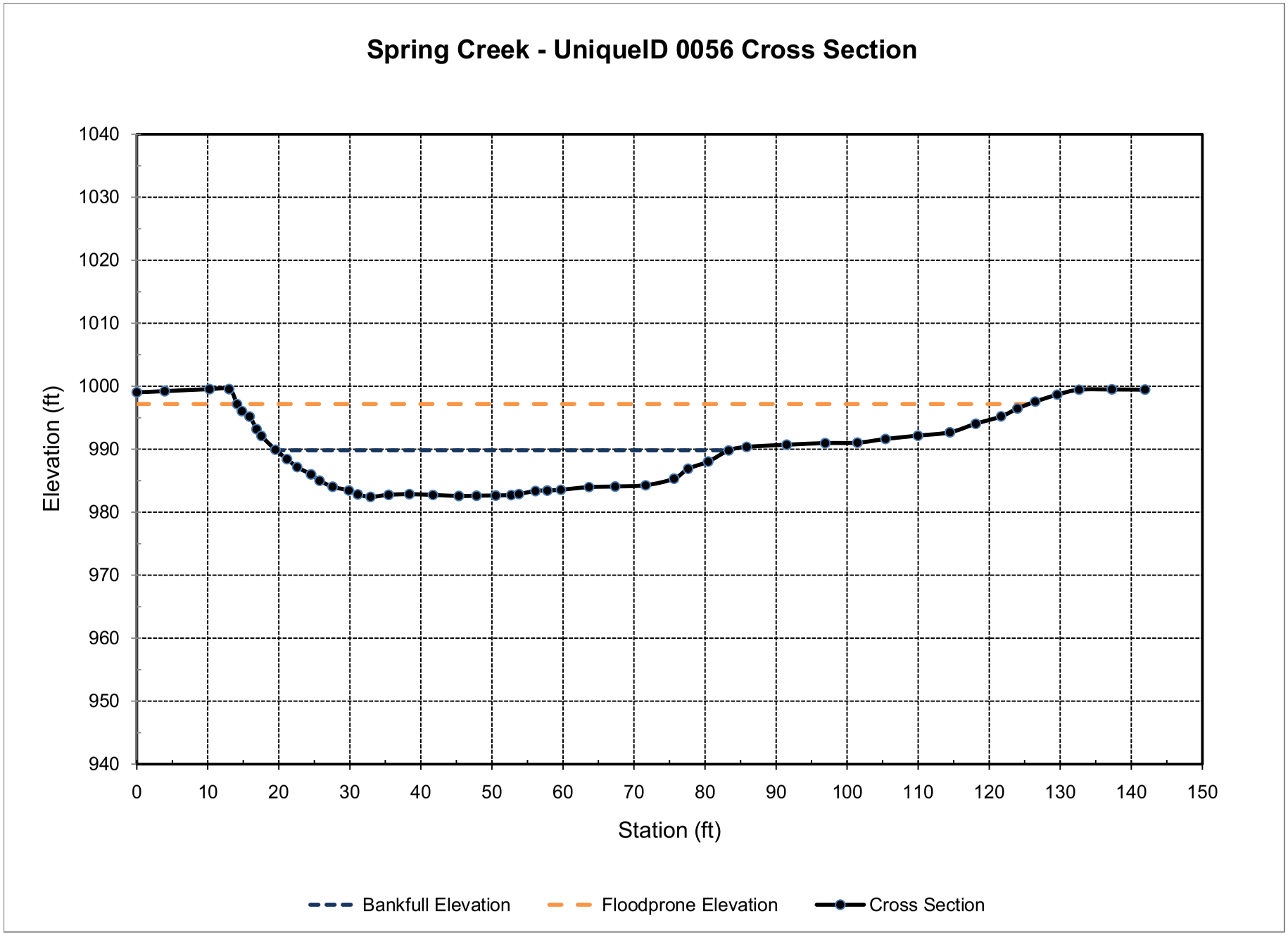
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

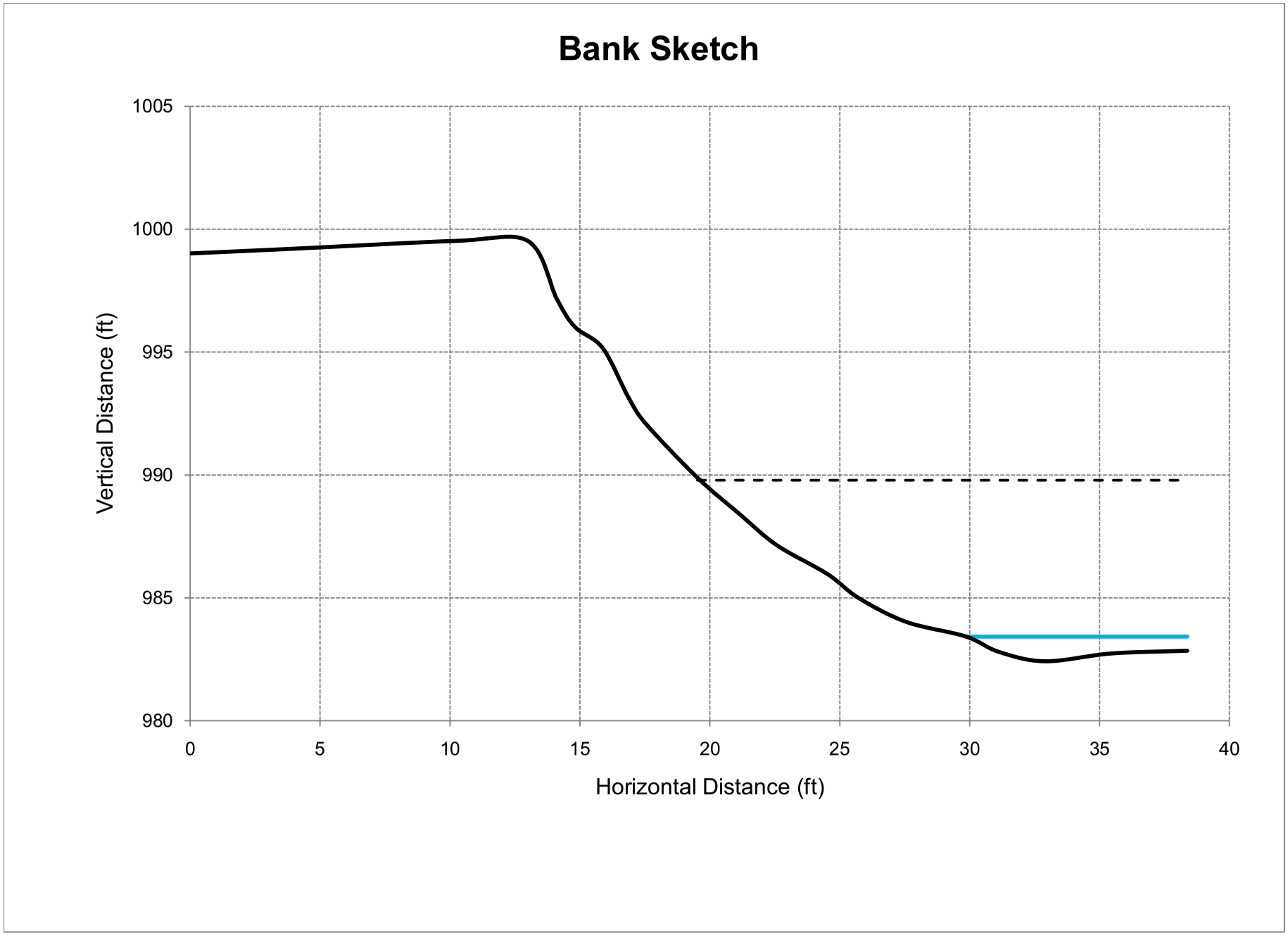
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		28.5





Copyright © 2006 Wildland Hydrology


Spring Creek - UniqueID 0056 Cross Section
Elevation (ft)
1040
1030
1020
1010
1000
990
980
970
960
950
940
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1005
1000
995
990
985
980
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0057

A-12 Delaware Hot-Spot UniqueID: 0057

Location of Stream Segment: Straight Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0057	38.2	High	1.52	3.93

Description of Survey Site: This site has no ripairan cooridor. There are some willows along the bank toe, but they do not provide very much protection. Banks consist of silty clay.

Length of Bank (feet): 256

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	94%
Reduction of Rate of Erosion (tons/foot/year):	2.75	3.69
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$16,128	$16,128
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	704	946
***Cost of Soil Reduction Per Ton:**	**$2.29**	**$1.71**
***Cost of Soil Reduction Per Cubic Yard:**	**$2.98**	**$2.22**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Straight Creek **Date:** 10-Nov-10
14 Digit HUC: 10270103030020
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0057
County: Jackson County
Legal Description: W 1/2 Sec 11 T6S R15E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland			Industrial	

Channel Width:	Top of Bank to Top of Bank	219.0	Feet
	Edge of Water to Edge of Water	33.2	Feet
Water Depth:	Thalweg	2.1	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 19 Feet (Measure)
Root Depth of Riparian Vegetation: 3.7 Feet

Bank Slope:	Undercut		Comments: Average Bank Angle is 51 Degrees
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		256	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 4.36 Average Feet / year

Comments on Erosion:

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Straight Creek - UniqueID 0057**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/10/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	18.7 (A)	Bankfull Height (ft) =	1.1 (B)	(A) / (B) =	17 (C)	10.0
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	3.7 (D)	Study Bank Height (ft) =	18.7 (A)	(D) / (A) =	0.2 (E)	7.2
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	4.0 (G)	10.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	57 (H)	3.8
Surface Protection (I)						
				Surface Protection as % =	20 (I)	7.2

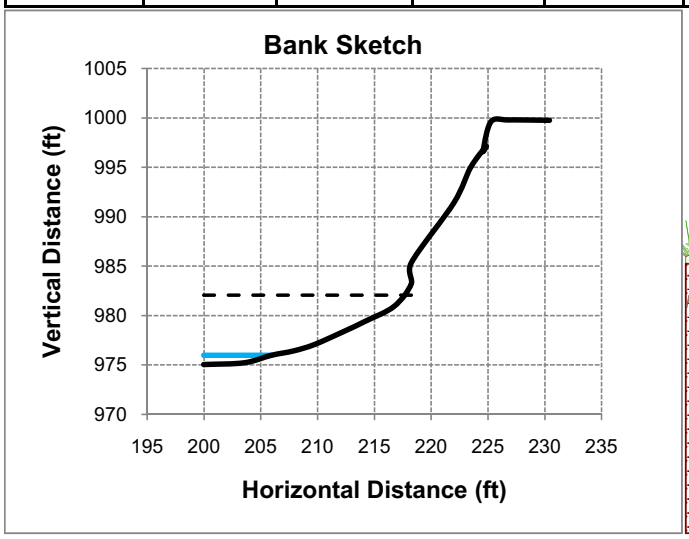
Bank Material Adjustment:

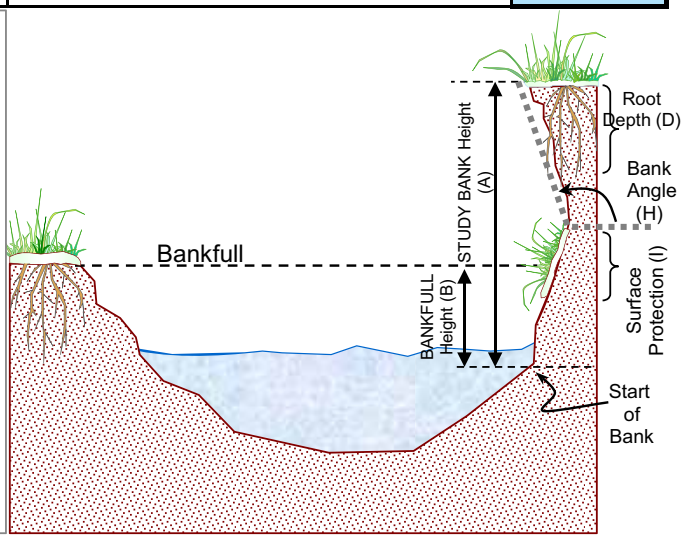
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0.0

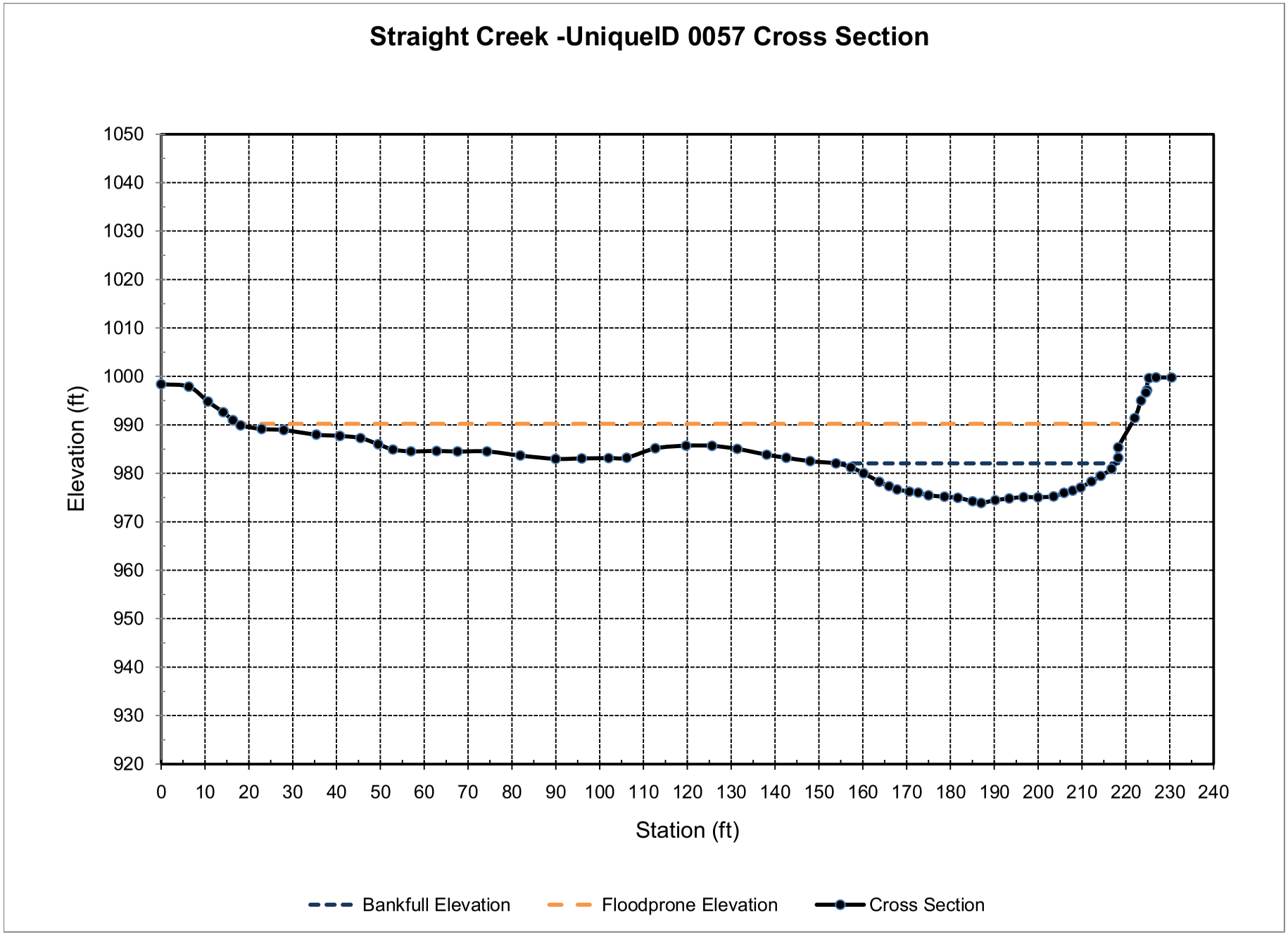
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

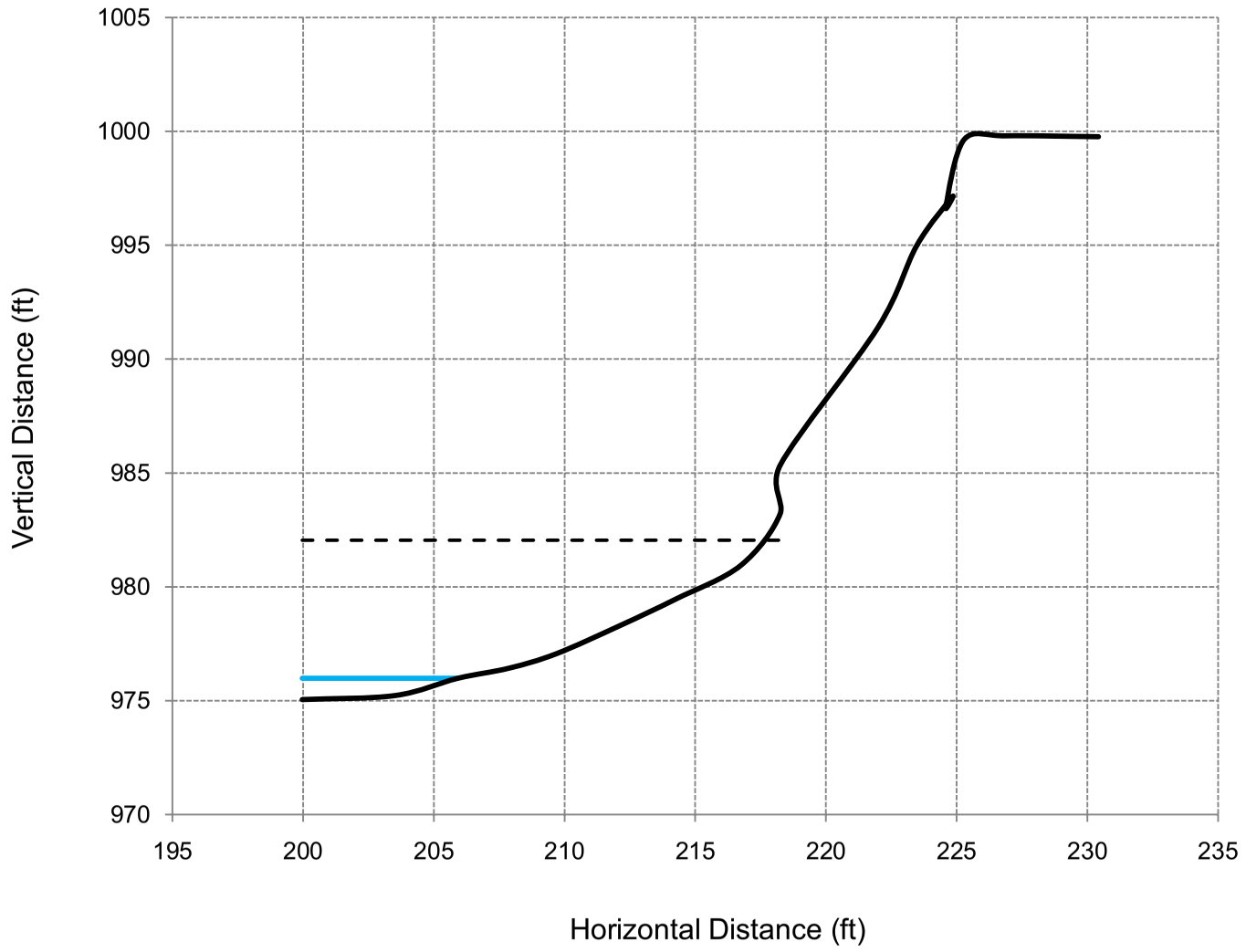
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		38.2





Copyright © 2006 Wildland Hydrology


Straight Creek -UniqueID 0057 Cross Section
Elevation (ft)
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
920
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1005
1000
995
990
985
980
975
970
Vertical Distance (ft)
195
200
205
210
215
220
225
230
235
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0062

A-13 Delaware Hot-Spot UniqueID: 0062

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0062	38.5	High	1.53	6.41

Description of Survey Site: This site has no ripaian cooridor on the upstream half and a narrow ripaian cooridor on the downstream half. Banks materials are predominately silty clay.

Length of Bank (feet): 580

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	89%
Reduction of Rate of Erosion (tons/foot/year):	4.49	5.70
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$46,400	$46,400
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	2602	3309
***Cost of Soil Reduction Per Ton:**	**$1.78**	**$1.40**
***Cost of Soil Reduction Per Cubic Yard:**	**$2.32**	**$1.82**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 19-Nov-10
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0062
County: Atchison County
Legal Description: NE1/4 Sec 32 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	282.1	Feet
	Edge of Water to Edge of Water	47.5	Feet
Water Depth:	Thalweg	2.3	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 36.2 Feet (Measure)
Root Depth of Riparian Vegetation: 9.5 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 32 degrees.
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		580	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 3.68 Average Feet / year

Comments on Erosion:

View across channel at cross section

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0062**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/19/10**	Stream Type: **-**	Valley Type: **VIII**

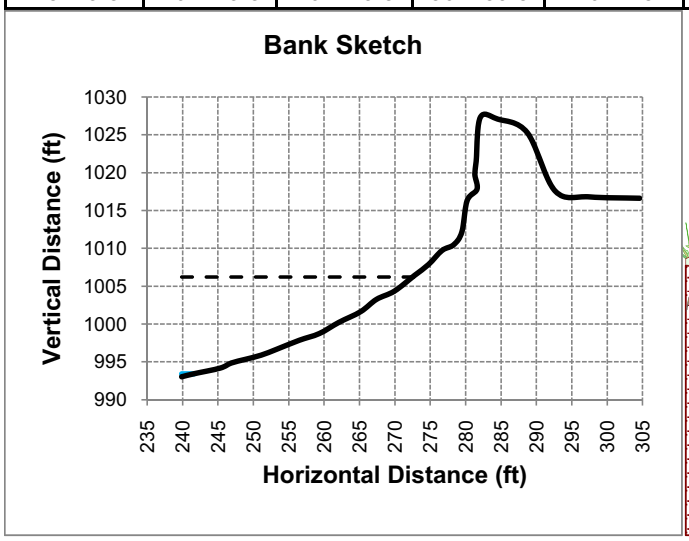
						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	36.2 (A)	Bankfull Height (ft) =	15.1 (B)	(A) / (B) =	2.4 (C)	8.4
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	9.5 (D)	Study Bank Height (ft) =	36.2 (A)	(D) / (A) =	0.3 (E)	6.4
Weighted Root Density (G)						
		Root Density as % =	10 (F)	(F) x (E) =	2.6 (G)	10.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	34 (H)	2.6
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

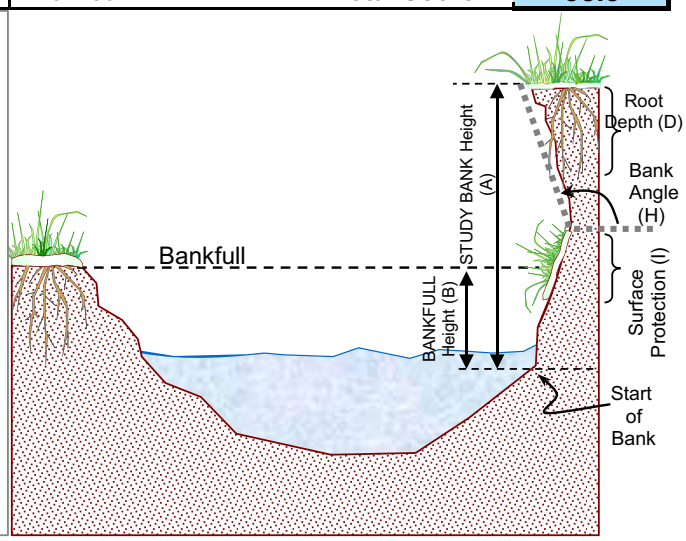
Bank Material Adjustment:

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 (no adjustment)

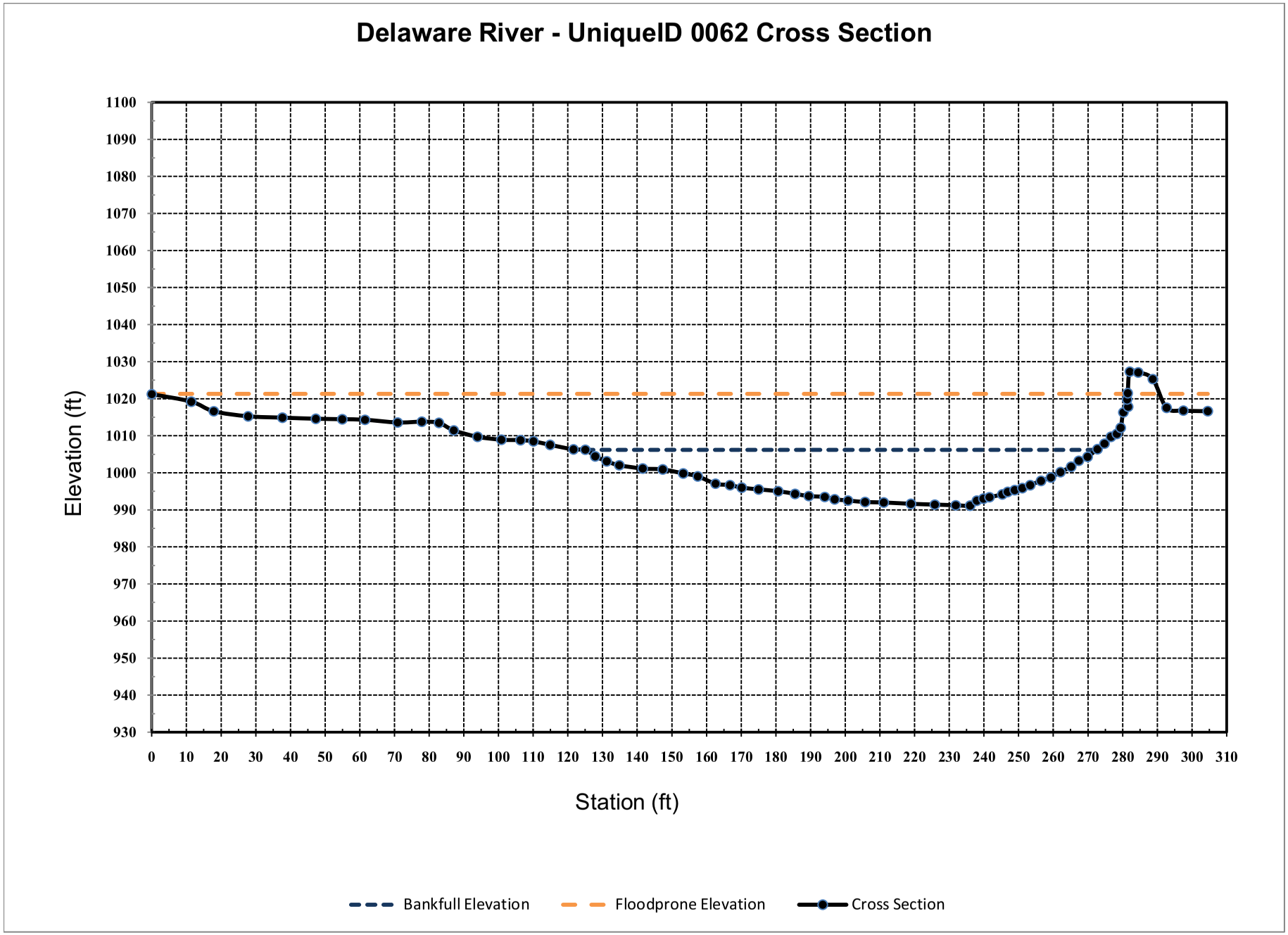
Bank Material Adjustment	2.0
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	0.0

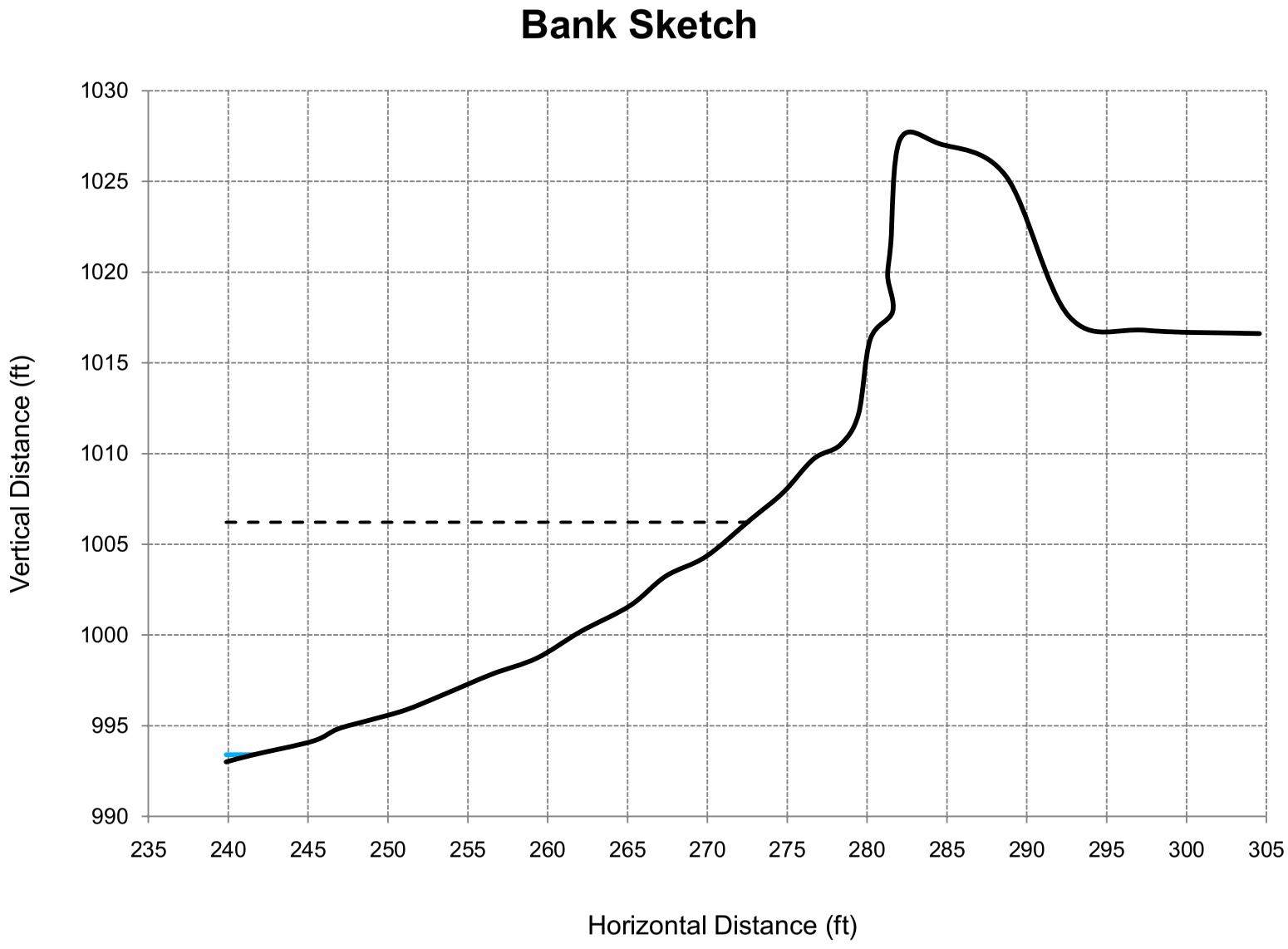
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		38.5





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0062 Cross Section
Elevation (ft)
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
Vertical Distance (ft)
1030
1025
1020
1015
1010
1005
1000
995
990
235
240
245
250
255
260
265
270
275
280
285
290
295
300
305
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0065

A-14 Delaware Hot-Spot UniqueID: 0065

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0065	27.8	Moderate	1.53	3.57

Description of Survey Site: There is a narrow riparian corridor. The banks are steep and are mainly composed of silty materials. There is a large slump at the lower end of the meander.

Length of Bank (feet): 494

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	53%	82%
Reduction of Rate of Erosion (tons/foot/year):	1.89	2.93
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$39,520	$39,520
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	935	1446
***Cost of Soil Reduction Per Ton:**	**$4.23**	**$2.73**
***Cost of Soil Reduction Per Cubic Yard:**	**$5.50**	**$3.55**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 2-Sep-09
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0065
County: Atchison County
Legal Description: NW1/4 Sec 29 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	30	Feet	Pasture	
	Crop field			Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	212.8	Feet
	Edge of Water to Edge of Water	41.1	Feet
Water Depth:	Thalweg	1.2	Feet

Livestock access to Riparian Area **Yes** ____ **No** X
If yes, what is the duration in months per year? ____

Debris or Channel Blockages **Yes** ____ **No** X

Buildings or Structures Threatened **Yes** ____ **No** X
If yes, what is their distance from the streambank? ____ Feet

Bank Erosion Inventory

Average Bank Height: 25.4 Feet (Measure)
Root Depth of Riparian Vegetation: 15.0 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 24 degrees.
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		494	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 2.92 Average Feet / year

Comments on Erosion:

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0065**	Location:	**Atchison County**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **09/02/09**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	25.4 (A)	Bankfull Height (ft) =	14.5 (B)	(A) / (B) =	1.8 (C)	6.7
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	15 (D)	Study Bank Height (ft) =	25.4 (A)	(D) / (A) =	0.6 (E)	3.5
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	11.8 (G)	8.2
Bank Angle (H)						
				Bank Angle as *Degrees* =	24 (H)	2.2
Surface Protection (I)						
				Surface Protection as % =	20 (I)	7.2

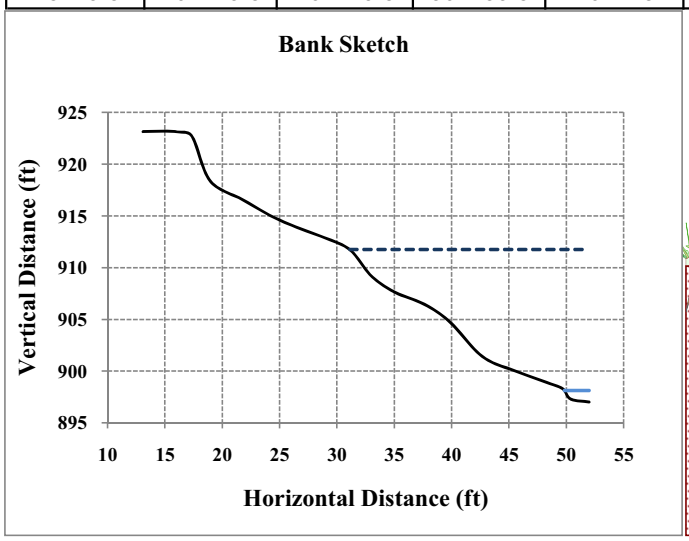
Bank Material Adjustment:

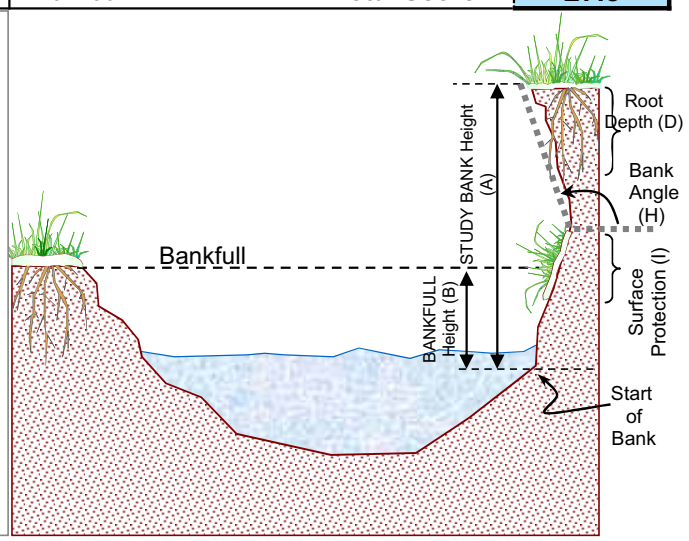
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0

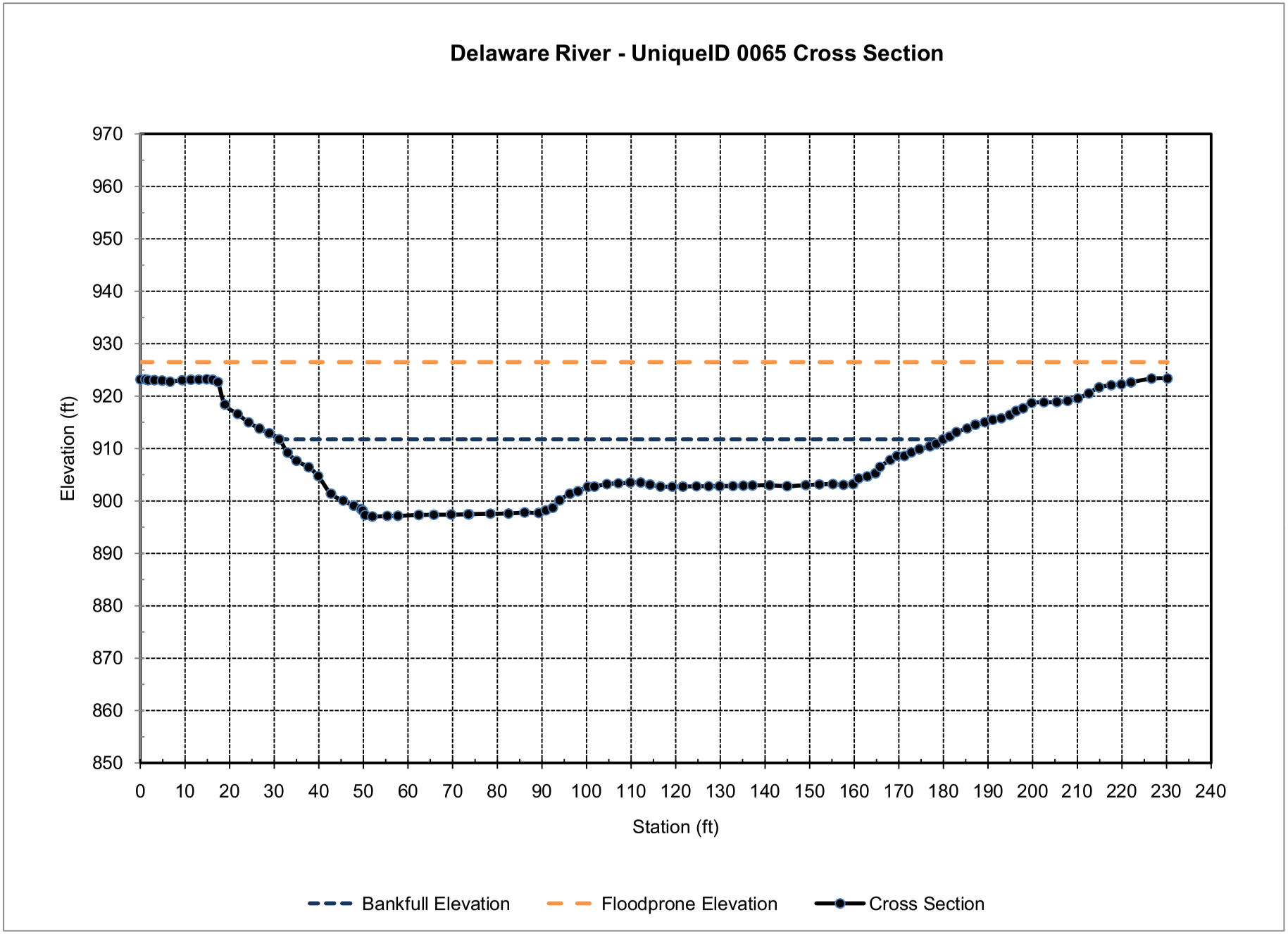
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		27.8

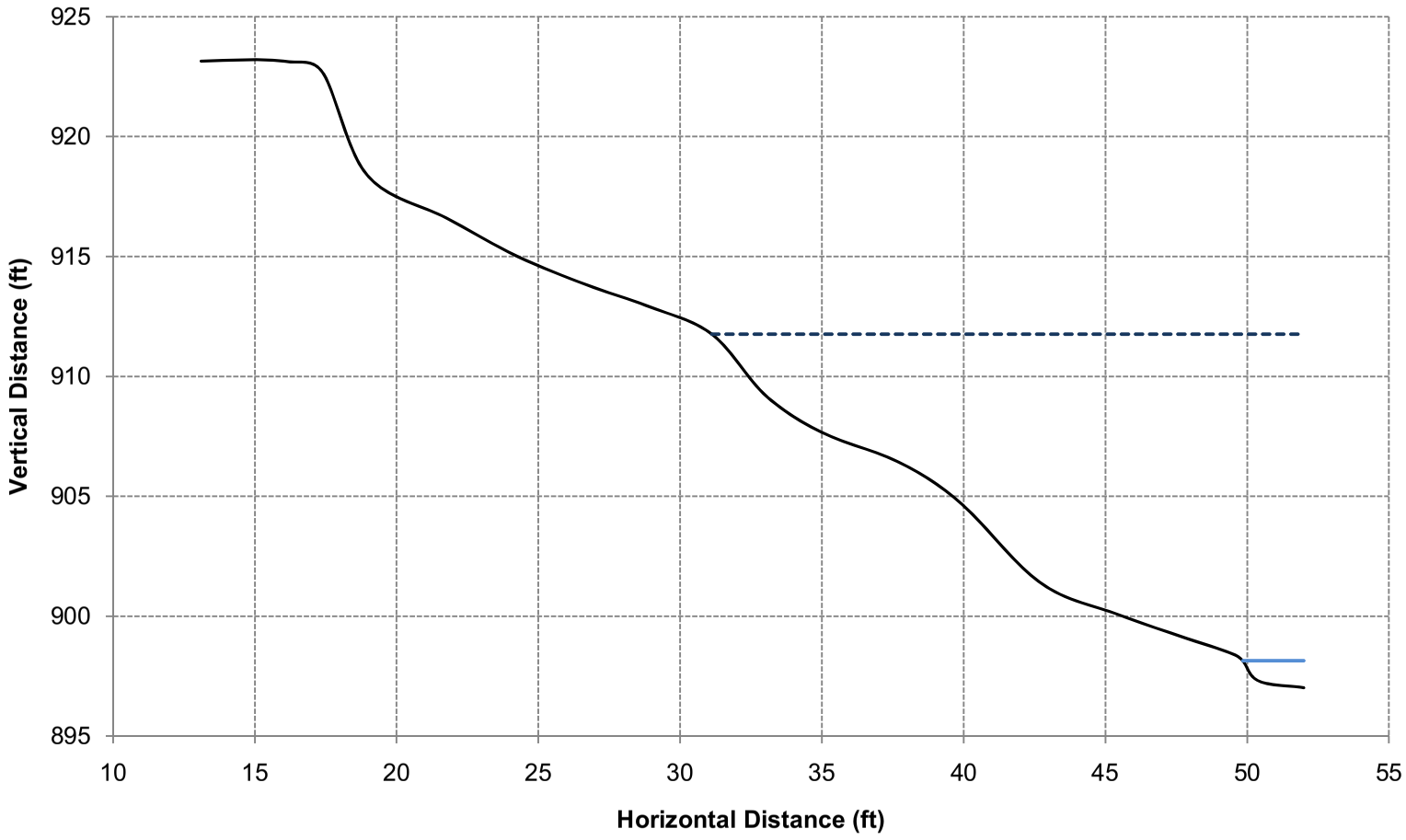




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0065 Cross Section
Elevation (ft)
970
960
950
940
930
920
910
900
890
880
870
860
850
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


925
920
915
910
905
900
895
Vertical Distance (ft)
10
15
20
25
30
35
40
45
50
55
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0066

A-15 Delaware Hot-Spot UniqueID: 0066

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0066	31.8	High	1.44	4.25

Description of Survey Site: The landowner has planted a native grass buffer along the top of bank. This project is scheduled for BMP implementation later this year.

Length of Bank (feet): 778

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	2.13	3.44
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$62,240	$62,240
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	1653	2678
***Cost of Soil Reduction Per Ton:**	**$3.76**	**$2.32**
***Cost of Soil Reduction Per Cubic Yard:**	**$4.89**	**$3.02**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 31-Aug-09
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0066
County: Atchison County
Legal Description: NE1/4 Sec 20 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	75	Feet	Pasture	X
	Crop field			Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	189.3	Feet
	Edge of Water to Edge of Water	54.5	Feet
Water Depth:	Thalweg	1.1	Feet

Livestock access to Riparian Area **Yes** _____ **No** X
If yes, what is the duration in months per year? _____

Debris or Channel Blockages **Yes** _____ **No** X

Buildings or Structures Threatened **Yes** _____ **No** X
If yes, what is their distance from the streambank? _____ Feet

Bank Erosion Inventory

Average Bank Height: 23.9 Feet (Measure)
Root Depth of Riparian Vegetation: 10.8 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 47 degrees. There is a grass buffer strip between bank and field
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		778	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 3.69 Average Feet / year

Comments on Erosion:

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0066**	Location:	**Atchison County**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **08/31/09**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	23.9 (A)	Bankfull Height (ft) =	13.9 (B)	(A) / (B) =	1.7 (C)	6.6
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	10.8 (D)	Study Bank Height (ft) =	23.9 (A)	(D) / (A) =	0.5 (E)	4.4
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	9.0 (G)	8.6
Bank Angle (H)						
				Bank Angle as *Degrees* =	47 (H)	3.3
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9

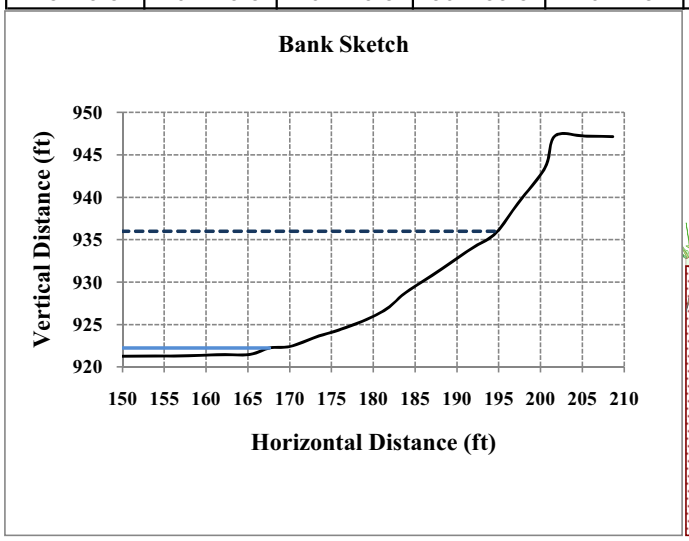
Bank Material Adjustment:

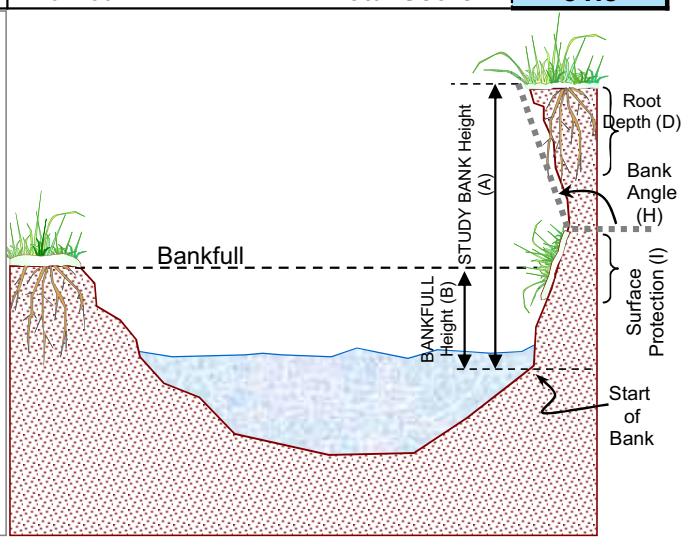
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0

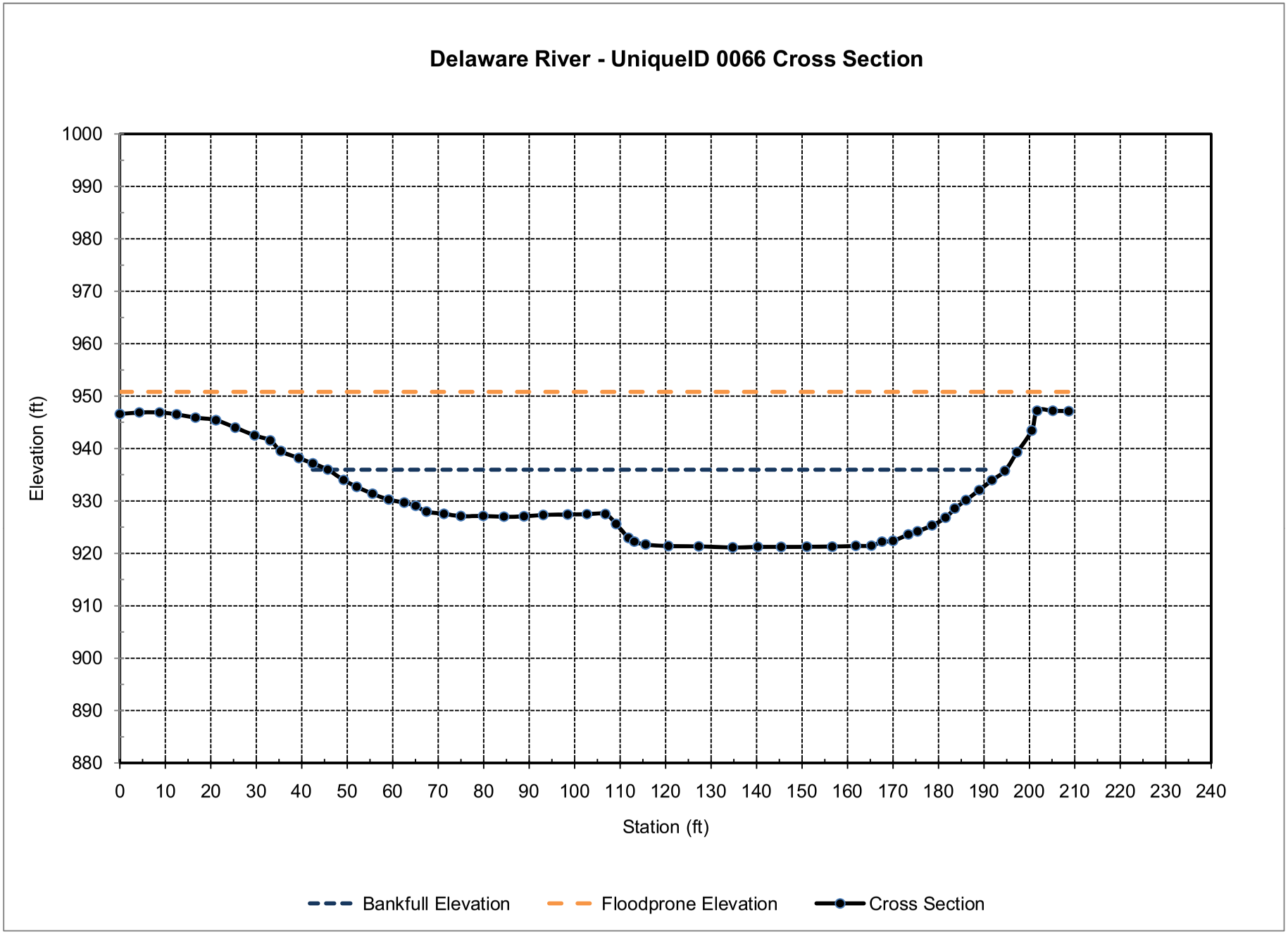
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		31.8

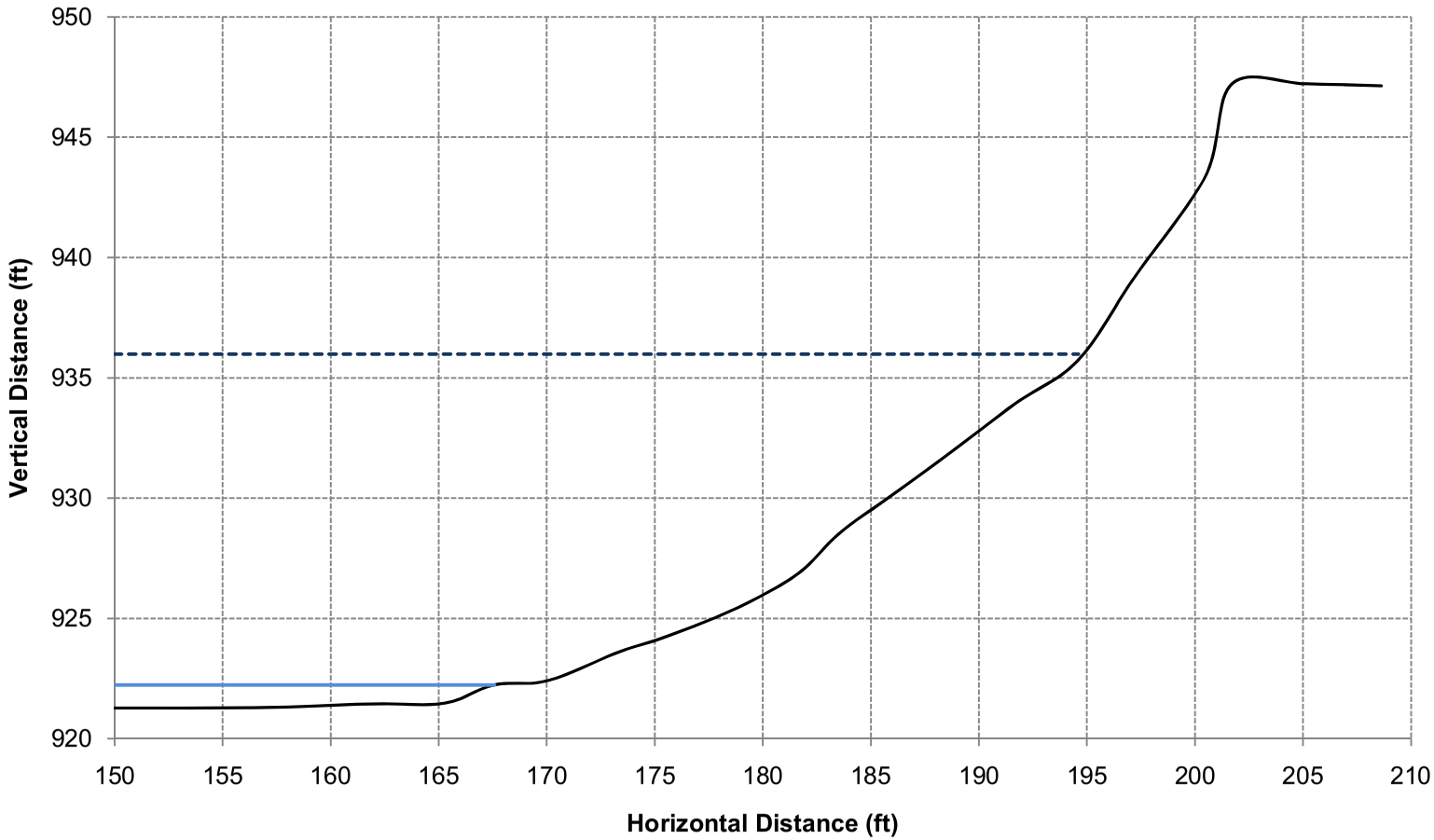




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0066 Cross Section
Elevation (ft)
1000
990
980
970
960
950
940
930
920
910
900
890
880
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


950
945
940
935
930
925
920
Vertical Distance (ft)
150
155
160
165
170
175
180
185
190
195
200
205
210
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0067

A-16 Delaware Hot-Spot UniqueID: 0067

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0067	29.5	Moderate	1.44	2.13

Description of Survey Site: This site has a narrow riparian corrdior that show signs of active slumping and seep erosion.

Length of Bank (feet): 433

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	0%	62%
Reduction of Rate of Erosion (tons/foot/year):	0.00	1.32
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$34,640	$34,640
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	0	572
***Cost of Soil Reduction Per Ton:**	**$10,392**	**$6.06**
***Cost of Soil Reduction Per Cubic Yard:**	**$13,510**	**$7.88**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume 1 cubic yard weighs 1.3 tons. For year 1 through 3, modeling results did not produce an erosion reduction; therefore 3 years of BMP installation costs were added to calculate the cost-benefits associated with year 1 through 3.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 31-Aug-09
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0067
County: Atchison County
Legal Description: NE1/4 Sec 20 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	25	Feet	Pasture	
	Crop field			Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	189.3	Feet
	Edge of Water to Edge of Water	54.5	Feet
Water Depth:	Thalweg	1.1	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 23.9 Feet (Measure)
Root Depth of Riparian Vegetation: 10.8 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 47 degrees.
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	

Eroding Bank Length: 433 Feet

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.85 Average Feet / year

Comments on Erosion:

View of the left bank (in background).

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0067**	Location:	**Atchison County**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **08/31/09**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	23.9 (A)	Bankfull Height (ft) =	13.9 (B)	(A) / (B) =	1.7 (C)	6.6
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	10.8 (D)	Study Bank Height (ft) =	23.9 (A)	(D) / (A) =	0.5 (E)	4.4
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	9.0 (G)	8.6
Bank Angle (H)						
				Bank Angle as *Degrees* =	47 (H)	3.3
Surface Protection (I)						
				Surface Protection as % =	30 (I)	5.9

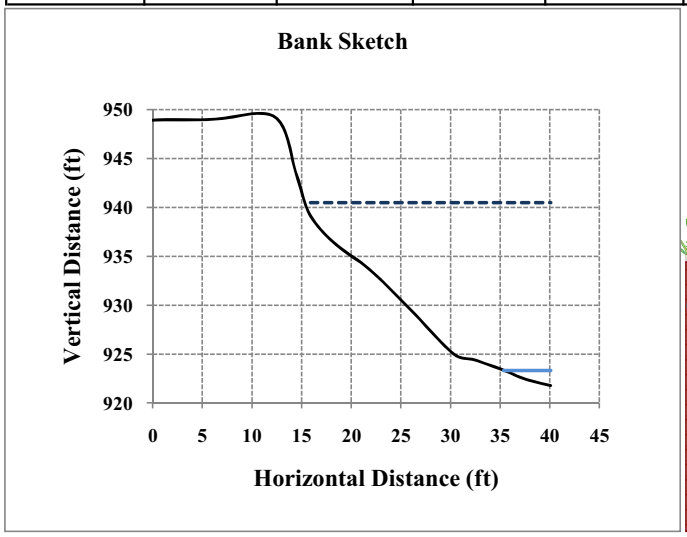
Bank Material Adjustment:

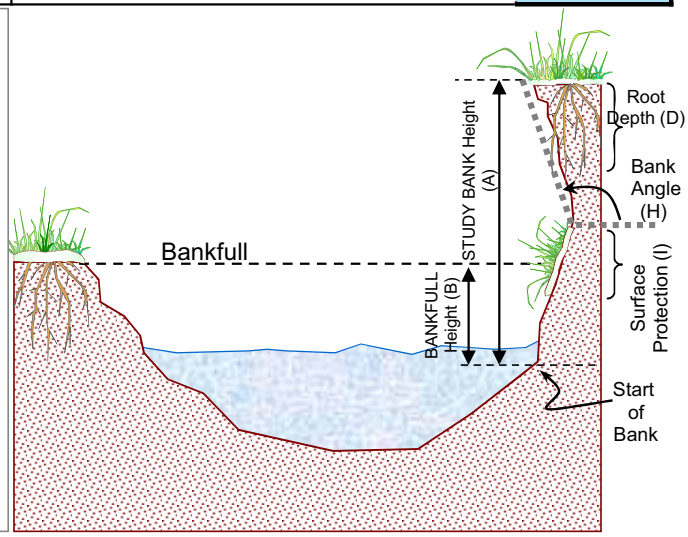
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0

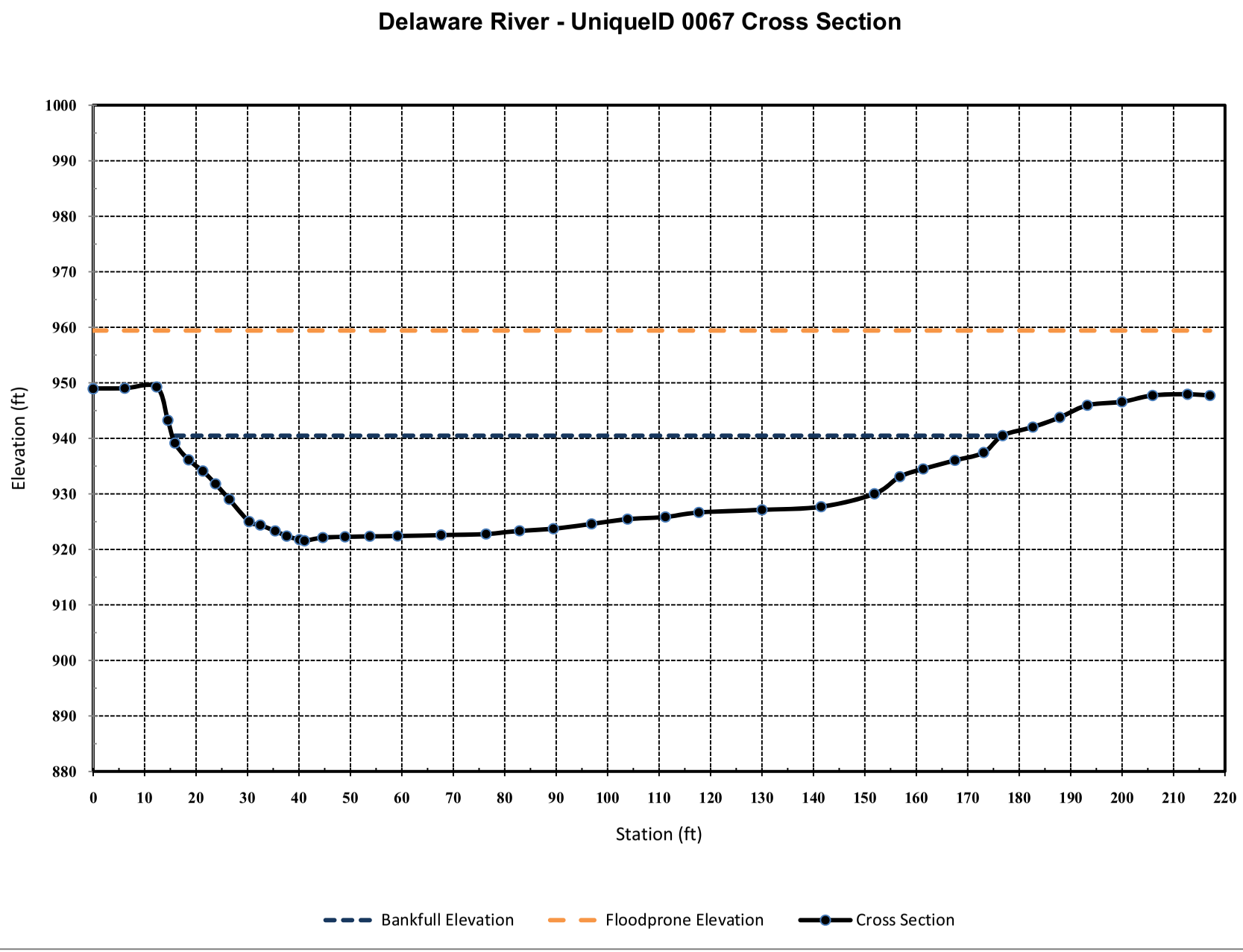
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		28.7

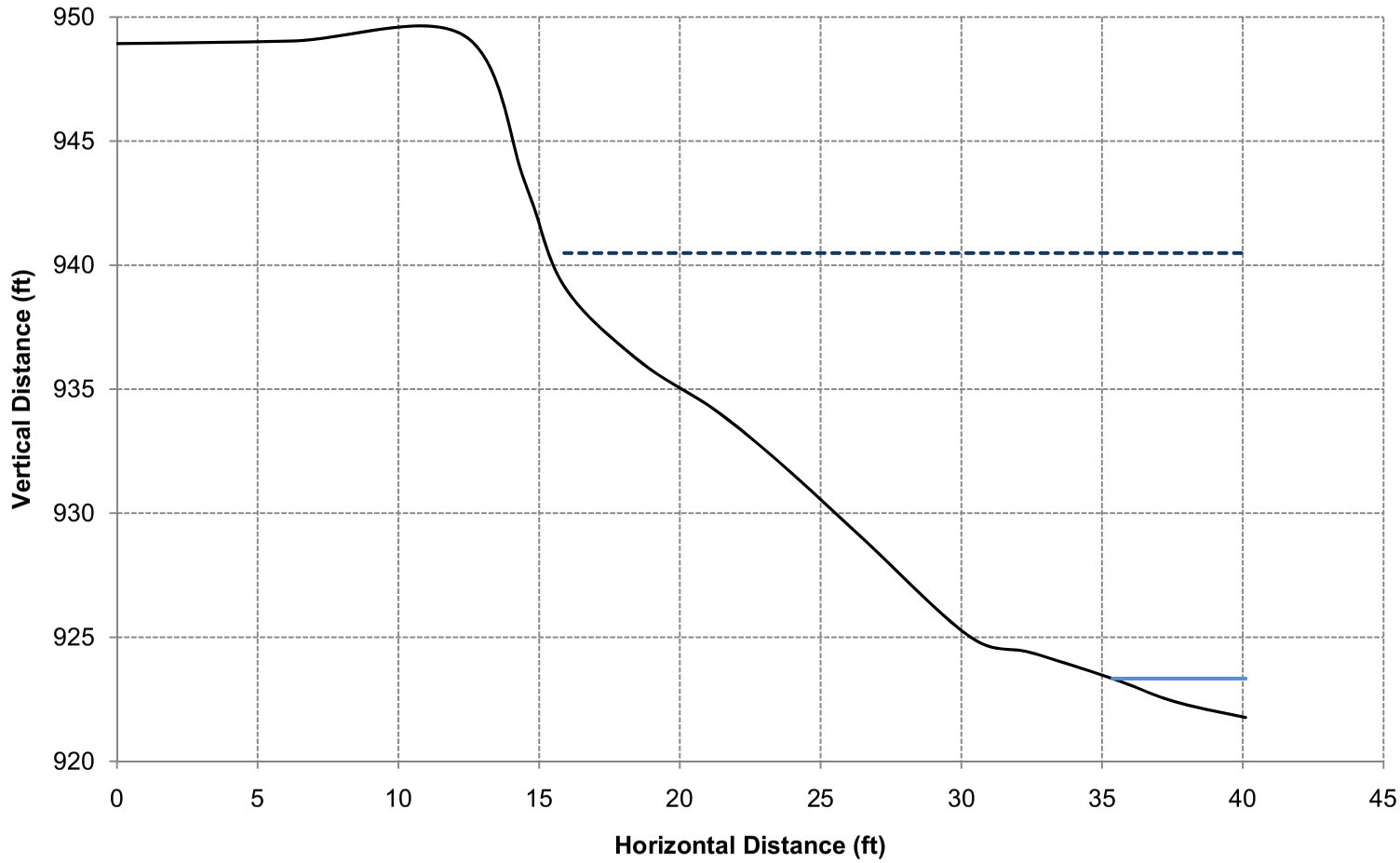




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0067 Cross Section
Elevation (ft)
1000
990
980
970
960
950
940
930
920
910
900
890
880
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


950
945
940
935
930
925
920
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0068

A-17 Delaware Hot-Spot UniqueID: 0068

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0068	31.8	High	1.41	1.41

Description of Survey Site: This site has steep banks with little wooded riparian vegetation. Bank materials are primarily silts.

Length of Bank (feet): 561

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	0.71	1.14
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$44,880	$44,880
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	396	641
***Cost of Soil Reduction Per Ton:**	**$11.35**	**$7.00**
***Cost of Soil Reduction Per Cubic Yard:**	**$14.75**	**$9.11**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 31-Aug-09
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0068
County: Atchison County
Legal Description: NW1/4 Sec 21 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	200.4	Feet
	Edge of Water to Edge of Water	47.5	Feet
Water Depth:	Thalweg	1.8	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 23.9 Feet (Measure)
Root Depth of Riparian Vegetation: 10.8 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 47 degrees.
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		561	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.22 Average Feet / year

Comments on Erosion:

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0068**	Location:	**Atchison county**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **08/31/09**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	23.9 (A)	Bankfull Height (ft) =	13.9 (B)	(A) / (B) =	1.7 (C)	6.6
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	10.8 (D)	Study Bank Height (ft) =	23.9 (A)	(D) / (A) =	0.5 (E)	4.4
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	9.0 (G)	8.6
Bank Angle (H)						
				Bank Angle as *Degrees* =	47 (H)	3.3
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9

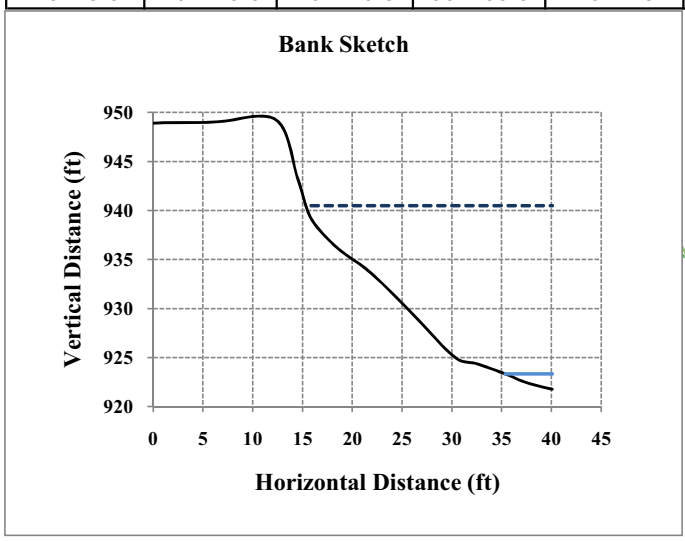
Bank Material Adjustment:

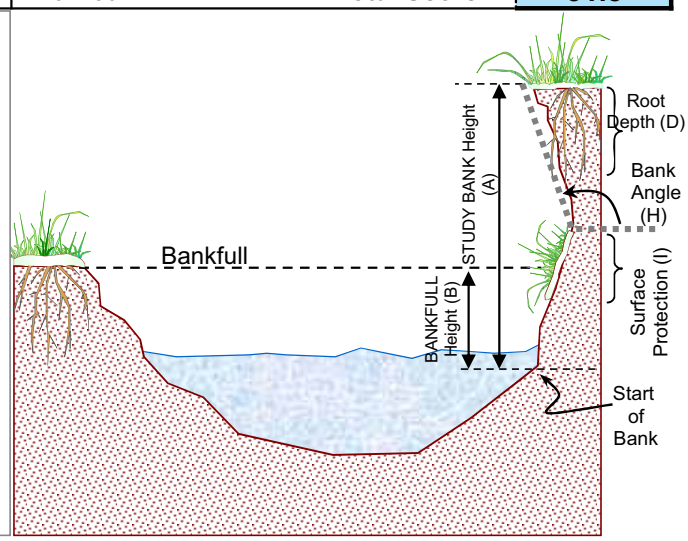
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0

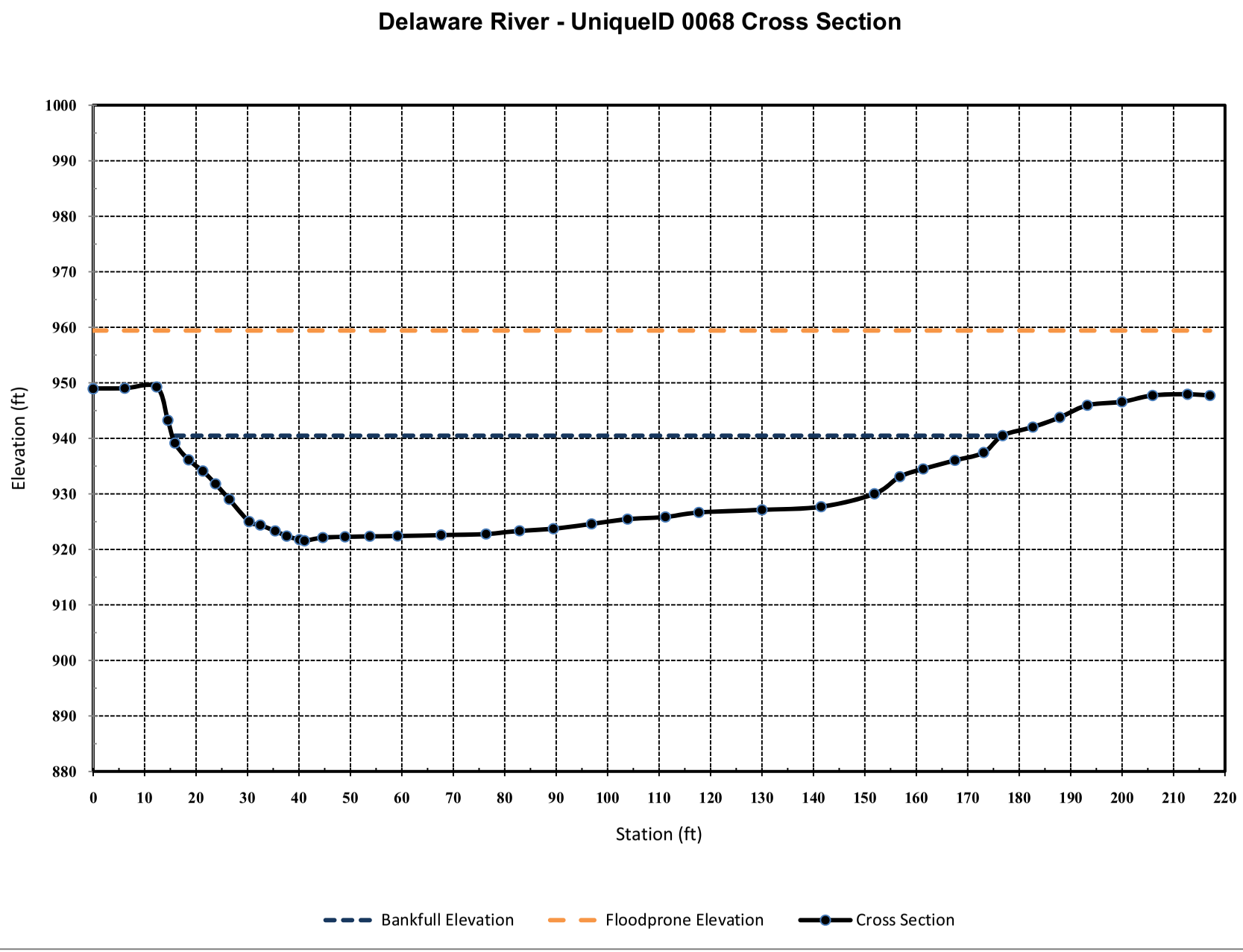
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		31.8

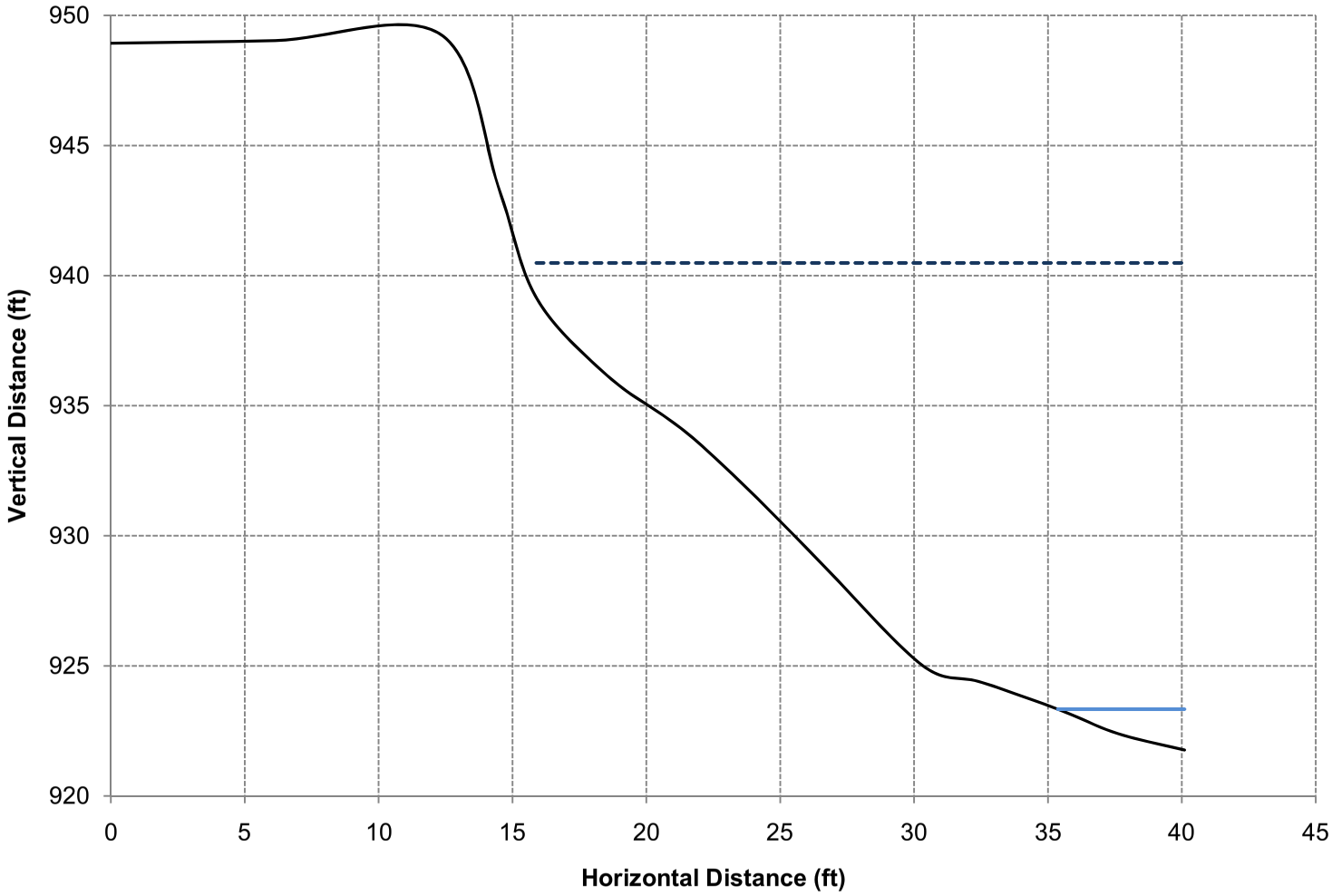




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0068 Cross Section
Elevation (ft)
1000
990
980
970
960
950
940
930
920
910
900
890
880
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


950
945
940
935
930
925
920
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0069

A-18 Delaware Hot-Spot UniqueID: 0069:

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0069	41.90	Very High	1.46	1.82

Description of Survey Site: This site has no riparian corridor. A small tributary enters the stream on the downstream end. Bank materials are primarily silts..

Length of Bank (feet): 560

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	82%
Reduction of Rate of Erosion (tons/foot/year):	0.91	1.49
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$44,800	$44,800
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	510	836
***Cost of Soil Reduction Per Ton:**	**$8.79**	**$5.36**
***Cost of Soil Reduction Per Cubic Yard:**	**$11.43**	**$6.97**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 18-Nov-10
14 Digit HUC: 10270103020050
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Afilliation(s): Gulf South Resaerch Corporation, Watershed Institute, Inc.

Location: Site Number: 0069
County: Atchison County
Legal Description: SE 1/4 Sec 16 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Cropfield	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	313.5	Feet
	Edge of Water to Edge of Water	55.6	Feet
Water Depth:	Thalweg	1.8	Feet

Livestock access to Riparian Area **Yes** _____ **No** X
If yes, what is the duration in months per year? _____

Debris or Channel Blockages **Yes** _____ **No** X

Buildings or Structures Threatened **Yes** _____ **No** X
If yes, what is their distance from the streambank? _____ Feet

Bank Erosion Inventory

Average Bank Height: 25.6 Feet (Measure)
Root Depth of Riparian Vegetation: 1.3 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 38 degrees.
	Vertical		Acitve seeps observed in bank.
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		560	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.46 Average Feet / year

Comments on Erosion:

View of the left bank.

View of slump at downstream end.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0069**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/18/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	25.6 (A)	Bankfull Height (ft) =	10.2 (B)	(A) / (B) =	2.5 (C)	8.6
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	1.3 (D)	Study Bank Height (ft) =	25.6 (A)	(D) / (A) =	0.1 (E)	9.0
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	1.0 (G)	10.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	74 (H)	5.3
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

Bank Material Adjustment:

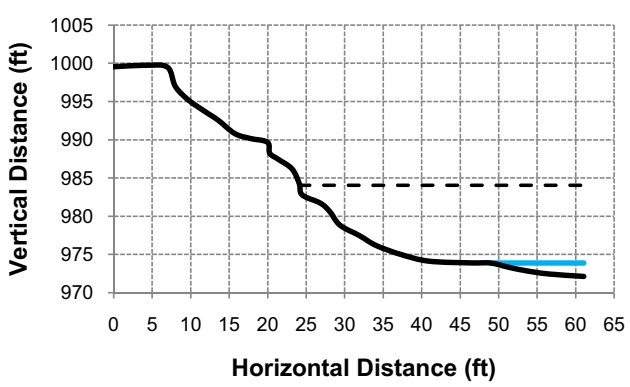
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

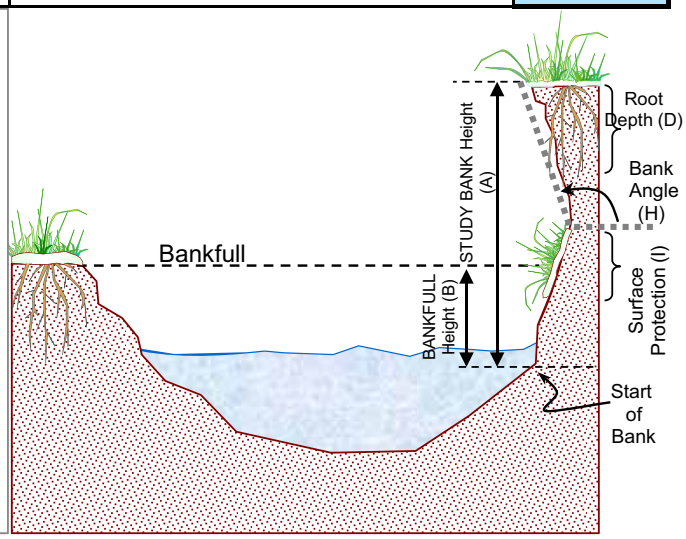
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

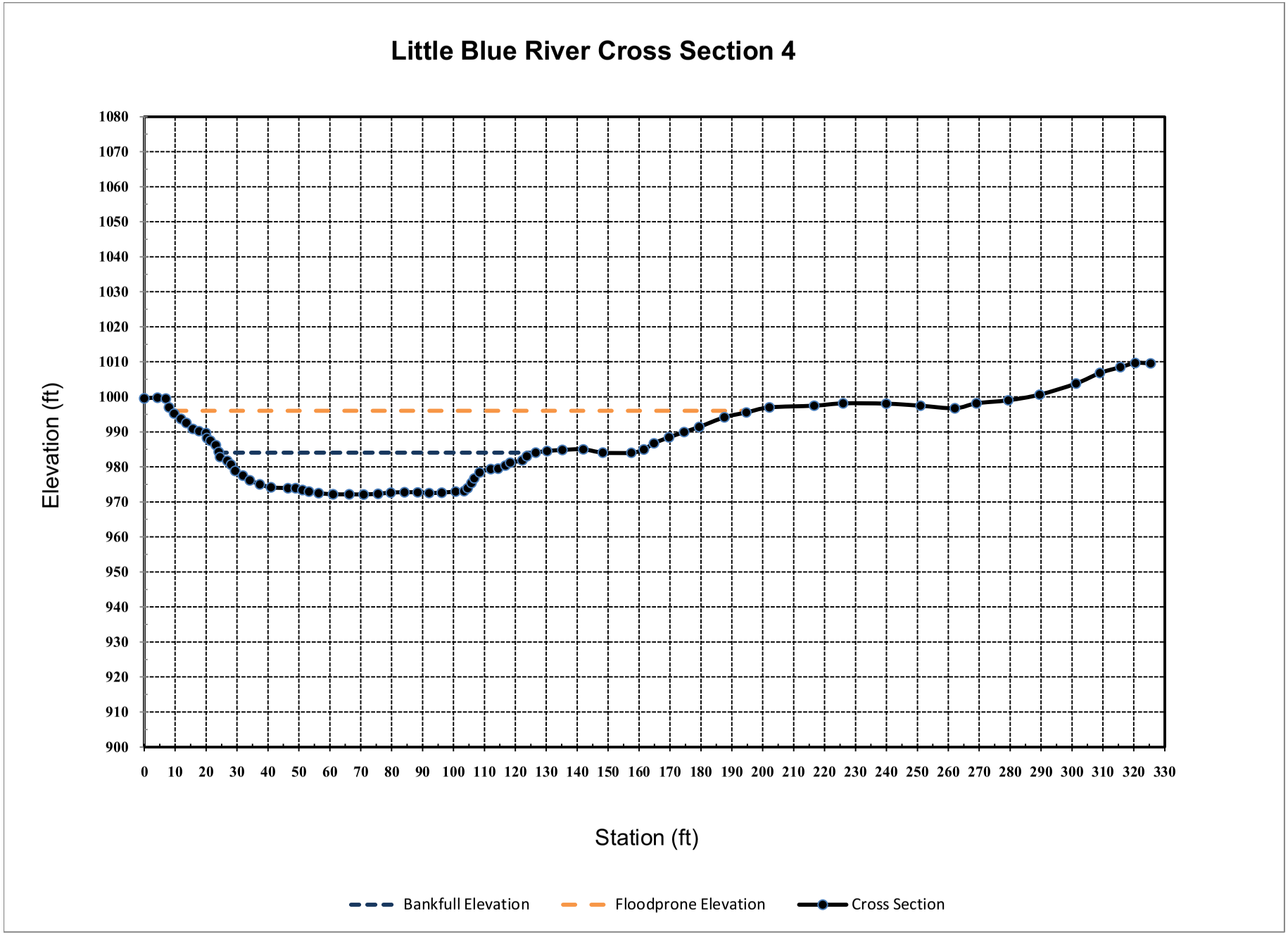
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Very High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		41.9

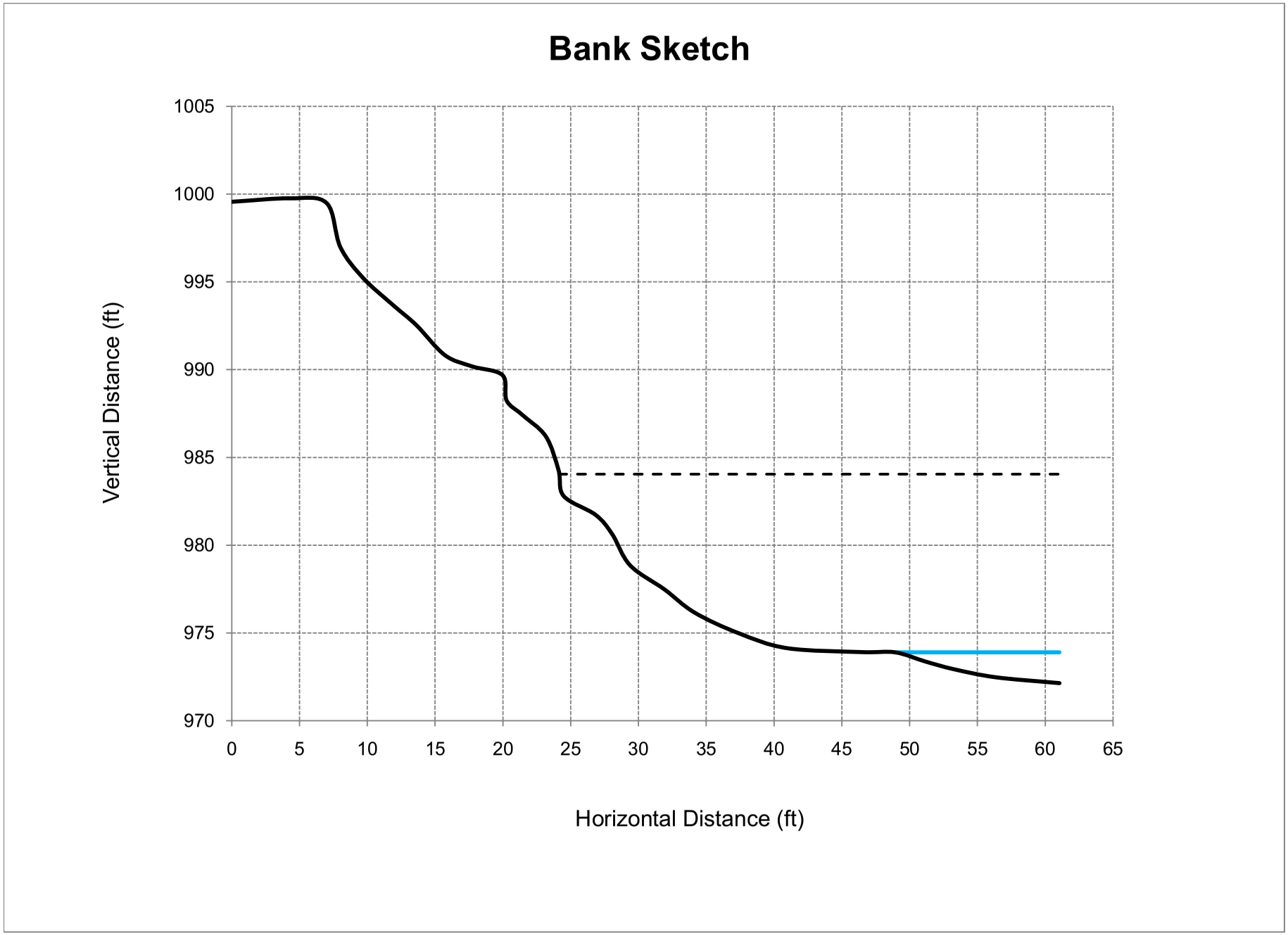
Bank Sketch





Copyright © 2006 Wildland Hydrology


Little Blue River Cross Section 4
Elevation (ft)
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
920
910
900
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
Vertical Distance (ft)
1005
1000
995
990
985
980
975
970
0
5
10
15
20
25
30
35
40
45
50
55
60
65
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0070

A-19 Delaware Hot-Spot UniqueID: 0070

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0070	37.7	High	1.98	3.44

Description of Survey Site: This site has no ripaian cooridor. Overland flow is creating some erosion. The lower portion of the bank is saturated. Bank matarials are mainly silts.

Length of Bank (feet): 971

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	83%	94%
Reduction of Rate of Erosion (tons/foot/year):	2.86	3.23
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$77,680	$77,680
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	2772	3140
***Cost of Soil Reduction Per Ton:**	**$2.80**	**$2.47**
***Cost of Soil Reduction Per Cubic Yard:**	**$3.64**	**$3.22**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 18-Nov-10
14 Digit HUC: 10270103020050
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0070
County: Atchison County
Legal Description: NW 1/4 Sec16 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	286.2	Feet
	Edge of Water to Edge of Water	57.6	Feet
Water Depth:	Thalweg	3.1	Feet

Livestock access to Riparian Area **Yes** _____ **No** X
If yes, what is the duration in months per year? _____

Debris or Channel Blockages **Yes** _____ **No** X

Buildings or Structures Threatened **Yes** _____ **No** X
If yes, what is their distance from the streambank? _____ Feet

Bank Erosion Inventory

Average Bank Height: 27.2 Feet (Measure)
Root Depth of Riparian Vegetation: 1.4 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 27 degrees.
	Vertical		Active seeps observed in banks.
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		971	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 2.63 Average Feet / year

Comments on Erosion:

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0070**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/18/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	27.2 (A)	Bankfull Height (ft) =	16.1 (B)	(A) / (B) =	1.7 (C)	6.4
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	1.4 (D)	Study Bank Height (ft) =	27.2 (A)	(D) / (A) =	0.1 (E)	9.0
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	1.0 (G)	10
Bank Angle (H)						
				Bank Angle as *Degrees* =	35 (H)	2.7
Surface Protection (I)						
				Surface Protection as % =	25 (I)	6.5

Bank Material Adjustment:

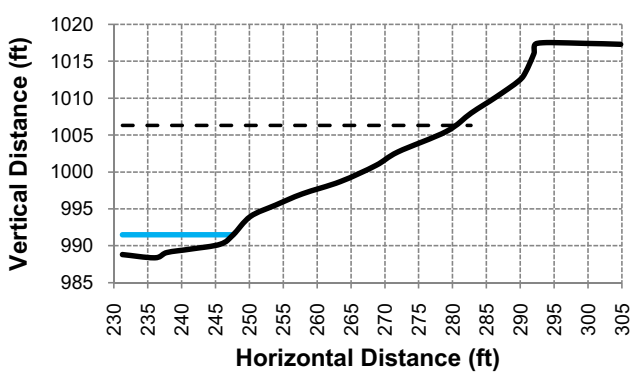
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

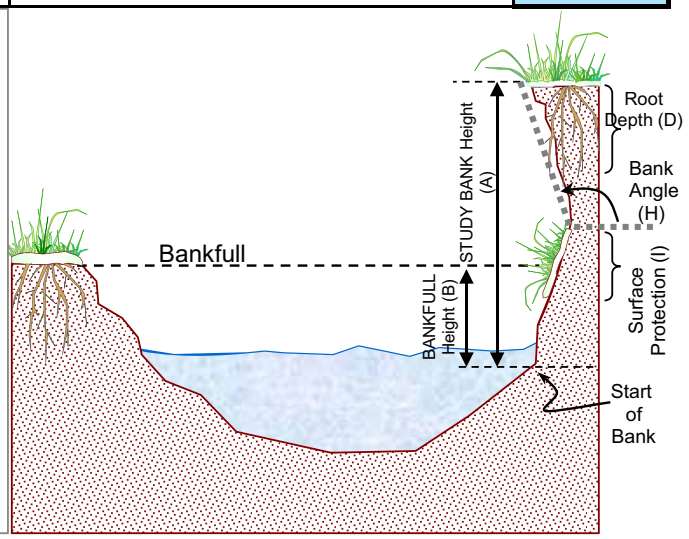
Bank Material Adjustment 3.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

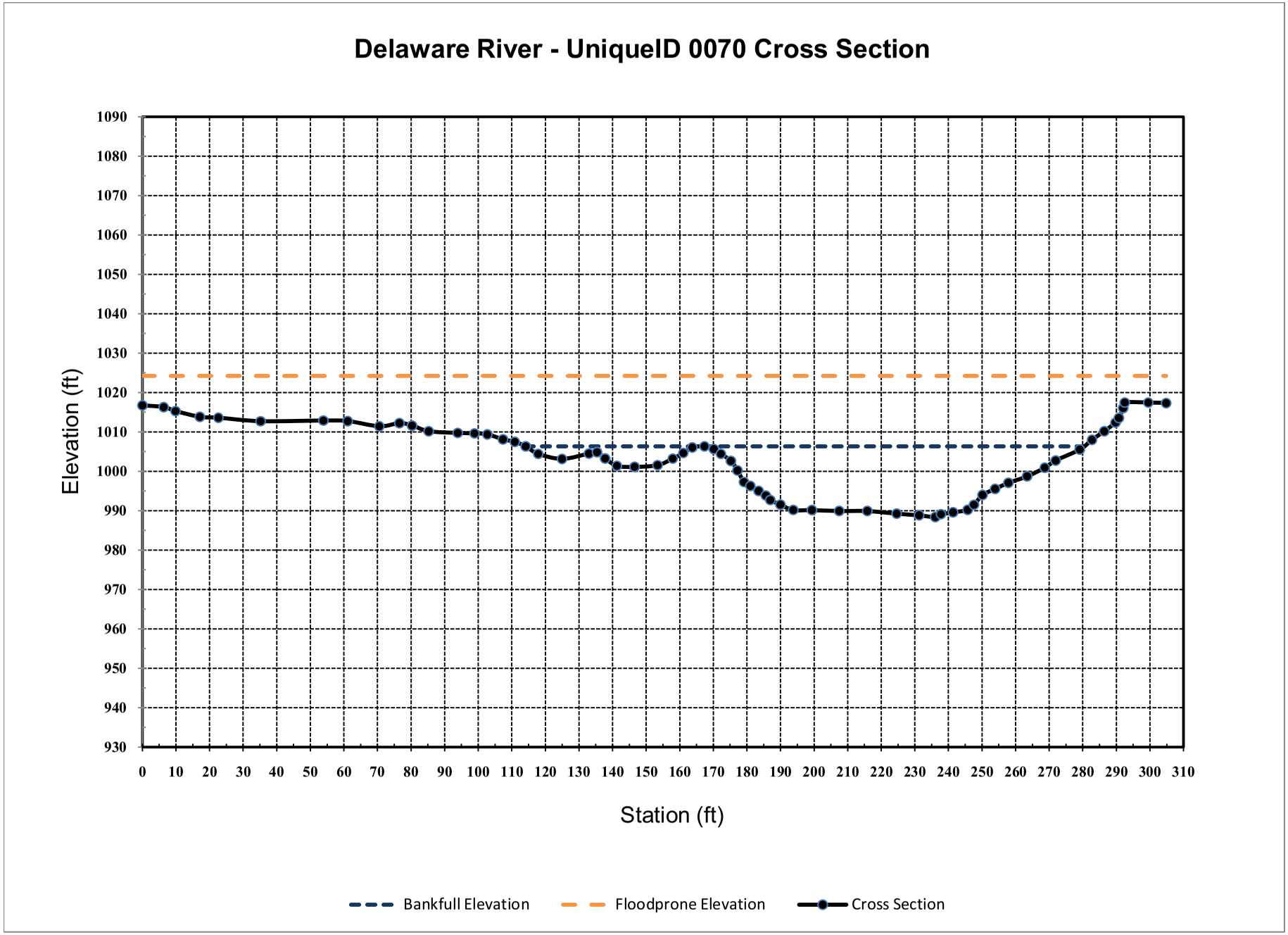
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		37.7

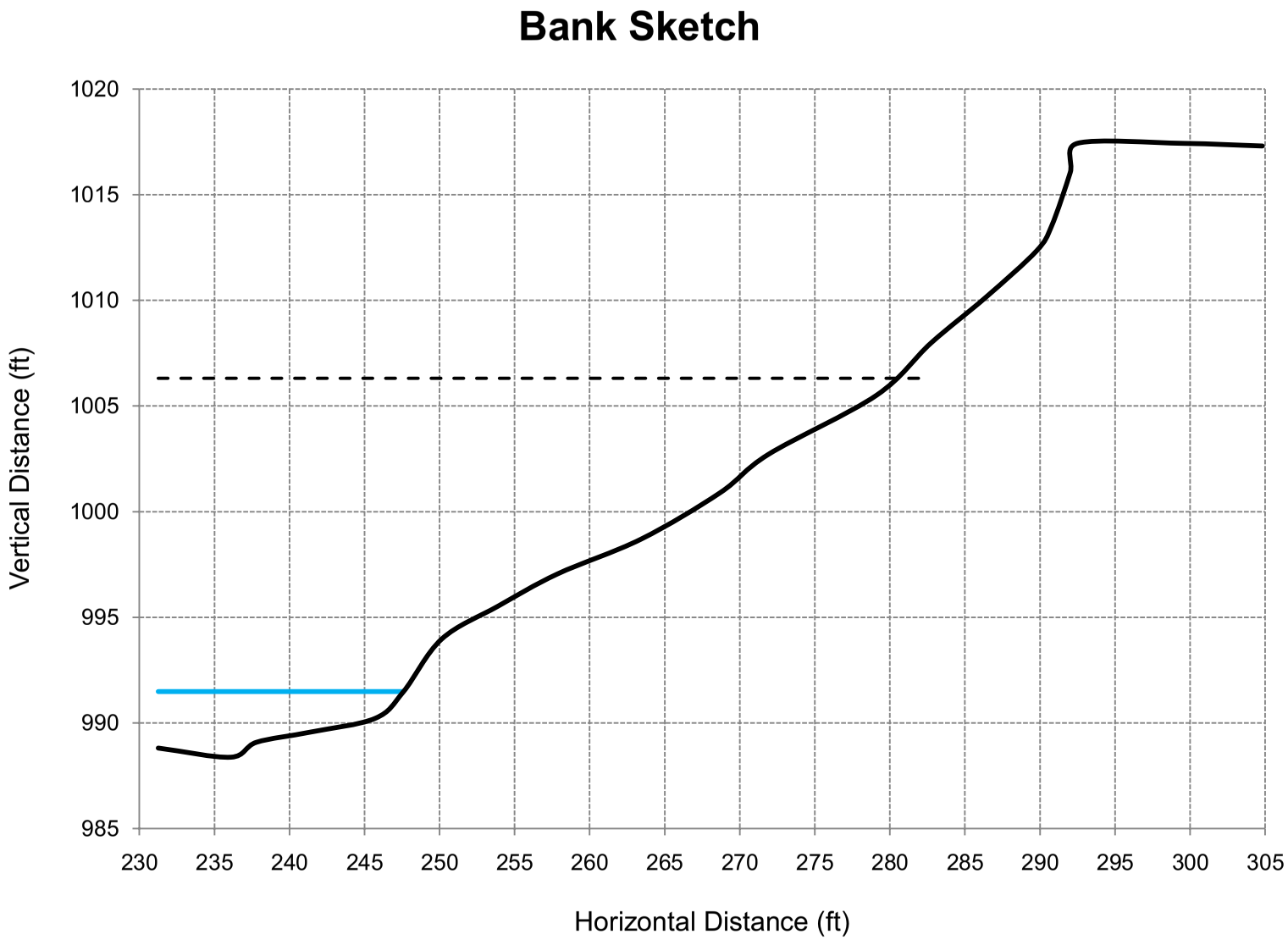
Bank Sketch





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0070 Cross Section
Elevation (ft)
1090
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
Vertical Distance (ft)
1020
1015
1010
1005
1000
995
990
985
230
235
240
245
250
255
260
265
270
275
280
285
290
295
300
305
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0072

A-20 Delaware Hot-Spot UniqueID: 0072

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0072	35.2	High	1.37	1.46

Description of Survey Site: This site has no riparian corridor. Banks are actively slumping. Tension cracks are visible on the top of bank.

Length of Bank (feet): 481

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	0.73	1.18
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$38,480	$38,480
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	351	569
***Cost of Soil Reduction Per Ton:**	**$10.96**	**$6.76**
***Cost of Soil Reduction Per Cubic Yard:**	**$14.25**	**$8.79**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 18-Nov-10
14 Digit HUC: 10270103020050
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Afilliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0072
County: Atchison County
Legal Description: SE 1/4 Sec 9 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Cropfield	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	NA	Feet
	Edge of Water to Edge of Water	52.2	Feet
Water Depth:	Thalweg	1.5	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?			Feet	

Bank Erosion Inventory

Average Bank Height: 25.9 Feet (Measure)
Root Depth of Riparian Vegetation: 2.3 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 22 degrees.
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		481	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.17 Average Feet / year

Comments on Erosion:

View of left bank.

View of left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0072**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/18/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	25.9 (A)	Bankfull Height (ft) =	12 (B)	(A) / (B) =	2.2 (C)	8.1
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	2.3 (D)	Study Bank Height (ft) =	25.9 (A)	(D) / (A) =	0.1 (E)	8.6
Weighted Root Density (G)						
		Root Density as % =	10 (F)	(F) x (E) =	0.9 (G)	10.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	22 (H)	2.1
Surface Protection (I)						
				Surface Protection as % =	25 (I)	6.5

Bank Material Adjustment:

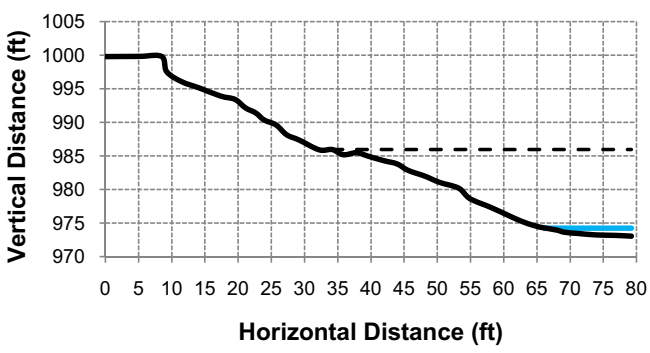
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

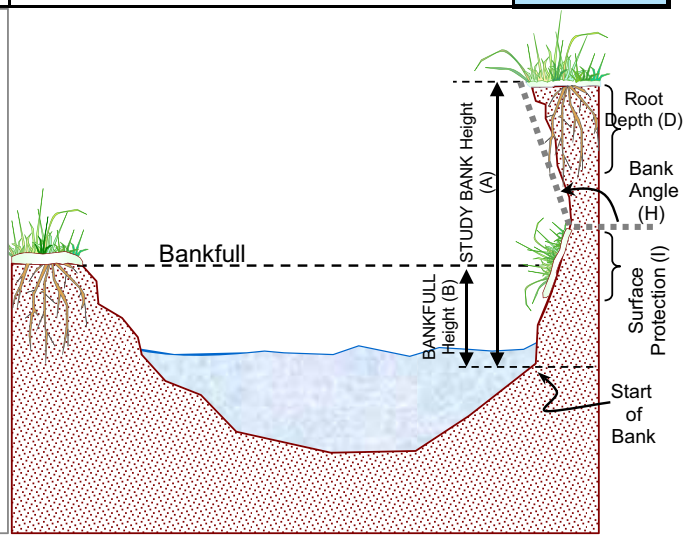
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

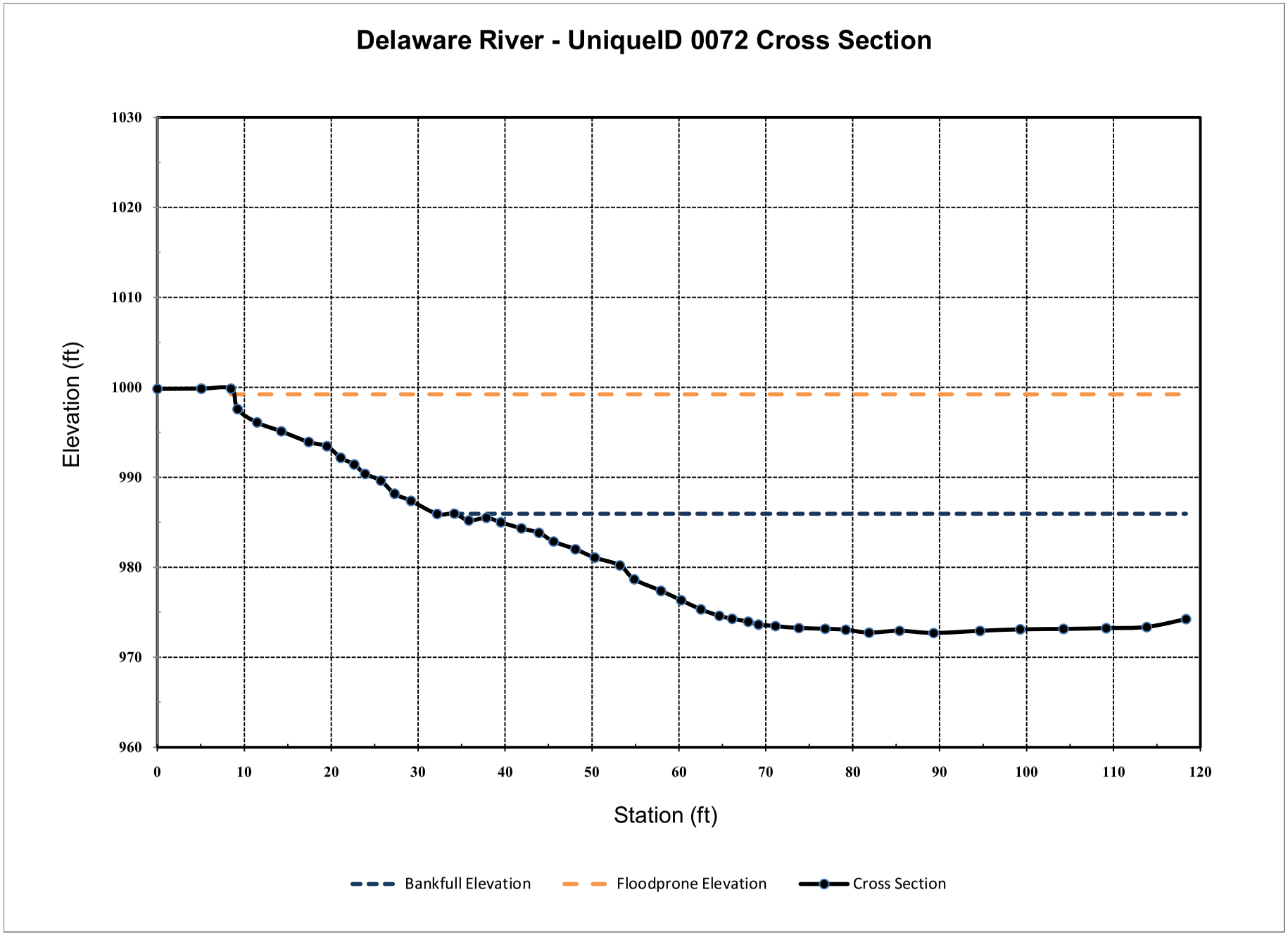
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		35.2

Bank Sketch

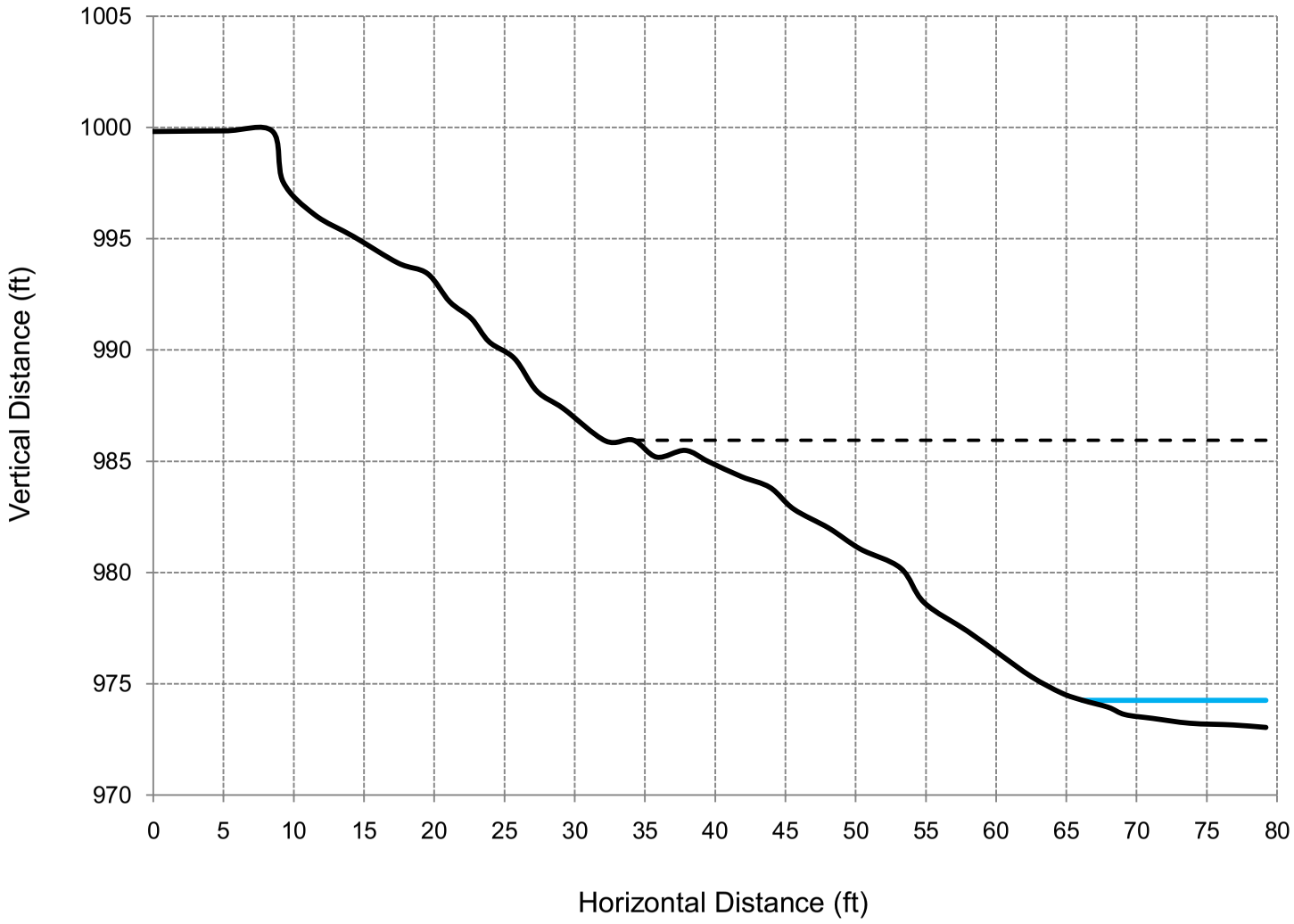




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0072 Cross Section
Elevation (ft)
1030
1020
1010
1000
990
980
970
960
0
10
20
30
40
50
60
70
80
90
100
110
120
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1005
1000
995
990
985
980
975
970
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0074

A-21 Delaware Hot-Spot UniqueID: 0074

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0074	39.3	High	1.38	2.57

Description of Survey Site: This site has no riparian corridor. Banks are actively slumping. Tension cracks are visible on the top of bank.

Length of Bank (feet): 635

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	1.29	2.08
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$50,800	$50,800
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	816	1322
***Cost of Soil Reduction Per Ton:**	**$6.23**	**$3.84**
***Cost of Soil Reduction Per Cubic Yard:**	**$8.09**	**$5.00**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 29-Dec-10
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0074
County: Atchison County
Legal Description: SE 1/4 Sec 31 T5S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	278.3	Feet
	Edge of Water to Edge of Water	32.2	Feet
Water Depth:	Thalweg	1.7	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 27 Feet (Measure)
Root Depth of Riparian Vegetation: 1.9 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 34 degrees.
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.
	Sand		.062-2 mm dia
	Gravels		.08 - 2.5 inches

Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles		2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders		10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock		

Eroding Bank Length: 635 Feet

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.98 Average Feet / year

Comments on Erosion:

View of tension crack on top of right bank.

View upstream from cross section.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0074**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**12/29/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	27 (A)	Bankfull Height (ft) =	12.8 (B)	(A) / (B) =	2.1 (C)	8.0
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	1.9 (D)	Study Bank Height (ft) =	27 (A)	(D) / (A) =	0.1 (E)	8.8
Weighted Root Density (G)						
		Root Density as % =	10 (F)	(F) x (E) =	0.7 (G)	10.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	31 (H)	2.5
Surface Protection (I)						
				Surface Protection as % =	0 (I)	10.0

Bank Material Adjustment:

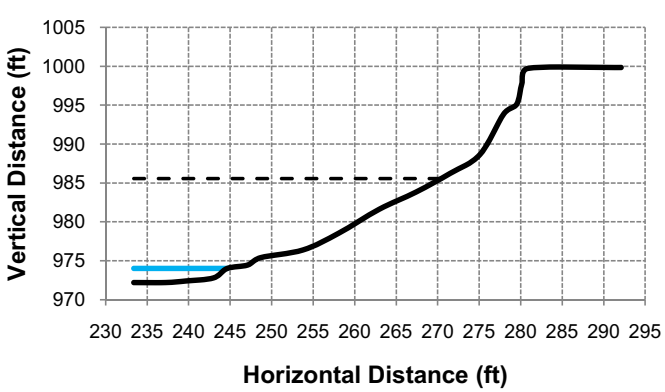
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

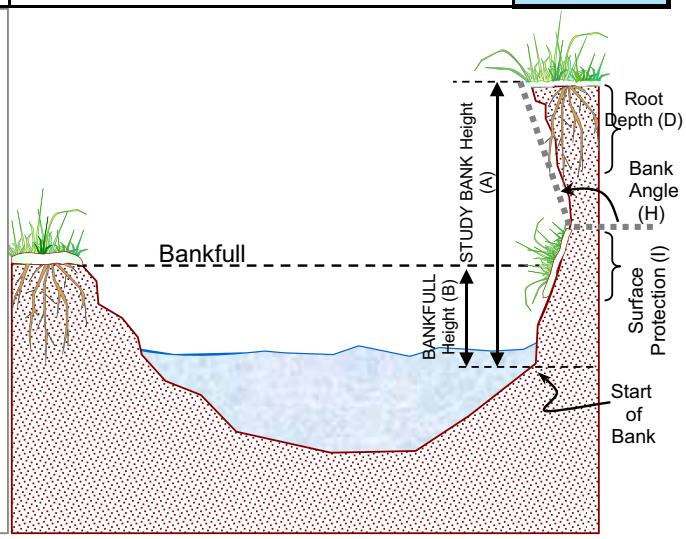
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

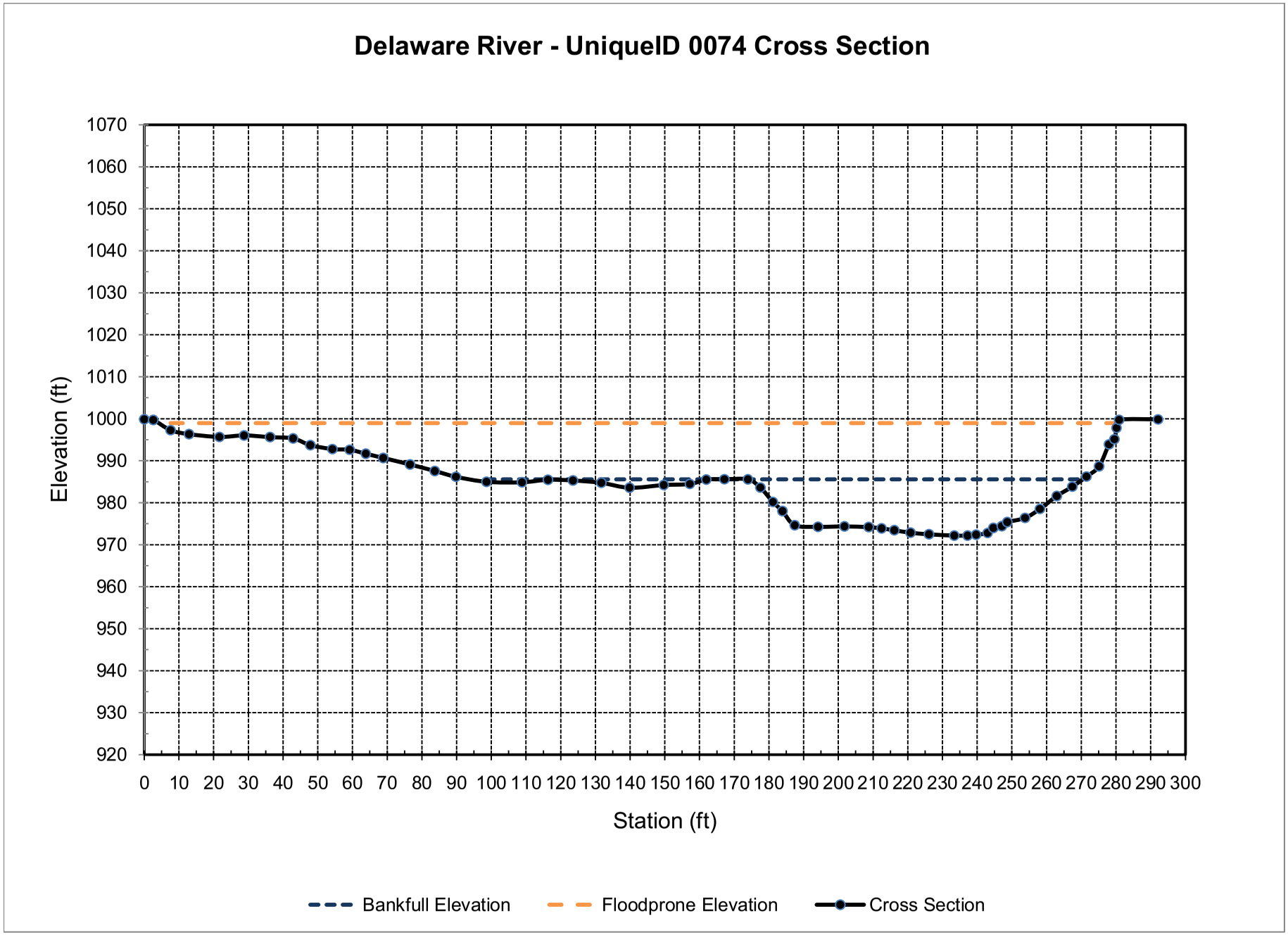
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		39.3

Bank Sketch

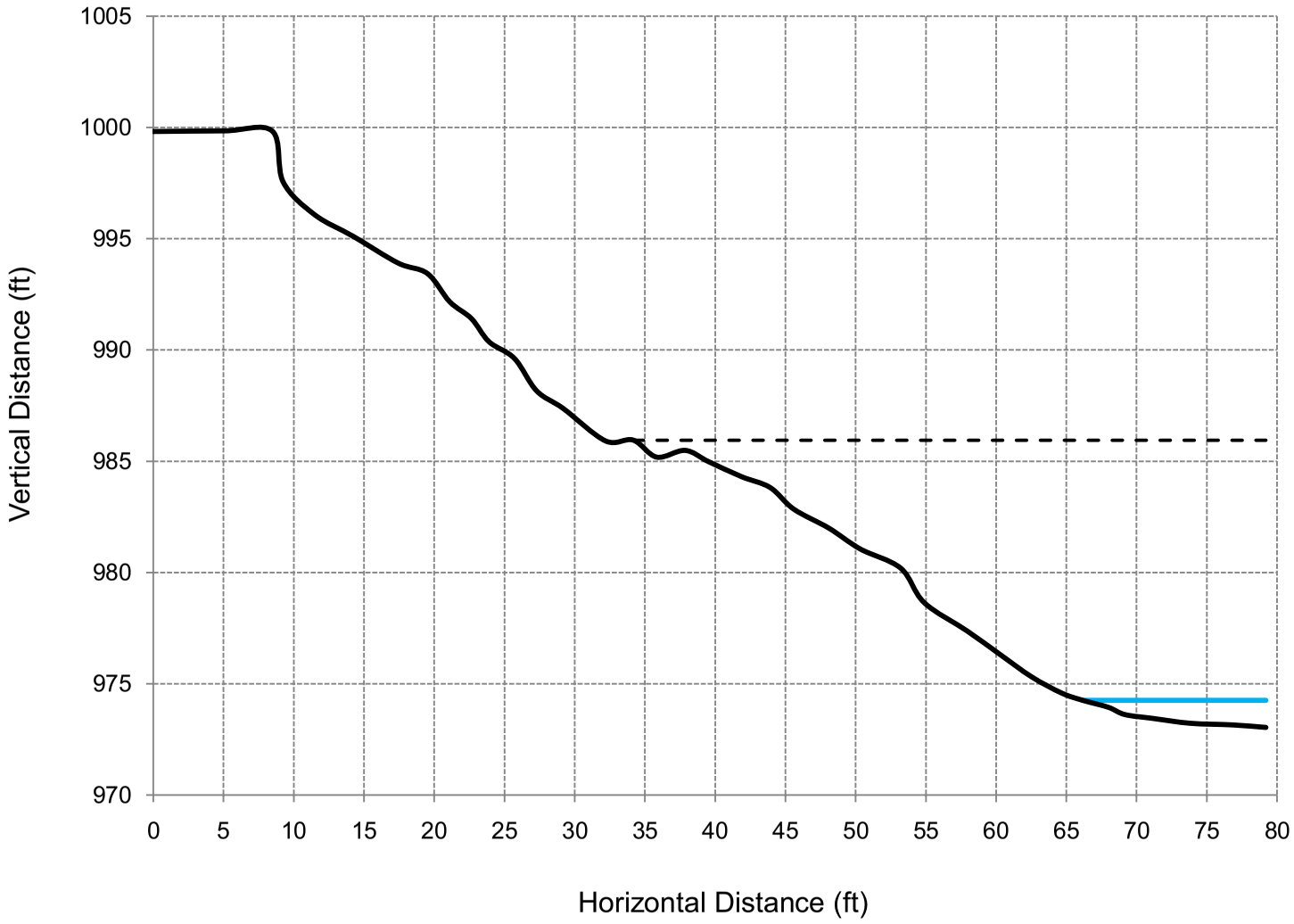




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0074 Cross Section
Elevation (ft)
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
920
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1005
1000
995
990
985
980
975
970
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0076

A-22 Delaware Hot-Spot UniqueID: 0076

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0076	19.7	Low	2.00	1.08

Description of Survey Site: This site begins just downstream from bedrock falls. Water is diverging downstream from falls, and a large well vegetated mid bar is now present. Velocities are strong along the right bank. On the right bank a large slump has formed due to seepage creating saturated banks along the bank toe.

Length of Bank (feet): 524

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	31%	74%
Reduction of Rate of Erosion (tons/foot/year):	0.33	0.80
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$41,920	$41,920
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	175	419
***Cost of Soil Reduction Per Ton:**	**$23.89**	**$10.01**
***Cost of Soil Reduction Per Cubic Yard:**	**$31.06**	**$13.01**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 30-Dec-10
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0076
County: Jackson County
Legal Description: SW1/4 Sec 30 T5S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	319.3	Feet
	Edge of Water to Edge of Water	35.2	Feet
Water Depth:	Thalweg	2.8	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 23.2 Feet (Measure)
Root Depth of Riparian Vegetation: 23.2 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 18 degrees.
	Vertical			Active seeps observed in banks.
	1H:1V			
	2H:1V	X		

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.			
	Sand		.062-2 mm dia			
	Gravels		.08 - 2.5 inches			
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles		2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders		10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock		

Eroding Bank Length: 524 Feet

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 0.97 Average Feet / year

Comments on Erosion: The river diverges into two channels just downstream from bedrock outcrop.

Photos not available

Photos not available

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0076**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**12/30/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	23.2 (A)	Bankfull Height (ft) =	11.5 (B)	(A) / (B) =	2.0 (C)	7.9
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	23.2 (D)	Study Bank Height (ft) =	23.2 (A)	(D) / (A) =	1.0 (E)	1.0
Weighted Root Density (G)						
		Root Density as % =	30 (F)	(F) x (E) =	30 (G)	5.9
Bank Angle (H)						
				Bank Angle as *Degrees* =	32 (H)	2.5
Surface Protection (I)						
				Surface Protection as % =	75 (I)	2.3

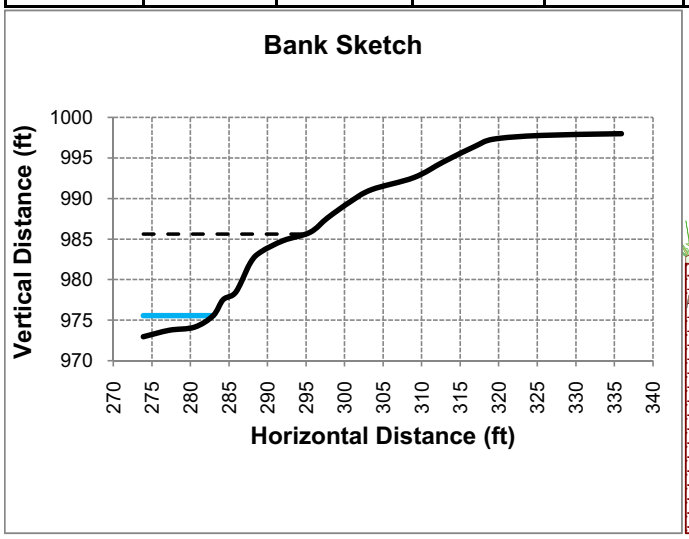
Bank Material Adjustment:

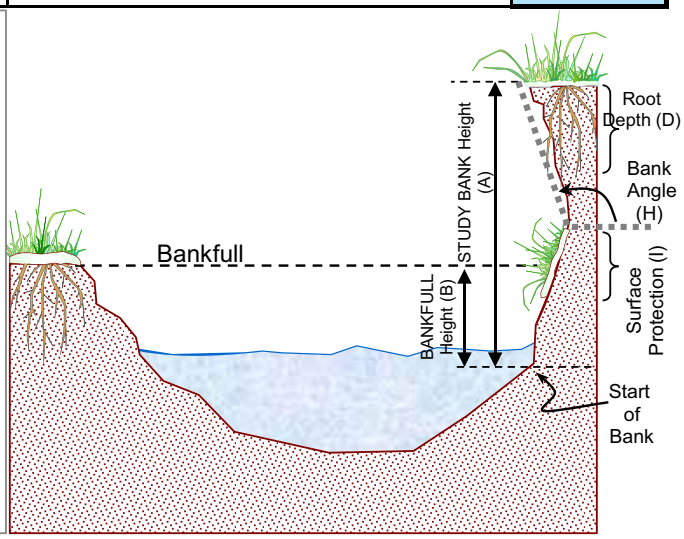
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0.0

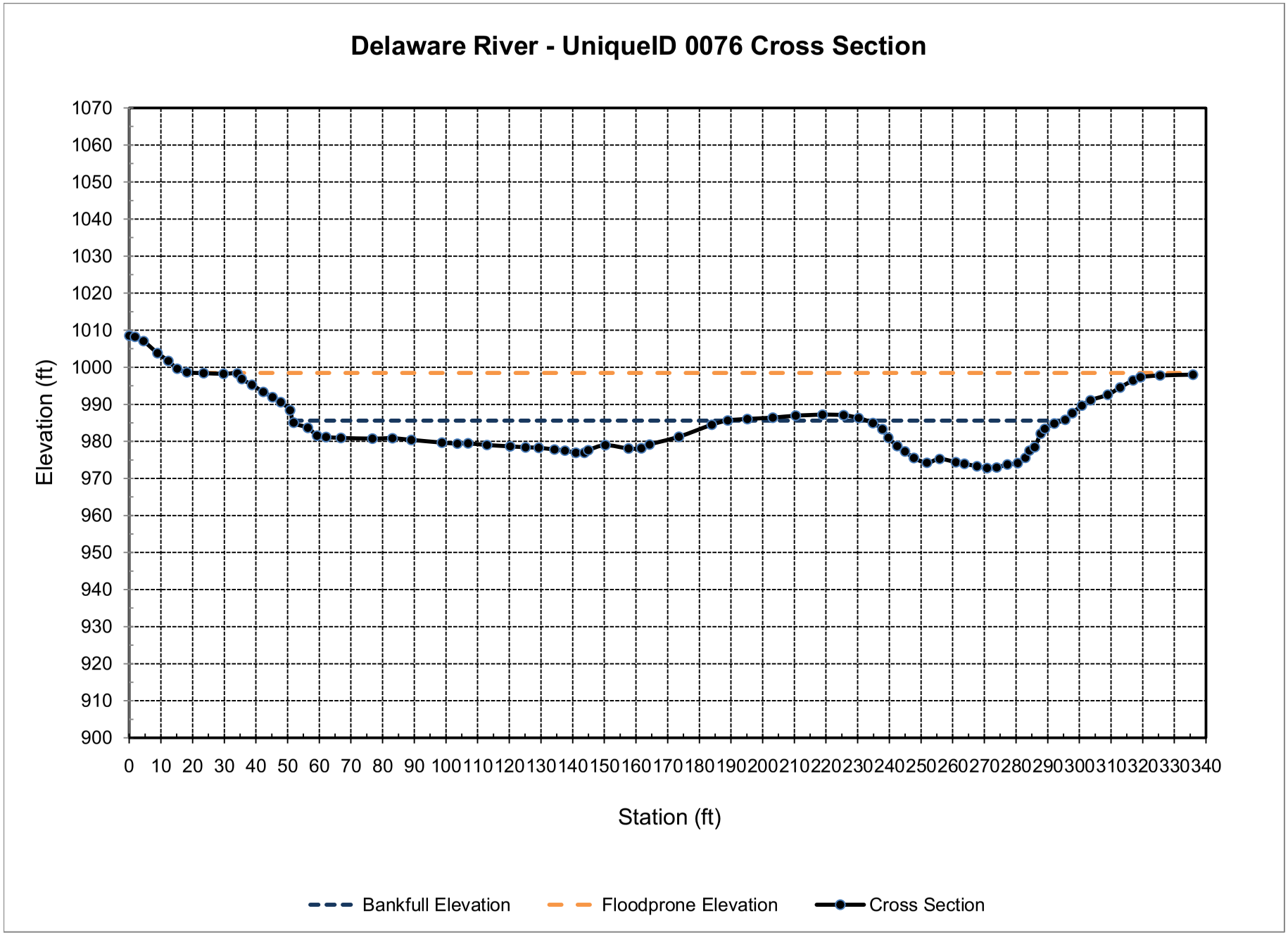
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

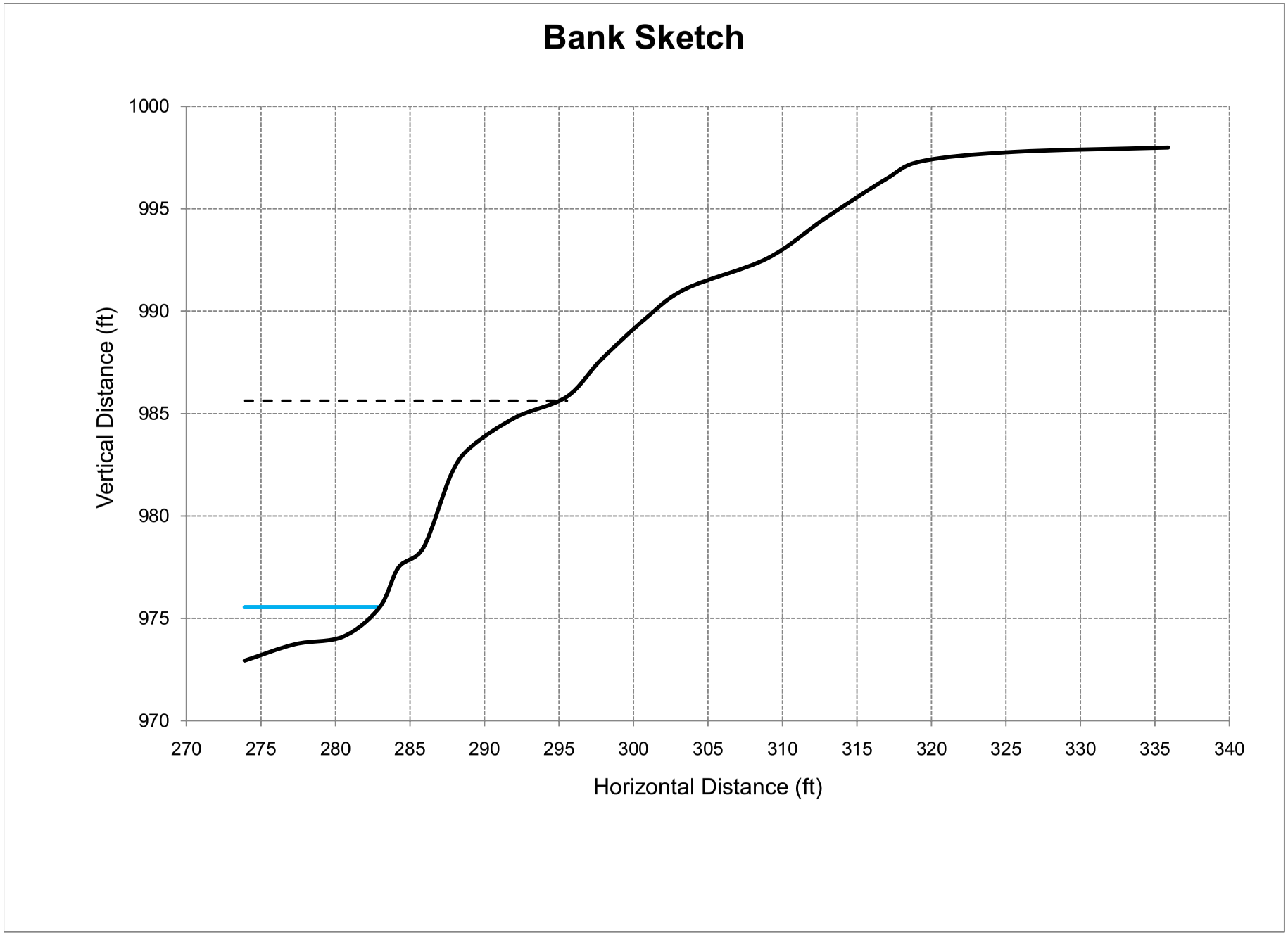
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Low
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		19.7





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0076 Cross Section
Elevation (ft)
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
920
910
900
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1000
995
990
985
980
975
970
Vertical Distance (ft)
270
275
280
285
290
295
300
305
310
315
320
325
330
335
340
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0077

A-23 Delaware Hot-Spot UniqueID: 0077

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0077	17.3	Low	1.51	0.66

Description of Survey Site: This site has a very narrow riparian corridor. Once this corridor has eroded away the erosion potential will dramatically increase.

Length of Bank (feet): 386

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	44%	44%
Reduction of Rate of Erosion (tons/foot/year):	0.29	0.29
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$30,880	$30,880
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	112	112
***Cost of Soil Reduction Per Ton:**	**$27.55**	**$27.55**
***Cost of Soil Reduction Per Cubic Yard:**	**$35.81**	**$35.81**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 18-Nov-10
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0077
County: Jackson County
Legal Description: NW 1/4 Sec 30 T5S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	219.7	Feet
	Edge of Water to Edge of Water	82.9	Feet
Water Depth:	Thalweg	3.8	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 21.3 Feet (Measure)
Root Depth of Riparian Vegetation: 21.3 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 23 degrees.
	Vertical			
	1H:1V	X		
	2H:1V			

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		386	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 0.64 Average Feet / year

Comments on Erosion:

View of left bank looking upstream.

View of left bank looking downstream.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0077**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/18/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	21.3 (A)	Bankfull Height (ft) =	14.8 (B)	(A) / (B) =	1.4 (C)	5.5
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	21.3 (D)	Study Bank Height (ft) =	21.3 (A)	(D) / (A) =	1.0 (E)	1.0
Weighted Root Density (G)						
		Root Density as % =	30 (F)	(F) x (E) =	30 (G)	5.9
Bank Angle (H)						
				Bank Angle as *Degrees* =	41 (H)	3.0
Surface Protection (I)						
				Surface Protection as % =	80 (I)	1.9

Bank Material Adjustment:

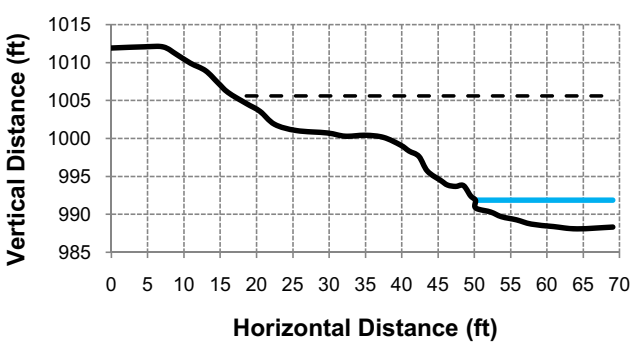
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

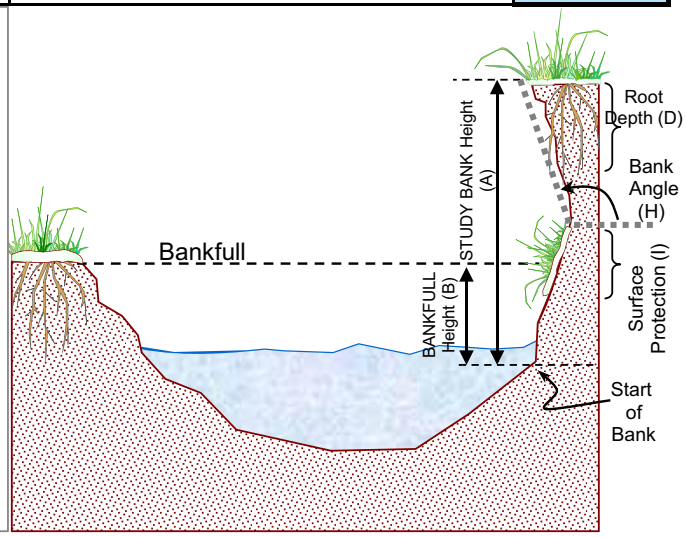
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

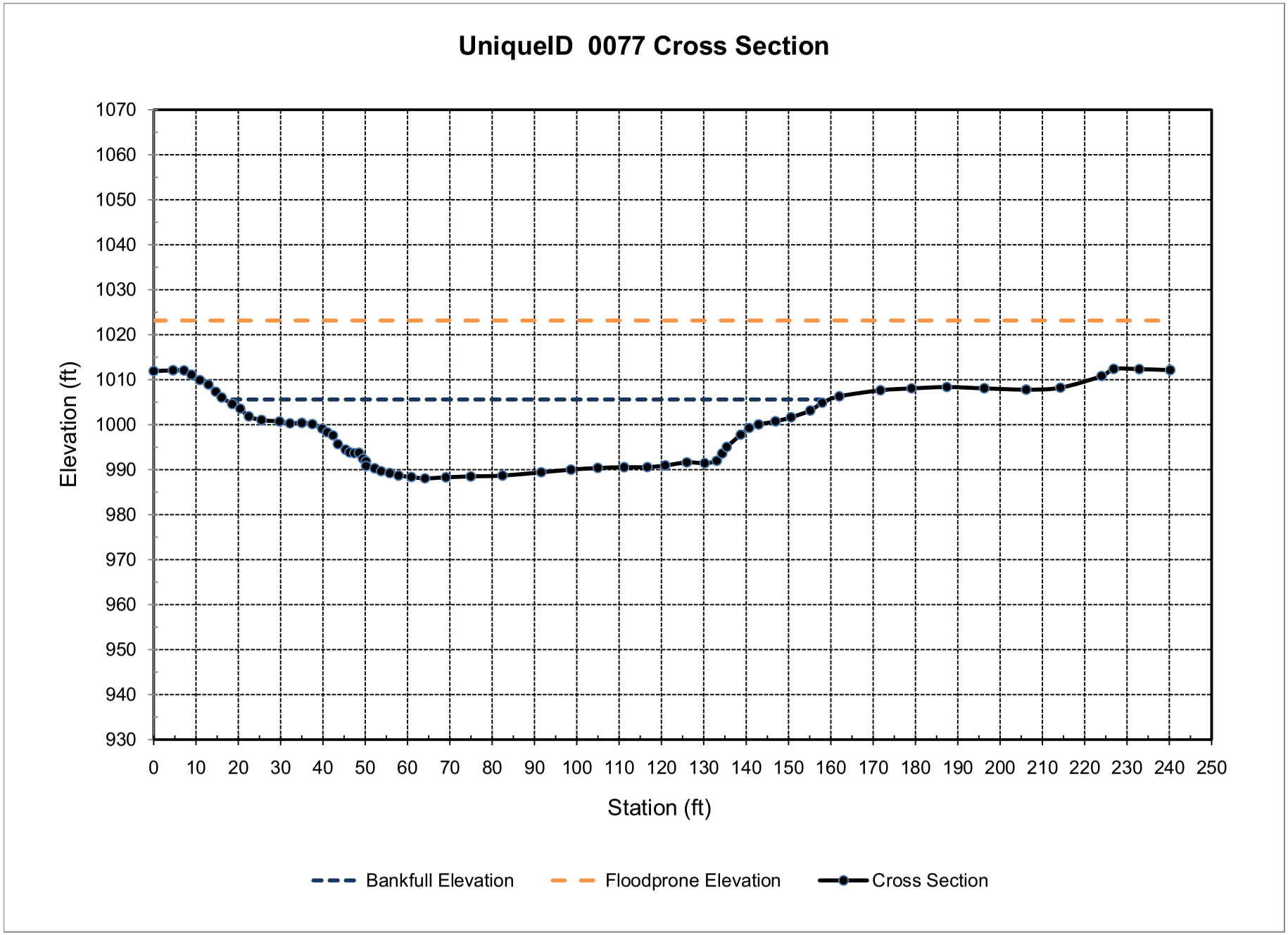
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Low
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		17.3

Bank Sketch

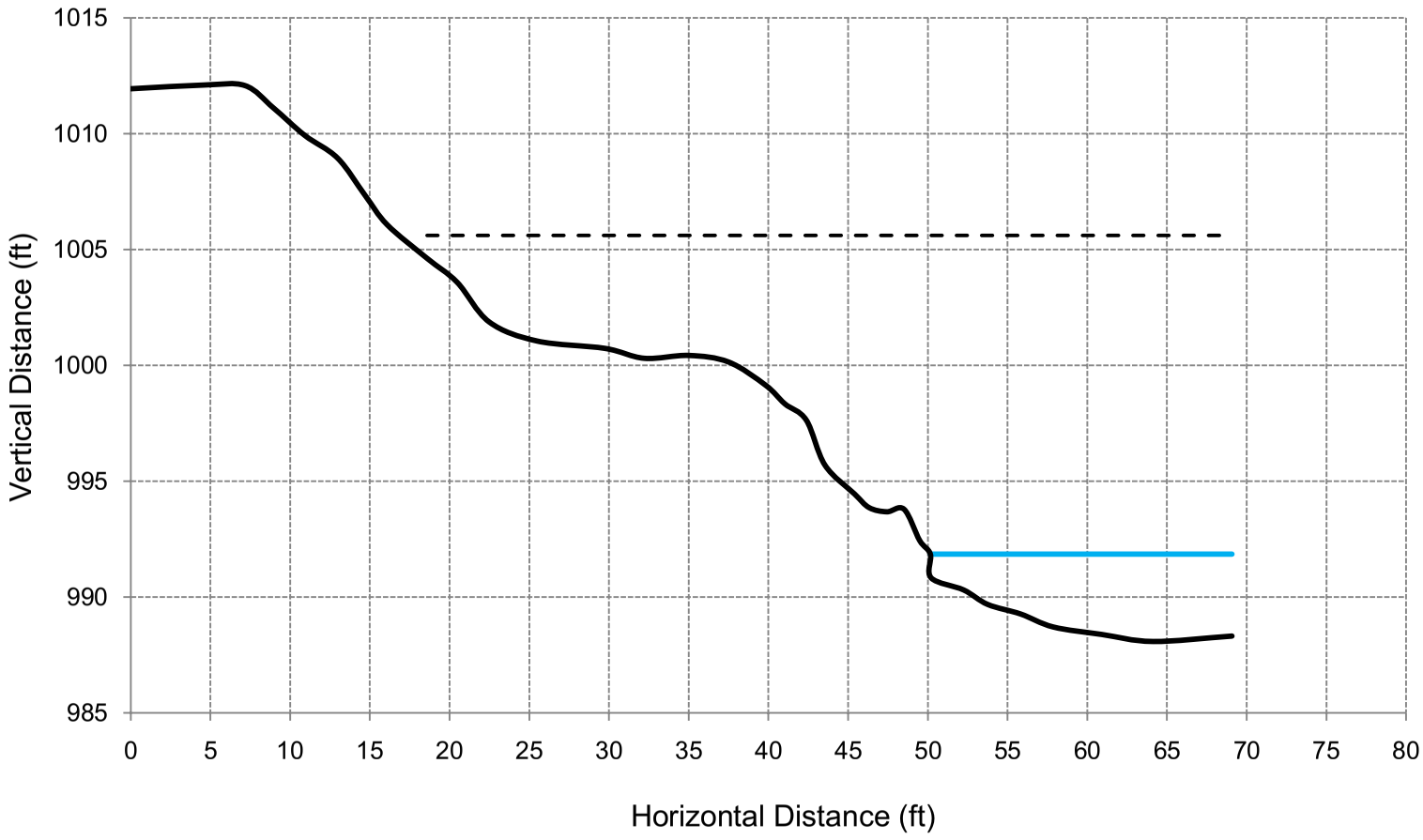




Copyright © 2006 Wildland Hydrology


UniqueID 0077 Cross Section
Elevation (ft)
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1015
1010
1005
1000
995
990
985
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0080

A-24 Delaware Hot-Spot UniqueID: 0080

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0080	25.3	Moderate	1.61	3.71

Description of Survey Site: This site has a narrow riparian corridor. This site has active slumps.

Length of Bank (feet): 421

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	1.86	3.01
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$33,680	$33,680
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	781	1265
***Cost of Soil Reduction Per Ton:**	**$4.31**	**$2.66**
***Cost of Soil Reduction Per Cubic Yard:**	**$5.61**	**$3.46**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 11-Nov-10
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0080
County: Jackson County
Legal Description: SW 1/4 Sec 11 T5S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	45	Feet	Pasture	
	Crop field			Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture	X		Urban	
	Timber			Residential	
	Cropland			Industrial	

Channel Width:	Top of Bank to Top of Bank	221.8	Feet
	Edge of Water to Edge of Water	20.8	Feet
Water Depth:	Thalweg	1.4	Feet

Livestock access to Riparian Area **Yes** ____ **No** X
If yes, what is the duration in months per year? ____

Debris or Channel Blockages **Yes** ____ **No** X

Buildings or Structures Threatened **Yes** ____ **No** X
If yes, what is their distance from the streambank? ____ Feet

Bank Erosion Inventory

Average Bank Height: 28.0 Feet (Measure)
Root Depth of Riparian Vegetation: 18.4 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 24 degrees.
	Vertical		Active seeps observed in banks.
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		421	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 2.72 Average Feet / year

Comments on Erosion:

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0080**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/11/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	**28.3** (A)	**Bankfull Height** (ft) =	**18** (B)	(A) / (B) =	**1.6** (C)	**5.9**
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	**18.4** (D)	**Study Bank Height** (ft) =	**28.3** (A)	(D) / (A) =	**0.7** (E)	**3.2**
Weighted Root Density (G)						
		Root Density as % =	**30** (F)	(F) x (E) =	**19.5** (G)	**7.3**
Bank Angle (H)						
				Bank Angle as *Degrees* =	**60** (H)	**3.9**
Surface Protection (I)						
				Surface Protection as % =	**40** (I)	**5.1**

Bank Material Adjustment:

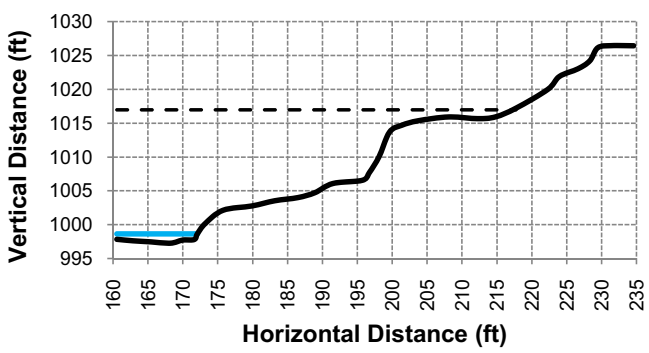
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

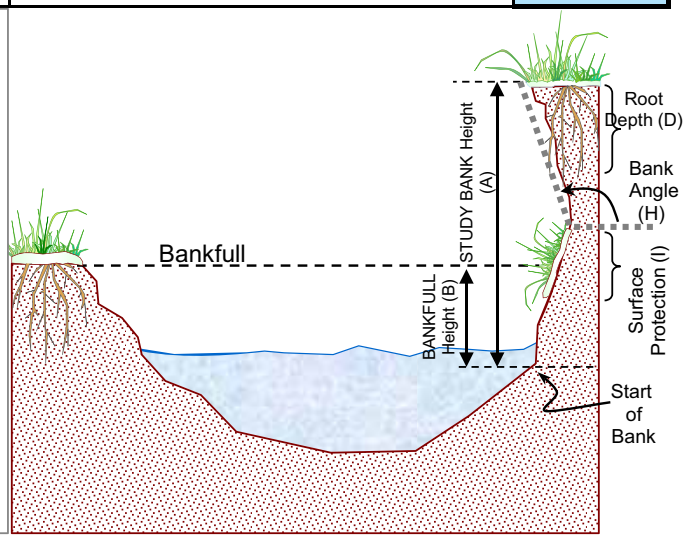
Bank Material Adjustment **0.0**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage **0.0**

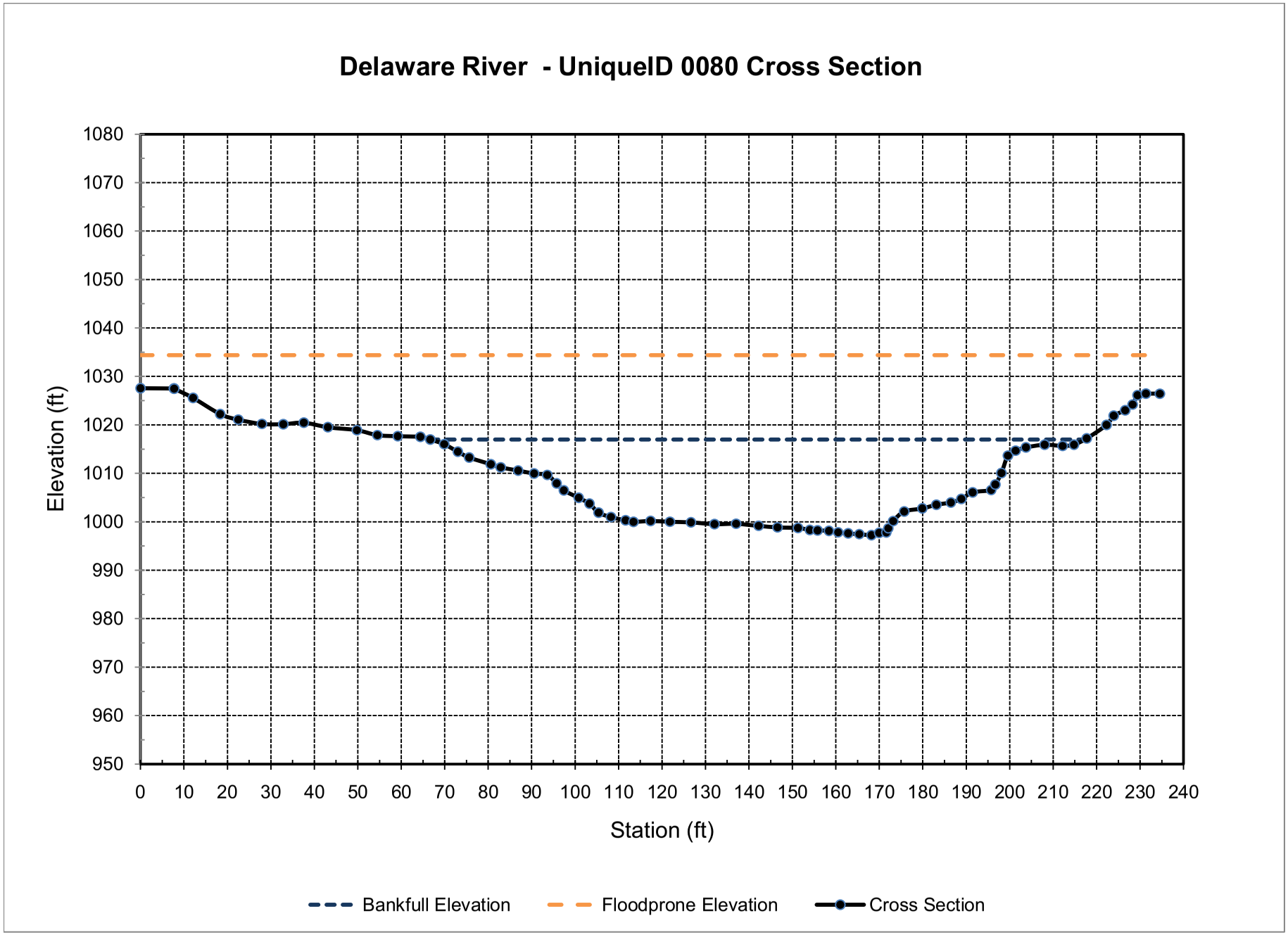
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		25.3

Bank Sketch

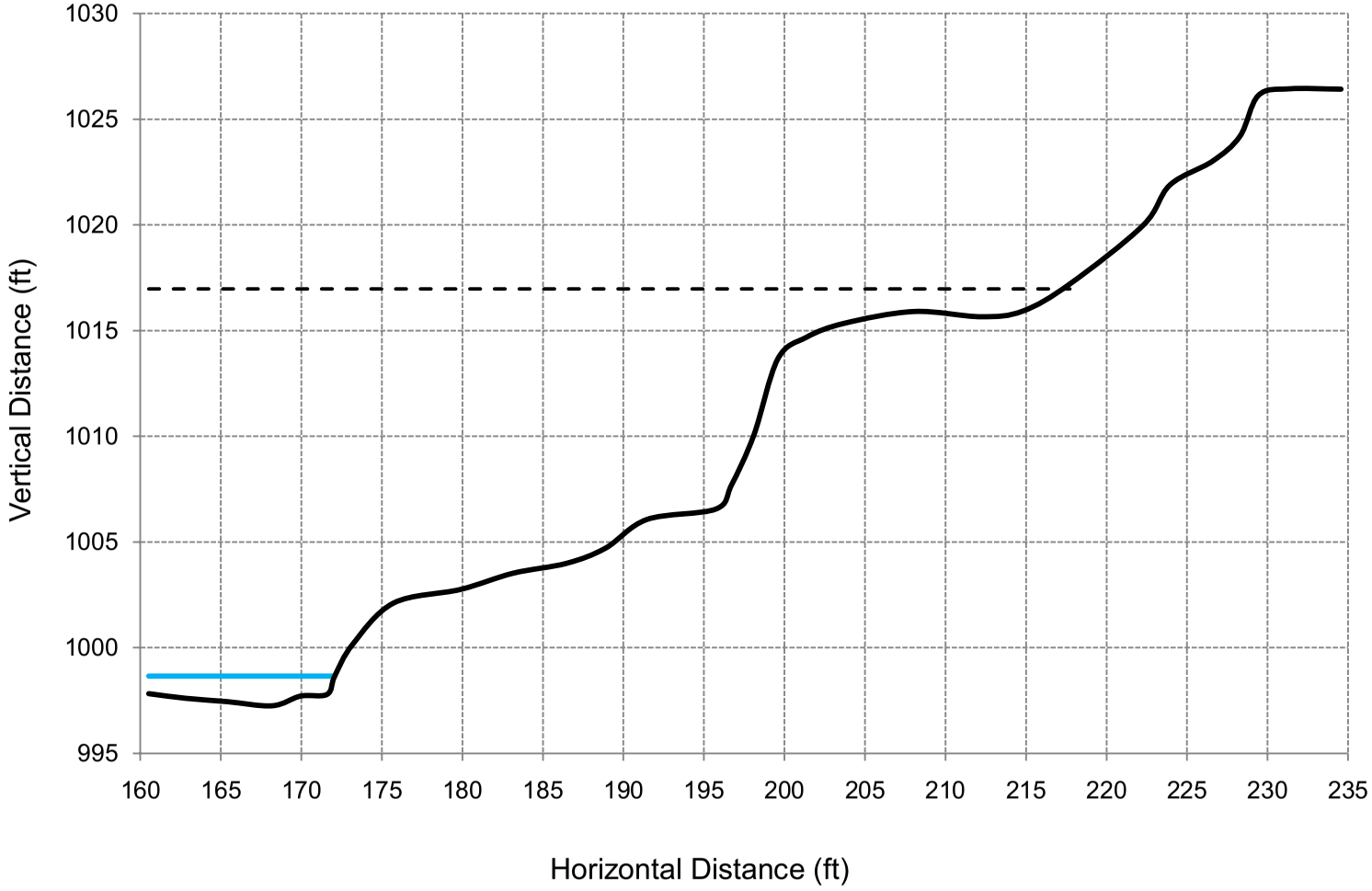




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0080 Cross Section
Elevation (ft)
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1030
1025
1020
1015
1010
1005
1000
995
Vertical Distance (ft)
160
165
170
175
180
185
190
195
200
205
210
215
220
225
230
235
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0081

A-25 Delaware Hot-Spot UniqueID: 0081

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0081	33.8	High	1.55	4.87

Description of Survey Site: The banks are actively slumping. The river is about ready to flank a small, narrow row of willow that will form a mid bar. There is active gully erosion from overland flow. Also, there is a well near the top of bank.

Length of Bank (feet): 979

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	87%
Reduction of Rate of Erosion (tons/foot/year):	3.41	4.24
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$78,320	$78,320
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	3337	4148
***Cost of Soil Reduction Per Ton:**	**$2.35**	**$1.89**
***Cost of Soil Reduction Per Cubic Yard:**	**$3.05**	**$2.45**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 14-Sep-09
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0081
County: Jackson County
Legal Description: NE 1/4 Sec 9 T5S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	159.9	Feet
	Edge of Water to Edge of Water	30.9	Feet
Water Depth:	Thalweg	0.8	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 28.1 Feet (Measure)
Root Depth of Riparian Vegetation: 1.6 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 27 degrees.
	Vertical			Active seeps observed in banks.
	1H:1V			
	2H:1V	X		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		979	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 3.6 Average Feet / year

Comments on Erosion:

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0081**	Location:	**Jackson County**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **09/14/09**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	28.1 (A)	Bankfull Height (ft) =	14.7 (B)	(A) / (B) =	1.9 (C)	7.5
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	1.6 (D)	Study Bank Height (ft) =	28.1 (A)	(D) / (A) =	0.1 (E)	8.9
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	1.1 (G)	10.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	27 (H)	2.3
Surface Protection (I)						
				Surface Protection as % =	40 (I)	5.1

Bank Material Adjustment:

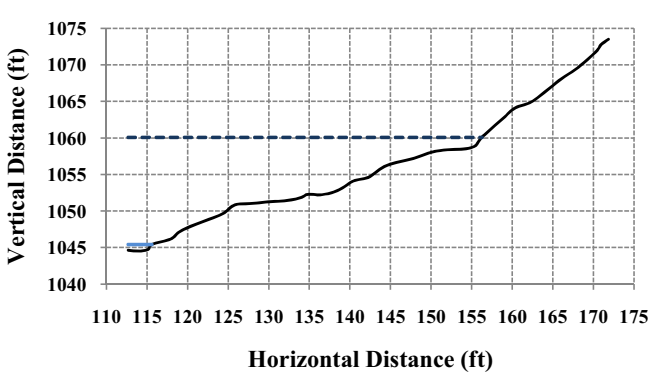
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

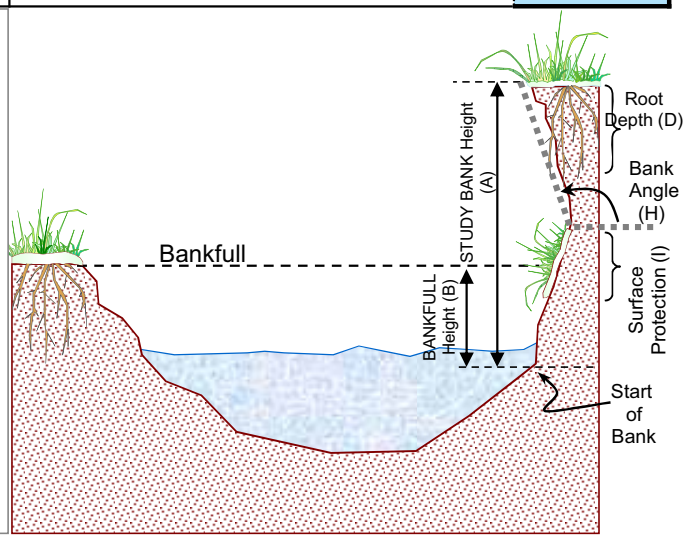
Bank Material Adjustment 0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

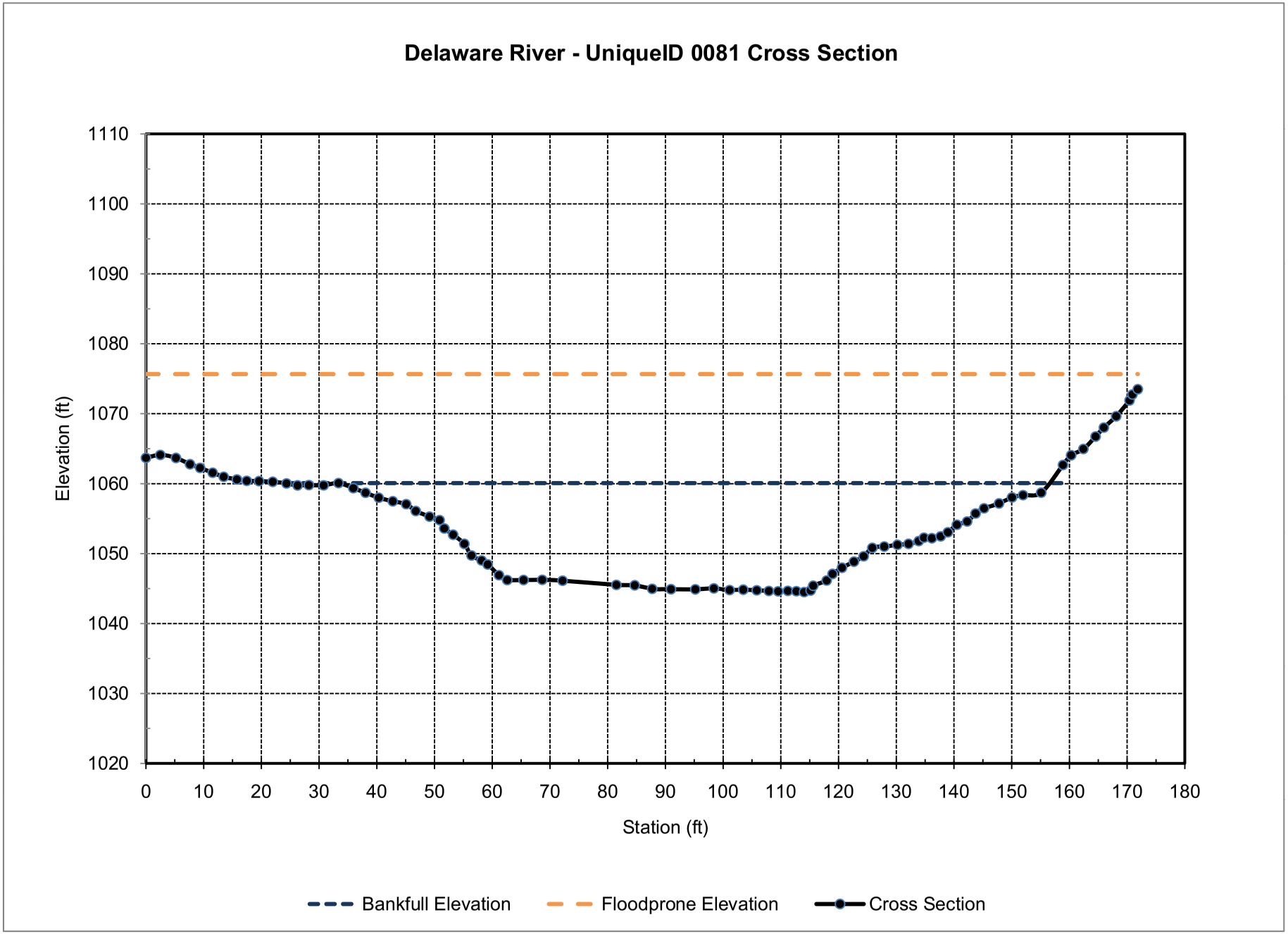
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		33.8

Bank Sketch

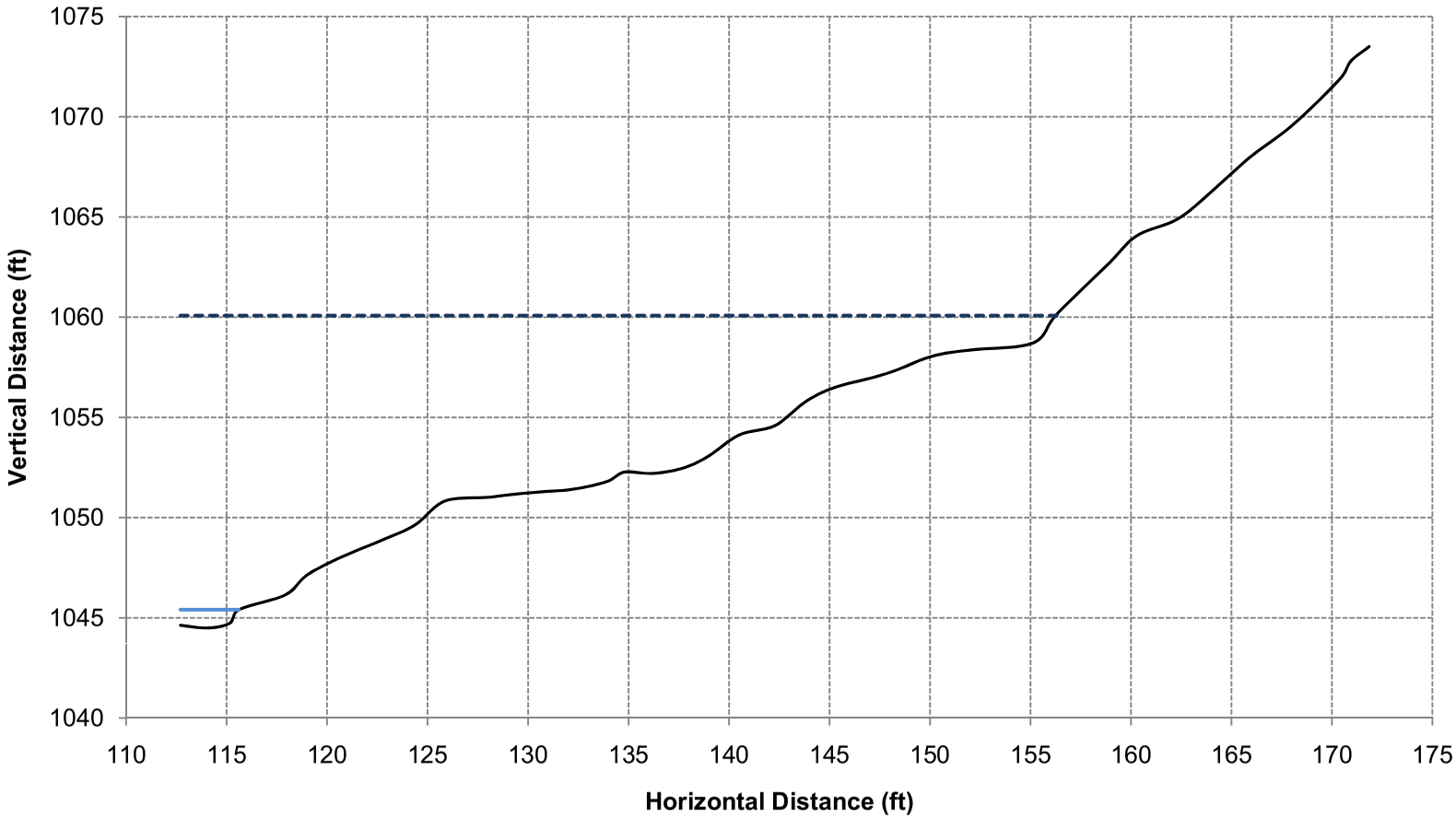




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0081 Cross Section
Elevation (ft)
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1075
1070
1065
1060
1055
1050
1045
1040
Vertical Distance (ft)
110
115
120
125
130
135
140
145
150
155
160
165
170
175
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0082

A-26 Delaware Hot-Spot UniqueID: 0082

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0082	28.3	Moderate	1.41	1.83

Description of Survey Site: A BMP project was completed in 2010.

Length of Bank (feet): 377

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	0%	62%
Reduction of Rate of Erosion (tons/foot/year):	0.00	1.13
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$30,160	$30,160
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	0	428
***Cost of Soil Reduction Per Ton:**	**$9,048**	**$7.05**
***Cost of Soil Reduction Per Cubic Yard:**	**$11,762**	**$9.17**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume 1 cubic yard weighs 1.3 tons. For year 1 through 3, modeling results did not produce an erosion reduction; therefore 3 years of BMP installation costs were added to calculate the cost-benefits associated with year 1 through 3.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 14-Sep-09
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0082
County: Jackson County
Legal Description: NE 1/4 Sec 9 T5S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	157.1	Feet
	Edge of Water to Edge of Water	33.0	Feet
Water Depth:	Thalweg	0.8	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 26.9 Feet (Measure)
Root Depth of Riparian Vegetation: 26.9 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 47 degrees.
	Vertical			
	1H:1V			
	2H:1V	X		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		377	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.41 Average Feet / year

Comments on Erosion:

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0082**	Location:	**Jackson County**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **09/14/09**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	26.9 (A)	Bankfull Height (ft) =	15.7 (B)	(A) / (B) =	1.7 (C)	6.5
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	26.9 (D)	Study Bank Height (ft) =	26.9 (A)	(D) / (A) =	1 (E)	1
Weighted Root Density (G)						
		Root Density as % =	10 (F)	(F) x (E) =	10 (G)	8.4
Bank Angle (H)						
				Bank Angle as *Degrees* =	47 (H)	3.3
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9

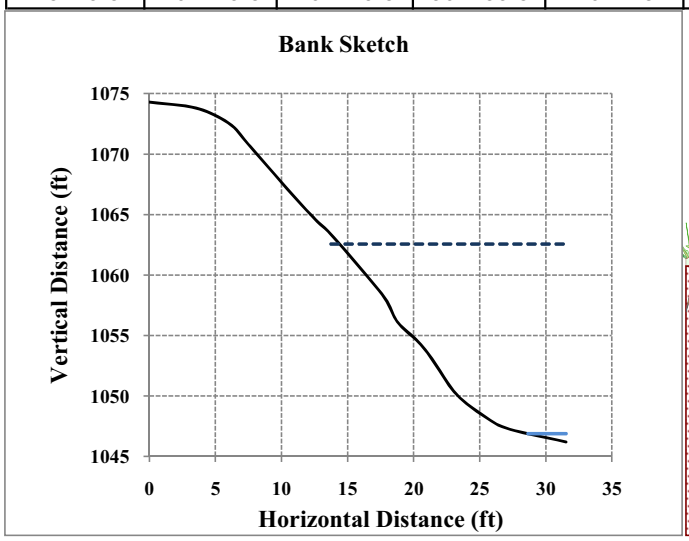
Bank Material Adjustment:

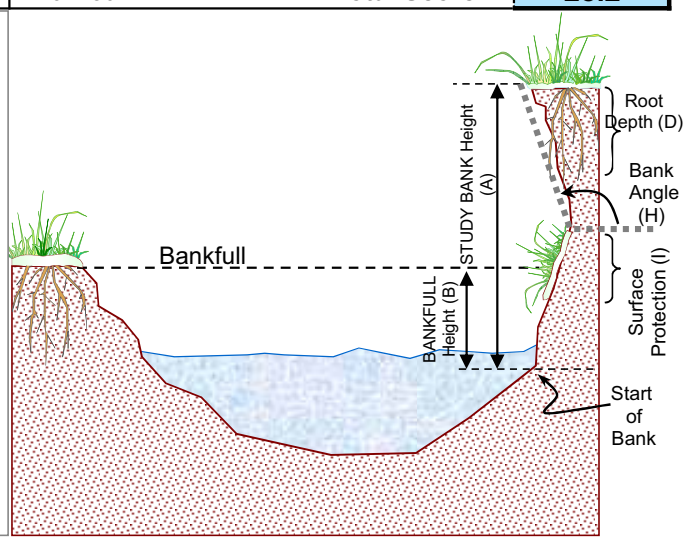
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0

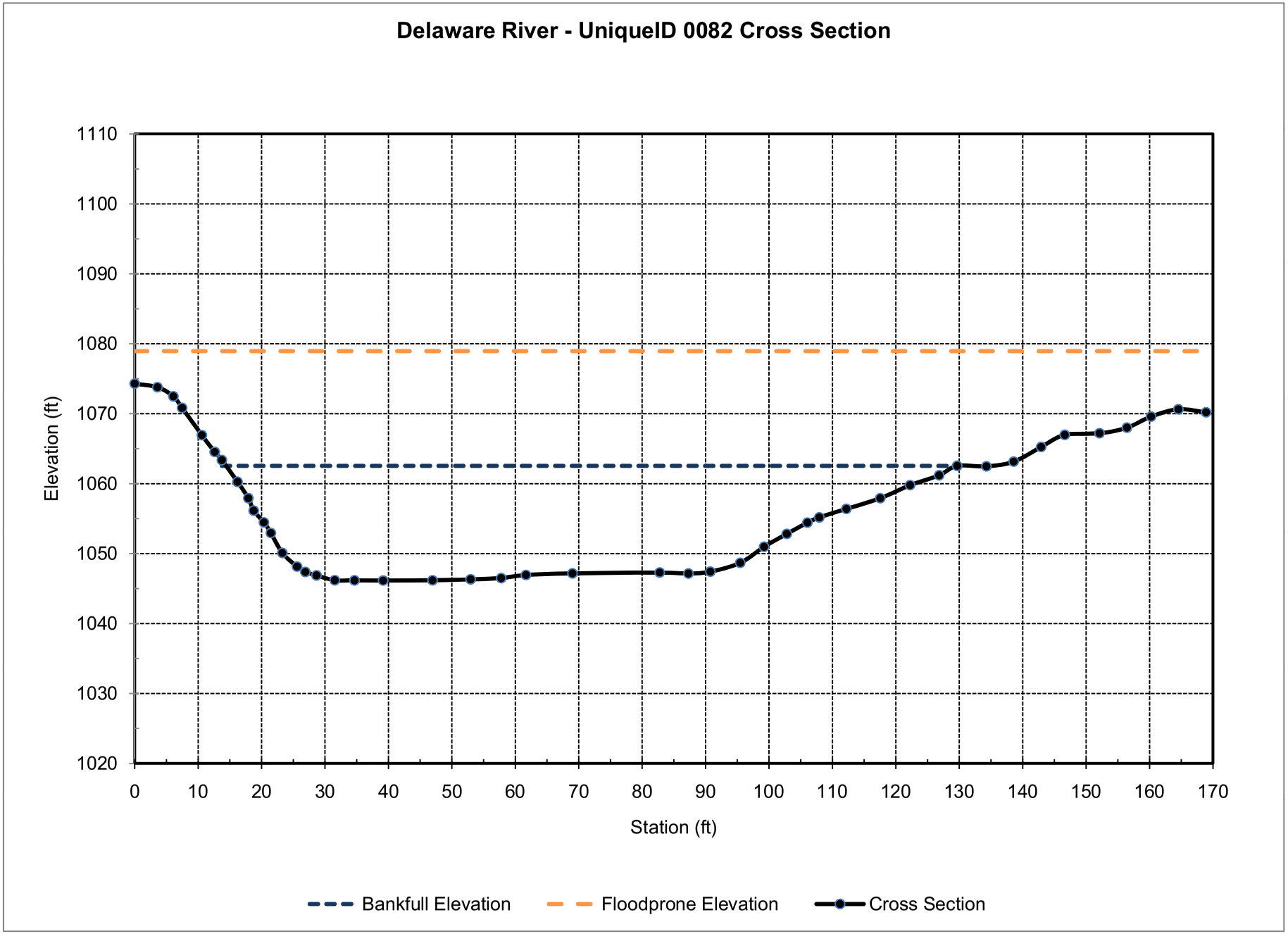
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		28.2

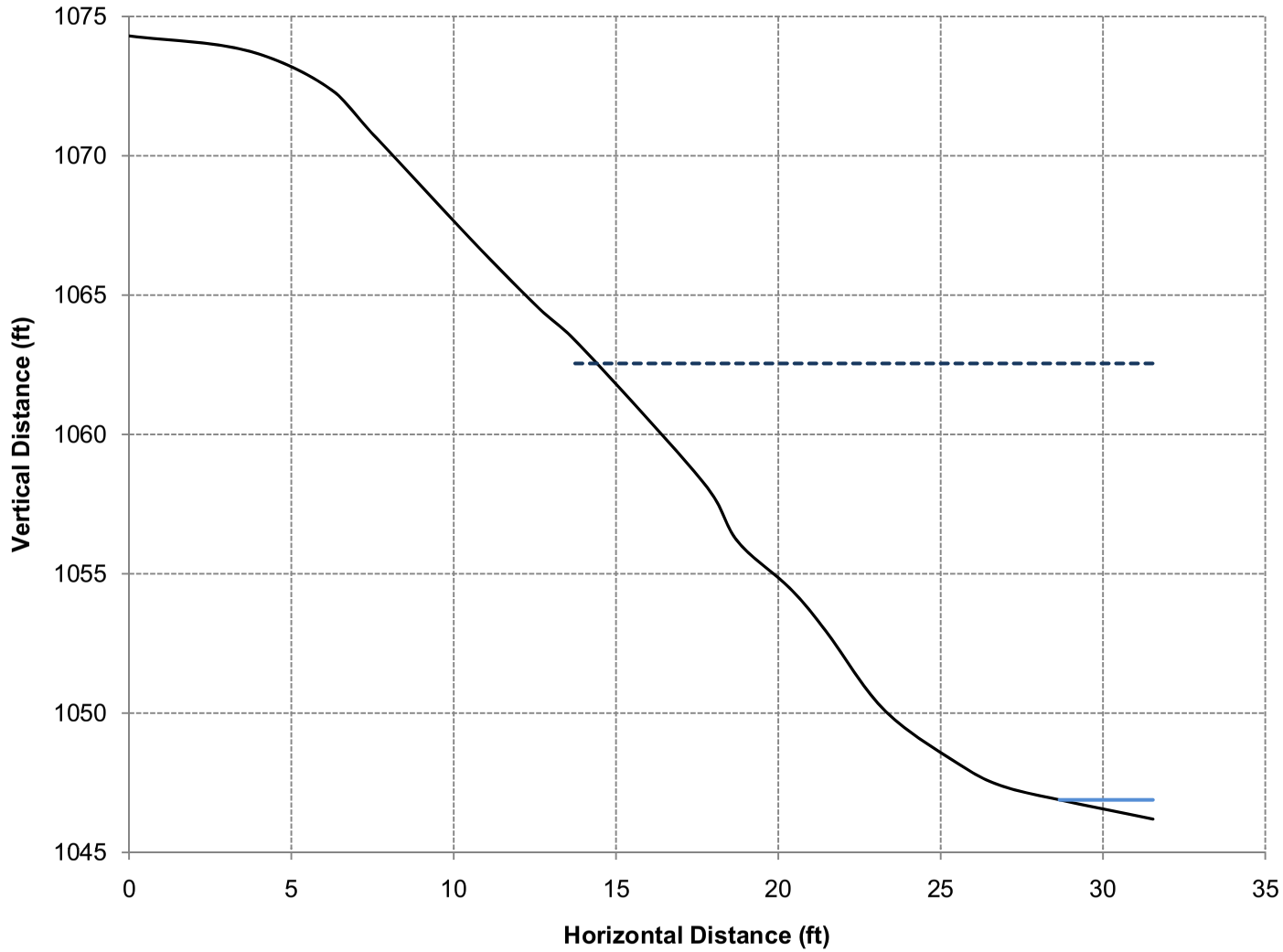




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0082 Cross Section
Elevation (ft)
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1075
1070
1065
1060
1055
1050
1045
Vertical Distance (ft)
0
5
10
15
20
25
30
35
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0083

A-27 Delaware Hot-Spot UniqueID: 0083

Location of Stream Segment: Muddy Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0083	36.1	High	1.55	1.69

Description of Survey Site: This site has no riparian corridor. It's experiencing significant slumping. Previously slumped material has become a mid-bar. Banks consists of a mixture of silt loam on top with sand and silty clay along the toe.

Length of Bank (feet): 311

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	87%
Reduction of Rate of Erosion (tons/foot/year):	1.18	1.47
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$19,593	$19,593
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	368	457
***Cost of Soil Reduction Per Ton:**	**$5.33**	**$4.28**
***Cost of Soil Reduction Per Cubic Yard:**	**$6.92**	**$5.57**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Muddy Creek **Date:** 9-Nov-10
14 Digit HUC: 10270103010090
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0083
County: Jackson County
Legal Description: NE1/4 Sec 9 T5S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	161.6	Feet
	Edge of Water to Edge of Water	29.4	Feet
Water Depth:	Thalweg	1.4	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 21.0 Feet (Measure)
Root Depth of Riparian Vegetation: 1.0 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 28 degrees.
	Vertical		Active seeps observed inbanks.
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		311	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.70 Average Feet / year

Comments on Erosion:

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Muddy Creek - UniqueID 0083**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/09/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	20.7 (A)	Bankfull Height (ft) =	8.8 (B)	(A) / (B) =	2.4 (C)	8.4
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	3 (D)	Study Bank Height (ft) =	20.7 (A)	(D) / (A) =	0.1 (E)	8.0
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	2.9 (G)	10.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	58 (H)	3.8
Surface Protection (I)						
				Surface Protection as % =	30 (I)	5.9

Bank Material Adjustment:

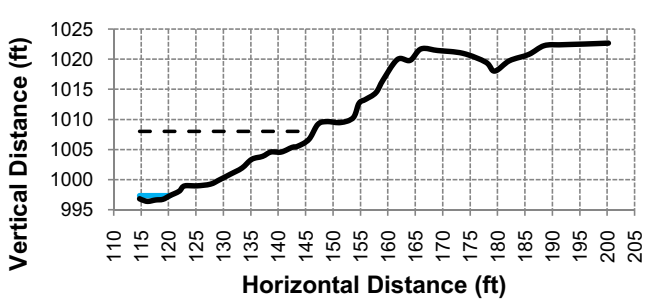
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

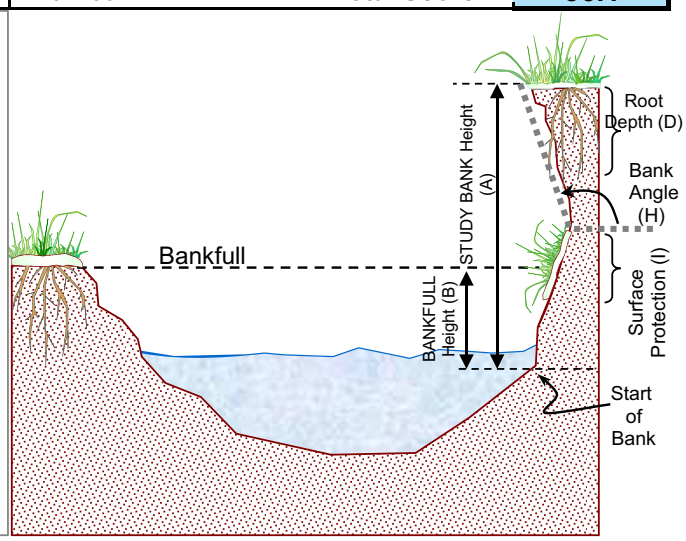
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

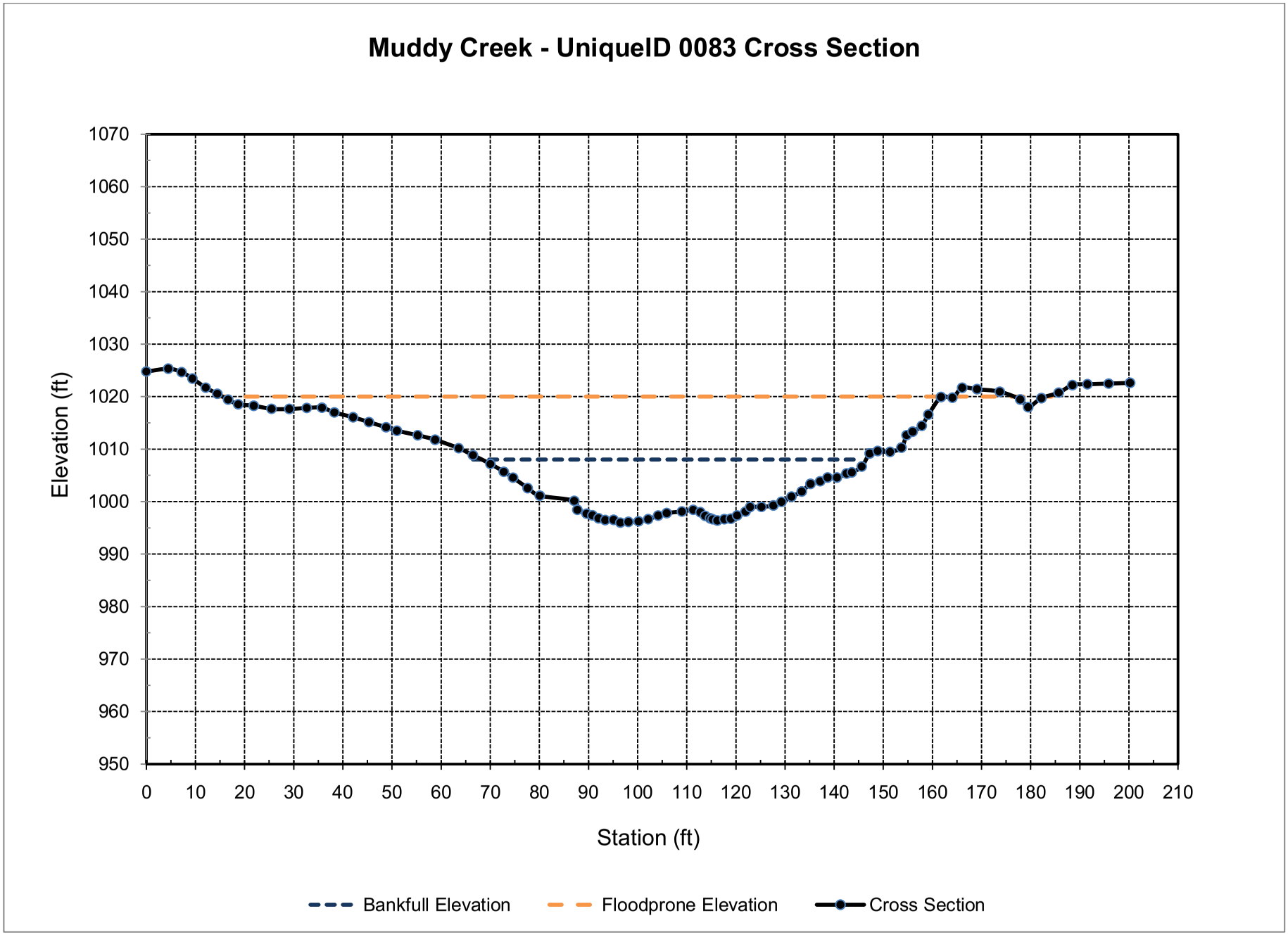
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		36.1

Bank Sketch

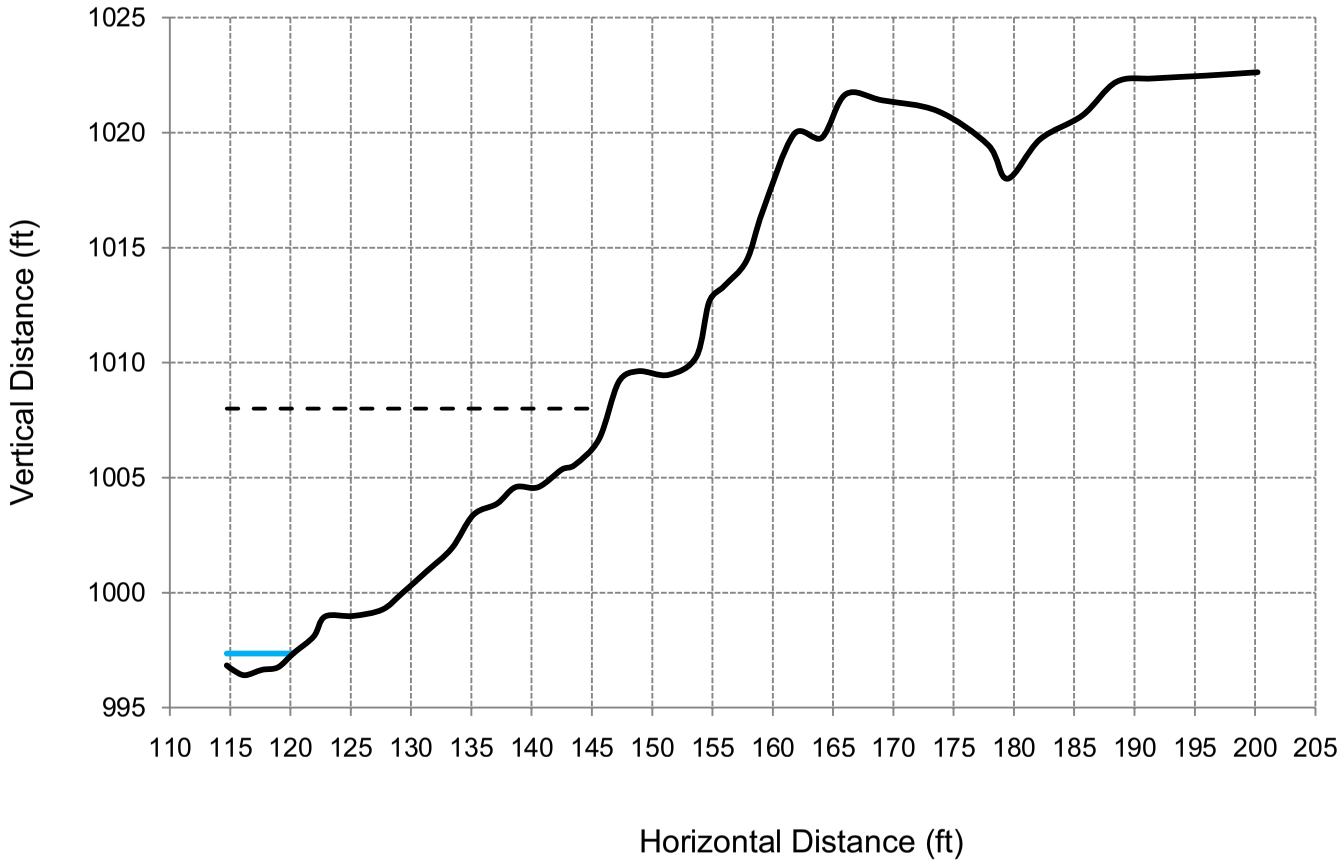




Copyright © 2006 Wildland Hydrology


Muddy Creek - UniqueID 0083 Cross Section
Elevation (ft)
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1025
1020
1015
1010
1005
1000
995
Vertical Distance (ft)
110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0084

A-28 Delaware Hot-Spot UniqueID: 0084

Location of Stream Segment: Muddy Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0084	36.6	High	2.22	3.76

Description of Survey Site: This site has no riprian corridor. A large amount of seeps are found on this site causing slumping.

Length of Bank (feet): 382

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	85%	94%
Reduction of Rate of Erosion (tons/foot/year):	3.20	3.53
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$30,560	$30,560
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	1221	1350
***Cost of Soil Reduction Per Ton:**	**$2.50**	**$2.26**
***Cost of Soil Reduction Per Cubic Yard:**	**$3.25**	**$2.94**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Muddy Creek **Date:** 9-Nov-10
14 Digit HUC: 10270103010090
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0084
County: Jackson County
Legal Description: SE 1/4 Sec 8 T5S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	X
	Crop field			Rangeland	
	Timber				
Adjacent Landuse:	Pasture	X		Urban	
	Timber			Residential	
	Cropland			Industrial	

Channel Width:	Top of Bank to Top of Bank	289.8	Feet
	Edge of Water to Edge of Water	22.6	Feet
Water Depth:	Thalweg	2.5	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 35.0 Feet (Measure)
Root Depth of Riparian Vegetation: 6.5 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 18 degrees.
	Vertical			Active seeps observed in banks.
	1H:1V	X		
	2H:1V			

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		382	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 2.23 Average Feet / year

Comments on Erosion:

View of a rotational slump.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Muddy Creek - UniqueID 0084**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/09/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	**35** (A)	**Bankfull Height** (ft) =	**9.1** (B)	(A) / (B) =	**3.8** (C)	**10.0**
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	**6.5** (D)	**Study Bank Height** (ft) =	**35** (A)	(D) / (A) =	**0.2** (E)	**7.4**
Weighted Root Density (G)						
		Root Density as % =	**40** (F)	(F) x (E) =	**7.4** (G)	**8.7**
Bank Angle (H)						
				Bank Angle as *Degrees* =	**67** (H)	**4.6**
Surface Protection (I)						
				Surface Protection as % =	**30** (I)	**5.9**

Bank Material Adjustment:

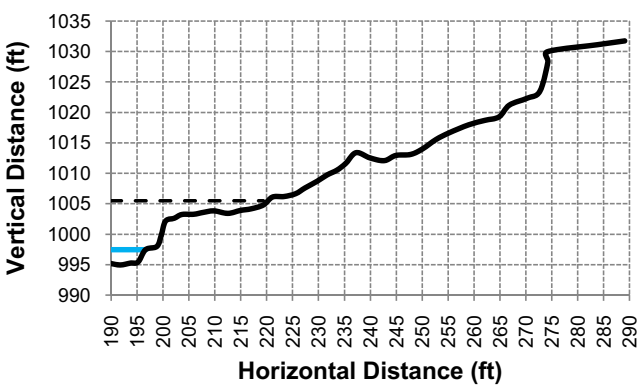
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

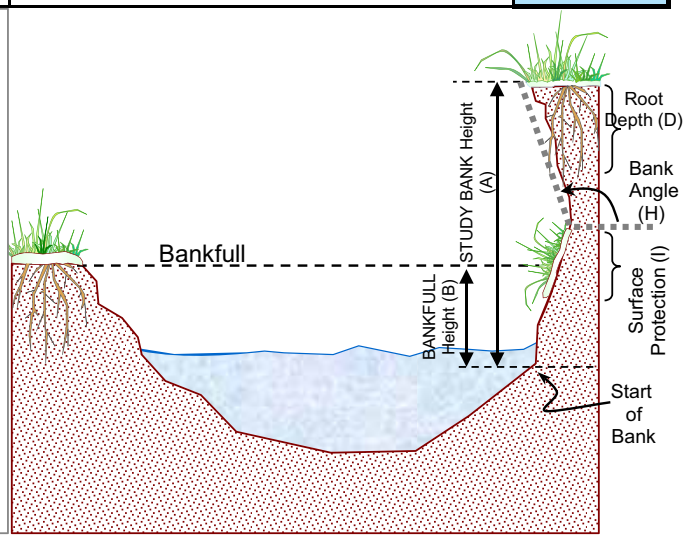
Bank Material Adjustment **0.0**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage **0.0**

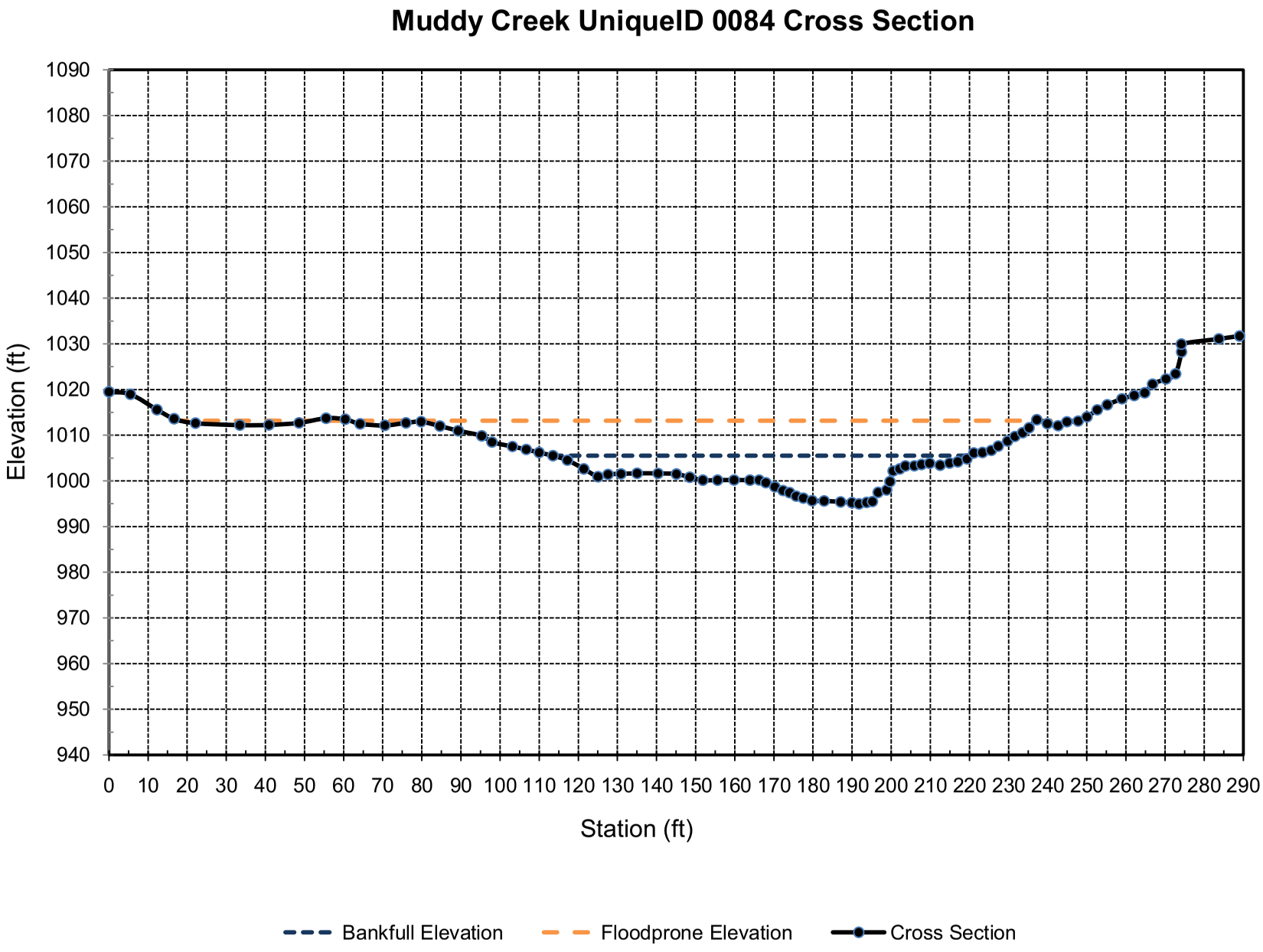
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		36.6

Bank Sketch

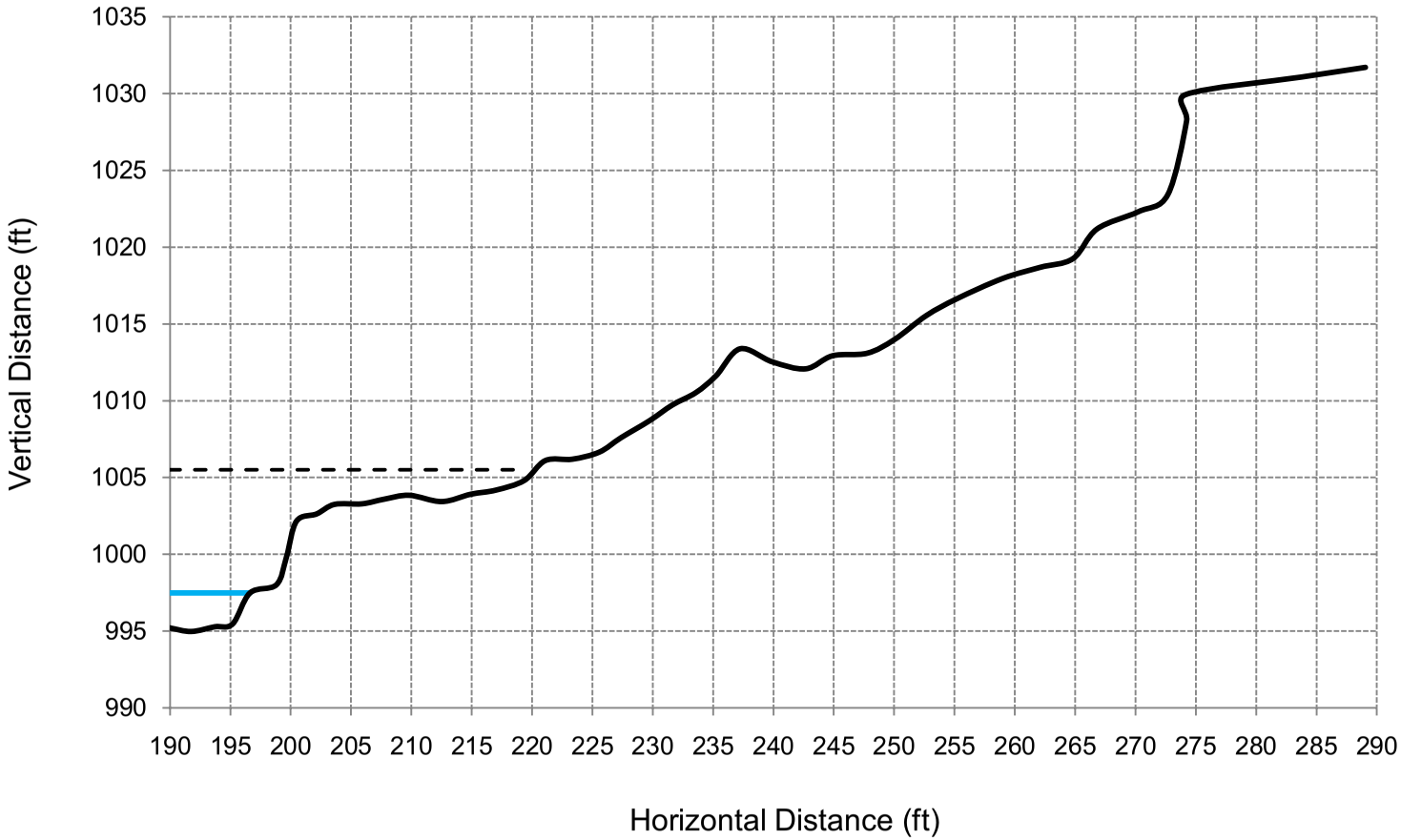




Copyright © 2006 Wildland Hydrology


Muddy Creek UniqueID 0084 Cross Section
Elevation (ft)
1090
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1035
1030
1025
1020
1015
1010
1005
1000
995
990
Vertical Distance (ft)
190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0086

A-29 Delaware Hot-Spot UniqueID: 0086

Location of Stream Segment: Muddy Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0086	41.9	Very High	1.56	2.93

Description of Survey Site: This site has no riparian corridor. A mid-bar is forming from previously slumped material. Banks consist of silty material.

Length of Bank (feet): 718

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	87%
Reduction of Rate of Erosion (tons/foot/year):	2.05	2.55
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$45,234	$45,234
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	1473	1830
***Cost of Soil Reduction Per Ton:**	**$3.07**	**$2.47**
***Cost of Soil Reduction Per Cubic Yard:**	**$3.99**	**$3.21**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Muddy Creek **Date:** 10-Nov-10
14 Digit HUC: 10270103010090
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0086
County: Jackson County
Legal Description: SE 1/4 Sec 7 T5S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	179.3	Feet
	Edge of Water to Edge of Water	24.6	Feet
Water Depth:	Thalweg	1.0	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 18.0 Feet (Measure)
Root Depth of Riparian Vegetation: 1.6 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 42 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		718	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 3.27 Average Feet / year

Comments on Erosion:

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Muddy Creek - UniqueID 0086**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/10/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	**18.6** (A)	**Bankfull Height** (ft) =	**5.6** (B)	(A) / (B) =	**3.3** (C)	**10.0**
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	**1.6** (D)	**Study Bank Height** (ft) =	**18.6** (A)	(D) / (A) =	**0.1** (E)	**8.6**
Weighted Root Density (G)						
		Root Density as % =	**10** (F)	(F) x (E) =	**0.9** (G)	**10.0**
Bank Angle (H)						
				Bank Angle as *Degrees* =	**48** (H)	**3.3**
Surface Protection (I)						
				Surface Protection as % =	**0** (I)	**10.0**

Bank Material Adjustment:

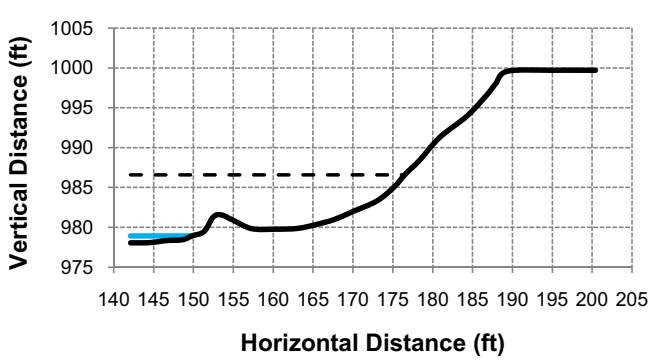
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

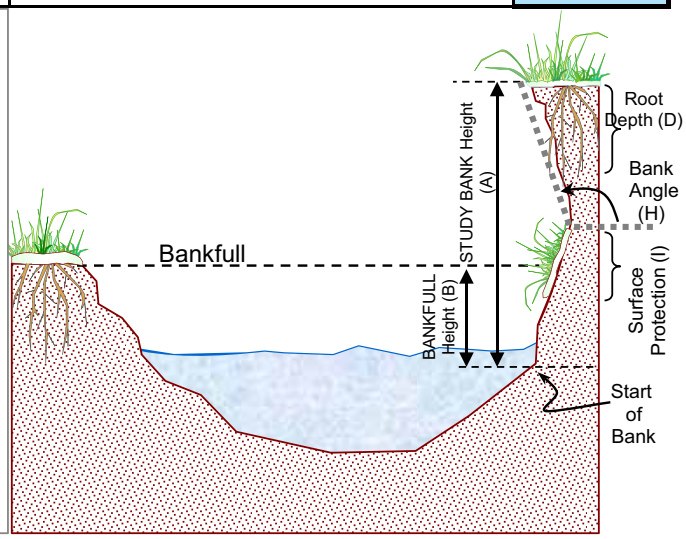
Bank Material Adjustment **0.0**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage **0.0**

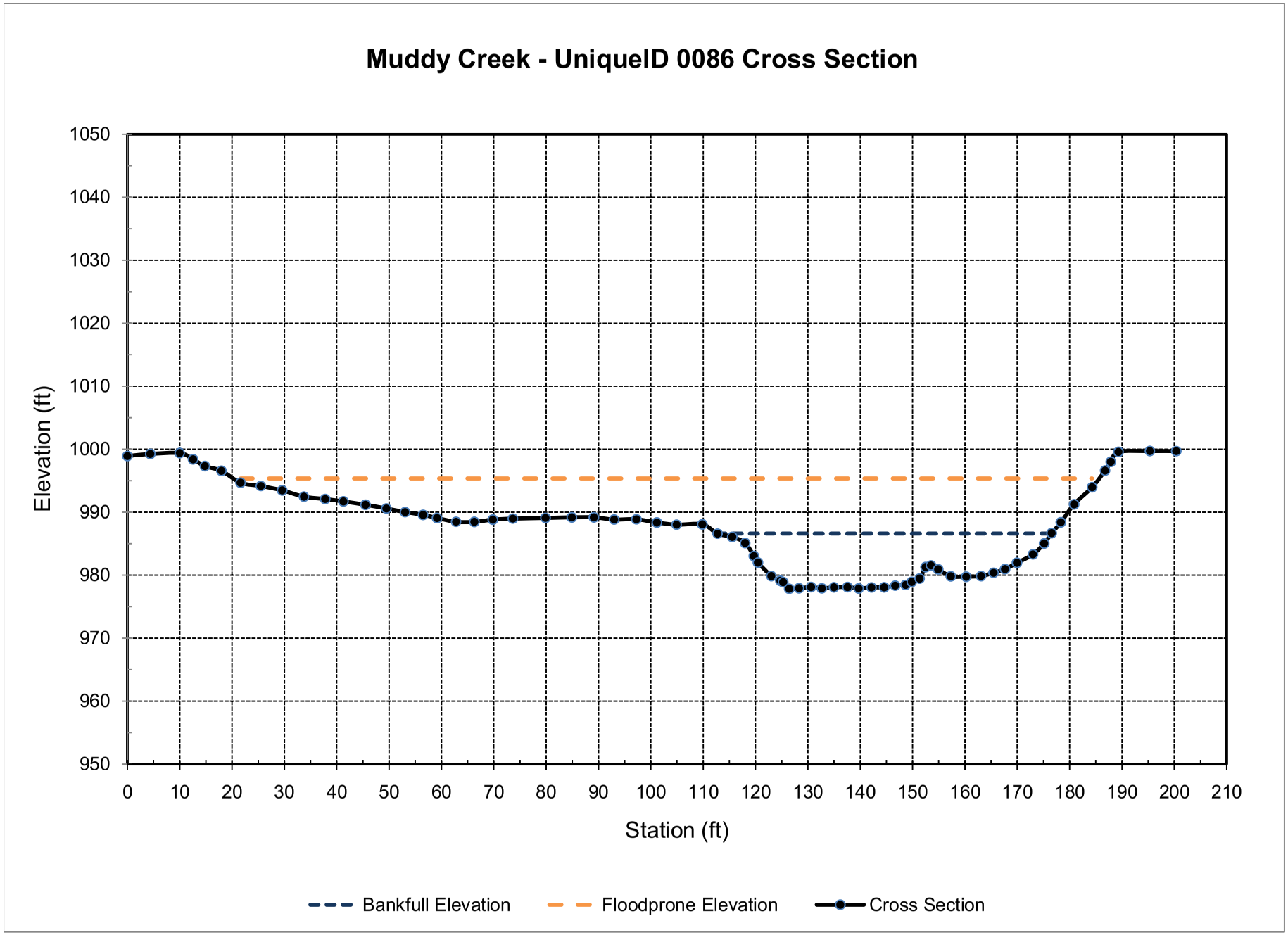
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Very High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		41.9

Bank Sketch

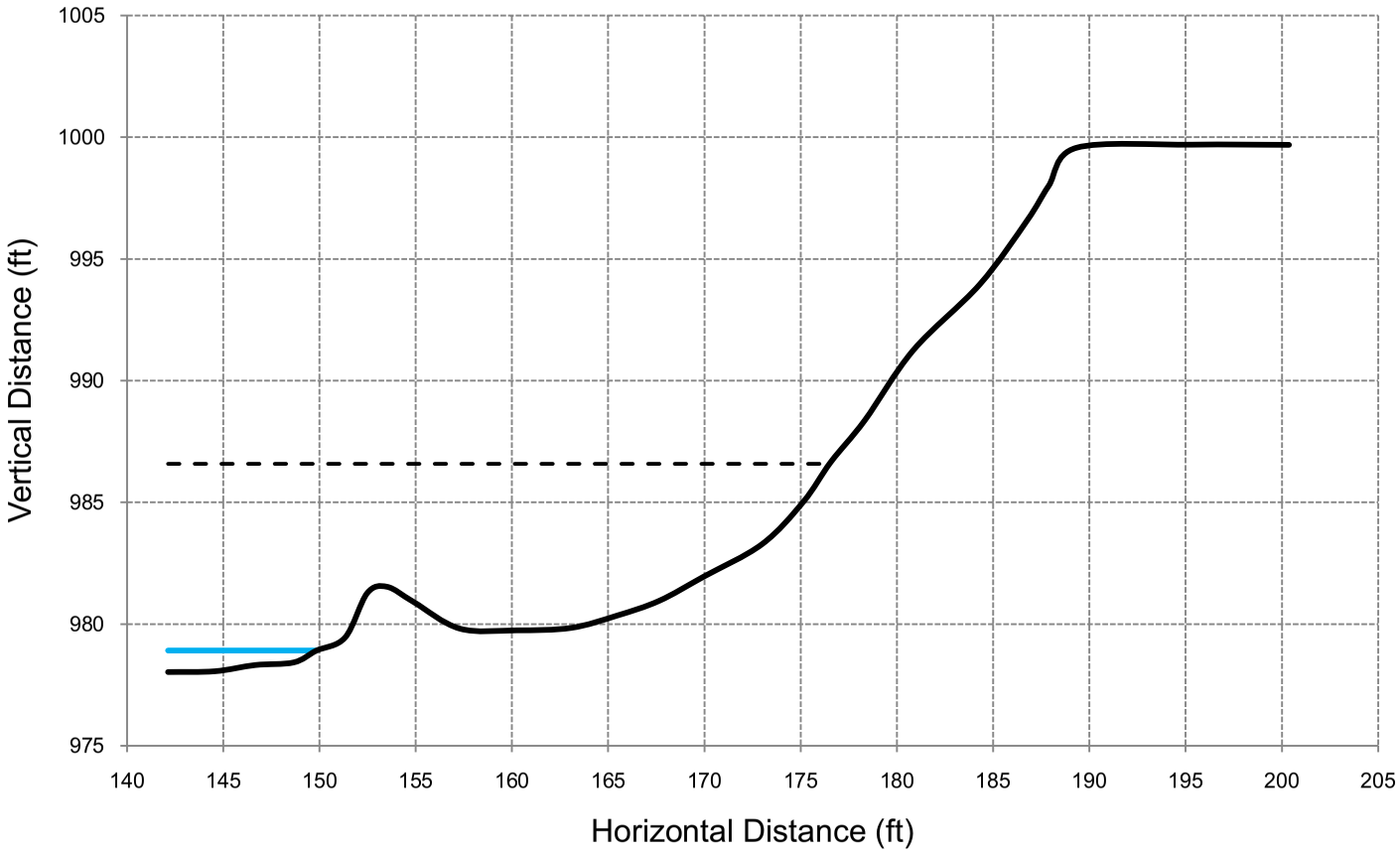




Copyright © 2006 Wildland Hydrology


Muddy Creek - UniqueID 0086 Cross Section
Elevation (ft)
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1005
1000
995
990
985
980
975
Vertical Distance (ft)
140
145
150
155
160
165
170
175
180
185
190
195
200
205
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0088

A-30 Delaware Hot-Spot UniqueID: 0088

Location of Stream Segment: Muddy Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0088	37.8	High	1.37	1.51

Description of Survey Site: This site has a few scattered trees for a riparian corridor. Bank material is silty materials.

Length of Bank (feet): 565

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	0.76	1.22
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$35,595	$35,595
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	427	691
***Cost of Soil Reduction Per Ton:**	**$8.34**	**$5.15**
***Cost of Soil Reduction Per Cubic Yard:**	**$10.85**	**$6.70**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Muddy Creek **Date:** 10-Nov-10
14 Digit HUC: 10270103010090
Person(s) Filling out Form: Emmert, McCurdy,vKolian
Afilliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0088
County: Jackson County
Legal Description: NE 1/4 Sec 13 T5S R15E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Cropfield	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	166.9	Feet
	Edge of Water to Edge of Water	23.3	Feet
Water Depth:	Thalweg	0.7	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 13.0 Feet (Measure)
Root Depth of Riparian Vegetation: 0.0 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 30 degrees.
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		565	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 2.38 Average Feet / year

Comments on Erosion:

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Muddy Creek - UniqueID 0088**	Location:	**Jackson County**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **12/14/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	13.2 (A)	Bankfull Height (ft) =	5.2 (B)	(A) / (B) =	2.5 (C)	8.6
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	3 (D)	Study Bank Height (ft) =	13.2 (A)	(D) / (A) =	0.2 (E)	6.8
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	4.5 (G)	10.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	28 (H)	2.3
Surface Protection (I)						
				Surface Protection as % =	0 (I)	10.0

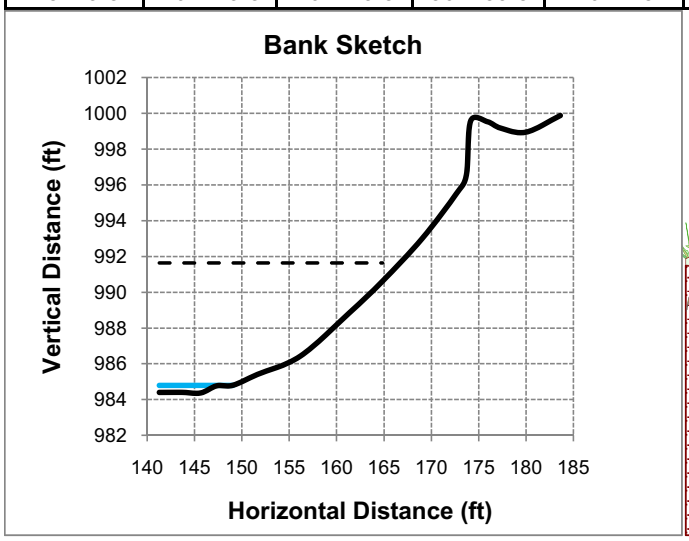
Bank Material Adjustment:

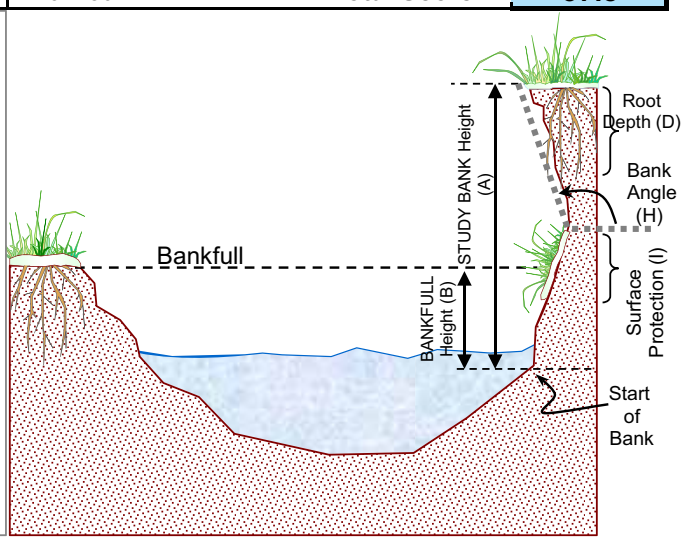
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0.0

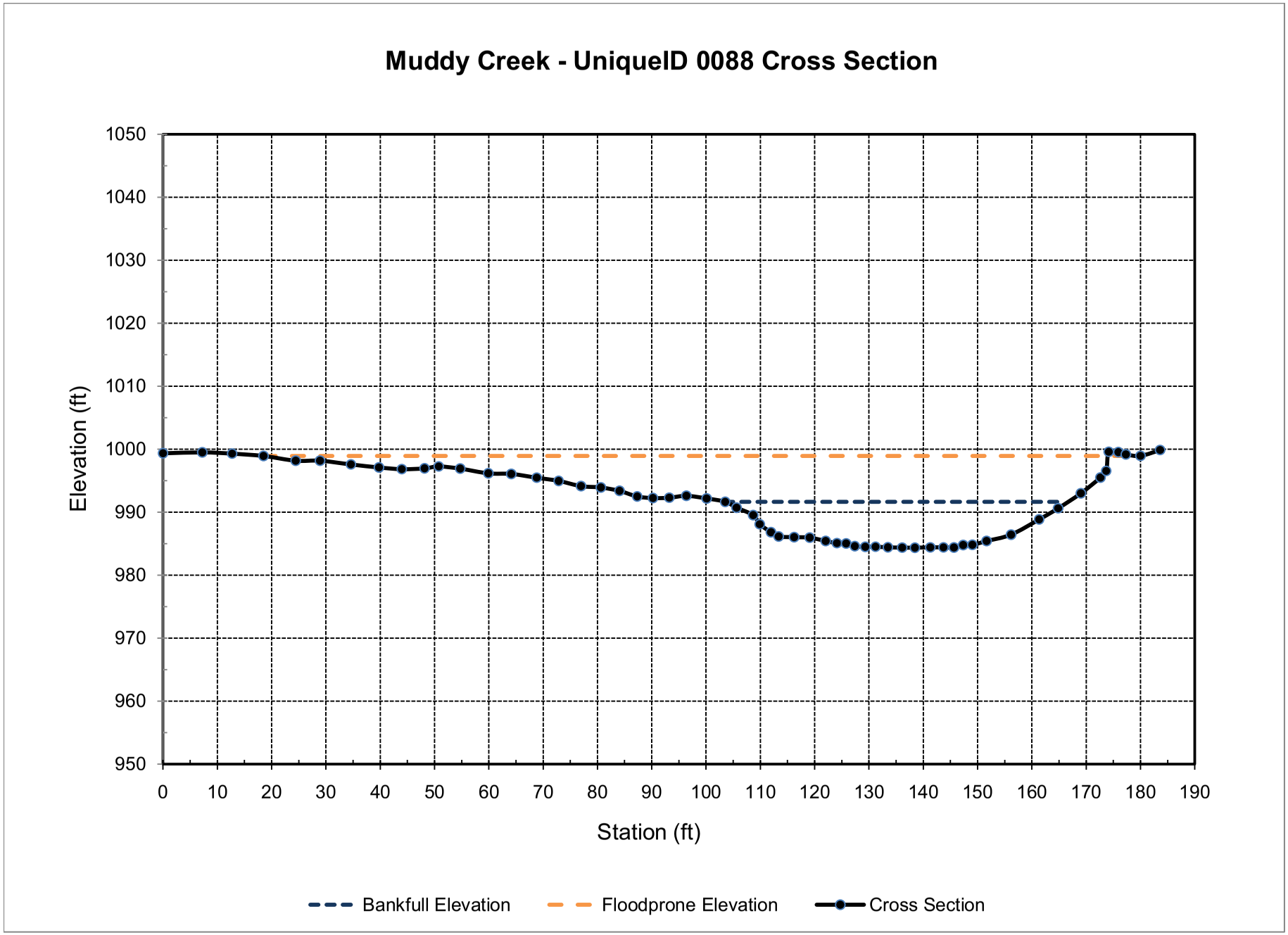
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		37.8

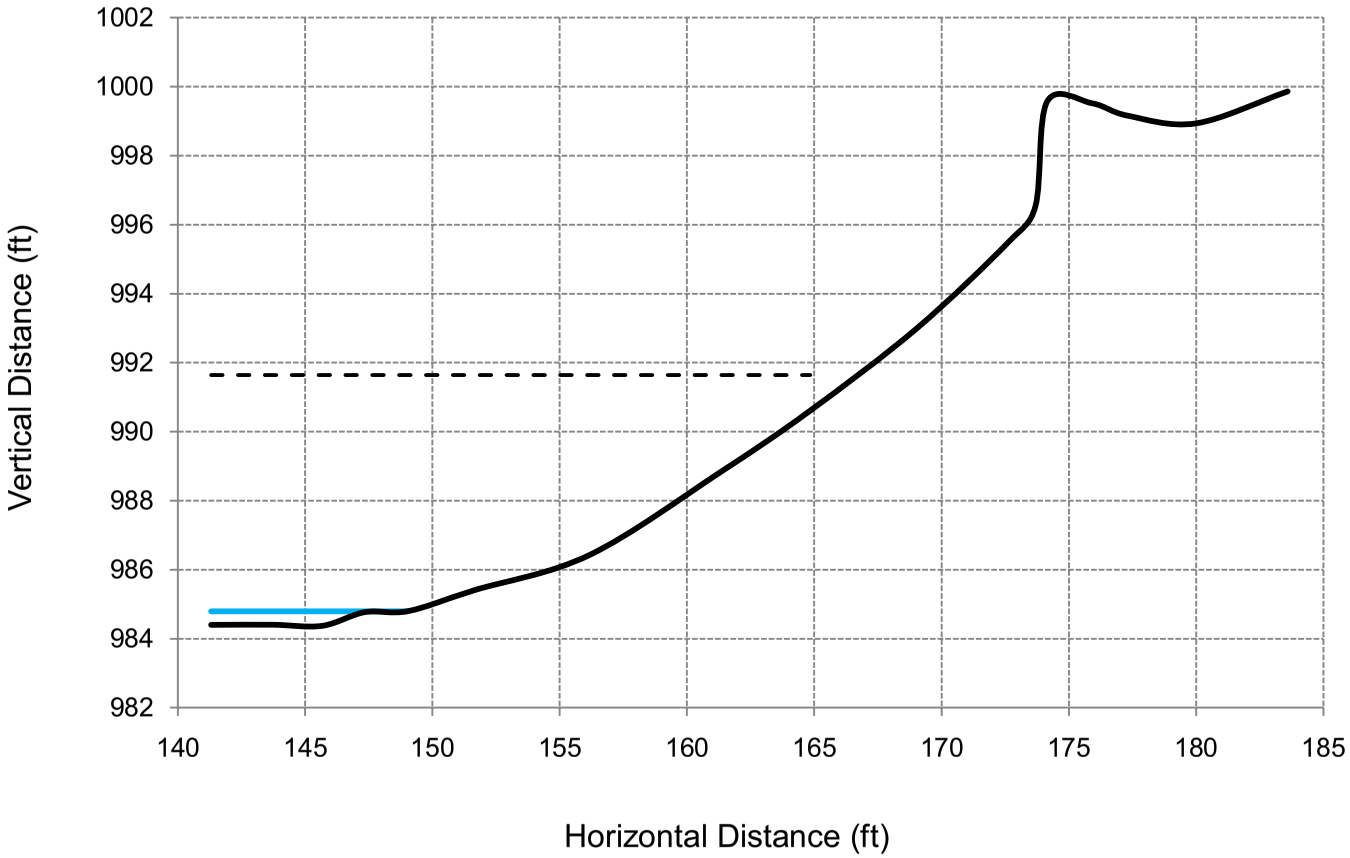




Copyright © 2006 Wildland Hydrology


Muddy Creek - UniqueID 0088 Cross Section
Elevation (ft)
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1002
1000
998
996
994
992
990
988
986
984
982
Vertical Distance (ft)
140
145
150
155
160
165
170
175
180
185
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0089

A-31 Delaware Hot-Spot UniqueID: 0089

Location of Stream Segment: Muddy Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0089	34.6	High	1.53	0.85

Description of Survey Site: This site has no riparian corridor. At the upstream end of the site overland flow has created a gulley. Bank materials are mainly silt materials.

Length of Bank (feet): 643

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	87%
Reduction of Rate of Erosion (tons/foot/year):	0.60	0.74
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$40,509	$40,509
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	383	475
***Cost of Soil Reduction Per Ton:**	**$10.59**	**$8.52**
***Cost of Soil Reduction Per Cubic Yard:**	**$13.76**	**$11.08**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Muddy Creek **Date:** 9-Nov-10
14 Digit HUC: 10270103010090
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0089
County: Jackson County
Legal Description: SW 1/4 Sec 12 T5S R15E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	156.7	Feet
	Edge of Water to Edge of Water	20.4	Feet
Water Depth:	Thalweg	0.7	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 12.0 Feet (Measure)
Root Depth of Riparian Vegetation: 0.0 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 33 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		643	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.48 Average Feet / year

Comments on Erosion:

View of the right bank.

View downstream from cross section

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Muddy Creek - UniqueID 0089**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/09/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	**11.9** (A)	**Bankfull Height** (ft) =	**7.2** (B)	(A) / (B) =	**1.7** (C)	**6.2**
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	**2.3** (D)	**Study Bank Height** (ft) =	**11.9** (A)	(D) / (A) =	**0.2** (E)	**7.4**
Weighted Root Density (G)						
		Root Density as % =	**10** (F)	(F) x (E) =	**1.9** (G)	**10.0**
Bank Angle (H)						
				Bank Angle as *Degrees* =	**58** (H)	**3.8**
Surface Protection (I)						
				Surface Protection as % =	**20** (I)	**7.2**

Bank Material Adjustment:

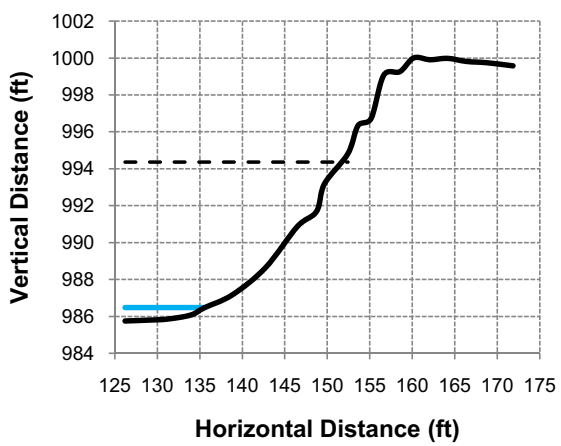
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

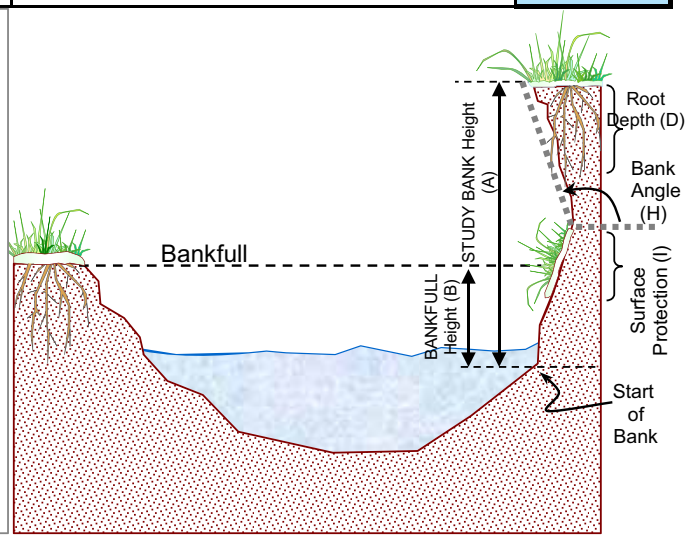
Bank Material Adjustment **0.0**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage **0.0**

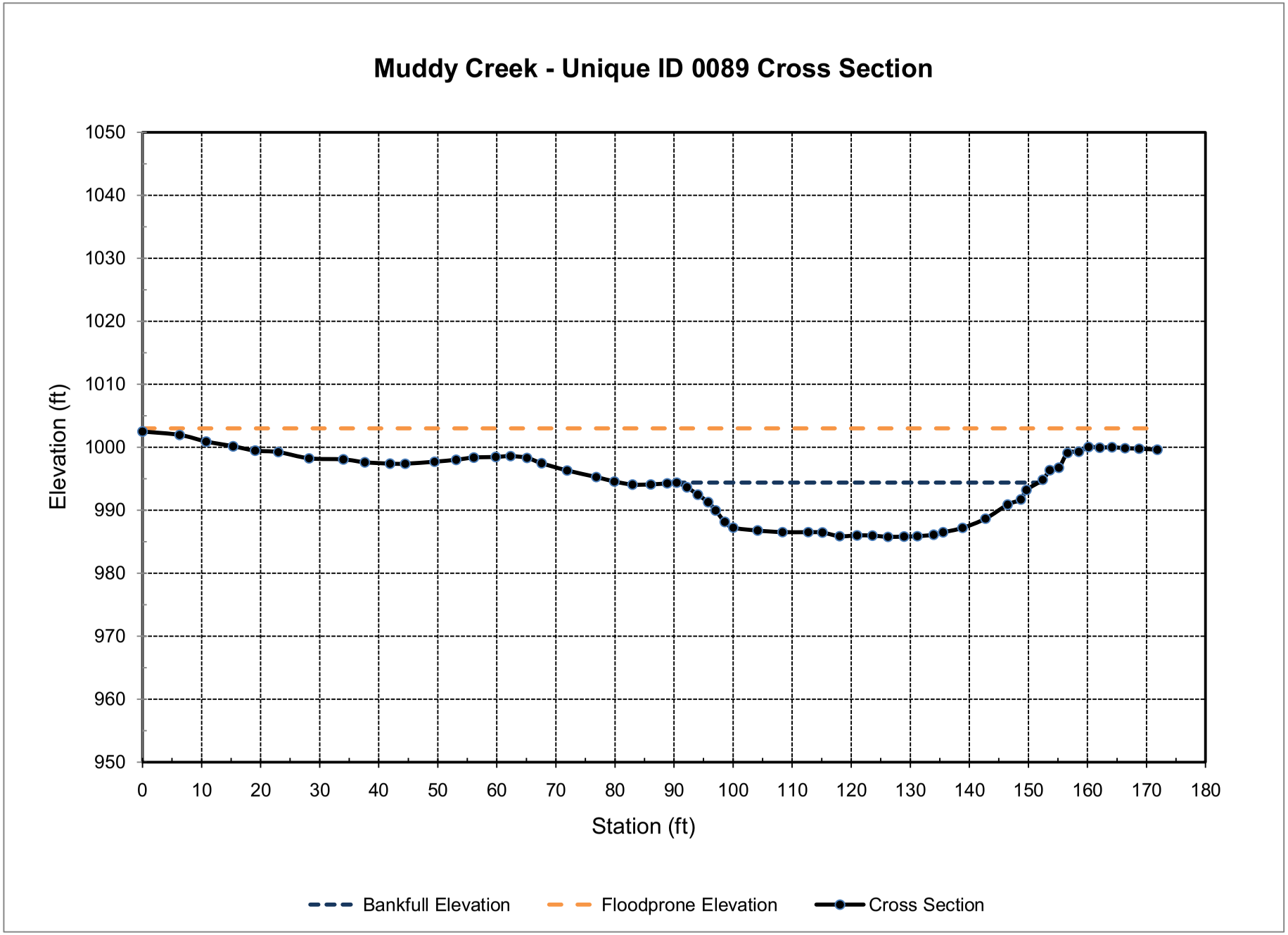
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		34.6

Bank Sketch

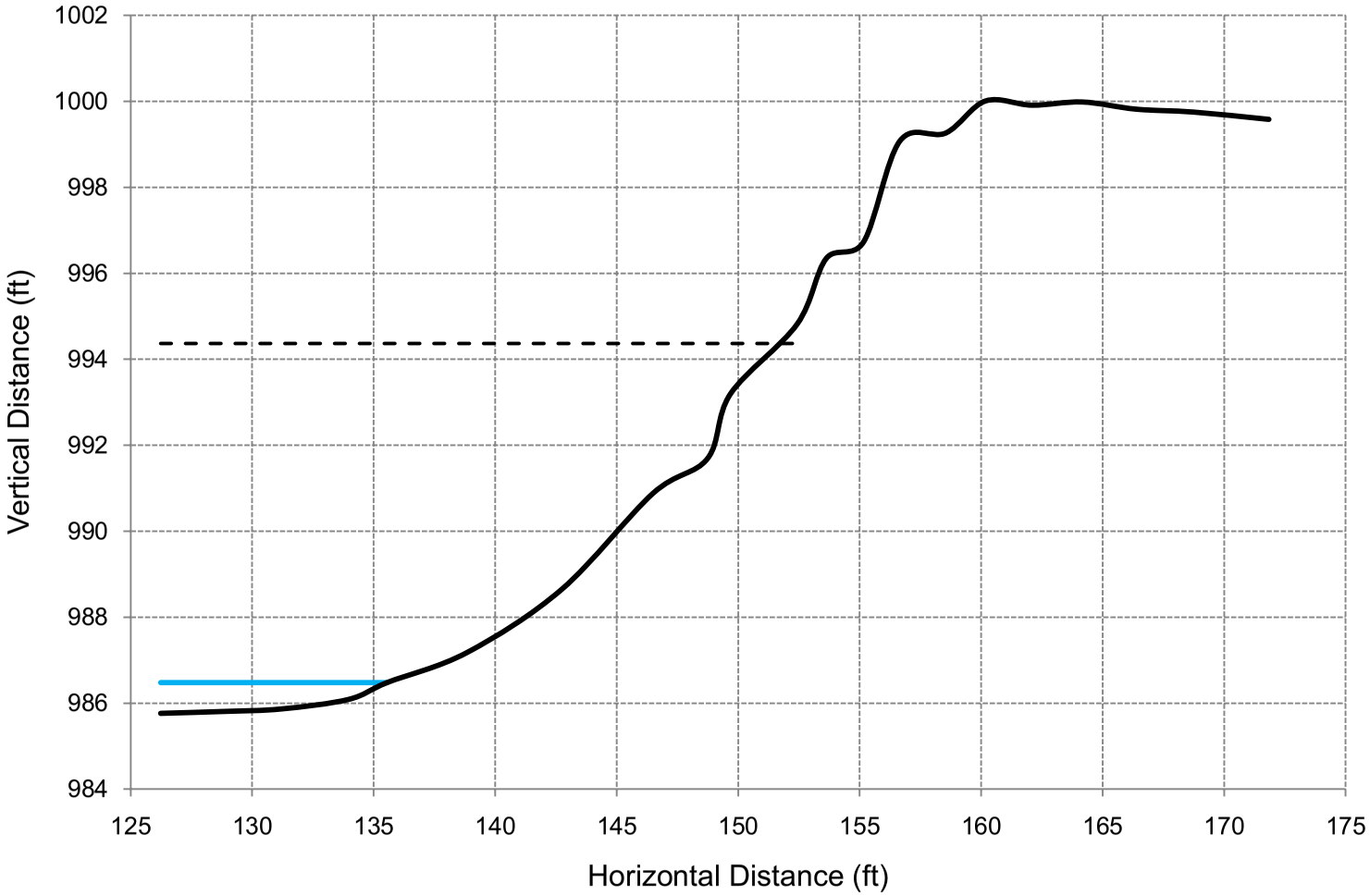




Copyright © 2006 Wildland Hydrology


Muddy Creek - Unique ID 0089 Cross Section
Elevation (ft)
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1002
1000
998
996
994
992
990
988
986
984
Vertical Distance (ft)
125
130
135
140
145
150
155
160
165
170
175
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0090

A-32 Delaware Hot-Spot UniqueID: 0090

Location of Stream Segment: Muddy Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0090	30.0	Moderate	1.73	0.79

Description of Survey Site: This site has no riparian corridor. There are active signs of bank toe erosion. Bank material are silts.

Length of Bank (feet): 381

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	82%	82%
Reduction of Rate of Erosion (tons/foot/year):	0.65	0.65
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$24,003	$24,003
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	247	247
***Cost of Soil Reduction Per Ton:**	**$9.73**	**$9.73**
***Cost of Soil Reduction Per Cubic Yard:**	**$12.64**	**$12.64**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Muddy Creek **Date:** 10-Nov-10
14 Digit HUC: 10270103010090
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0090
County: Jackson County
Legal Description: SE 1/4 Sec 11 T5S R15E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0-50	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	147.7	Feet
	Edge of Water to Edge of Water	21.2	Feet
Water Depth:	Thalweg	0.8	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 11.0 Feet (Measure)
Root Depth of Riparian Vegetation: 3.6 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 41 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		381	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.51 Average Feet / year

Comments on Erosion: The lower portion of site does have a wooded riparian corridor.

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Muddy Creek - UniqueID 0090**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/10/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	**10.8** (A)	**Bankfull Height** (ft) =	**9.8** (B)	(A) / (B) =	**1.1** (C)	**1.9**
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	**3.6** (D)	**Study Bank Height** (ft) =	**10.8** (A)	(D) / (A) =	**0.3** (E)	**5.6**
Weighted Root Density (G)						
		Root Density as % =	**20** (F)	(F) x (E) =	**6.7** (G)	**8.8**
Bank Angle (H)						
				Bank Angle as *Degrees* =	**55** (H)	**3.7**
Surface Protection (I)						
				Surface Protection as % =	**0** (I)	**10.0**

Bank Material Adjustment:

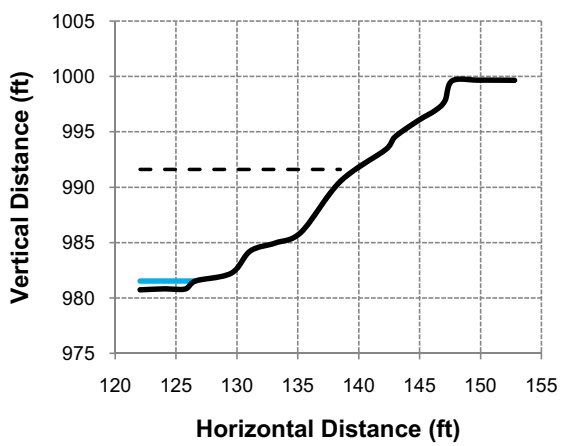
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

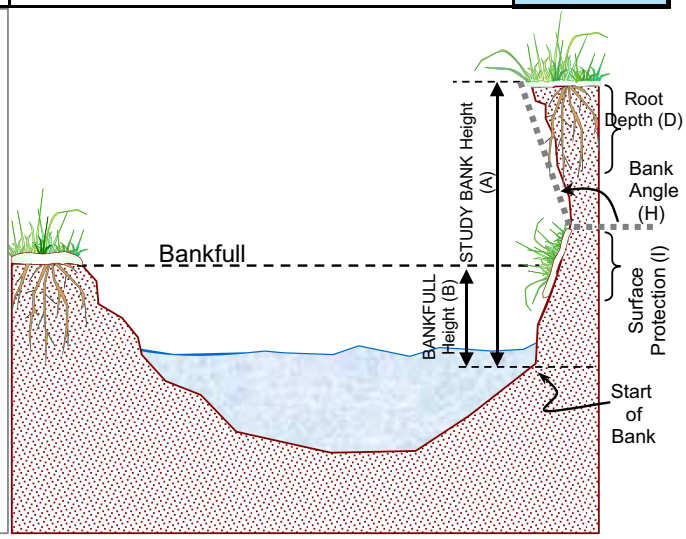
Bank Material Adjustment **0.0**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage **0.0**

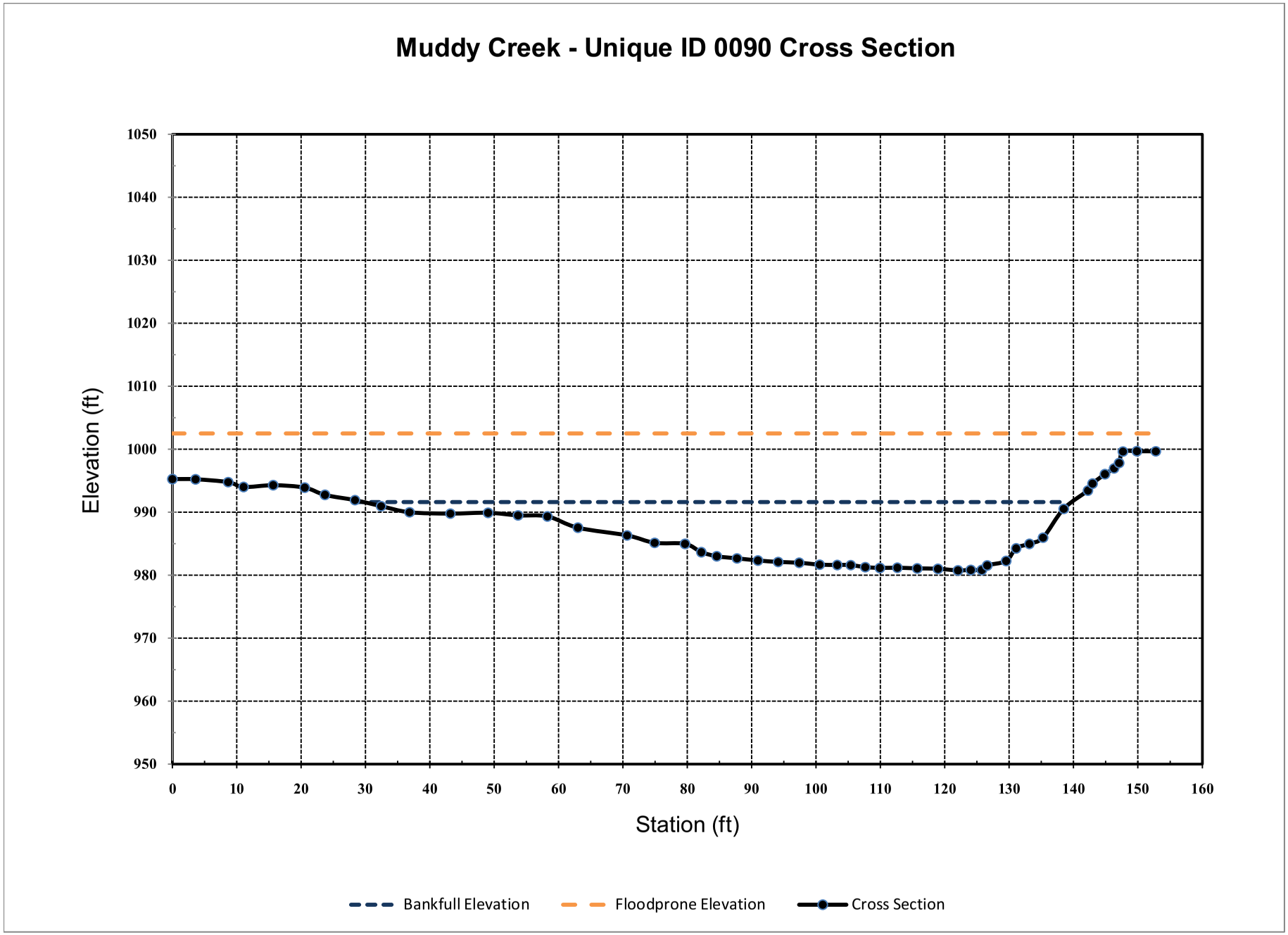
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		30.0

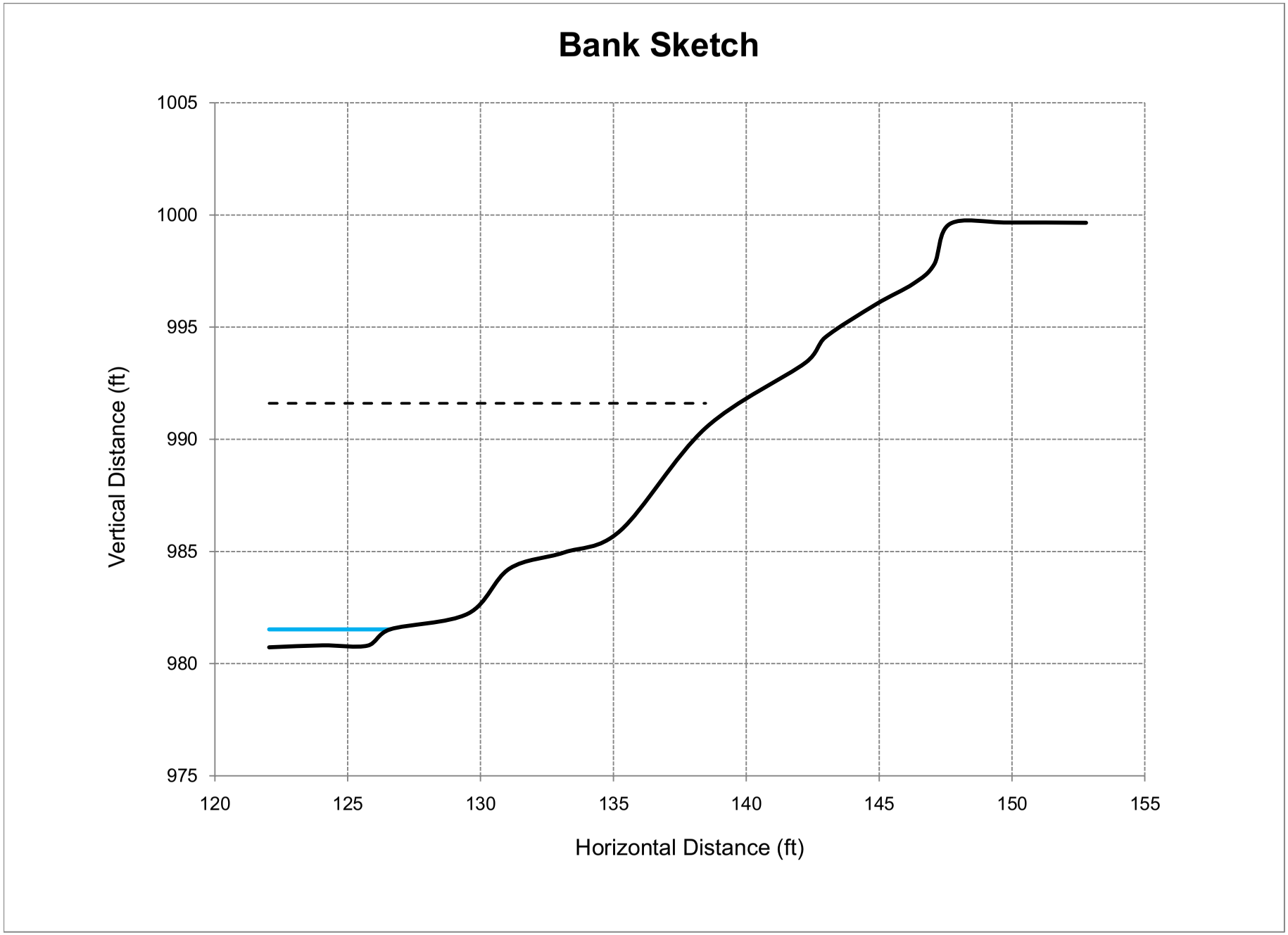
Bank Sketch





Copyright © 2006 Wildland Hydrology


Muddy Creek - Unique ID 0090 Cross Section
Elevation (ft)
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1005
1000
995
990
985
980
975
Vertical Distance (ft)
120
125
130
135
140
145
150
155
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0094

A-33 Delaware Hot-Spot UniqueID: 0094

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0094	39.4	High	1.53	5.46

Description of Survey Site: A BMP project was completed on this site in 2010.

Length of Bank (feet): 480

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	87%
Reduction of Rate of Erosion (tons/foot/year):	3.82	4.75
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$38,400	$38,400
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	1835	2280
***Cost of Soil Reduction Per Ton:**	**$2.09**	**$1.68**
***Cost of Soil Reduction Per Cubic Yard:**	**$2.72**	**$2.19**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 11-Sep-09
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0094
County: Jackson County
Legal Description: SE 1/4 Sec 4 T5S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	118.2	Feet
	Edge of Water to Edge of Water	30.0	Feet
Water Depth:	Thalweg	1.7	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 26.0 Feet (Measure)
Root Depth of Riparian Vegetation: 0.0 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 50 degrees.
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		480	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 4.37 Average Feet / year

Comments on Erosion:

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0094**	Location:	**Jackson County**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **09/11/09**	Stream Type: **-**	Valley Type:	**VIII**

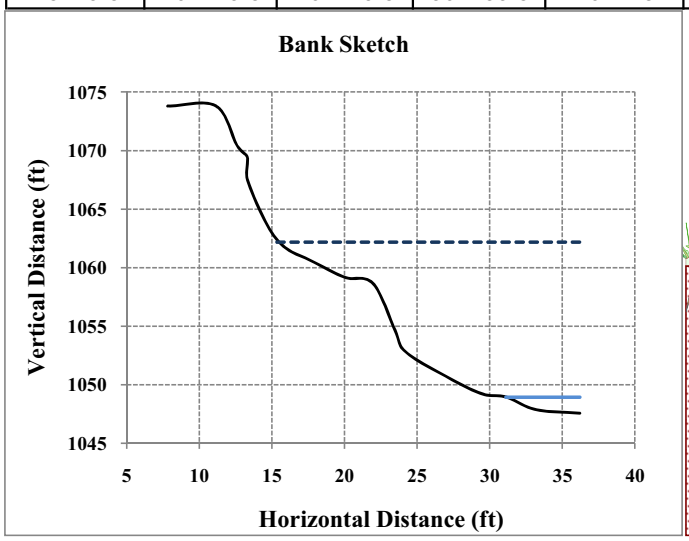
						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	26 (A)	Bankfull Height (ft) =	14.3 (B)	(A) / (B) =	1.8 (C)	7.1
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	0 (D)	Study Bank Height (ft) =	26 (A)	(D) / (A) =	0 (E)	10
Weighted Root Density (G)						
		Root Density as % =	0 (F)	(F) x (E) =	0 (G)	10
Bank Angle (H)						
				Bank Angle as *Degrees* =	50 (H)	3.4
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9

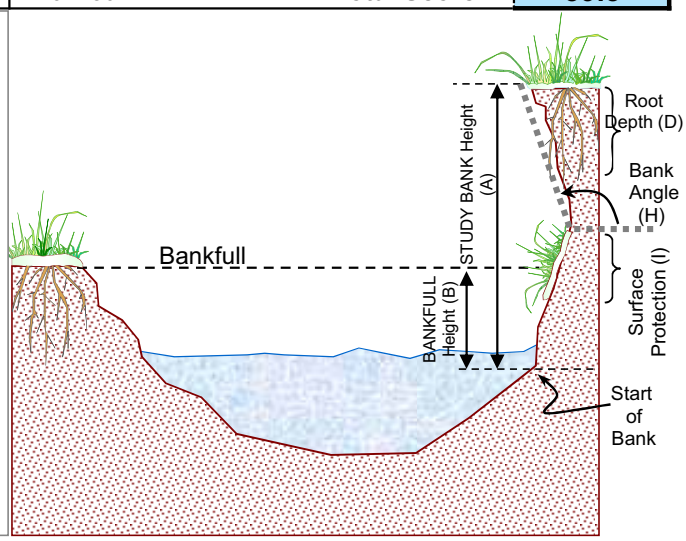
Bank Material Adjustment:

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 (no adjustment)

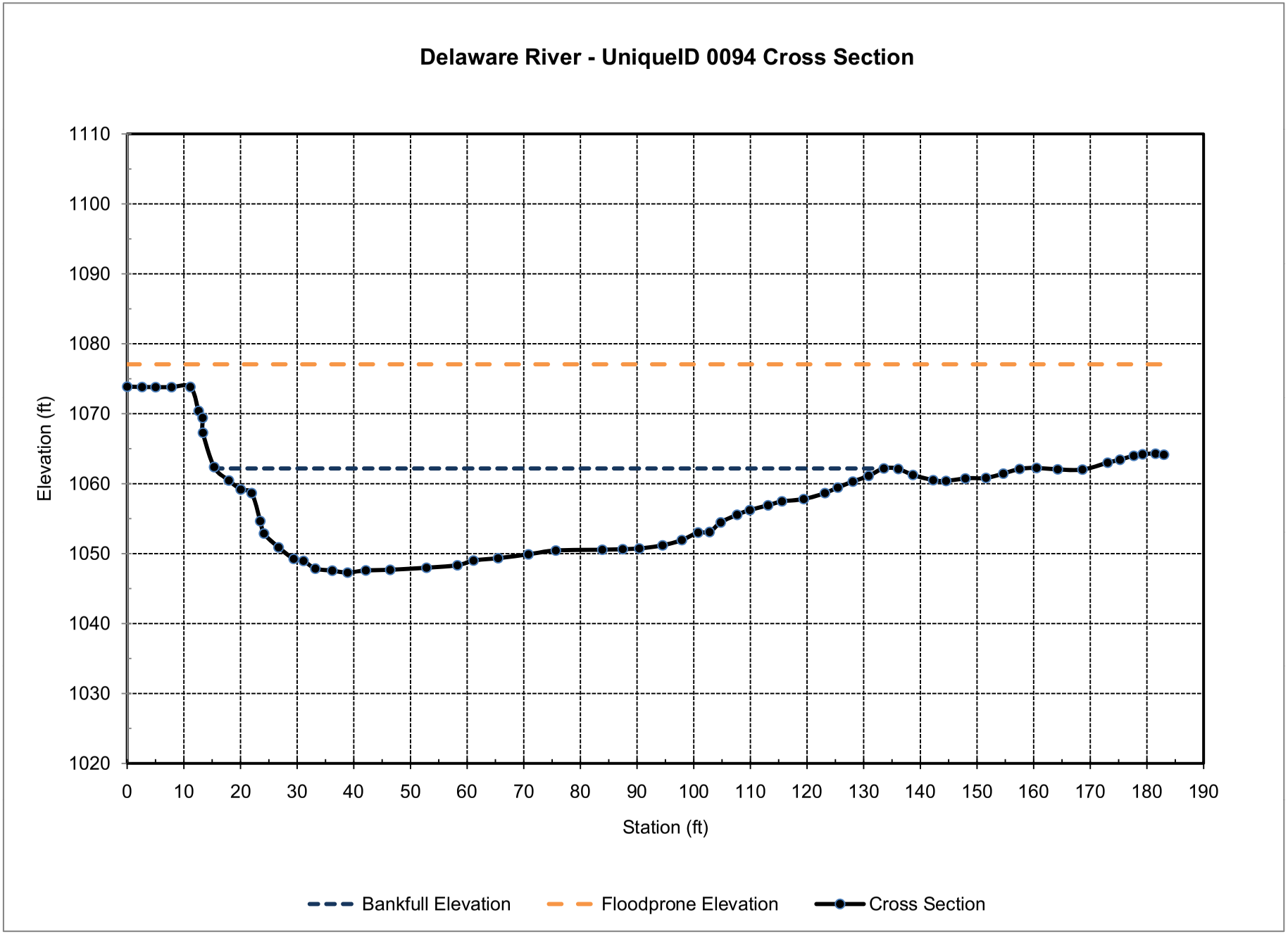
Bank Material Adjustment	0
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	0

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

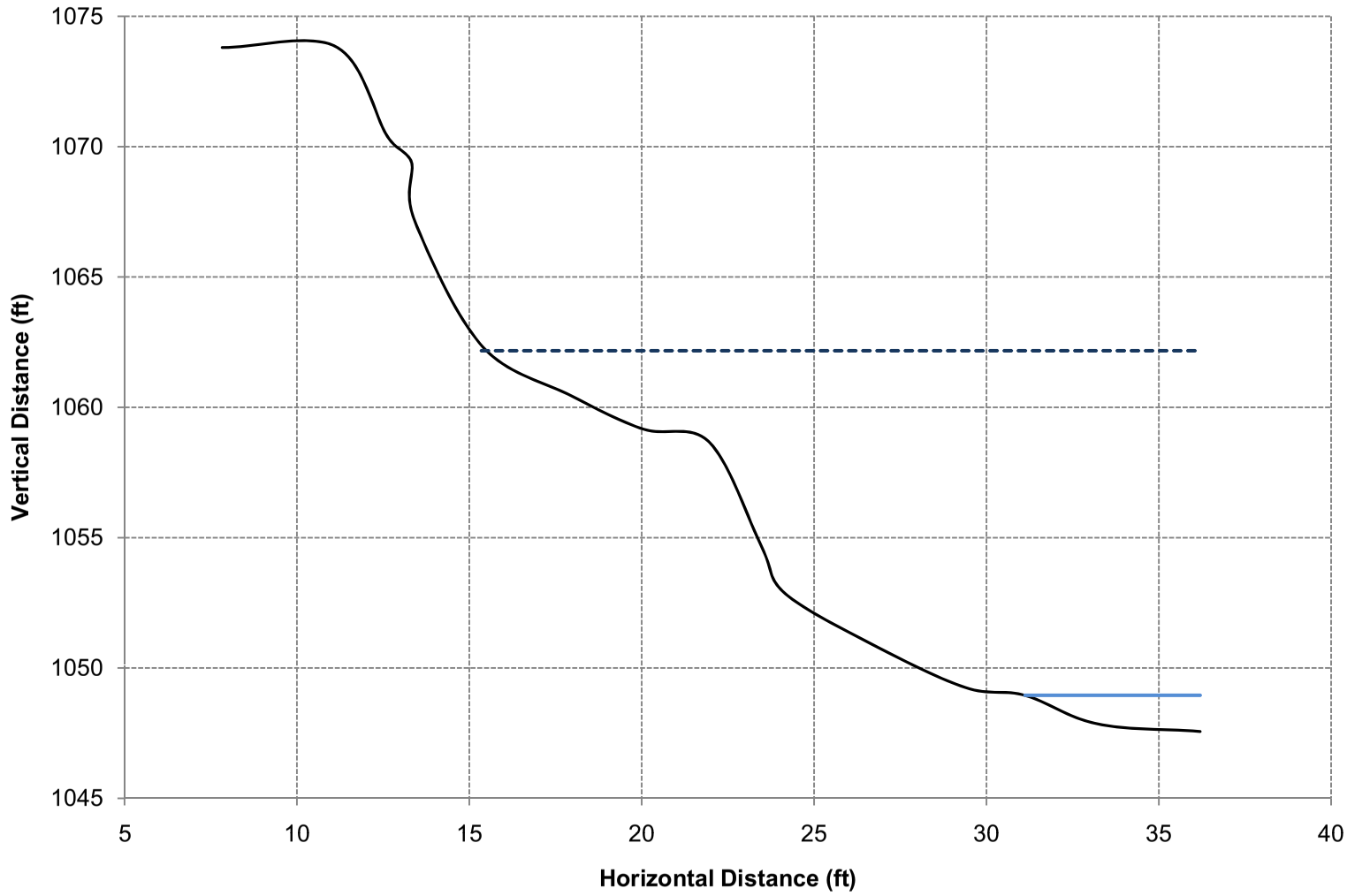




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0094 Cross Section
Elevation (ft)
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1075
1070
1065
1060
1055
1050
1045
Vertical Distance (ft)
5
10
15
20
25
30
35
40
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0096

A-34 Delaware Hot-Spot UniqueID: 0096

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0096	31.8	High	1.45	1.94

Description of Survey Site: This site is along county gravel road. There is a large seep daylighted in bank creating seep erosion.

Length of Bank (feet): 425

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	0.97	1.57
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$34,000	$34,000
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	412	668
***Cost of Soil Reduction Per Ton:**	**$8.25**	**$5.09**
***Cost of Soil Reduction Per Cubic Yard:**	**$10.72**	**$6.62**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 30-Dec-10
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Afilliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0096
County: Brown County
Legal Description: SW 1/4 Sec 16 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Cropfield	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	194.3	Feet
	Edge of Water to Edge of Water	45.1	Feet
Water Depth:	Thalweg	2.6	Feet

Livestock access to Riparian Area **Yes** _____ **No** X
If yes, what is the duration in months per year? _____

Debris or Channel Blockages **Yes** _____ **No** X

Buildings or Structures Threatened **Yes** _____ **No** X
If yes, what is their distance from the streambank? _____ Feet

Bank Erosion Inventory

Average Bank Height: 28.6 Feet (Measure)
Root Depth of Riparian Vegetation: 12.6 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 30 degrees.
	Vertical		Active seeps observed in banks.
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.			
	Sand		.062-2 mm dia			
	Gravels		.08 - 2.5 inches			
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles		2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders		10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock		

Eroding Bank Length: 425 Feet

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.41 Average Feet / year

Comments on Erosion:

View across channel at cross section

View downstream from cross section

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0096**	Location:	**Brown County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **12/30/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	28.6 (A)	Bankfull Height (ft) =	12.3 (B)	(A) / (B) =	2.3 (C)	8.3
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	12.6 (D)	Study Bank Height (ft) =	28.6 (A)	(D) / (A) =	0.4 (E)	4.5
Weighted Root Density (G)						
		Root Density as % =	40 (F)	(F) x (E) =	17.6 (G)	7.5
Bank Angle (H)						
				Bank Angle as *Degrees* =	29 (H)	2.4
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

Bank Material Adjustment:

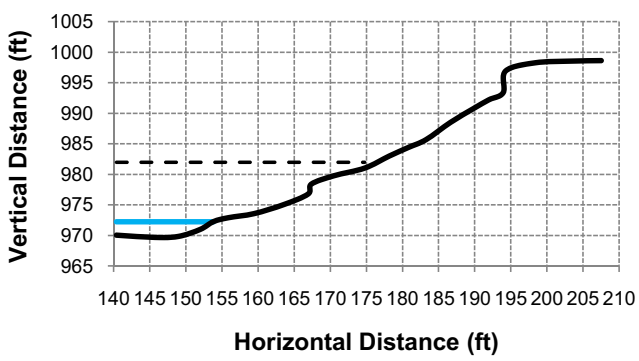
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

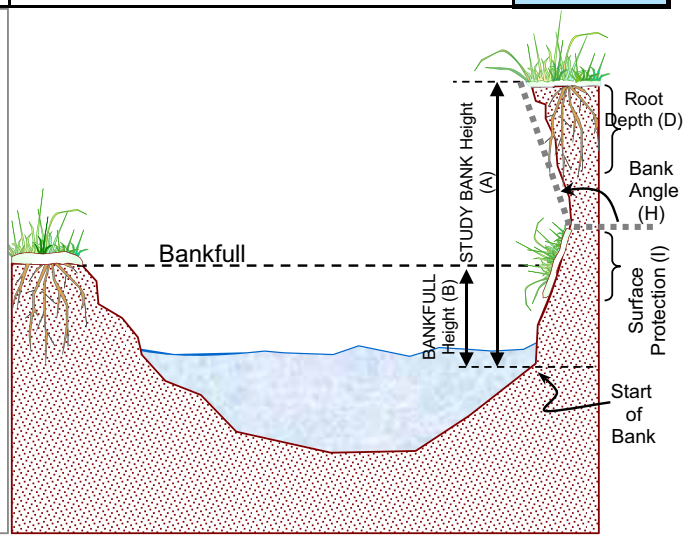
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

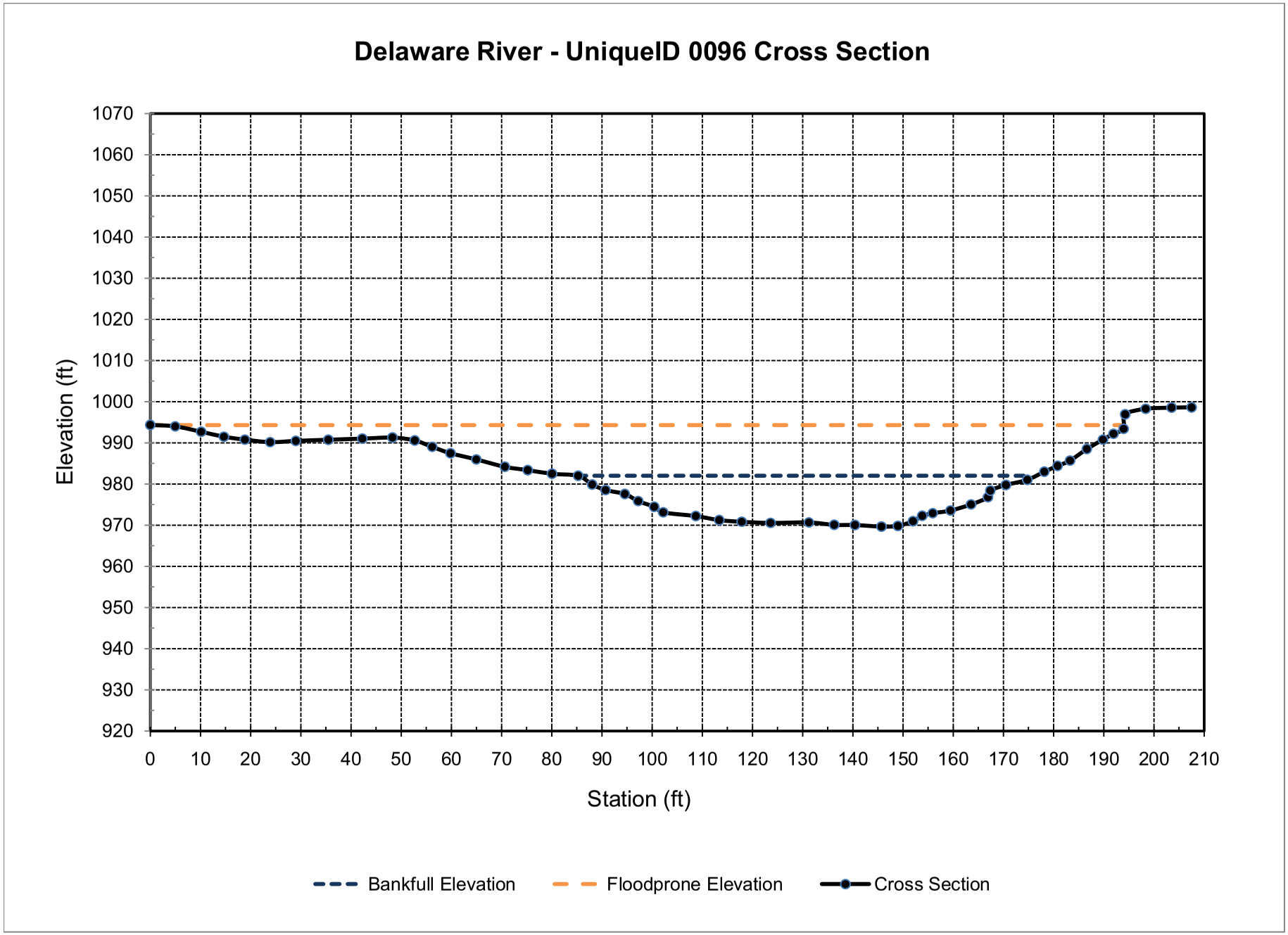
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		31.8

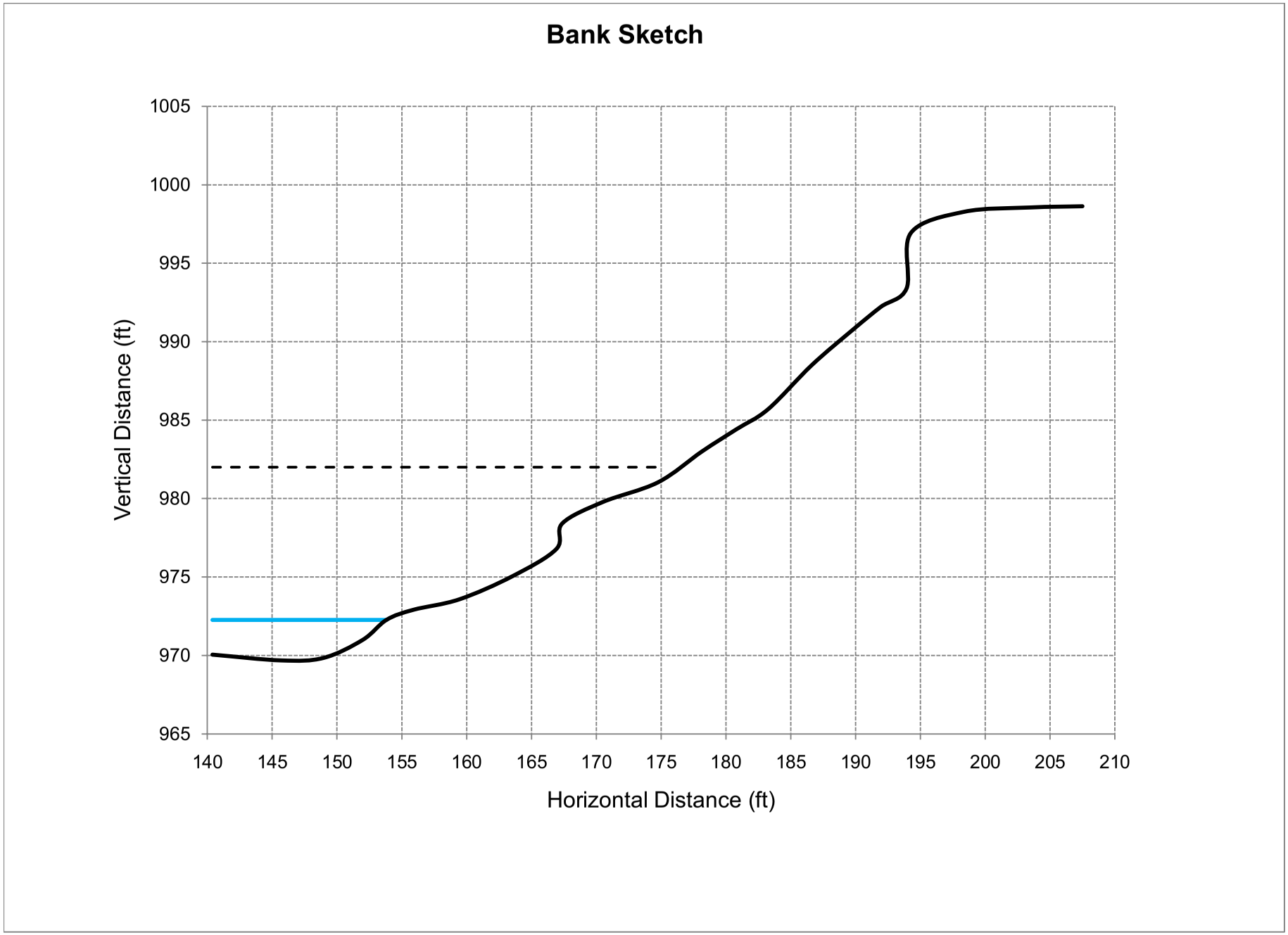
Bank Sketch





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0096 Cross Section
Elevation (ft)
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
920
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
Vertical Distance (ft)
1005
1000
995
990
985
980
975
970
965
140
145
150
155
160
165
170
175
180
185
190
195
200
205
210
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0112

A-35 Delaware Hot-Spot UniqueID: 0112

Location of Stream Segment: Straight Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0112	23.3	Moderate	1.45	3.69

Description of Survey Site: This site has no riparian corridor. A small island is present. Bank material are loamy silts and sand.

Length of Bank (feet): 308

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	0%	62%
Reduction of Rate of Erosion (tons/foot/year):	0.00	2.29
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$19,404	$19,404
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	0	705
***Cost of Soil Reduction Per Ton:**	**$5,821**	**$2.75**
***Cost of Soil Reduction Per Cubic Yard:**	**$7,568**	**$3.58**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume 1 cubic yard weighs 1.3 tons. For year 1 through 3, modeling results did not produce an erosion reduction; therefore 3 years of BMP installation costs were added to calculate the cost-benefits associated with year 1 through 3.

Field Assessment Form

Site Location

Stream Name: Straight Creek **Date:** 9-Nov-10
14 Digit HUC: 10270103030030
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Afilliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0112
County: Jackson County
Legal Description: SW 1/4 Sec24 T6S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Cropfield	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	127.6	Feet
	Edge of Water to Edge of Water	26.1	Feet
Water Depth:	Thalweg	0.8	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 18.0 Feet (Measure)
Root Depth of Riparian Vegetation: 15.8 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 31 degrees.
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		308	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 4.26 Average Feet / year

Comments on Erosion: Vegetation is beginning to establish on the bank slope creating good surface protection.

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Straight Creek - UniqueID 0112**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/09/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	18 (A)	Bankfull Height (ft) =	8.4 (B)	(A) / (B) =	2.1 (C)	8.1
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	15.8 (D)	Study Bank Height (ft) =	18 (A)	(D) / (A) =	0.9 (E)	2.1
Weighted Root Density (G)						
		Root Density as % =	30 (F)	(F) x (E) =	26.3 (G)	6.4
Bank Angle (H)						
				Bank Angle as *Degrees* =	31 (H)	2.5
Surface Protection (I)						
				Surface Protection as % =	50 (I)	4.3

Bank Material Adjustment:

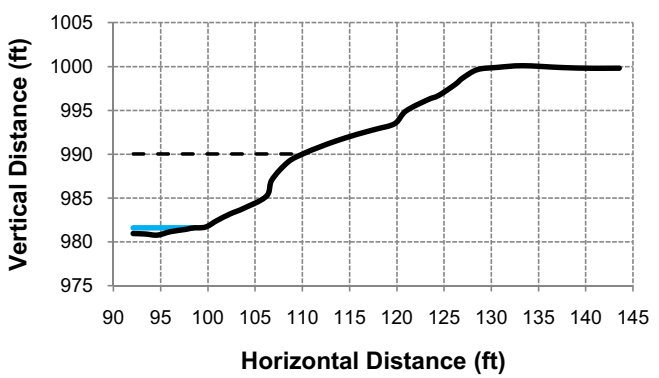
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

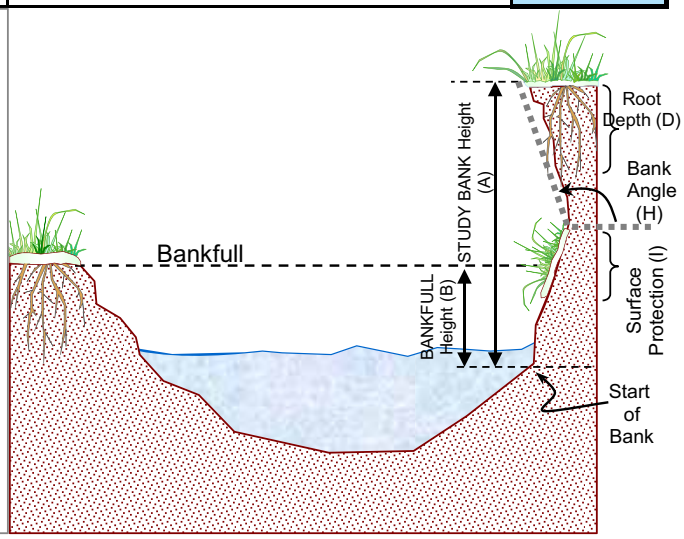
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

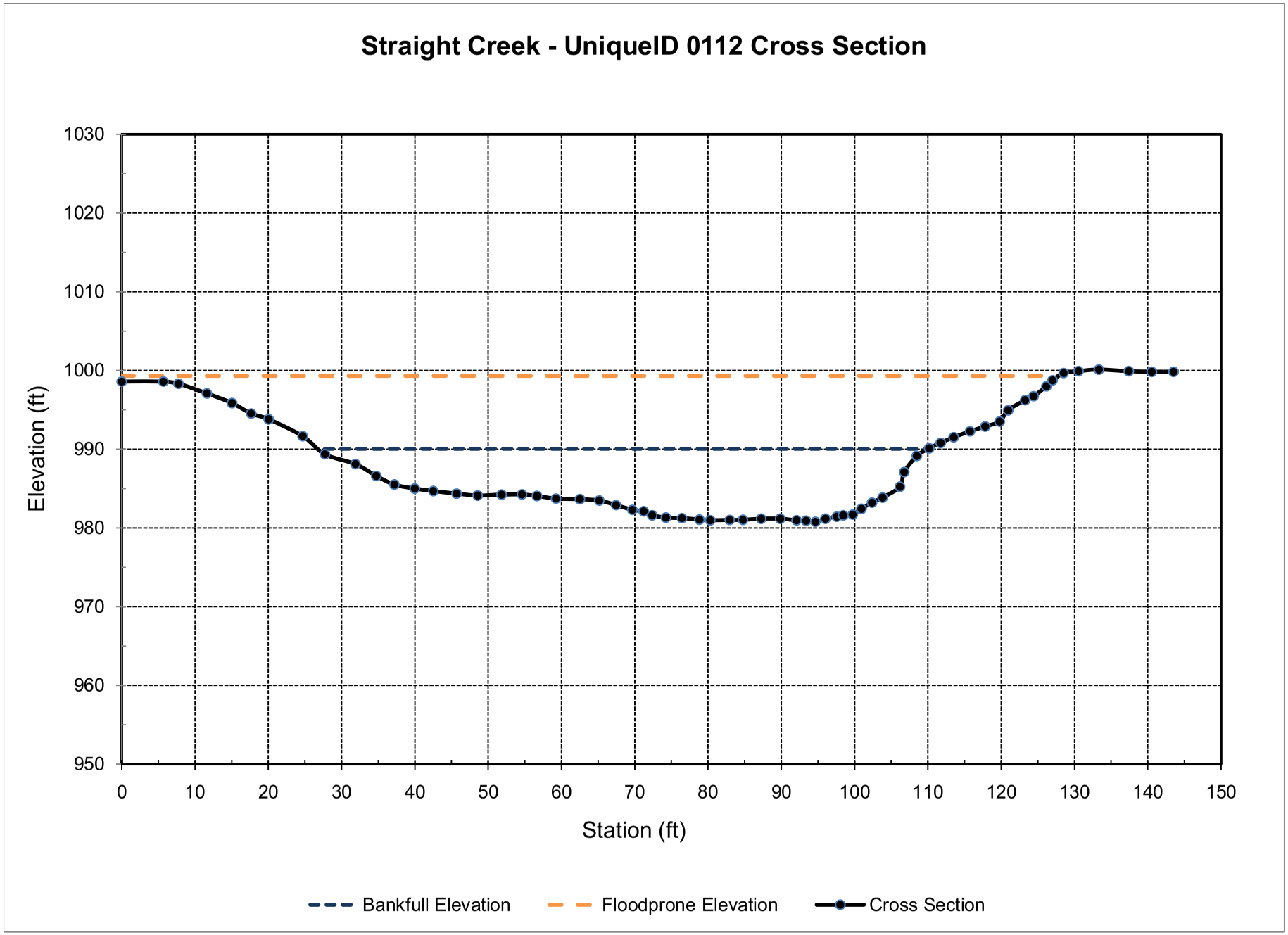
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		23.3

Bank Sketch

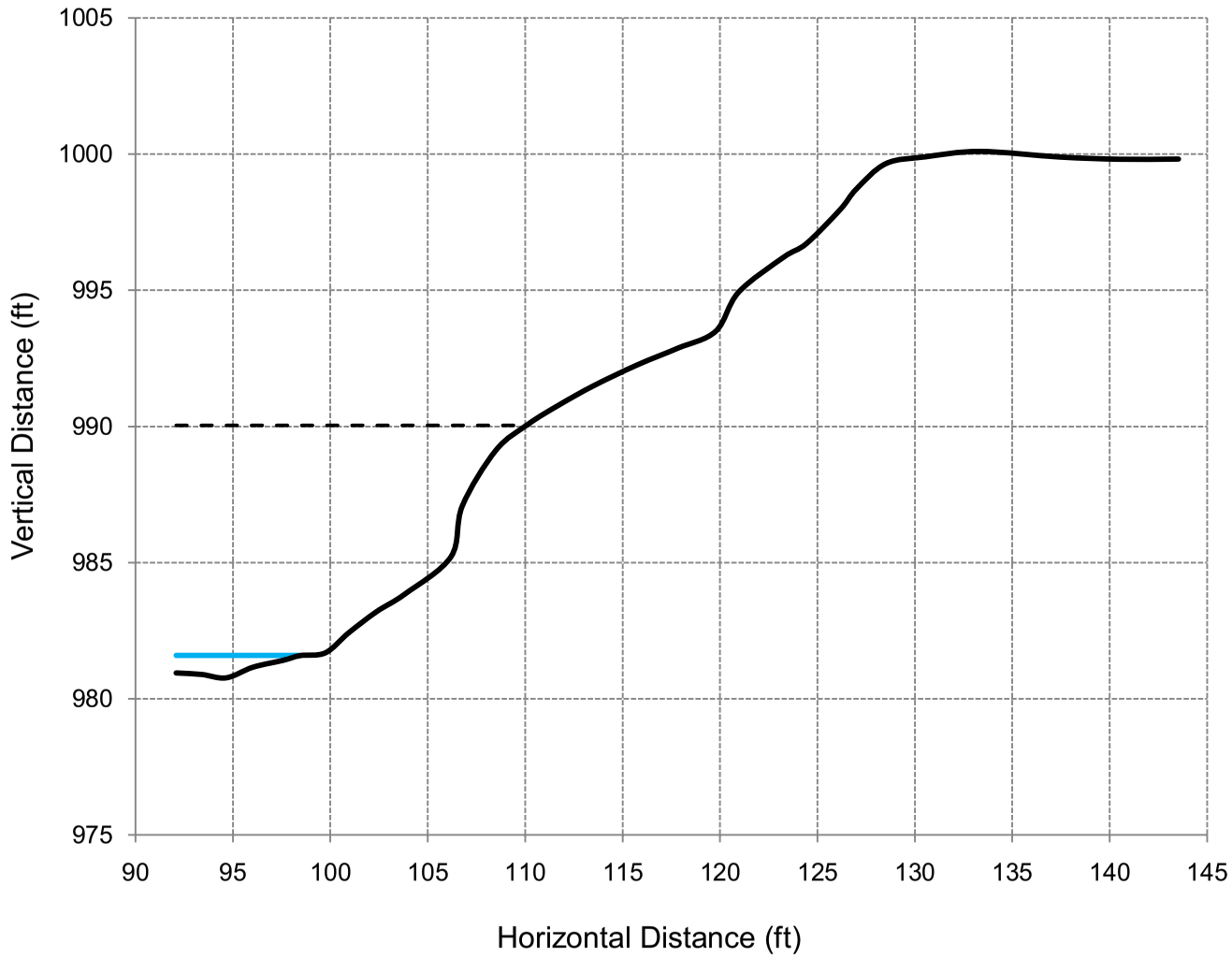




Copyright © 2006 Wildland Hydrology


Straight Creek - UniqueID 0112 Cross Section
Elevation (ft)
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


1005
1000
995
990
985
980
975
Vertical Distance (ft)
90
95
100
105
110
115
120
125
130
135
140
145
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0113

4.36 Delaware Hot-Spot UniqueID: 0113:

Location of Stream Segment: Straight Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0113	18.4	Low	1.74	0.62

Description of Survey Site: This site has a narrow riparian corridor. There are active signs of slumping. Bank material are mainly silts.

Length of Bank (feet): 378

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	29%	51%
Reduction of Rate of Erosion (tons/foot/year):	0.00	0.32
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$23,814	$23,814
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	0	120
***Cost of Soil Reduction Per Ton:**	**$7,144**	**$19.92**
***Cost of Soil Reduction Per Cubic Yard:**	**$9,287**	**$25.90**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume 1 cubic yard weighs 1.3 tons. For year 1 through 3, modeling results did not produce an erosion reduction; therefore 3 years of BMP installation costs were added to calculate the cost-benefits associated with year 1 through 3.

Field Assessment Form

Site Location

Stream Name: Straight Creek **Date:** 9-Nov-10
14 Digit HUC: 10270103030030
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0113
County: Jackson County
Legal Description: NW 1/4 Sec 25 T6S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	184.6	Feet
	Edge of Water to Edge of Water	29.5	Feet
Water Depth:	Thalweg	0.8	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 18.7 Feet (Measure)
Root Depth of Riparian Vegetation: 18.7 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 20 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		378	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 0.69 Average Feet / year

Comments on Erosion: Vegetation has established on bank slump increasing the bank stability.

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Straight Creek - UniqueID 0113**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/09/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	**18.7** (A)	**Bankfull Height** (ft) =	**10.1** (B)	(A) / (B) =	**1.9** (C)	**7.2**
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	**18.7** (D)	**Study Bank Height** (ft) =	**18.7** (A)	(D) / (A) =	**1.0** (E)	**1.0**
Weighted Root Density (G)						
		Root Density as % =	**40** (F)	(F) x (E) =	**40** (G)	**5.1**
Bank Angle (H)						
				Bank Angle as *Degrees* =	**37** (H)	**2.8**
Surface Protection (I)						
				Surface Protection as % =	**75** (I)	**2.3**

Bank Material Adjustment:

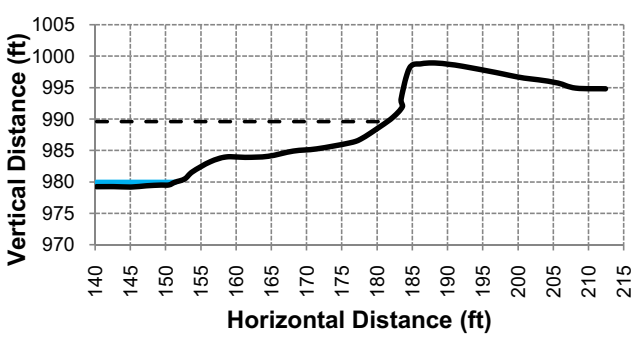
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

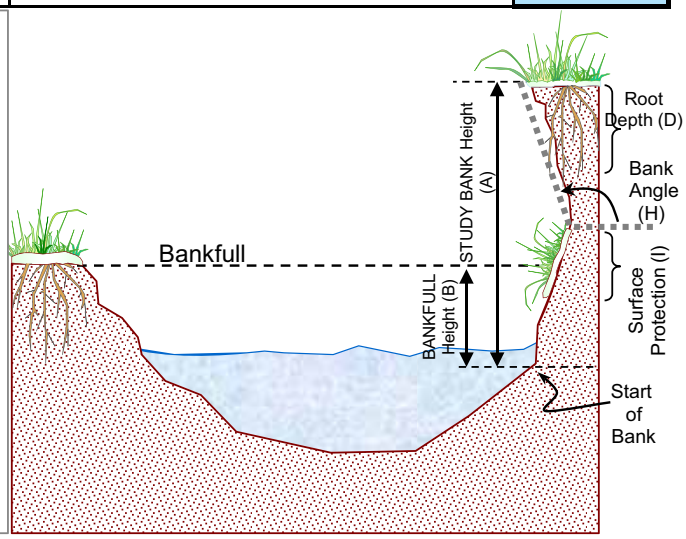
Bank Material Adjustment **0.0**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage **0.0**

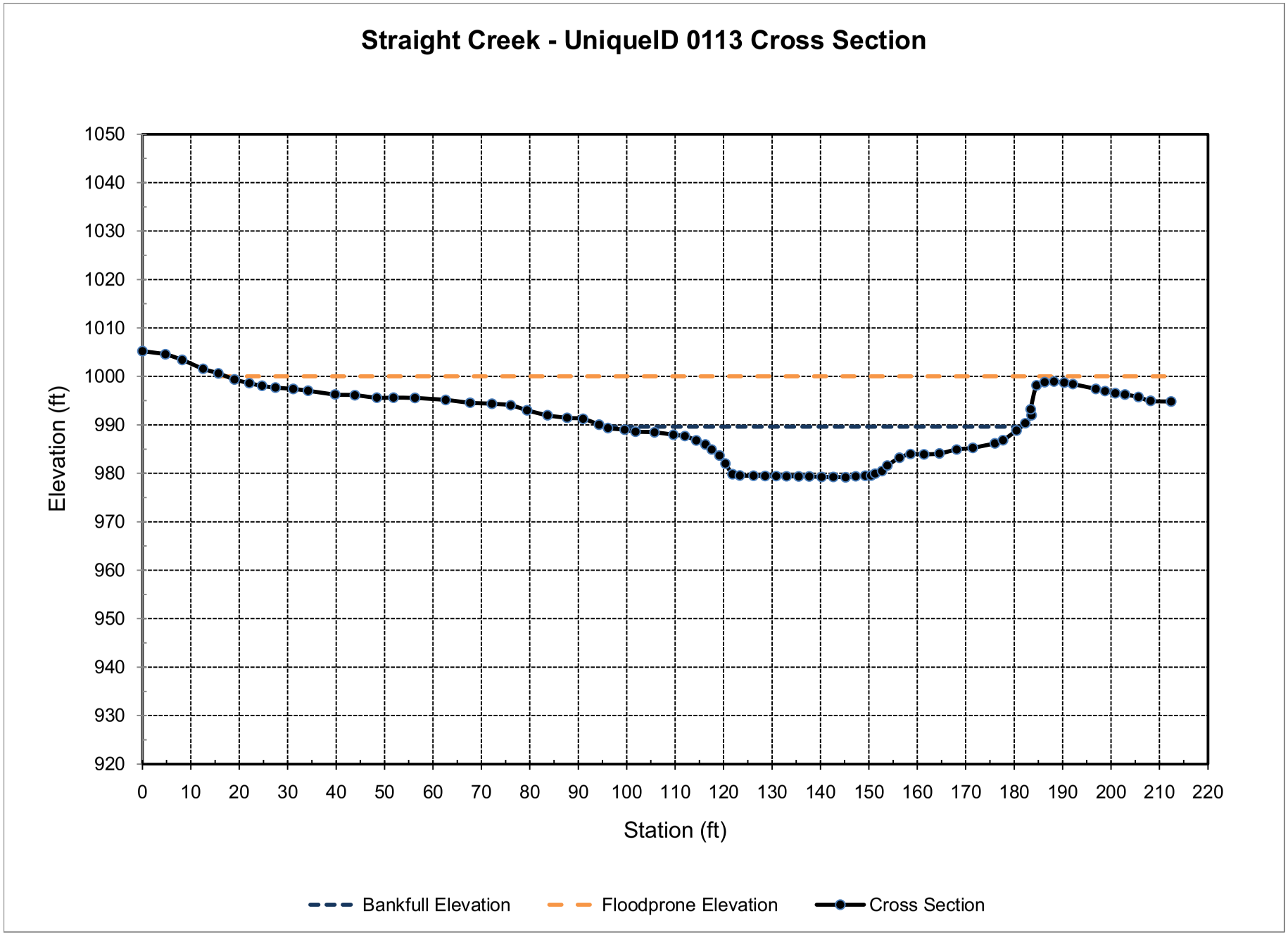
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Low
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		18.4

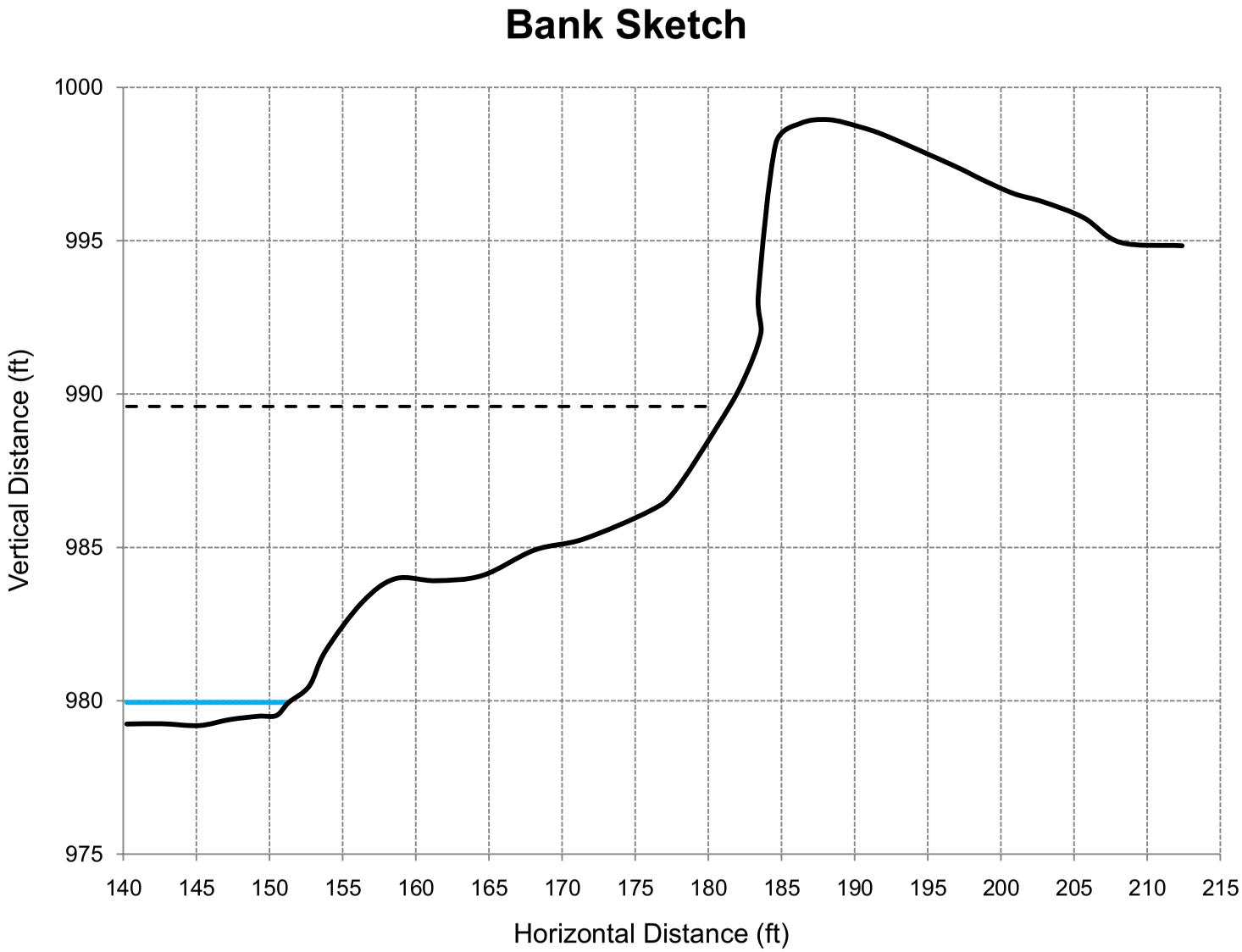
Bank Sketch





Copyright © 2006 Wildland Hydrology


Straight Creek - UniqueID 0113 Cross Section
Elevation (ft)
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
920
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1000
995
990
985
980
975
Vertical Distance (ft)
140
145
150
155
160
165
170
175
180
185
190
195
200
205
210
215
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0114

A-37 Delaware Hot-Spot UniqueID: 0114

Location of Stream Segment: Straight creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0114	32.3	High	1.48	0.27

Description of Survey Site: This site has a narrow riparian corridor. Bank materials are mainly silts.

Length of Bank (feet): 173

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	0.14	0.22
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$10,899	$10,899
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	23	38
***Cost of Soil Reduction Per Ton:**	**$46.67**	**$28.81**
***Cost of Soil Reduction Per Cubic Yard:**	**$60.67**	**$37.45**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Straight Creek **Date:** 9-Nov-10
14 Digit HUC: 10270103030030
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Afilliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0114
County: Jackson County
Legal Description: SW 1/4 Sec 25 T6S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	35	Feet	Pasture	
	Cropfield			Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber	X		Residential	
	Cropland			Industrial	

Channel Width:	Top of Bank to Top of Bank	133.5	Feet
	Edge of Water to Edge of Water	32.0	Feet
Water Depth:	Thalweg	2.0	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 19.0 Feet (Measure)
Root Depth of Riparian Vegetation: 9.7 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 32 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		173	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 0.29 Average Feet / year

Comments on Erosion:

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Straight Creek - UniqueID 0114**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/09/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	19.3 (A)	Bankfull Height (ft) =	9.3 (B)	(A) / (B) =	2.1 (C)	8.0
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	9.7 (D)	Study Bank Height (ft) =	19.3 (A)	(D) / (A) =	0.5 (E)	3.9
Weighted Root Density (G)						
		Root Density as % =	40 (F)	(F) x (E) =	20.1 (G)	7.2
Bank Angle (H)						
				Bank Angle as *Degrees* =	45 (H)	3.2
Surface Protection (I)						
				Surface Protection as % =	5 (I)	10.0

Bank Material Adjustment:

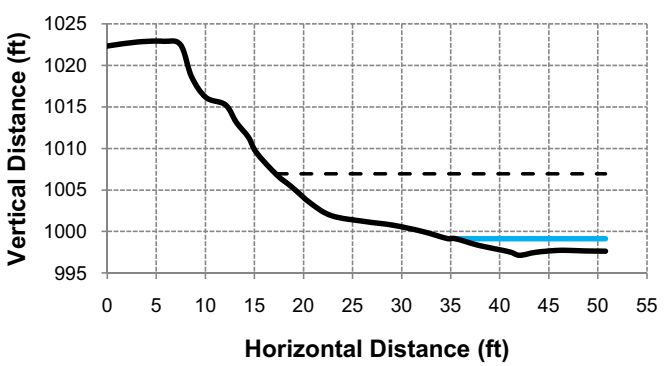
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

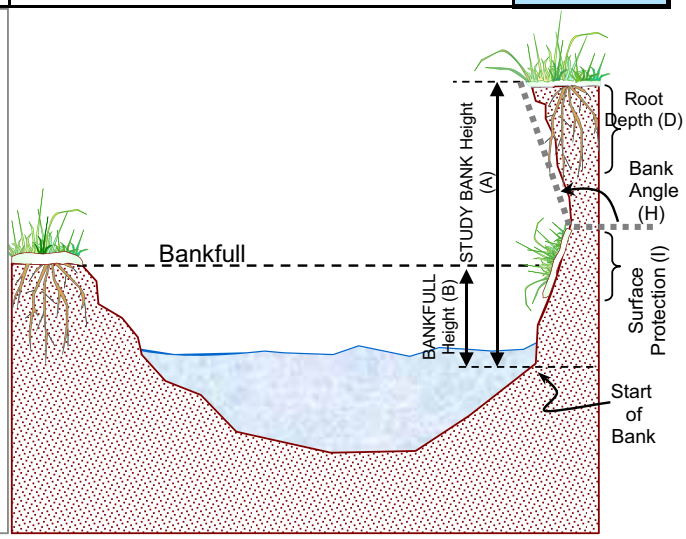
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

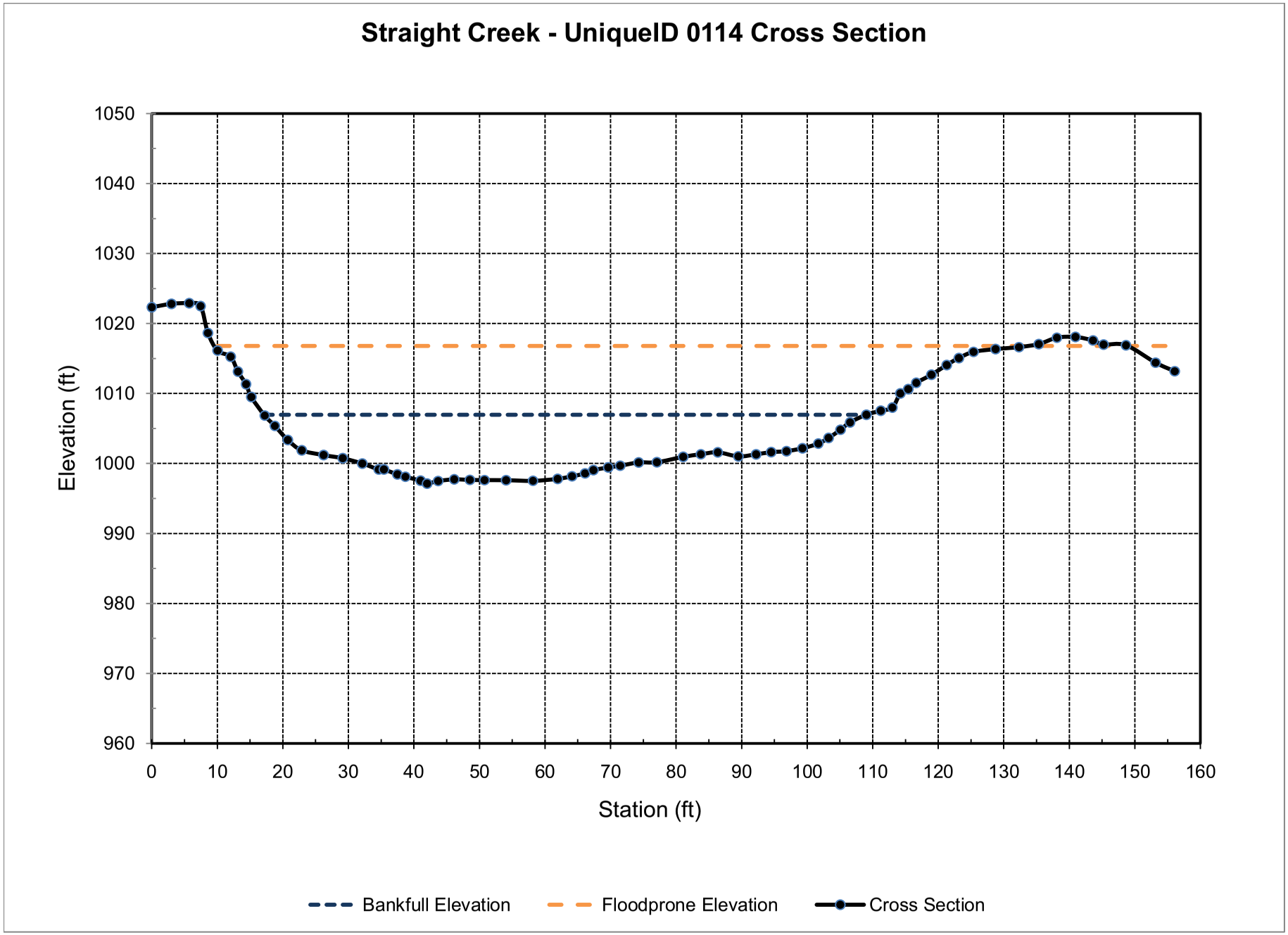
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		32.3

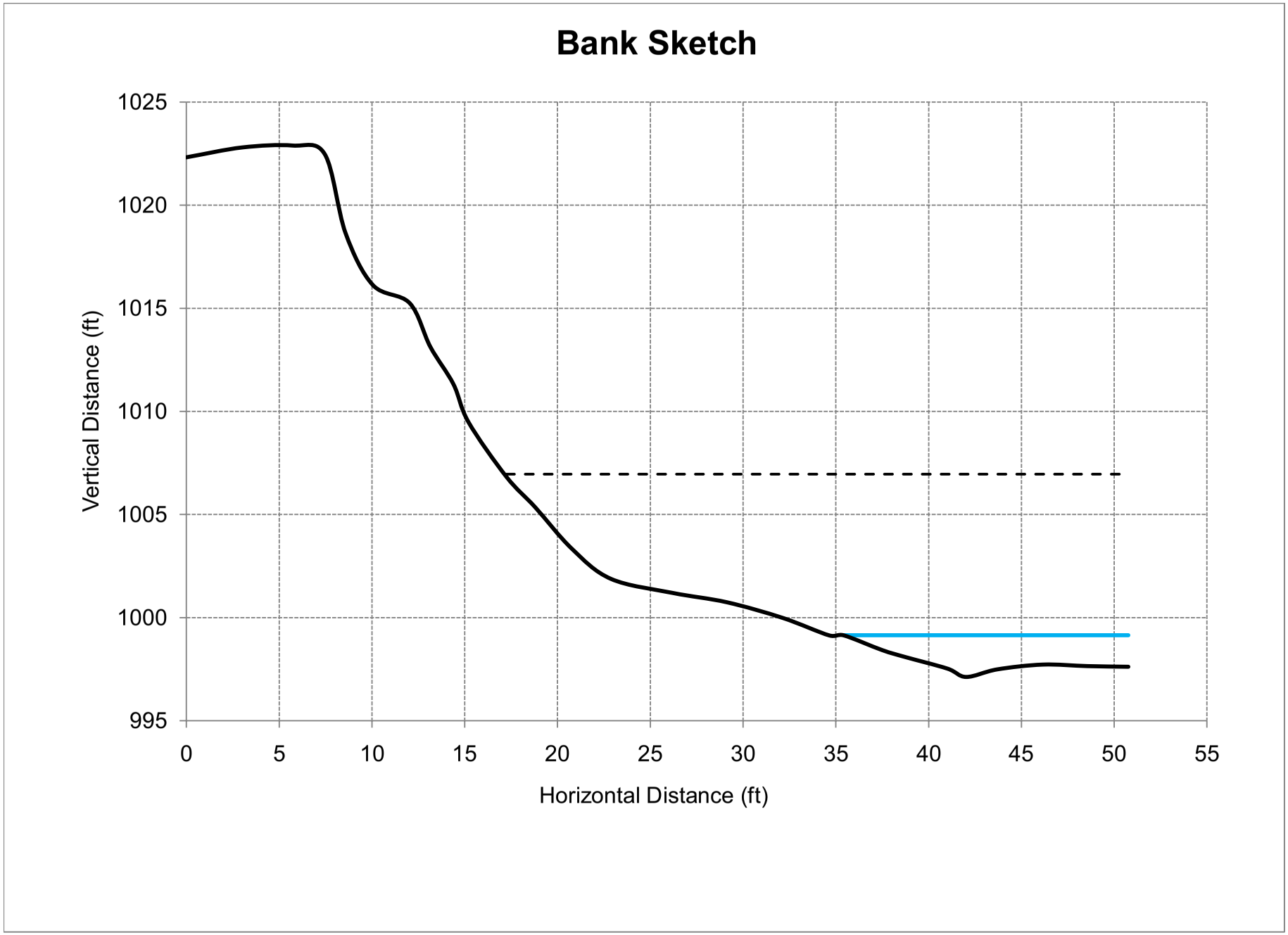
Bank Sketch





Copyright © 2006 Wildland Hydrology


Straight Creek - UniqueID 0114 Cross Section
Elevation (ft)
1050
1040
1030
1020
1010
1000
990
980
970
960
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1025
1020
1015
1010
1005
1000
995
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
50
55
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0115

A-38 Delaware Hot-Spot UniqueID: 0115

Location of Stream Segment: Muddy Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0115	38.0	High	1.31	1.02

Description of Survey Site: This site has a narrow riparian corridor. Bank materials are mainly silts.

Length of Bank (feet): 226

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 3+
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	0.51	0.83
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$14,238	$14,238
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	115	187
***Cost of Soil Reduction Per Ton:**	**$12.35**	**$7.63**
***Cost of Soil Reduction Per Cubic Yard:**	**$16.06**	**$9.91**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period.

Field Assessment Form

Site Location

Stream Name: Muddy Creek **Date:** 10-Nov-10
14 Digit HUC: 10270103010090
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0115
County: Jackson County
Legal Description: SE 1/4 Sec 7 T5S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	X
	Crop field			Rangeland	
	Timber				
Adjacent Landuse:	Pasture	X		Urban	
	Timber			Residential	
	Cropland			Industrial	

Channel Width: Top of Bank to Top of Bank 188.9 Feet
Edge of Water to Edge of Water 44.1 Feet
Water Depth: Thalweg 0.9 Feet

Livestock access to Riparian Area **Yes** Y **No**
If yes, what is the duration in months per year? 3

Debris or Channel Blockages **Yes** **No** X

Buildings or Structures Threatened **Yes** **No** X
If yes, what is their distance from the streambank? Feet

Bank Erosion Inventory

Average Bank Height: 21.0 Feet (Measure)
Root Depth of Riparian Vegetation: 1.5 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 39 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		226	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.01 Average Feet / year

Comments on Erosion:

View of the left bank.

View downstream from cross section

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Muddy Creek - UniqueID 0115**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/10/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	**21** (A)	**Bankfull Height** (ft) =	**6.4** (B)	(A) / (B) =	**3.3** (C)	**10.0**
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	**1.5** (D)	**Study Bank Height** (ft) =	**21** (A)	(D) / (A) =	**0.1** (E)	**8.8**
Weighted Root Density (G)						
		Root Density as % =	**20** (F)	(F) x (E) =	**1.4** (G)	**10.0**
Bank Angle (H)						
				Bank Angle as *Degrees* =	**49** (H)	**3.4**
Surface Protection (I)						
				Surface Protection as % =	**30** (I)	**5.9**

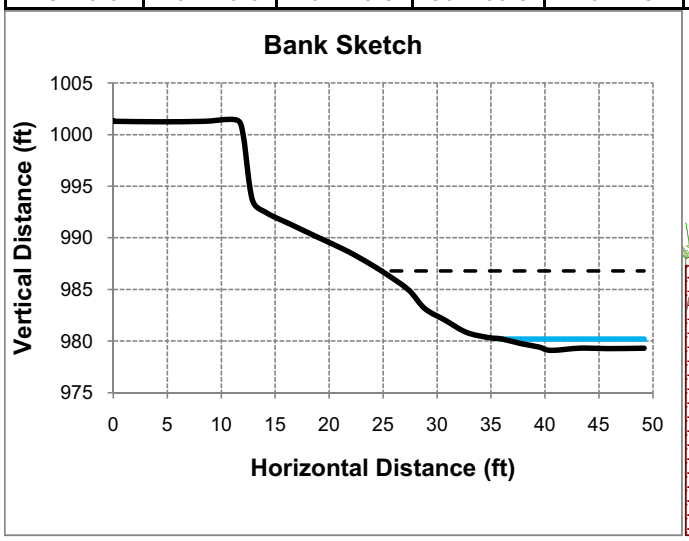
Bank Material Adjustment:

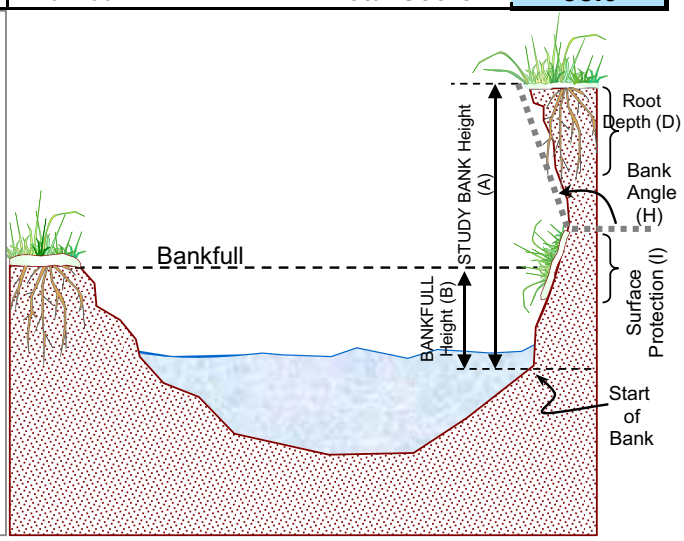
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment **0.0**

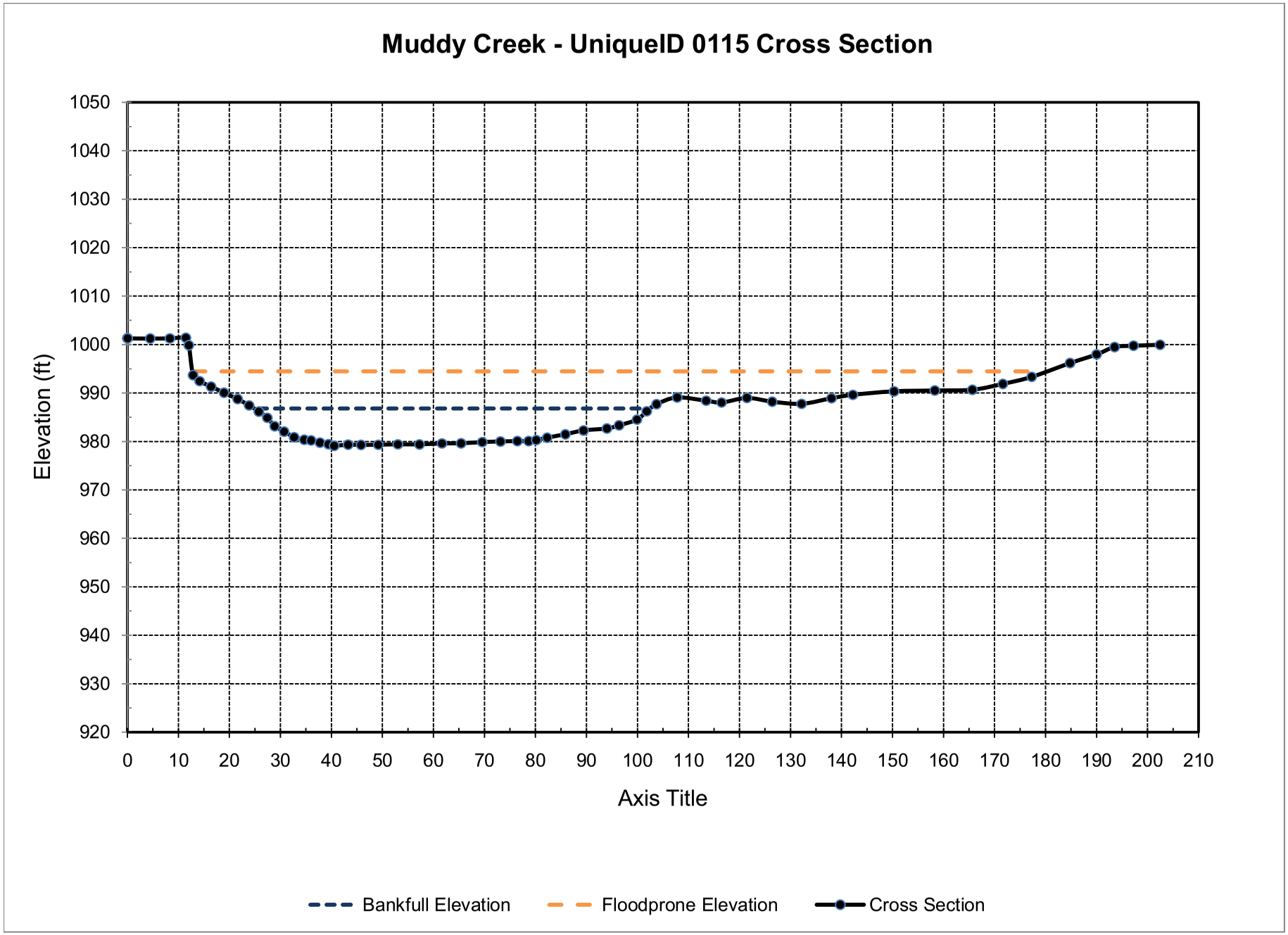
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage **0.0**

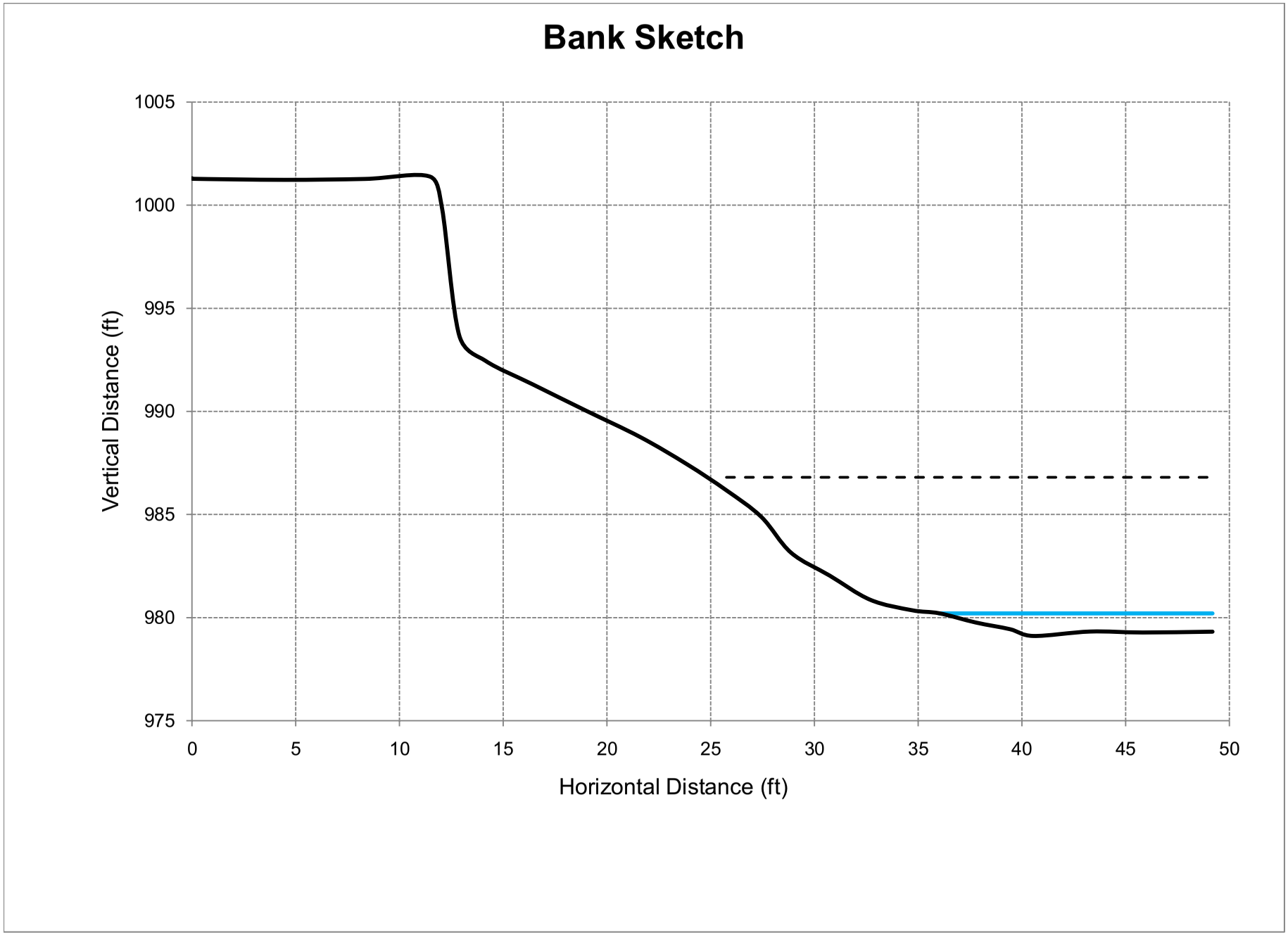
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		38.0





Copyright © 2006 Wildland Hydrology


Muddy Creek - UniqueID 0115 Cross Section
Elevation (ft)
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
920
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Axis Title
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1005
1000
995
990
985
980
975
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
45
50
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0116

A-39 Delaware Hot-Spot UniqueID: 0116

Location of Stream Segment: Muddy Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0116	29.3	Moderate	1.45	0.72

Description of Survey Site: This site has a narrow riparian corridor. There are active seeps daylighting 2-3 feet above the water. Bank materials are mainly silts.

Length of Bank (feet): 254

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	0%	62%
Reduction of Rate of Erosion (tons/foot/year):	0.00	0.45
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$16,002	$16,002
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	0	113
***Cost of Soil Reduction Per Ton:**	**$4,801**	**$14.11**
***Cost of Soil Reduction Per Cubic Yard:**	**$6,241**	**$18.35**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume 1 cubic yard weighs 1.3 tons. For year 1 through 3, modeling results did not produce an erosion reduction; therefore 3 years of BMP installation costs were added to calculate the cost-benefits associated with year 1 through 3.

Field Assessment Form

Site Location

Stream Name: Muddy Creek **Date:** 10-Nov-10
14 Digit HUC: 10270103010090
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Afilliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0116
County: Jackson county
Legal Description: SE 1/4 Sec 7 T5S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	25	Feet	Pasture	
	Cropfield			Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber	X		Residential	
	Cropland			Industrial	

Channel Width:	Top of Bank to Top of Bank	117.9	Feet
	Edge of Water to Edge of Water	28.3	Feet
Water Depth:	Thalweg	2.1	Feet

Livestock access to Riparian Area	**Yes**	X	**No**	
If yes, what is the duration in months per year?		3		
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?			Feet	

Bank Erosion Inventory

Average Bank Height: 23.0 Feet (Measure)
Root Depth of Riparian Vegetation: 14.8 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 30 degrees.
	Vertical			Active seeps observed in bank.
	1H:1V	X		
	2H:1V			

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		254	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 0.66 Average Feet / year

Comments on Erosion:

View of the right bank.

Tree leaning out over channel

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Muddy Creek - UniqueID 0116**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/10/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	22.5 (A)	Bankfull Height (ft) =	10.9 (B)	(A) / (B) =	2.1 (C)	7.9
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	14.8 (D)	Study Bank Height (ft) =	22.5 (A)	(D) / (A) =	0.7 (E)	3.1
Weighted Root Density (G)						
		Root Density as % =	40 (F)	(F) x (E) =	26.3 (G)	6.4
Bank Angle (H)						
				Bank Angle as *Degrees* =	38 (H)	2.8
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

Bank Material Adjustment:

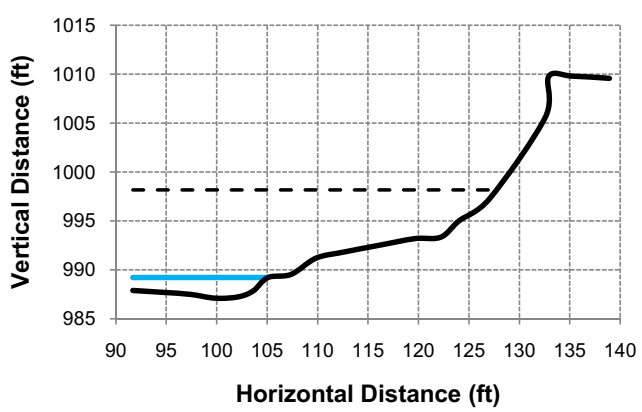
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

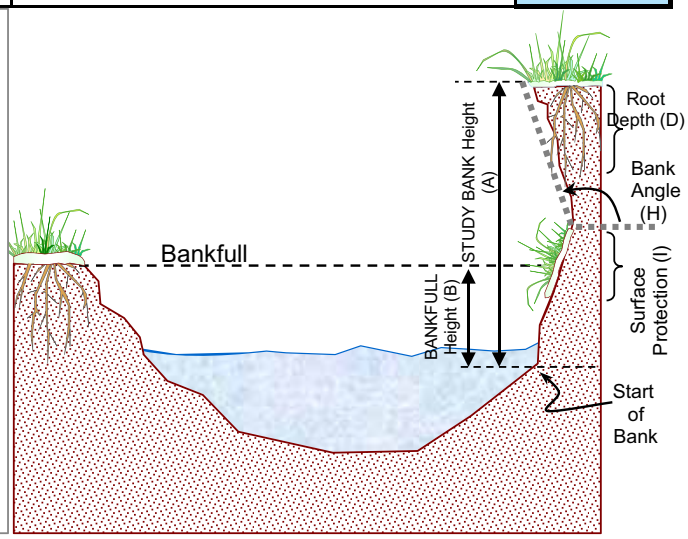
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

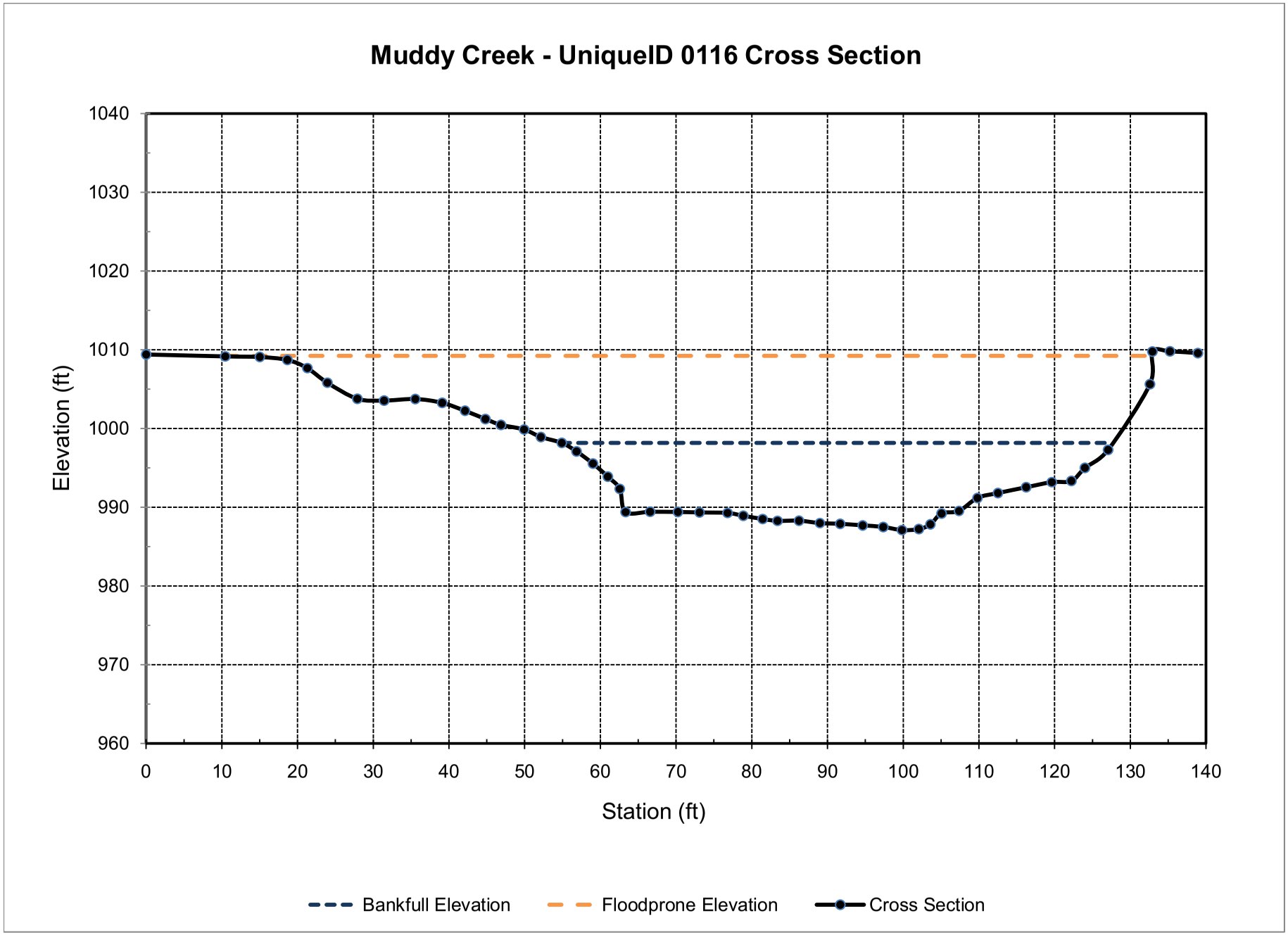
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		29.3

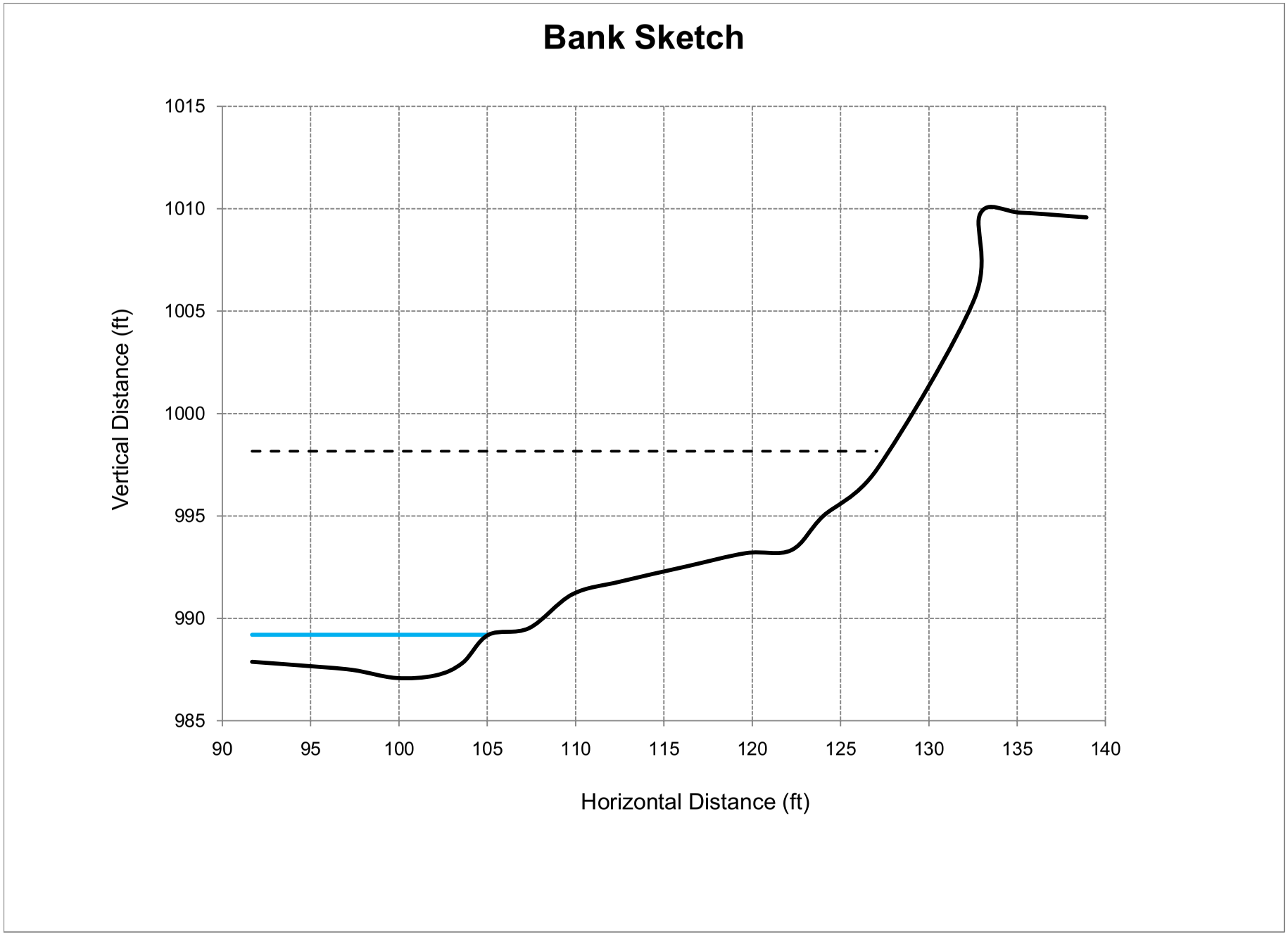
Bank Sketch





Copyright © 2006 Wildland Hydrology


Muddy Creek - UniqueID 0116 Cross Section
Elevation (ft)
1040
1030
1020
1010
1000
990
980
970
960
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1015
1010
1005
1000
995
990
985
Vertical Distance (ft)
90
95
100
105
110
115
120
125
130
135
140
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0117

A-40 Delaware Hot-Spot UniqueID: 0117

Location of Stream Segment: Straight Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0117	37.3	High	1.27	1.00

Description of Survey Site: This site has no riparian corridor. Bank materials are mainly silts.

Length of Bank (feet): 426

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	0.50	0.81
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$26,838	$26,838
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	213	345
***Cost of Soil Reduction Per Ton:**	**$12.60**	**$7.78**
***Cost of Soil Reduction Per Cubic Yard:**	**$16.38**	**$10.11**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Straight Creek **Date:** 10-Nov-10
14 Digit HUC: 10270103030020
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0117
County: Jackson County
Legal Description: SW 1/4 Sec 14 T6S R15E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field			Rangeland	X
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	125.2	Feet
	Edge of Water to Edge of Water	14.8	Feet
Water Depth:	Thalweg	0.5	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 19.0 Feet (Measure)
Root Depth of Riparian Vegetation: 6.9 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 58 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		426	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.09 Average Feet / year

Comments on Erosion: The adjacent land has been planted to native grasses.

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Straight Creek - UniqueID 0117**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/10/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	19 (A)	Bankfull Height (ft) =	2.4 (B)	(A) / (B) =	7.9 (C)	10.0
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	6.9 (D)	Study Bank Height (ft) =	19 (A)	(D) / (A) =	0.4 (E)	5.3
Weighted Root Density (G)						
		Root Density as % =	40 (F)	(F) x (E) =	14.5 (G)	7.9
Bank Angle (H)						
				Bank Angle as *Degrees* =	62 (H)	4.1
Surface Protection (I)						
				Surface Protection as % =	0 (I)	10.0

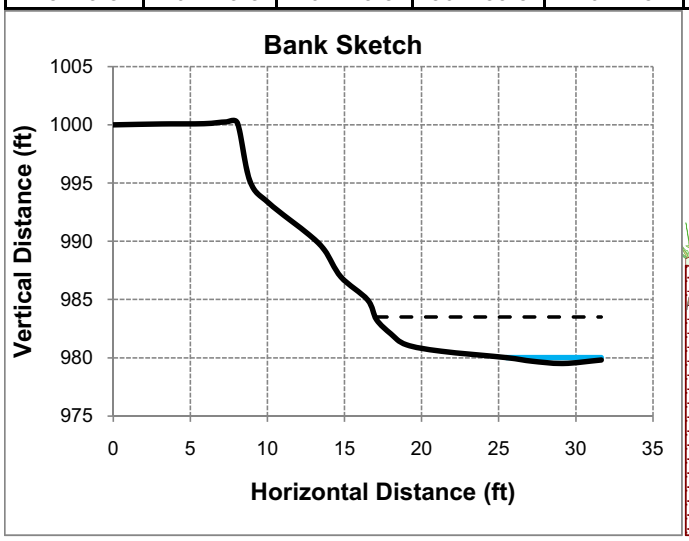
Bank Material Adjustment:

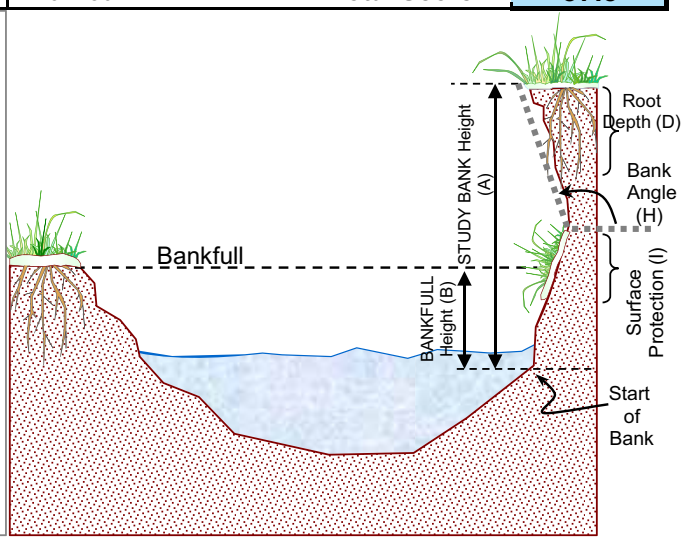
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0.0

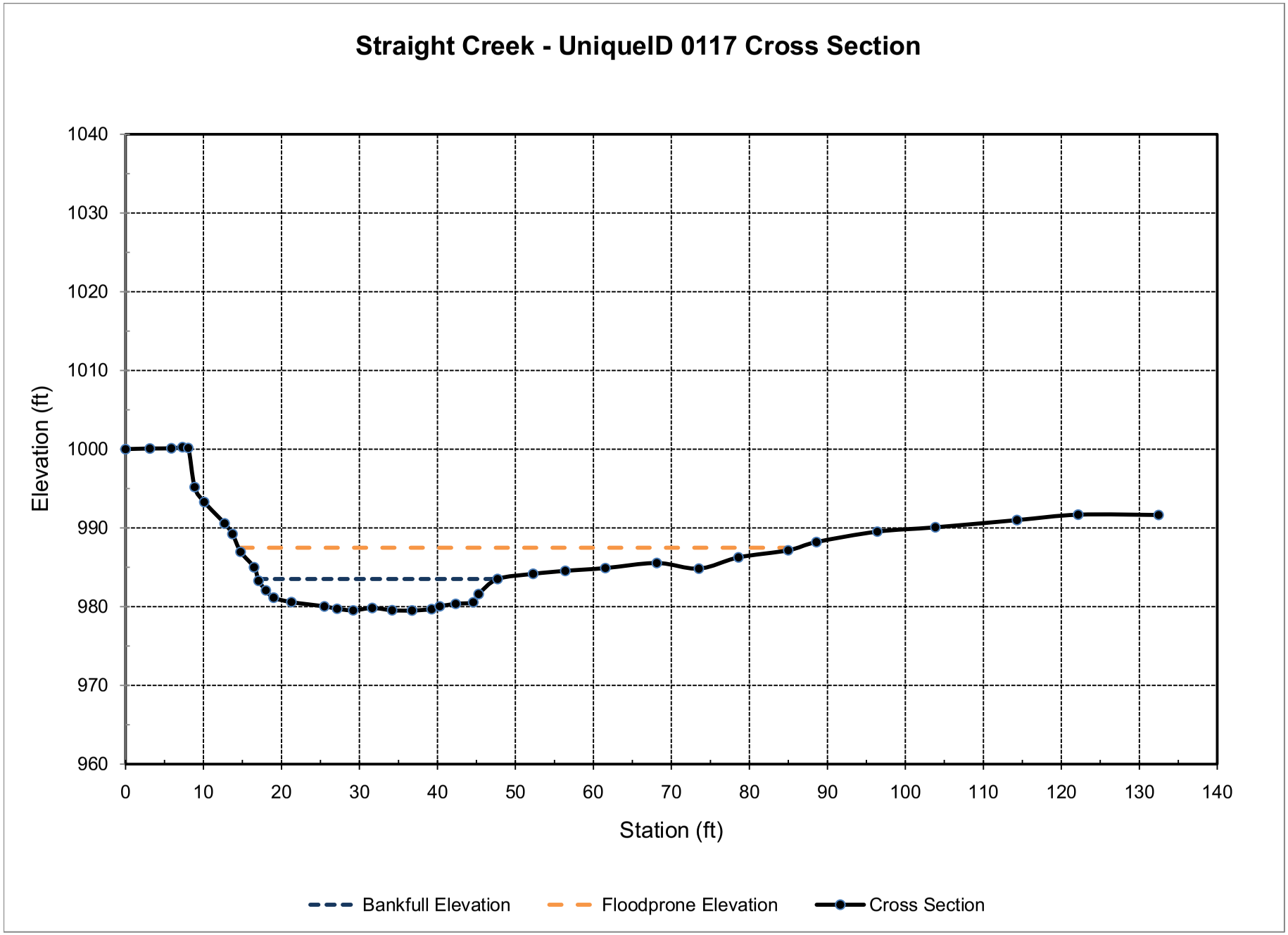
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

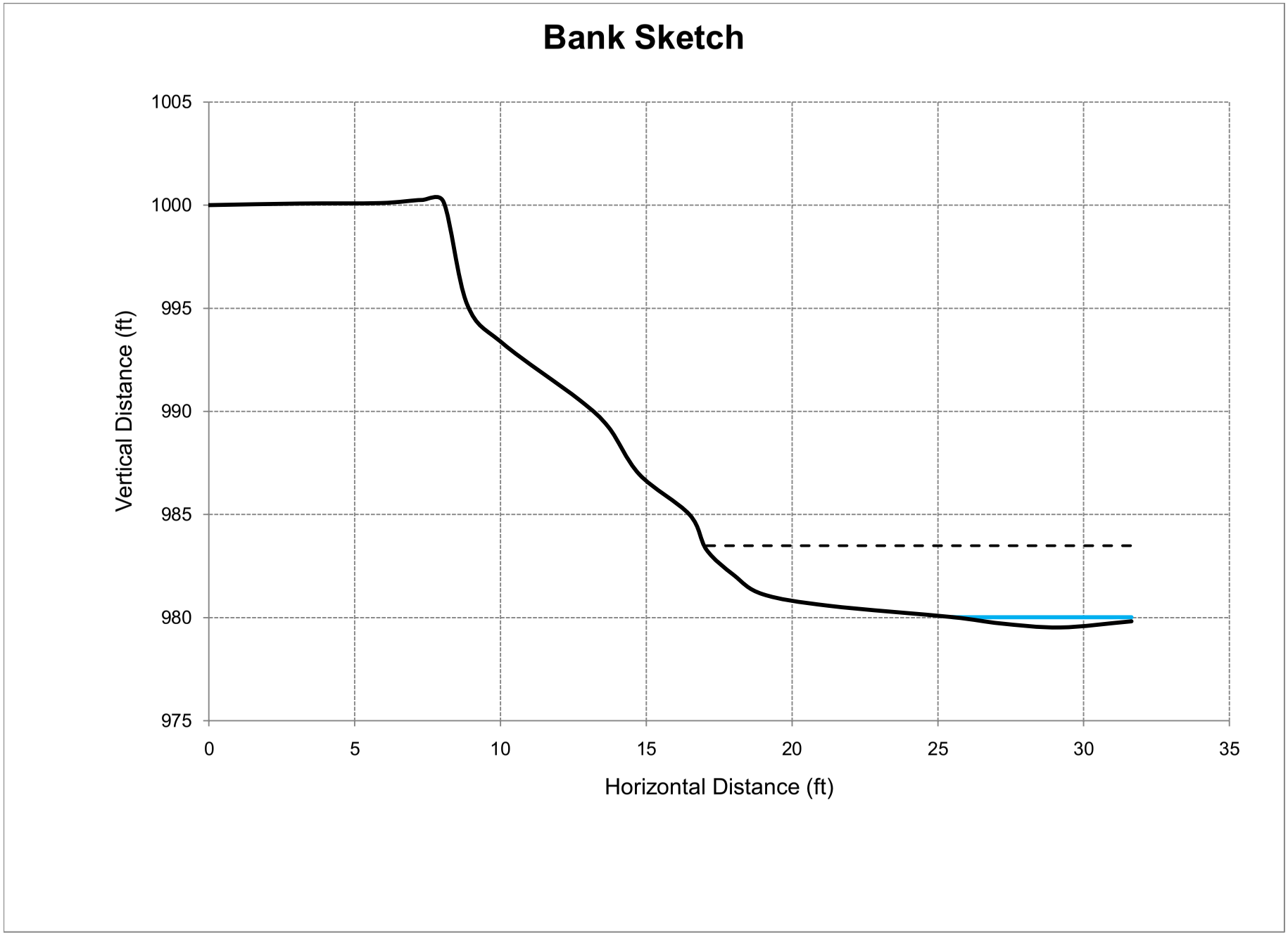
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		37.3





Copyright © 2006 Wildland Hydrology


Straight Creek - UniqueID 0117 Cross Section
Elevation (ft)
1040
1030
1020
1010
1000
990
980
970
960
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1005
1000
995
990
985
980
975
Vertical Distance (ft)
0
5
10
15
20
25
30
35
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0118

A-41 Delaware Hot-Spot UniqueID: 0118

Location of Stream Segment: Spring Creek

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0118	38.5	High	1.47	1.14

Description of Survey Site: This site has no riparian corridor. Prevcious slumps have now formed into mid-bars.

Length of Bank (feet): 428

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 3+
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	0.57	0.92
Cost of BMP Per Linear Foot:	63	63
Cost to Install BMP in Reach:	$26,964	$26,964
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	244	395
***Cost of Soil Reduction Per Ton:**	**$11.05**	**$6.82**
***Cost of Soil Reduction Per Cubic Yard:**	**$14.37**	**$8.87**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period.

Field Assessment Form

Site Location

Stream Name: Straight Creek **Date:** 10-Mar-11
14 Digit HUC: 10270103030010
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0118
County: Jackson County
Legal Description: SW1/4 Sec 34 T5S R15E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width: Top of Bank to Top of Bank 173.3 Feet
Edge of Water to Edge of Water 17.6 Feet
Water Depth: Thalweg 0.6 Feet

Livestock access to Riparian Area **Yes** _____ **No** X
If yes, what is the duration in months per year? _____

Debris or Channel Blockages **Yes** _____ **No** X

Buildings or Structures Threatened **Yes** _____ **No** X
If yes, what is their distance from the streambank? _____ Feet

Bank Erosion Inventory

Average Bank Height: 12.9 Feet (Measure)
Root Depth of Riparian Vegetation: 1.9 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 34 degree.
	Vertical			
	1H:1V	X		
	2H:1V			

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	x	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		428	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.84 Average Feet / year

Comments on Erosion:

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Spring Creek - UniqueID 0118**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/10/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	12.9 (A)	Bankfull Height (ft) =	6.6 (B)	(A) / (B) =	2.0 (C)	7.7
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	1.9 (D)	Study Bank Height (ft) =	12.9 (A)	(D) / (A) =	0.1 (E)	7.9
Weighted Root Density (G)						
		Root Density as % =	5 (F)	(F) x (E) =	0.7 (G)	10.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	40 (H)	2.9
Surface Protection (I)						
				Surface Protection as % =	0 (I)	10.0

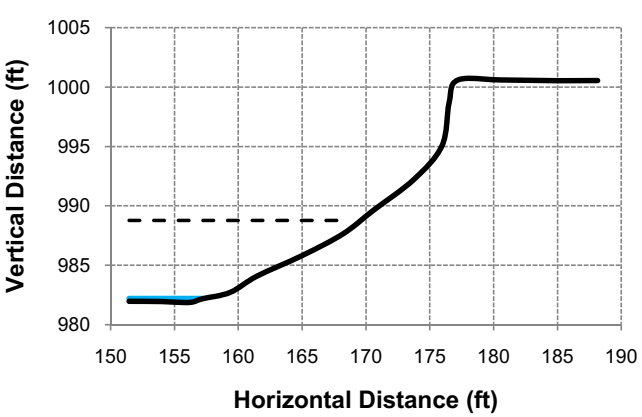
Bank Material Adjustment:

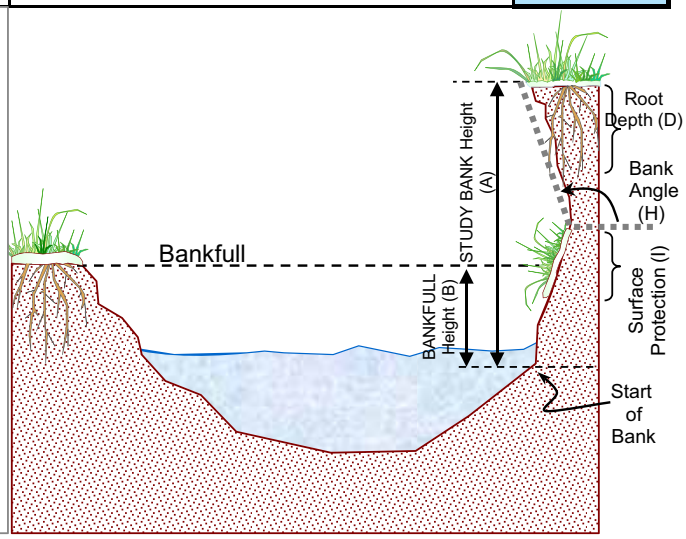
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment	0.0
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	0.0

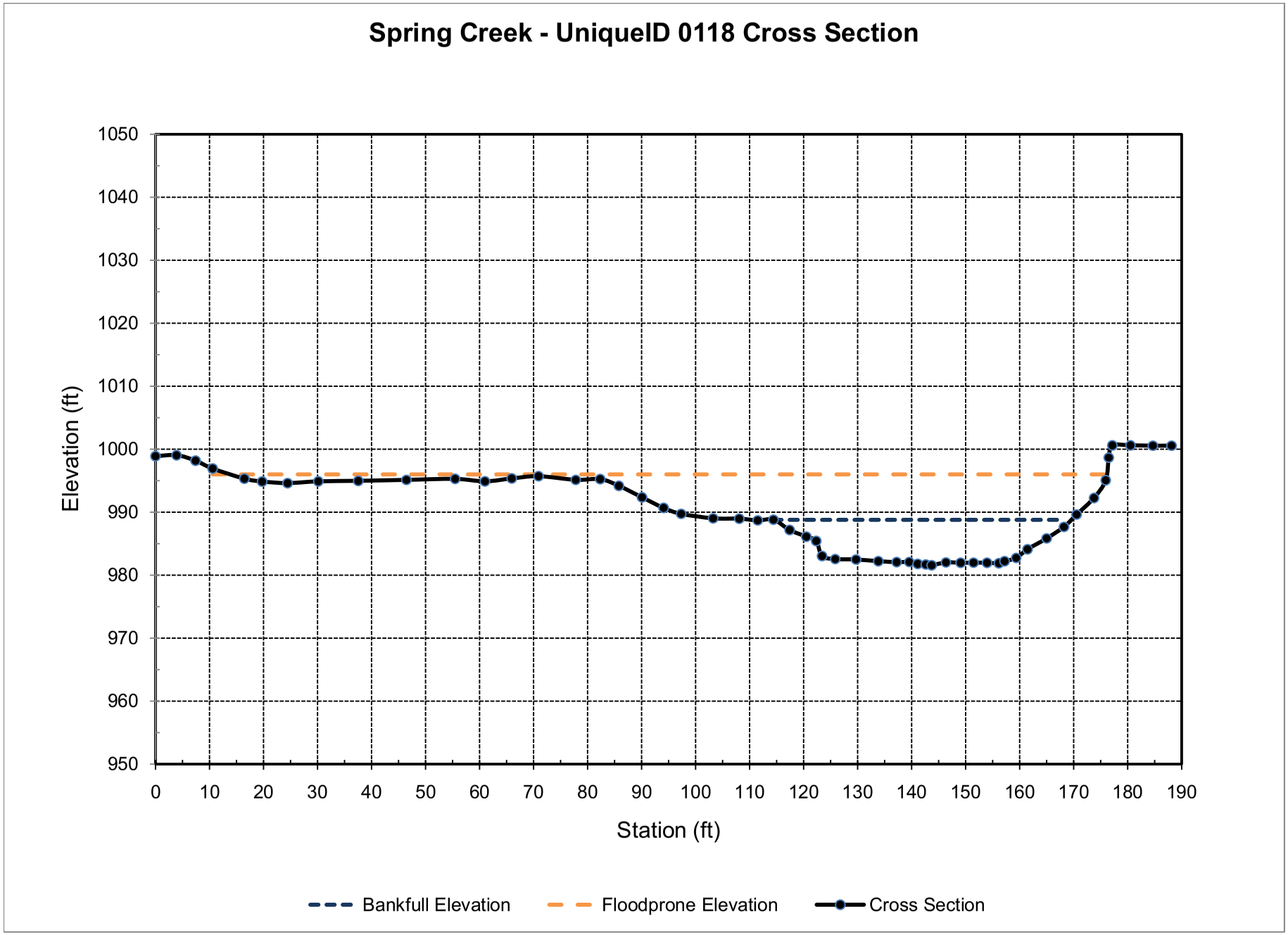
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		38.5

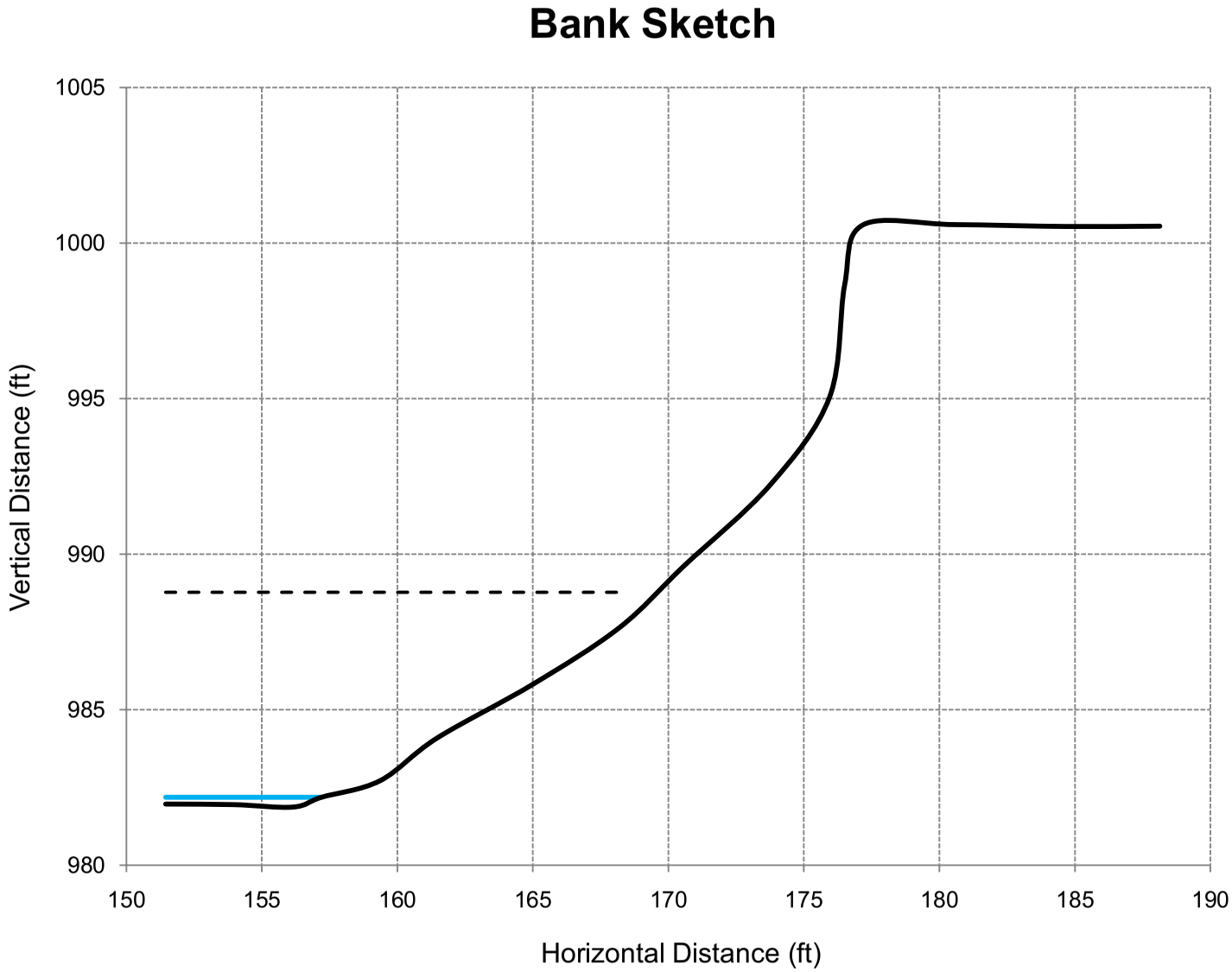
Bank Sketch





Copyright © 2006 Wildland Hydrology


Spring Creek - UniqueID 0118 Cross Section
Elevation (ft)
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1005
1000
995
990
985
980
Vertical Distance (ft)
150
155
160
165
170
175
180
185
190
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0119

A-42 Delaware Hot-Spot UniqueID: 0119

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0119	40.9	Very High	1.53	1.38

Description of Survey Site: This site has no riparian corridor. There is a highly active slump at the downstream end.

Length of Bank (feet): 226

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	87%
Reduction of Rate of Erosion (tons/foot/year):	0.97	1.20
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$18,080	$18,080
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	218	271
***Cost of Soil Reduction Per Ton:**	**$8.28**	**$6.66**
***Cost of Soil Reduction Per Cubic Yard:**	**$10.77**	**$8.66**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 11-Nov-10
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Afilliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0119
County: Jackson county
Legal Description: NW1 /4 Sec 14 T5S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Cropfield	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	242.7	Feet
	Edge of Water to Edge of Water	23.9	Feet
Water Depth:	Thalweg	2.0	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 26.8 Feet (Measure)
Root Depth of Riparian Vegetation: 3.7 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 45 degrees.
	Vertical	X		Active seeps observed in banks.
	1H:1V			
	2H:1V			

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		226	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.07 Average Feet / year

Comments on Erosion:

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0119**	Location:	**Jackson County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/11/10**	Stream Type: **-**	Valley Type:	**VII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	26.8 (A)	Bankfull Height (ft) =	14.9 (B)	(A) / (B) =	1.8 (C)	7.0
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	3.7 (D)	Study Bank Height (ft) =	26.8 (A)	(D) / (A) =	0.1 (E)	8.0
Weighted Root Density (G)						
		Root Density as % =	10 (F)	(F) x (E) =	1.4 (G)	10.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	80 (H)	5.9
Surface Protection (I)						
				Surface Protection as % =	0 (I)	10.0

Bank Material Adjustment:

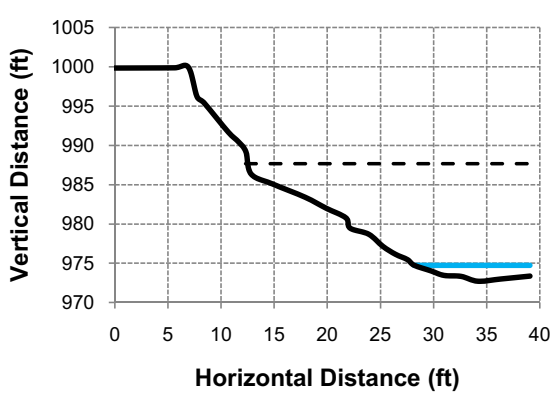
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

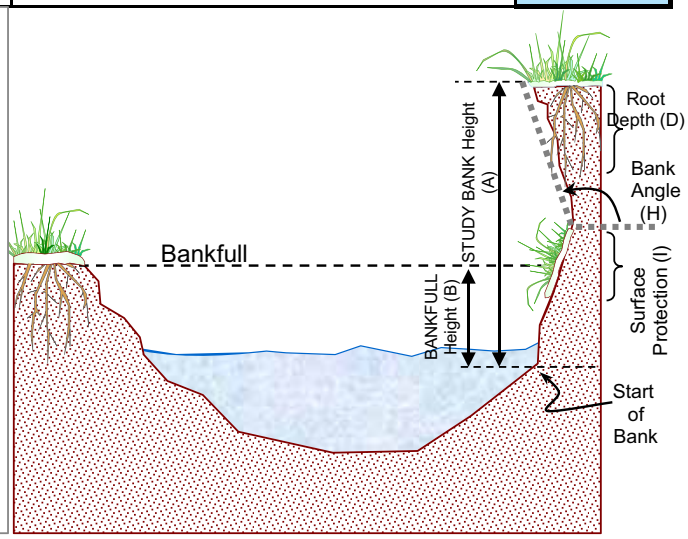
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

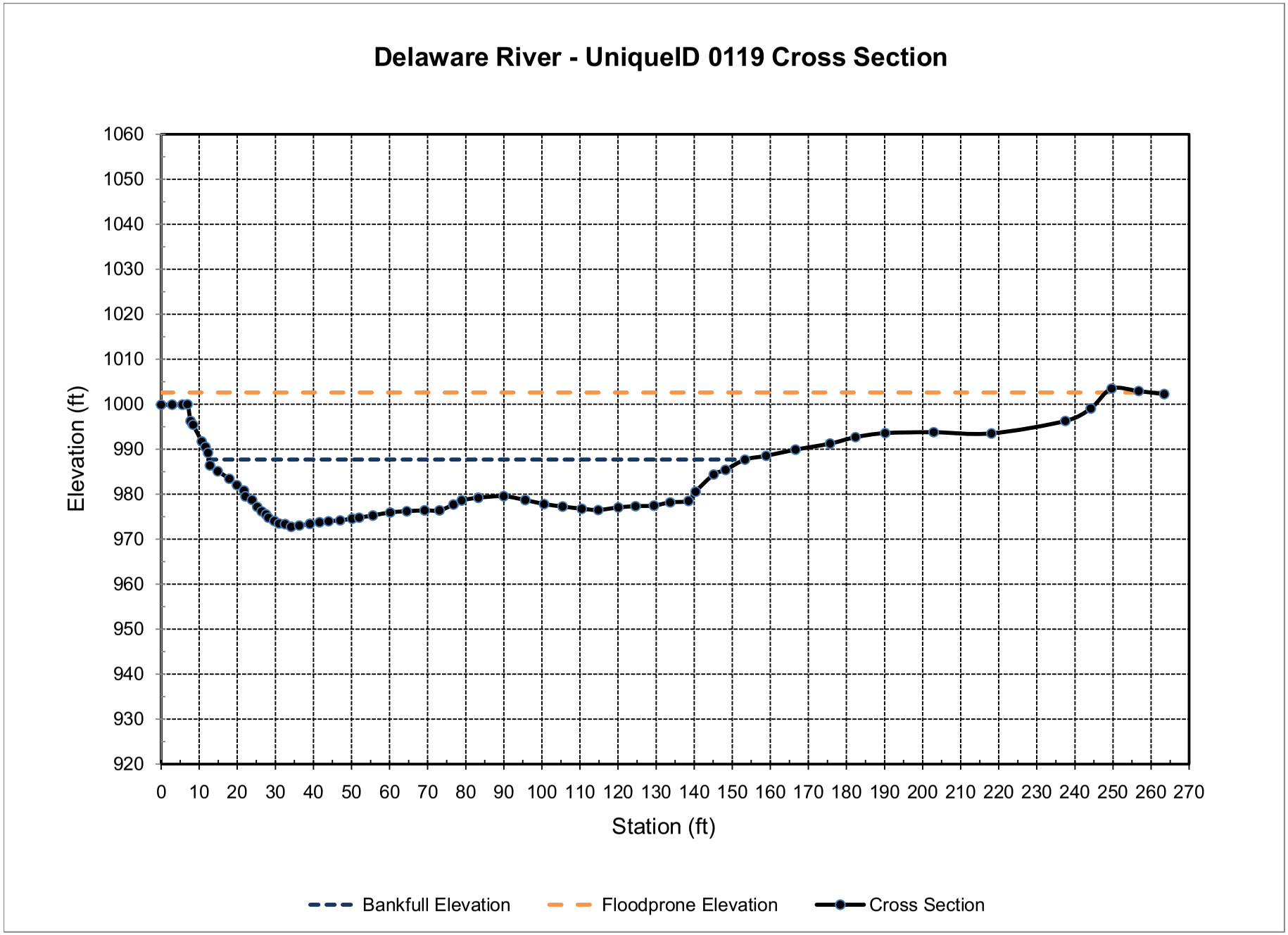
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Very High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		40.9

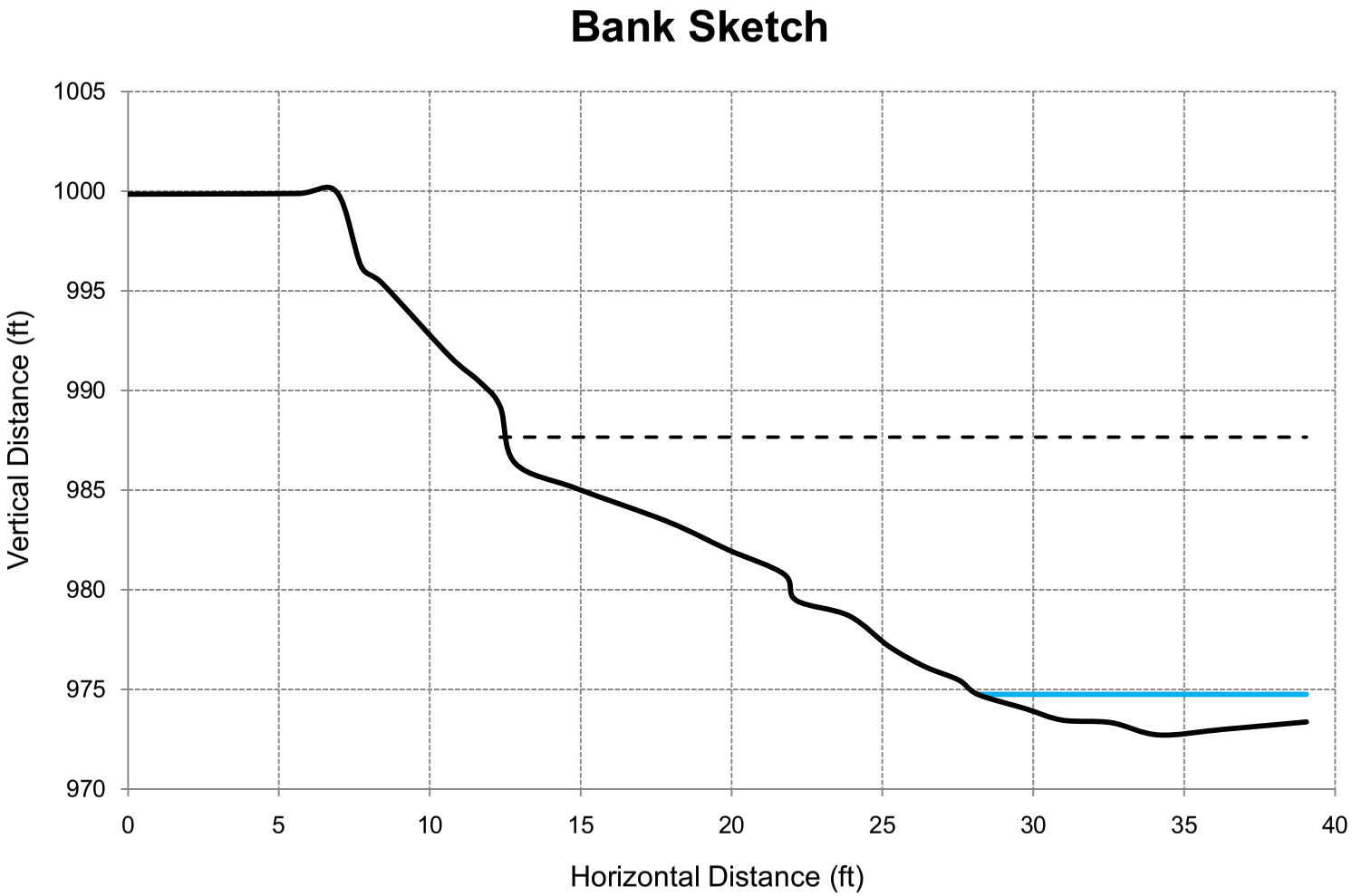
Bank Sketch





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0119 Cross Section
Elevation (ft)
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
920
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1005
1000
995
990
985
980
975
970
Vertical Distance (ft)
0
5
10
15
20
25
30
35
40
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0120

A-43 Delaware Hot-Spot UniqueID: 0120

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0120	26.6	Moderate	1.42	2.48

Description of Survey Site: This site has a narrow riparian corridor that is slowly eroding into the river.

Length of Bank (feet): 707

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 3+
BMP Estimated Percent Reduction:	62%	62%
Reduction of Rate of Erosion (tons/foot/year):	1.54	1.54
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$56,560	$56,560
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	1087	1087
***Cost of Soil Reduction Per Ton:**	**$5.20**	**$5.20**
***Cost of Soil Reduction Per Cubic Yard:**	**$6.76**	**$6.76**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period.

Field Assessment Form

Site Location

4 **Stream Name:** Delaware River **Date:** 11-Nov-10
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0120
County: Atchison County
Legal Description: SE 1/4 Sec 20 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	25	Feet	Pasture	
	Crop field			Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	194.3	Feet
	Edge of Water to Edge of Water	41.8	Feet
Water Depth:	Thalweg	2.1	Feet

Livestock access to Riparian Area **Yes** _____ **No** X
If yes, what is the duration in months per year? _____

Debris or Channel Blockages **Yes** _____ **No** X

Buildings or Structures Threatened **Yes** _____ **No** X
If yes, what is their distance from the streambank? _____ Feet

Bank Erosion Inventory

Average Bank Height: 25.0 Feet (Measure)
Root Depth of Riparian Vegetation: 15.7 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 42 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		707	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 2.08 Average Feet / year

Comments on Erosion:

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0120**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/11/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	24.8 (A)	Bankfull Height (ft) =	15.6 (B)	(A) / (B) =	1.6 (C)	6.0
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	15.7 (D)	Study Bank Height (ft) =	24.8 (A)	(D) / (A) =	0.6 (E)	3.3
Weighted Root Density (G)						
		Root Density as % =	40 (F)	(F) x (E) =	25.3 (G)	6.5
Bank Angle (H)						
				Bank Angle as *Degrees* =	54 (H)	3.6
Surface Protection (I)						
				Surface Protection as % =	20 (I)	7.2

Bank Material Adjustment:

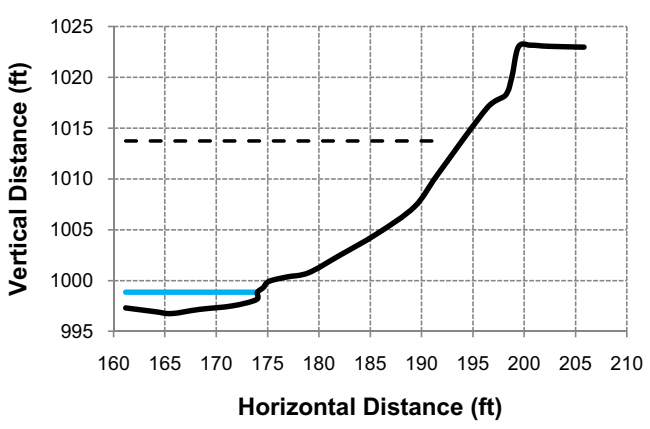
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

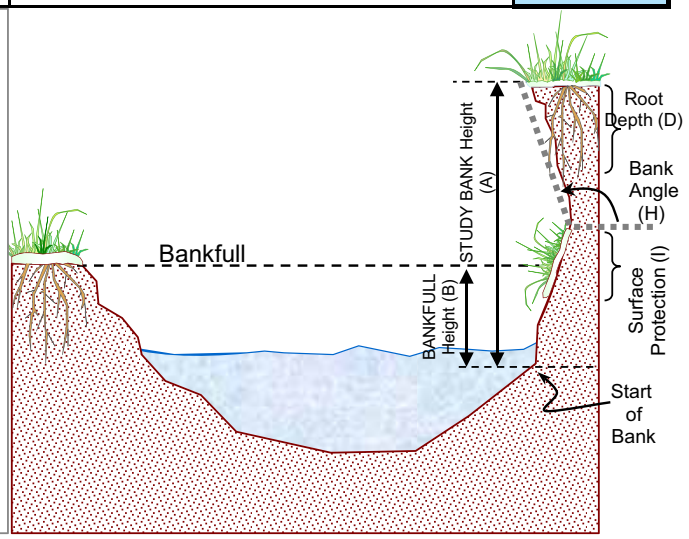
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

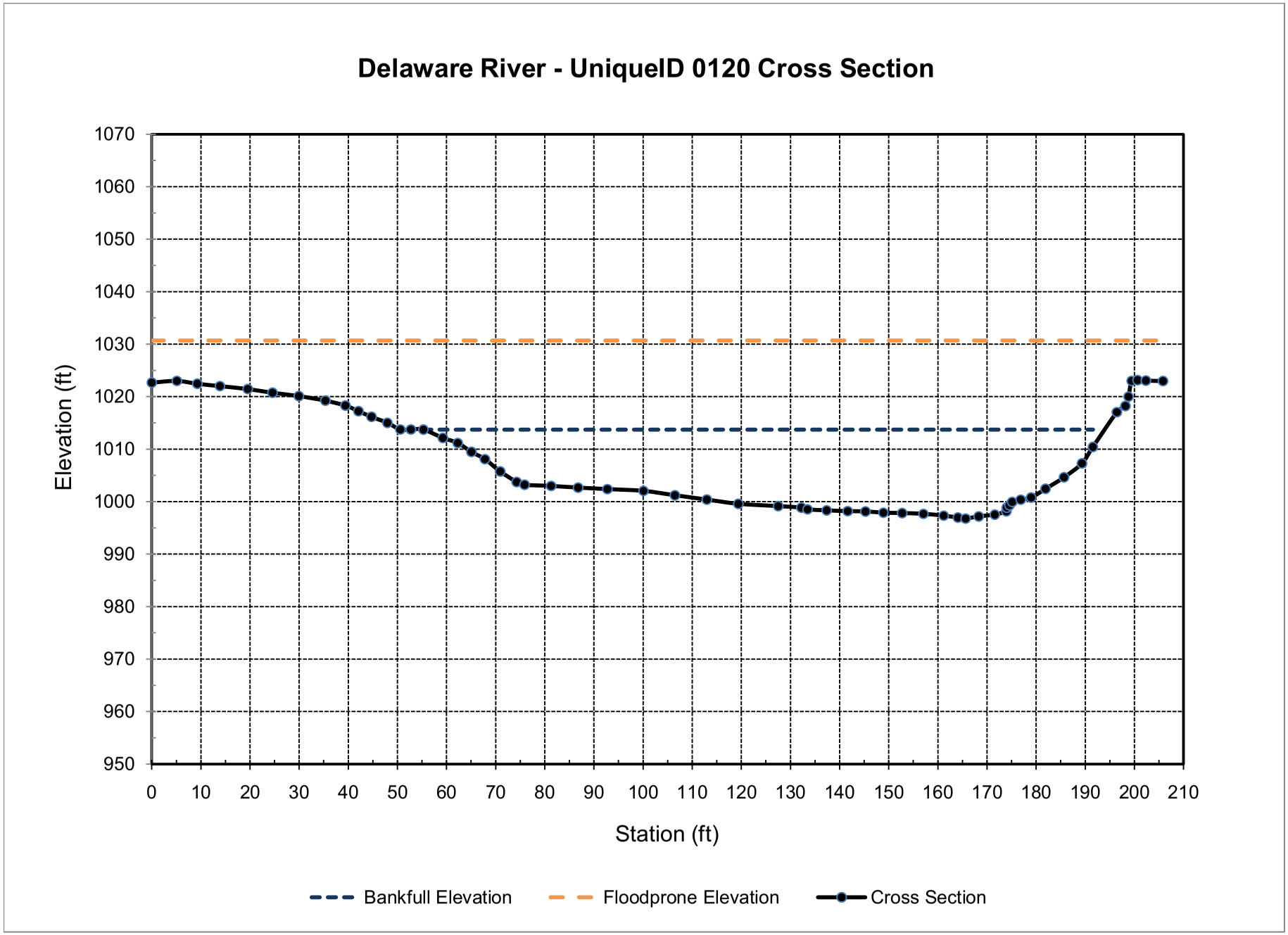
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		26.6

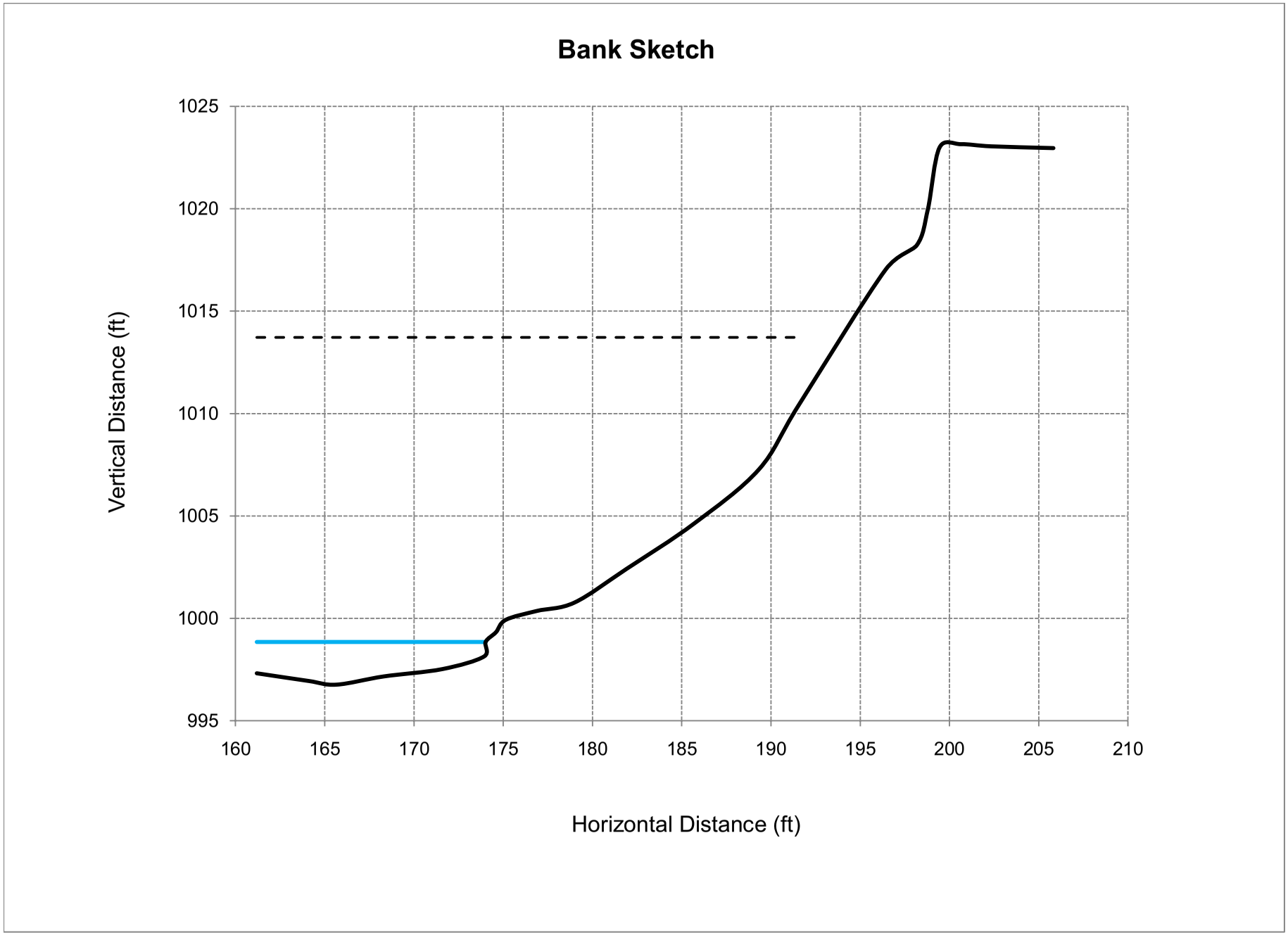
Bank Sketch





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0120 Cross Section
Elevation (ft)
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
Vertical Distance (ft)
1025
1020
1015
1010
1005
1000
995
160
165
170
175
180
185
190
195
200
205
210
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0121

A-44 Delaware Hot-Spot UniqueID: 0121

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0121	31.3	High	1.29	1.63

Description of Survey Site: This site has a narrow riparian corridor. A mid-bar exists from previously slumped banks at the downstream end. Bank materials are silt loam with clay along the toe.

Length of Bank (feet): 515

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	81%
Reduction of Rate of Erosion (tons/foot/year):	0.82	1.32
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$41,200	$41,200
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	420	680
***Cost of Soil Reduction Per Ton:**	**$9.82**	**$6.06**
***Cost of Soil Reduction Per Cubic Yard:**	**$12.76**	**$7.88**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 18-Nov-10
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0121
County: Jackson County
Legal Description: NW 1/4 Sec 10 T5S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0-40	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	237.4	Feet
	Edge of Water to Edge of Water	56.5	Feet
Water Depth:	Thalweg	1.7	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 27.0 Feet (Measure)
Root Depth of Riparian Vegetation: 1.5 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 30 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		515	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.25 Average Feet / year

Comments on Erosion: The upper portion of site has vegetation established on bank, while the lower portion does not have any surface protection.

View of the right bank.

View of the right bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0121**	Location:	**Jackson Countu, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/18/10**	Stream Type: **-**	Valley Type:	**VII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	27.1 (A)	Bankfull Height (ft) =	10.9 (B)	(A) / (B) =	2.5 (C)	8.6
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	13.5 (D)	Study Bank Height (ft) =	27.1 (A)	(D) / (A) =	0.5 (E)	3.9
Weighted Root Density (G)						
		Root Density as % =	40 (F)	(F) x (E) =	19.9 (G)	7.2
Bank Angle (H)						
				Bank Angle as *Degrees* =	33 (H)	2.6
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

Bank Material Adjustment:

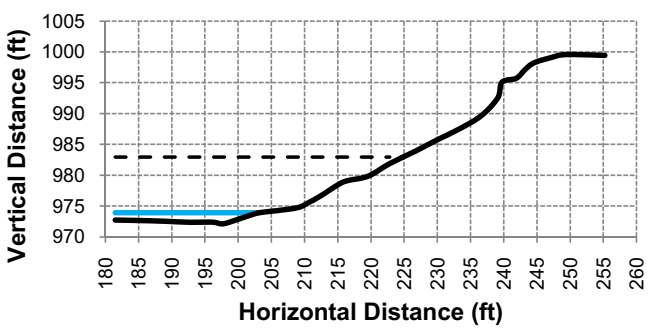
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

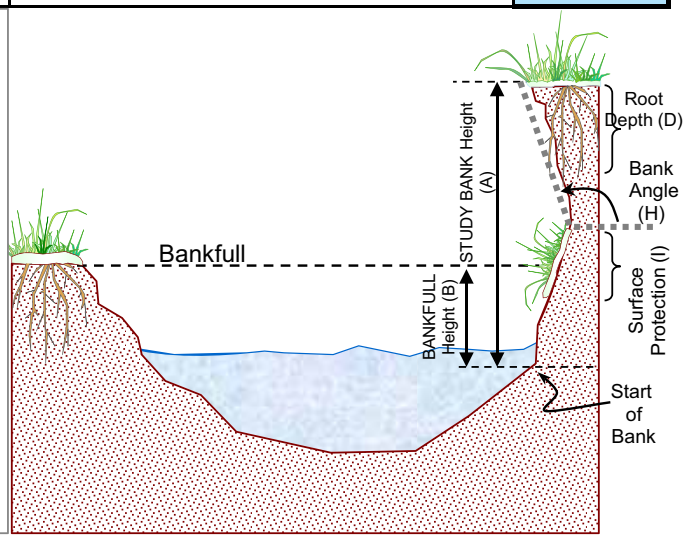
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		31.3

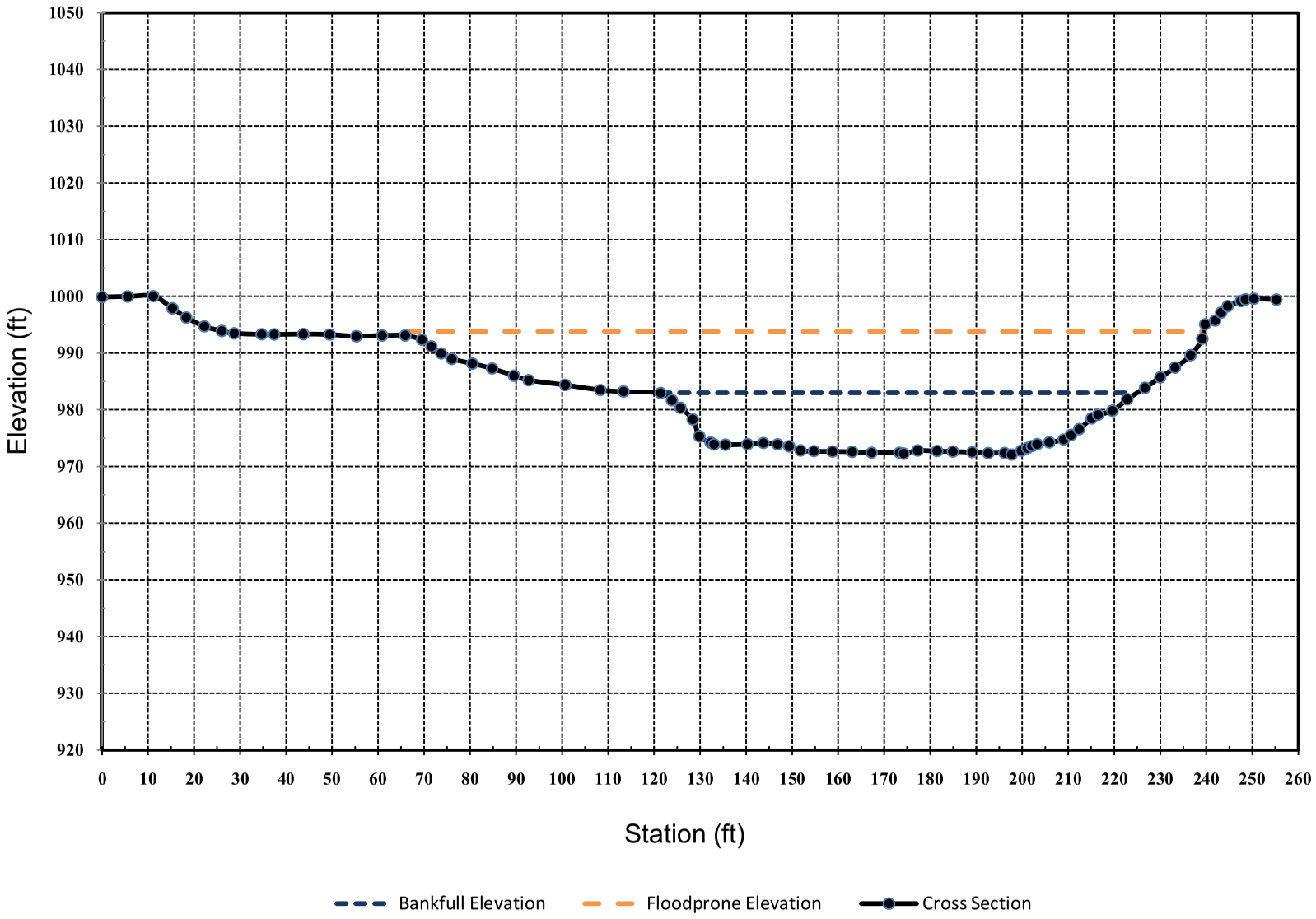
Bank Sketch



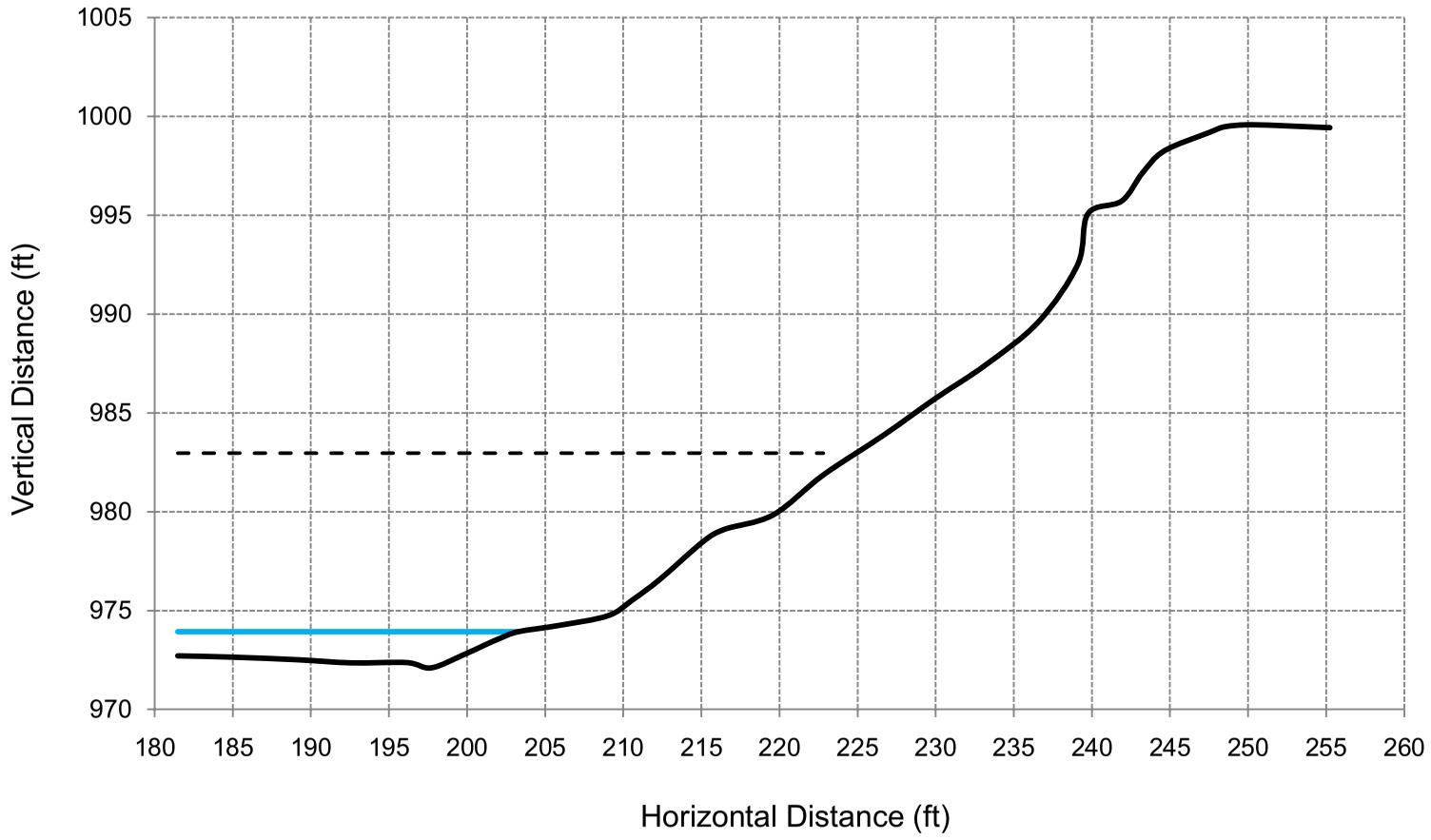


Copyright © 2006 Wildland Hydrology

Delaware River - UniqueID 0121 Cross Section



Bank Sketch


1005
1000
995
990
985
980
975
970
Vertical Distance (ft)
180
185
190
195
200
205
210
215
220
225
230
235
240
245
250
255
260
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0122

A-45 Delaware Hot-Spot UniqueID: 0122

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0122	28.8	Moderate	1.70	0.58

Description of Survey Site: This site has a good riparian corridor. Allthough many trees have exposed roots. Bank materials are silty loam on top with sandy loams toward the bottom.

Length of Bank (feet): 335

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	82%
Reduction of Rate of Erosion (tons/foot/year):	0.29	0.48
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$26,800	$26,800
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	97	159
***Cost of Soil Reduction Per Ton:**	**$27.59**	**$16.82**
***Cost of Soil Reduction Per Cubic Yard:**	**$35.86**	**$21.87**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 18-Nov-10
14 Digit HUC: 10270103020050
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf south Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0122
County: Atchison County
Legal Description: NW 1/4 Sec 16 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	75	Feet	Pasture	
	Crop field			Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber	X		Residential	
	Cropland			Industrial	

Channel Width:	Top of Bank to Top of Bank	215.7	Feet
	Edge of Water to Edge of Water	49.6	Feet
Water Depth:	Thalweg	2.5	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 25.5 Feet (Measure)
Root Depth of Riparian Vegetation: 19.7 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 39 degrees.
	Vertical			
	1H:1V	X		
	2H:1V			

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		335	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 0.47 Average Feet / year

Comments on Erosion: Site is downstream of bedrock outcrop. The limestone outcrop is steep creating high velocities along the bank toe.

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0122**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**11/18/10**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	25.5 (A)	Bankfull Height (ft) =	9.9 (B)	(A) / (B) =	2.6 (C)	8.7
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	19.7 (D)	Study Bank Height (ft) =	25.5 (A)	(D) / (A) =	0.8 (E)	2.6
Weighted Root Density (G)						
		Root Density as % =	40 (F)	(F) x (E) =	30.9 (G)	5.8
Bank Angle (H)						
				Bank Angle as *Degrees* =	44 (H)	3.1
Surface Protection (I)						
				Surface Protection as % =	25 (I)	6.5

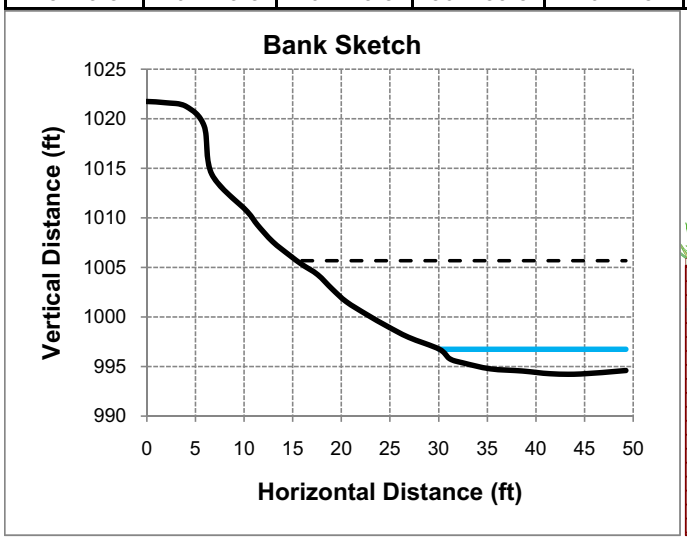
Bank Material Adjustment:

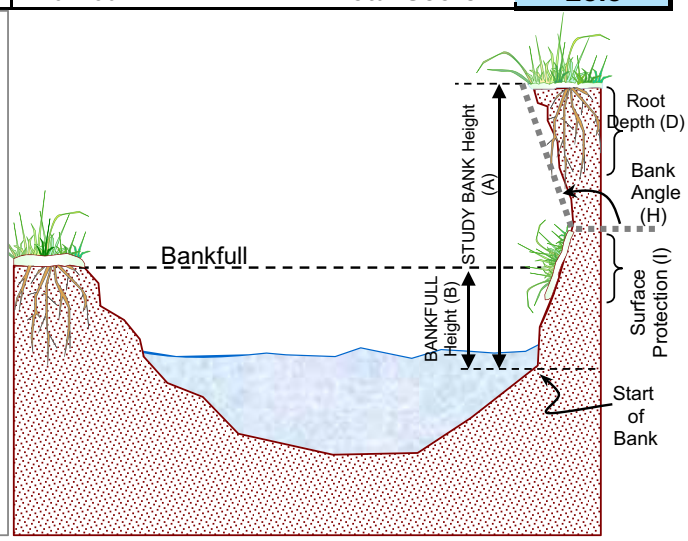
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 2.0

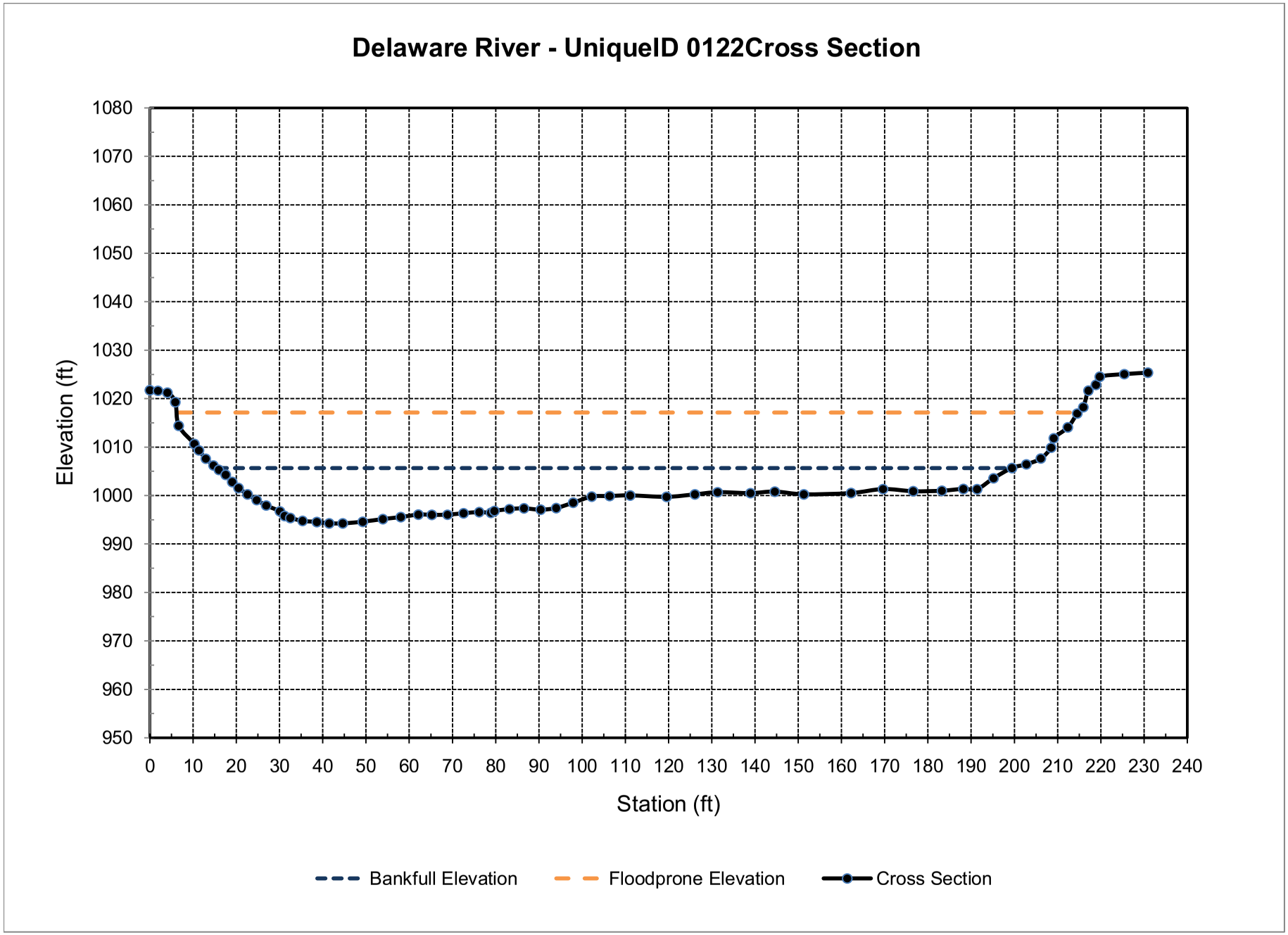
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

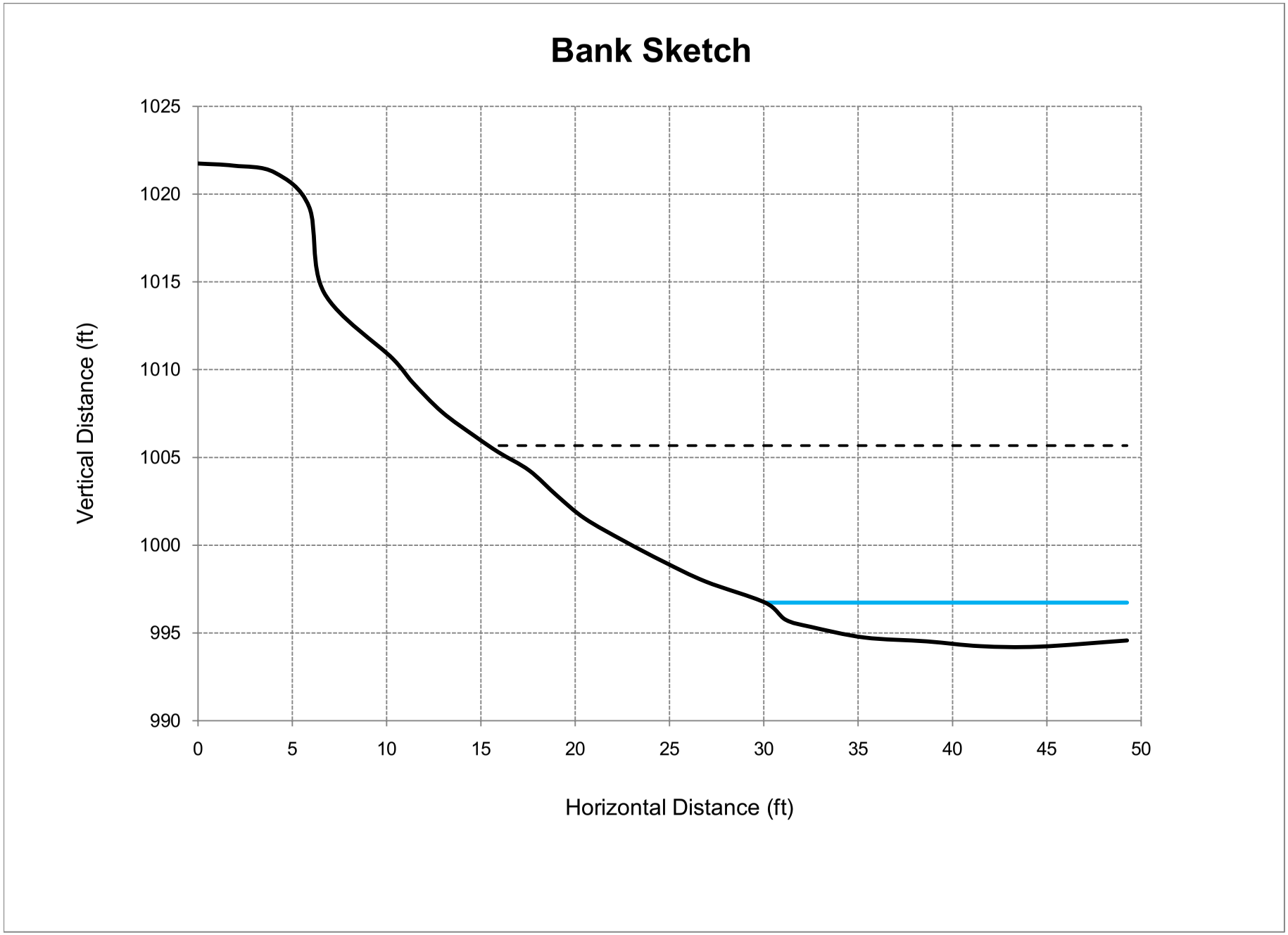
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		28.8





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0122Cross Section
Elevation (ft)
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
Vertical Distance (ft)
1025
1020
1015
1010
1005
1000
995
990
0
5
10
15
20
25
30
35
40
45
50
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0123

A-46 Delaware Hot-Spot UniqueID: 0123

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0123	28.8	Moderate	1.27	1.78

Description of Survey Site: This site has a narrow riparian corridor. Bank materials are silt/clay sized materials.

Length of Bank (feet): 580

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	0%	62%
Reduction of Rate of Erosion (tons/foot/year):	0.00	1.10
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$46,400	$46,400
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	0	640
***Cost of Soil Reduction Per Ton:**	**$13,920**	**$7.25**
***Cost of Soil Reduction Per Cubic Yard:**	**$18,096**	**$9.42**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume 1 cubic yard weighs 1.3 tons. For year 1 through 3, modeling results did not produce an erosion reduction; therefore 3 years of BMP installation costs were added to calculate the cost-benefits associated with year 1 through 3.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 19-Nov-10
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf south Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0123
County: Atchison County
Legal Description: SW 1/4 Sec 32 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width: Top of Bank to Top of Bank 182.3 Feet
Edge of Water to Edge of Water 60.2 Feet
Water Depth: Thalweg 2.0 Feet

Livestock access to Riparian Area **Yes** ____ **No** X
If yes, what is the duration in months per year? ____

Debris or Channel Blockages **Yes** ____ **No** X

Buildings or Structures Threatened **Yes** ____ **No** X
If yes, what is their distance from the streambank? ____ Feet

Bank Erosion Inventory

Average Bank Height: 26.4 Feet (Measure)
Root Depth of Riparian Vegetation: 19.7 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 40 degrees.
	Vertical			
	1H:1V	X		
	2H:1V			

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		580	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 1.40 Average Feet / year

Comments on Erosion:

View downstream.

Right Bank

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0123**	Location:	**Atchison County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **11/19/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	26.4 (A)	Bankfull Height (ft) =	12.5 (B)	(A) / (B) =	2.1 (C)	8.0
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	19.7 (D)	Study Bank Height (ft) =	26.4 (A)	(D) / (A) =	0.7 (E)	2.7
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	14.9 (G)	7.9
Bank Angle (H)						
				Bank Angle as *Degrees* =	42 (H)	3.0
Surface Protection (I)						
				Surface Protection as % =	20 (I)	7.2

Bank Material Adjustment:

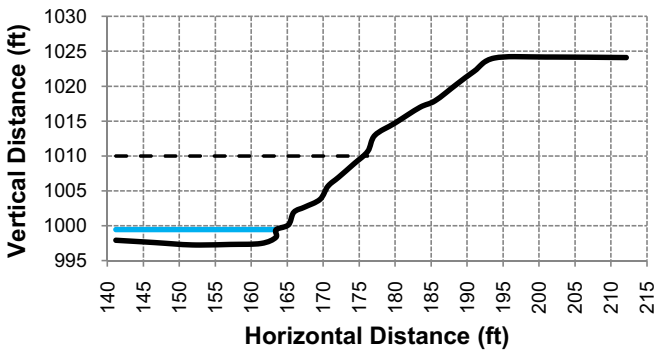
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

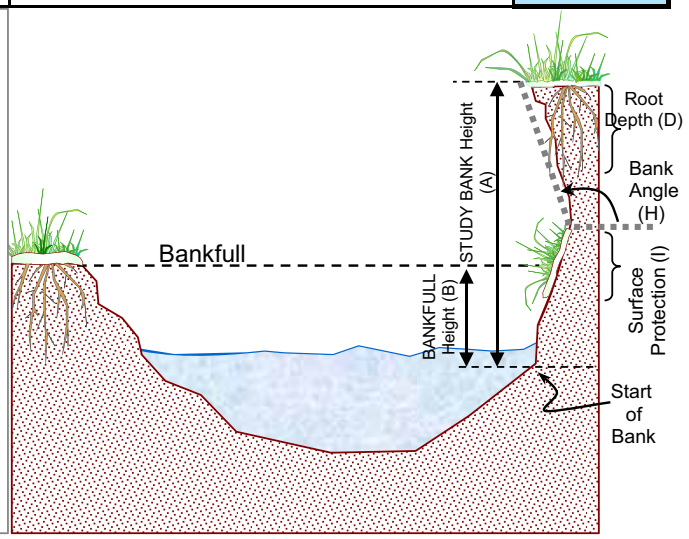
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

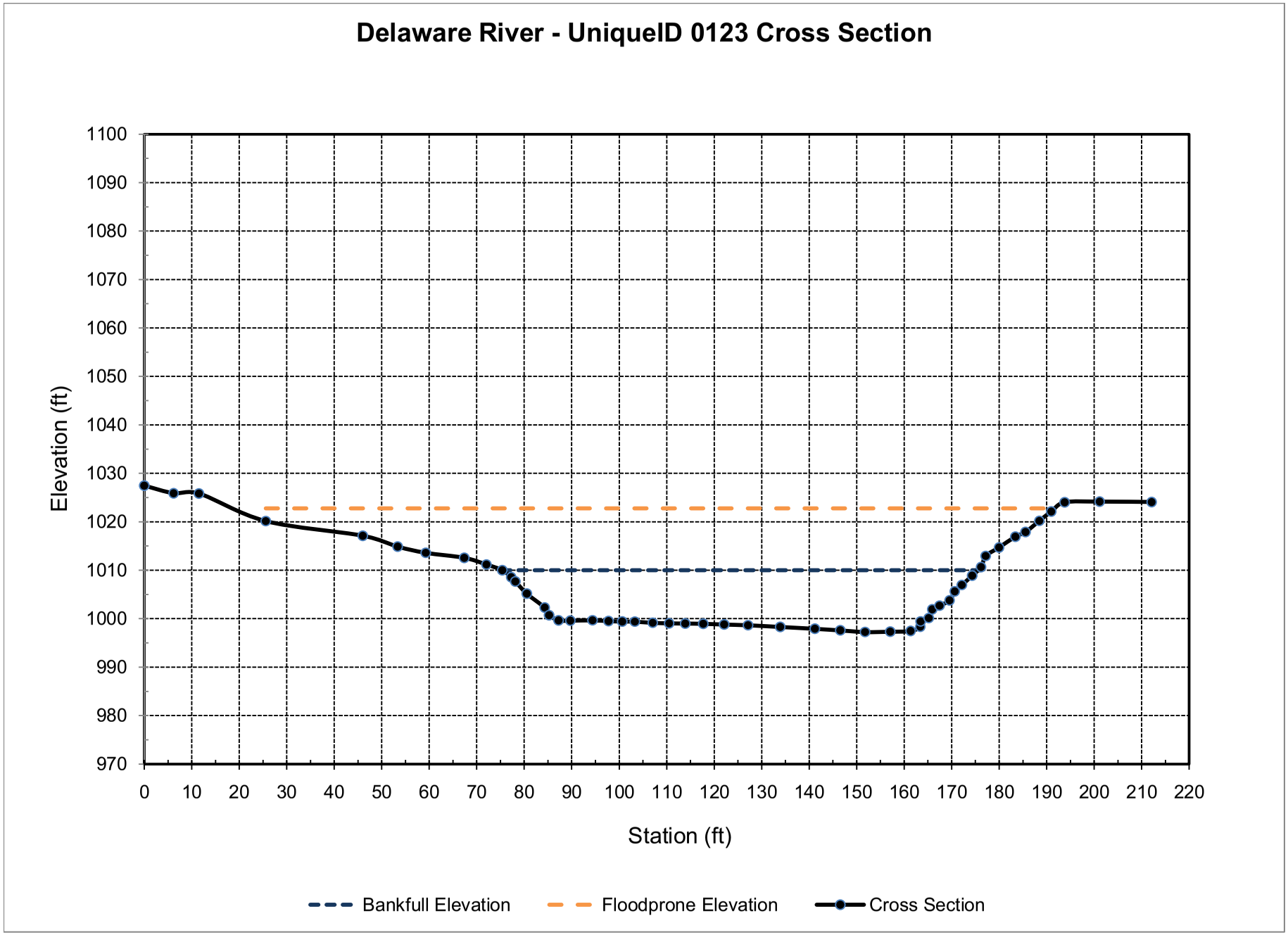
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		28.8

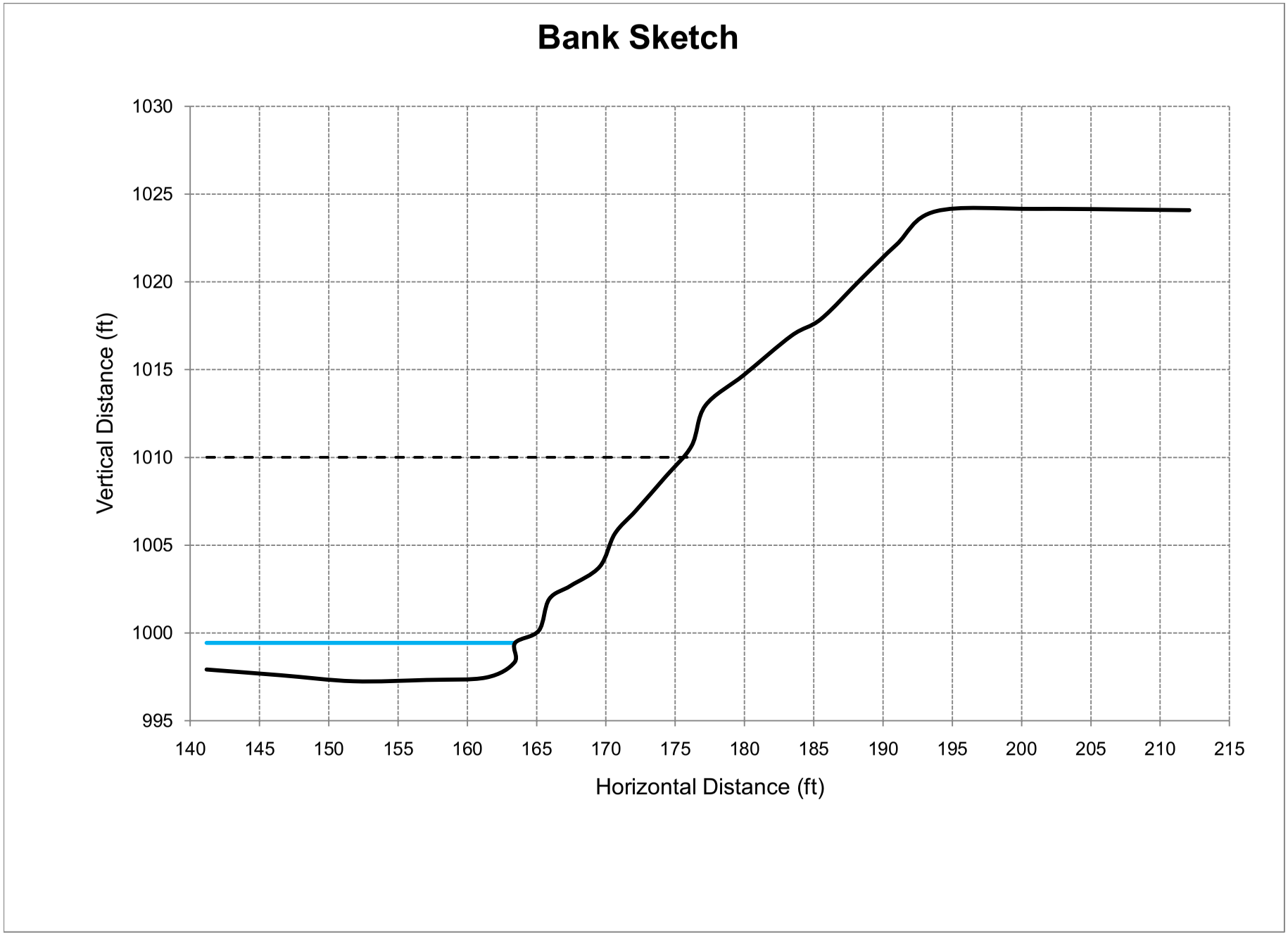
Bank Sketch





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0123 Cross Section
Elevation (ft)
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
Vertical Distance (ft)
1030
1025
1020
1015
1010
1005
1000
995
140
145
150
155
160
165
170
175
180
185
190
195
200
205
210
215
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0124

A-47 Delaware Hot-Spot UniqueID: 0124:

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0124	21.5	Moderate	1.81	1.17

Description of Survey Site: This site has no riparian corridor. Active seeps are creating slumping. Bank material is primarily silt.

Length of Bank (feet): 162

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	76%	91%
Reduction of Rate of Erosion (tons/foot/year):	0.89	1.06
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$12,960	$12,960
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	144	172
***Cost of Soil Reduction Per Ton:**	**$9.00**	**$7.51**
***Cost of Soil Reduction Per Cubic Yard:**	**$11.70**	**$9.77**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 30-Dec-10
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0124
County: Brown County
Legal Description: SE1/4 Sec 32 T4S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	20	Feet	Pasture	
	Crop field			Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland			Industrial	

Channel Width:	Top of Bank to Top of Bank	230.0	Feet
	Edge of Water to Edge of Water	40.1	Feet
Water Depth:	Thalweg	25.8	Feet

Livestock access to Riparian Area **Yes** _____ **No** X
If yes, what is the duration in months per year? _____

Debris or Channel Blockages **Yes** _____ **No** X

Buildings or Structures Threatened **Yes** _____ **No** X
If yes, what is their distance from the streambank? _____ Feet

Bank Erosion Inventory

Average Bank Height: 33.4 Feet (Measure)
Root Depth of Riparian Vegetation: 33.4 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 18 degrees.
	Vertical		Active seeps observed in banks.
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.			
	Sand		.062-2 mm dia			
	Gravels		.08 - 2.5 inches			
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles		2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders		10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock		

Eroding Bank Length: 162 Feet

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 0.73 Average Feet / year

Comments on Erosion: The site eroding into county road. Some vegetation has established on bank slump.

Photo Not Available

View across channel at cross section

Photo Not Available

View downstream from cross section

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0124**	Location:	**Brown County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **12/30/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	**33.4** (A)	**Bankfull Height** (ft) =	**17.5** (B)	(A) / (B) =	**1.9** (C)	**7.5**
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	**33.4** (D)	**Study Bank Height** (ft) =	**33.4** (A)	(D) / (A) =	**1.0** (E)	**1.0**
Weighted Root Density (G)						
		Root Density as % =	**30** (F)	(F) x (E) =	**30** (G)	**5.9**
Bank Angle (H)						
				Bank Angle as *Degrees* =	**69** (H)	**4.8**
Surface Protection (I)						
				Surface Protection as % =	**75** (I)	**2.3**

Bank Material Adjustment:

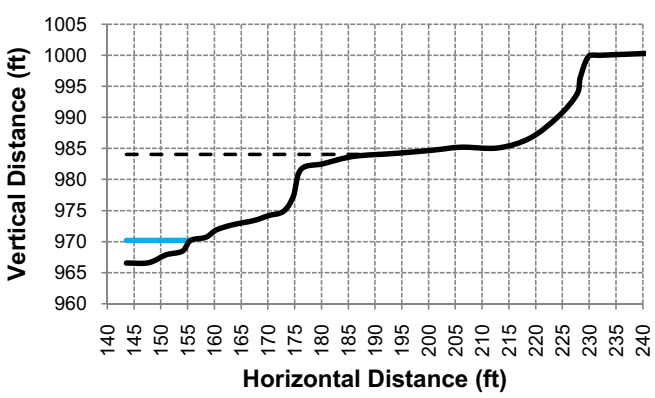
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

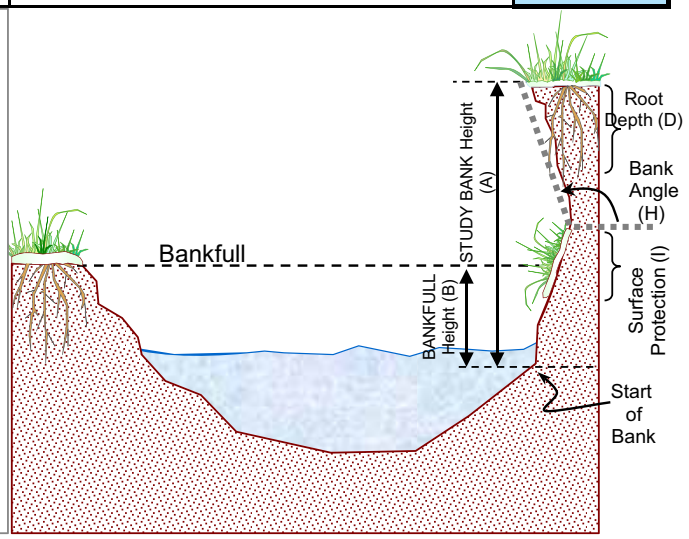
Bank Material Adjustment **0.0**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage **0.0**

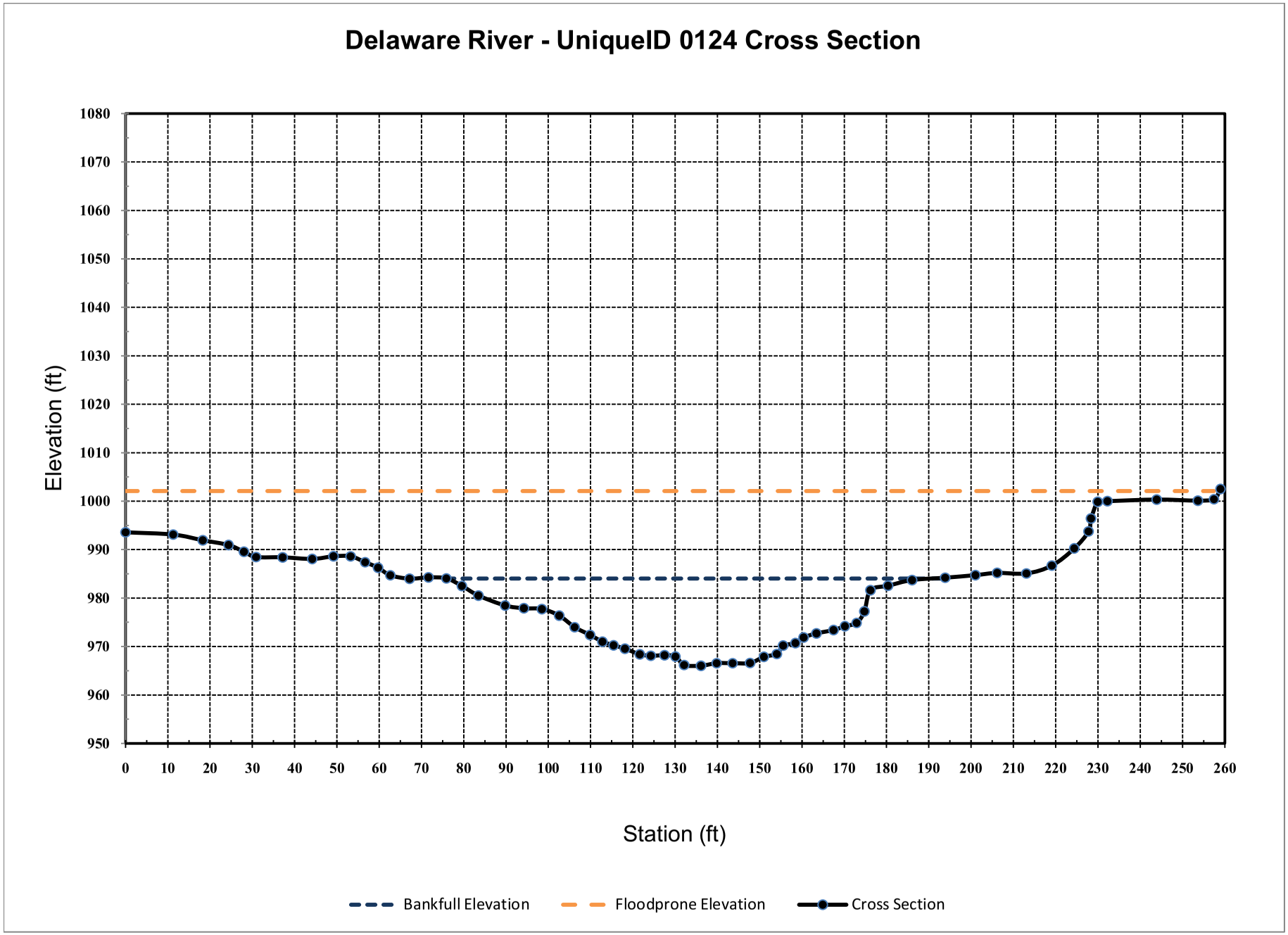
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		21.5

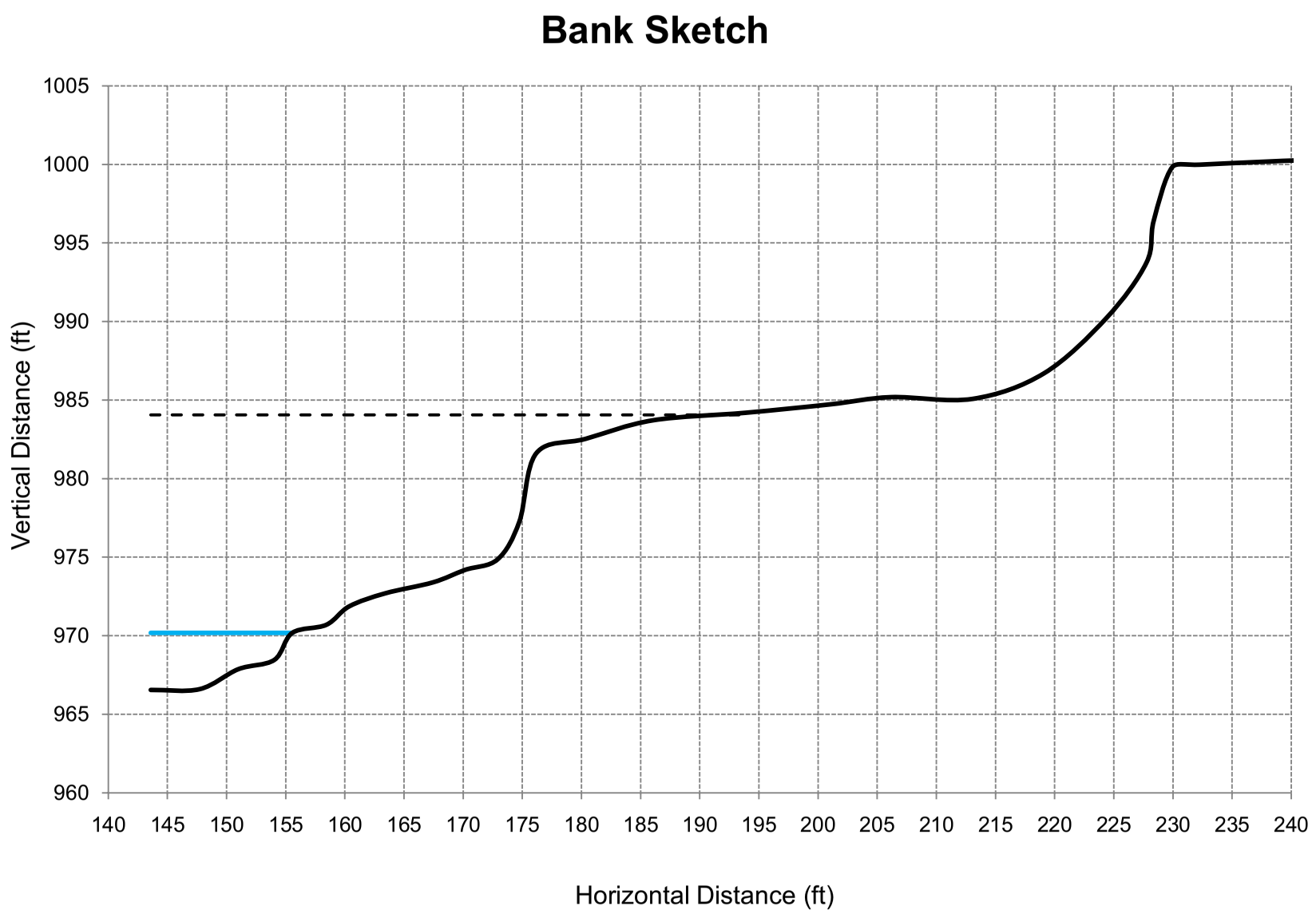
Bank Sketch





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0124 Cross Section
Elevation (ft)
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
Vertical Distance (ft)
1005
1000
995
990
985
980
975
970
965
960
140
145
150
155
160
165
170
175
180
185
190
195
200
205
210
215
220
225
230
235
240
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0125

A-48 Delaware Hot-Spot UniqueID: 0125

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0125	32.1	High	1.62	3.16

Description of Survey Site: This site has no riparian corridor on the upper half and a narrow corridor along the lower half. Bank material is silt.

Length of Bank (feet): 409

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	87%
Reduction of Rate of Erosion (tons/foot/year):	2.21	2.75
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$32,720	$32,720
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	905	1124
***Cost of Soil Reduction Per Ton:**	**$3.62**	**$2.91**
***Cost of Soil Reduction Per Cubic Yard:**	**$4.70**	**$3.78**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 30-Dec-10
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0125
County: Brown County
Legal Description: SE1/4 Sec 32 T4S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0-200	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber	X			
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	218.0	Feet
	Edge of Water to Edge of Water	38.1	Feet
Water Depth:	Thalweg	2.8	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 22.3 Feet (Measure)
Root Depth of Riparian Vegetation: 11.9 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 42 degrees.
	Vertical		
	1H:1V	X	
	2H:1V		

Bank Erosion Inventory (con't)

Check All That Apply

Bank Materials:	Silt/Clay	X	<.062 mm dia.			
	Sand		.062-2 mm dia			
	Gravels		.08 - 2.5 inches			
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles		2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders		10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock		

Eroding Bank Length: 409 Feet

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 2.94 Average Feet / year

Comments on Erosion: The lower section does have a wooded riparian corridor that widens to over 200 feet.

Photo Not Available

View across channel at cross section

Photo Not Available

View downstream from cross section

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0125**	Location:	**Brown County, Kansas**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **12/30/10**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	22.3 (A)	Bankfull Height (ft) =	10.4 (B)	(A) / (B) =	2.1 (C)	8.1
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	11.9 (D)	Study Bank Height (ft) =	22.3 (A)	(D) / (A) =	0.5 (E)	3.8
Weighted Root Density (G)						
		Root Density as % =	30 (F)	(F) x (E) =	16.0 (G)	7.8
Bank Angle (H)						
				Bank Angle as *Degrees* =	52 (H)	3.5
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

Bank Material Adjustment:

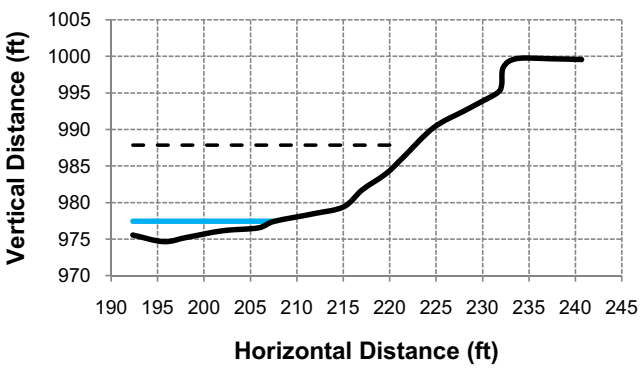
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

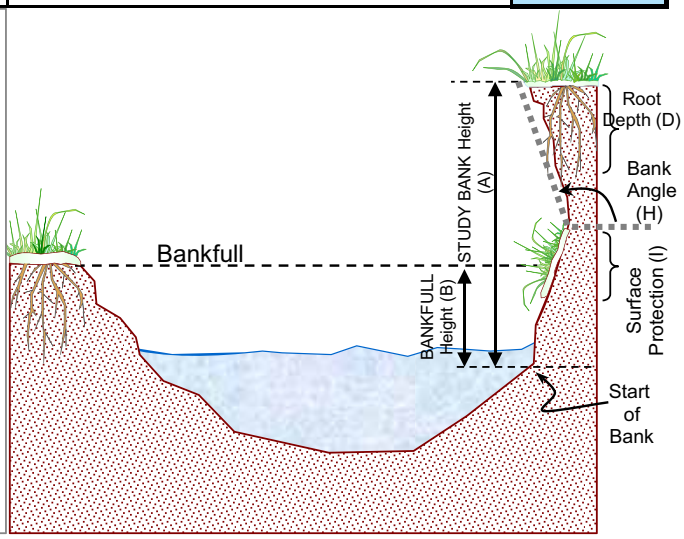
Bank Material Adjustment 0.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0.0

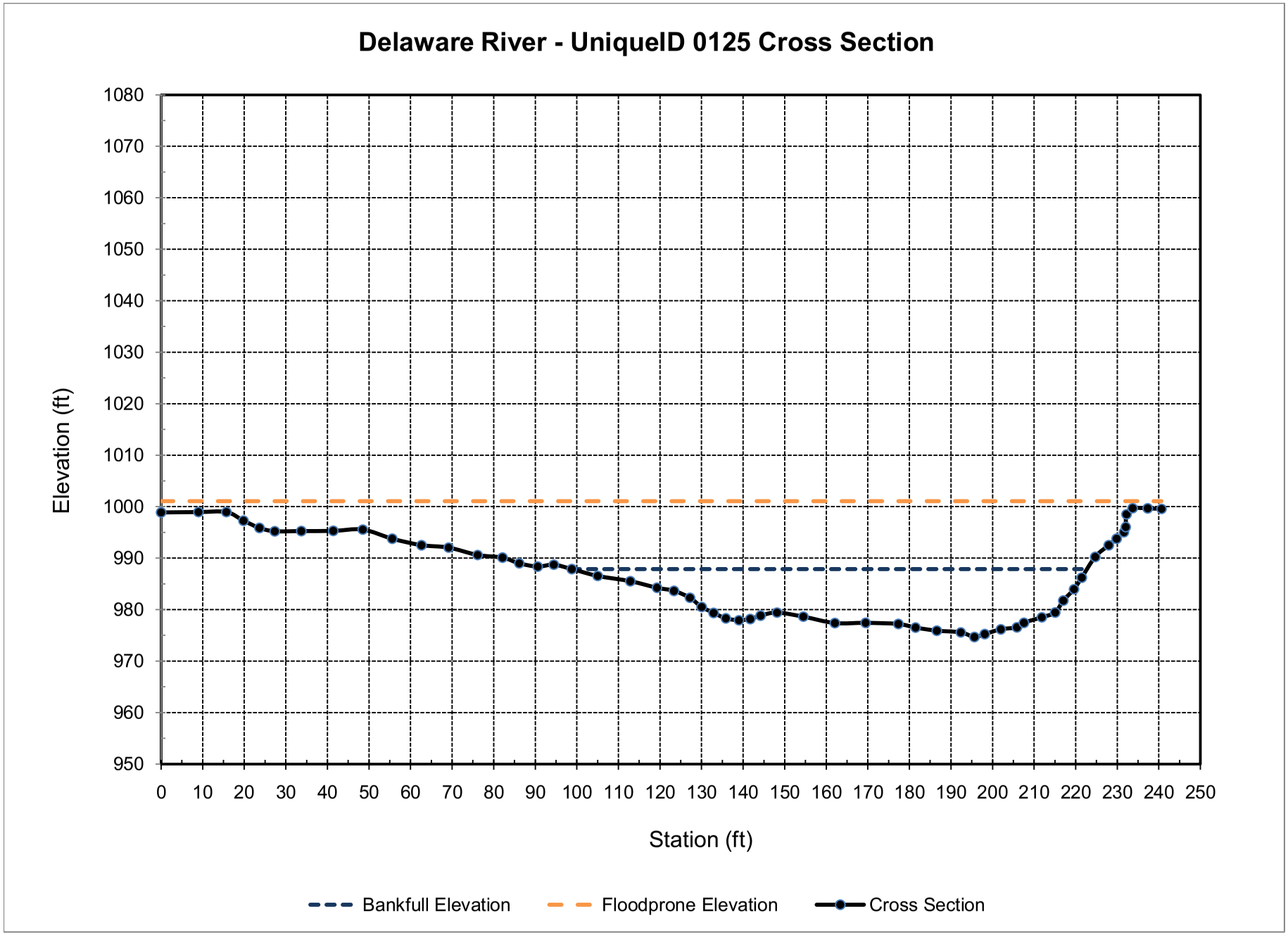
Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		32.1

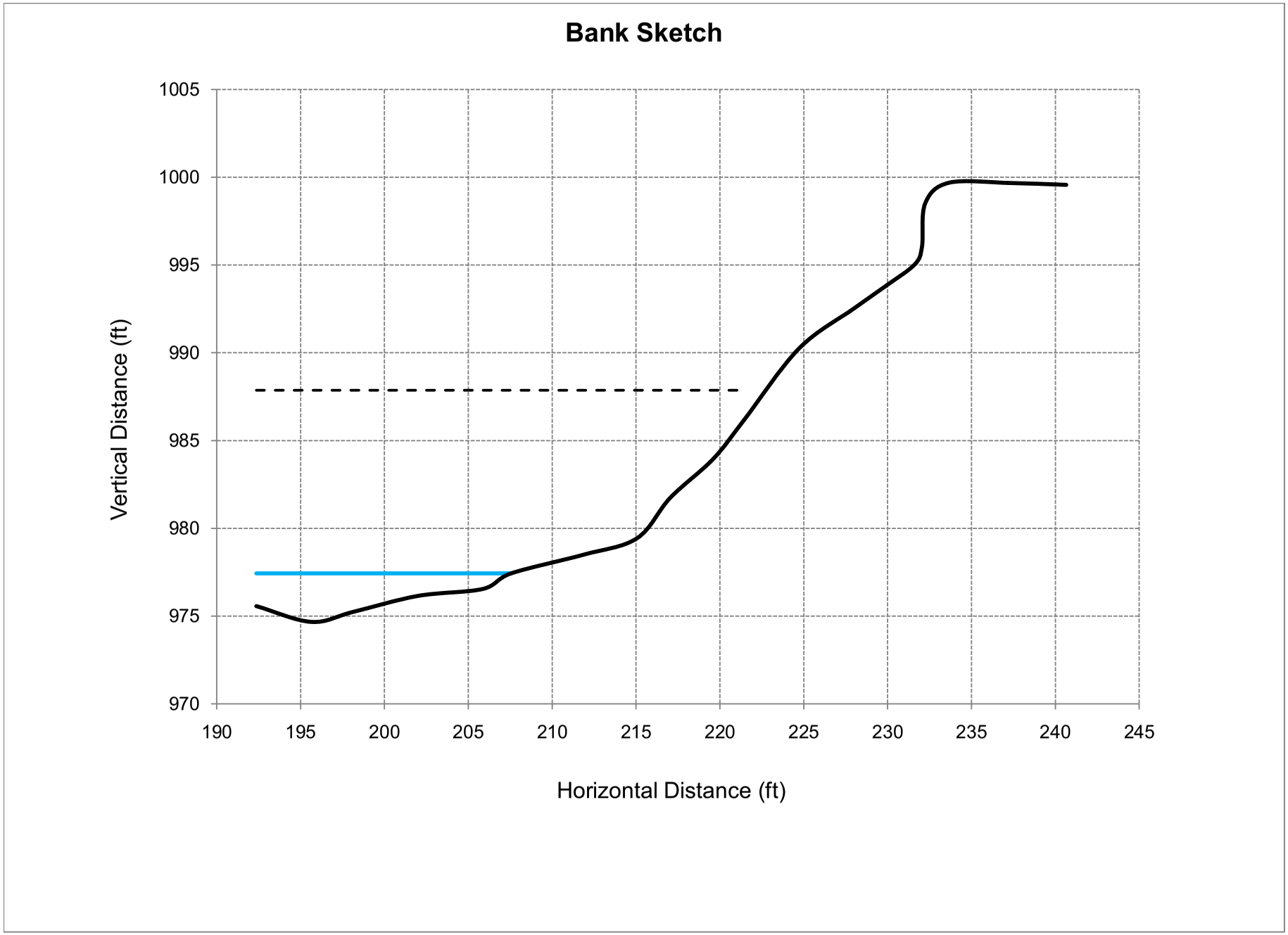
Bank Sketch





Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0125 Cross Section
Elevation (ft)
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section


Bank Sketch
1005
1000
995
990
985
980
975
970
Vertical Distance (ft)
190
195
200
205
210
215
220
225
230
235
240
245
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0126

A-49 Delaware Hot-Spot UniqueID: 0126

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0126	34.9	High	1.59	2.43

Description of Survey Site: There is no wood riparian corridor. There are active signs of recent erosion towards lower end of site.

Length of Bank (feet): 267

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	70%	89%
Reduction of Rate of Erosion (tons/foot/year):	1.70	2.16
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$21,360	$21,360
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	454	577
***Cost of Soil Reduction Per Ton:**	**$4.70**	**$3.70**
***Cost of Soil Reduction Per Cubic Yard:**	**$6.11**	**$4.81**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 8-Jul-08
14 Digit HUC: 10270103010100
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0126
County: Brown County
Legal Description: NE1/4 Sec 31 T4S R16E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	0	Feet	Pasture	
	Crop field	X		Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	117.7	Feet
	Edge of Water to Edge of Water	57.2	Feet
Water Depth:	Thalweg	4.4	Feet

Livestock access to Riparian Area	**Yes**		**No**	X
If yes, what is the duration in months per year?				
Debris or Channel Blockages	**Yes**		**No**	X
Buildings or Structures Threatened	**Yes**		**No**	X
If yes, what is their distance from the streambank?		Feet		

Bank Erosion Inventory

Average Bank Height: 21.9 Feet (Measure)
Root Depth of Riparian Vegetation: 2.3 Feet

Bank Slope:	Undercut		Comments:	Average bank angle is 28 degrees.
	Vertical			
	1H:1V			
	2H:1V	X		

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		502	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 2.30 Average Feet / year

Comments on Erosion:

View across channel at cross section

View downstream from cross section

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0126**	Location:	**Brown County**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date:	**07/08/08**	Stream Type: **-**	Valley Type: **VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	21.9 (A)	Bankfull Height (ft) =	15.8 (B)	(A) / (B) =	1.4 (C)	5.2
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	2.3 (D)	Study Bank Height (ft) =	21.9 (A)	(D) / (A) =	0.1 (E)	8.3
Weighted Root Density (G)						
		Root Density as % =	10 (F)	(F) x (E) =	1.1 (G)	10.0
Bank Angle (H)						
				Bank Angle as *Degrees* =	28 (H)	2.3
Surface Protection (I)						
				Surface Protection as % =	10 (I)	9.0

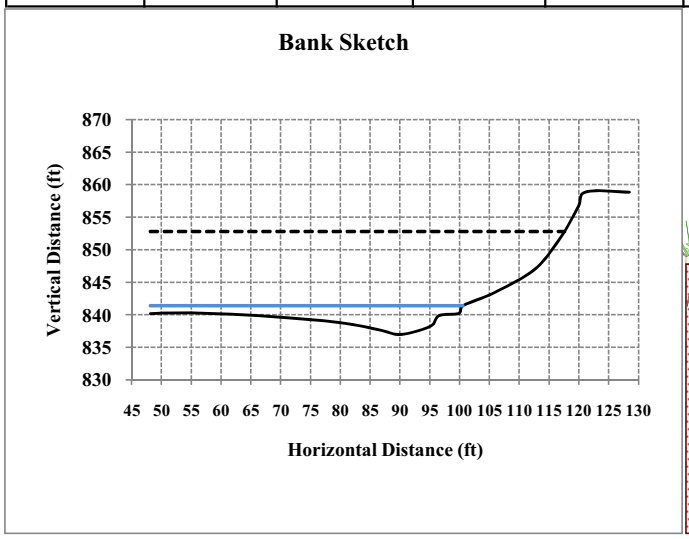
Bank Material Adjustment:

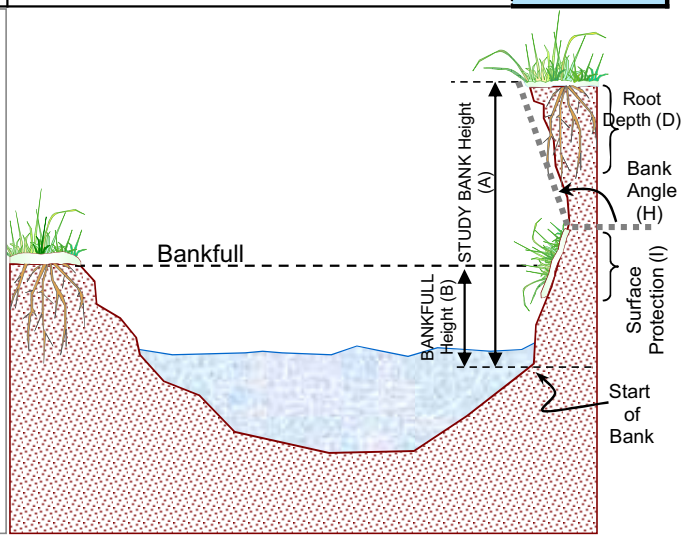
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0

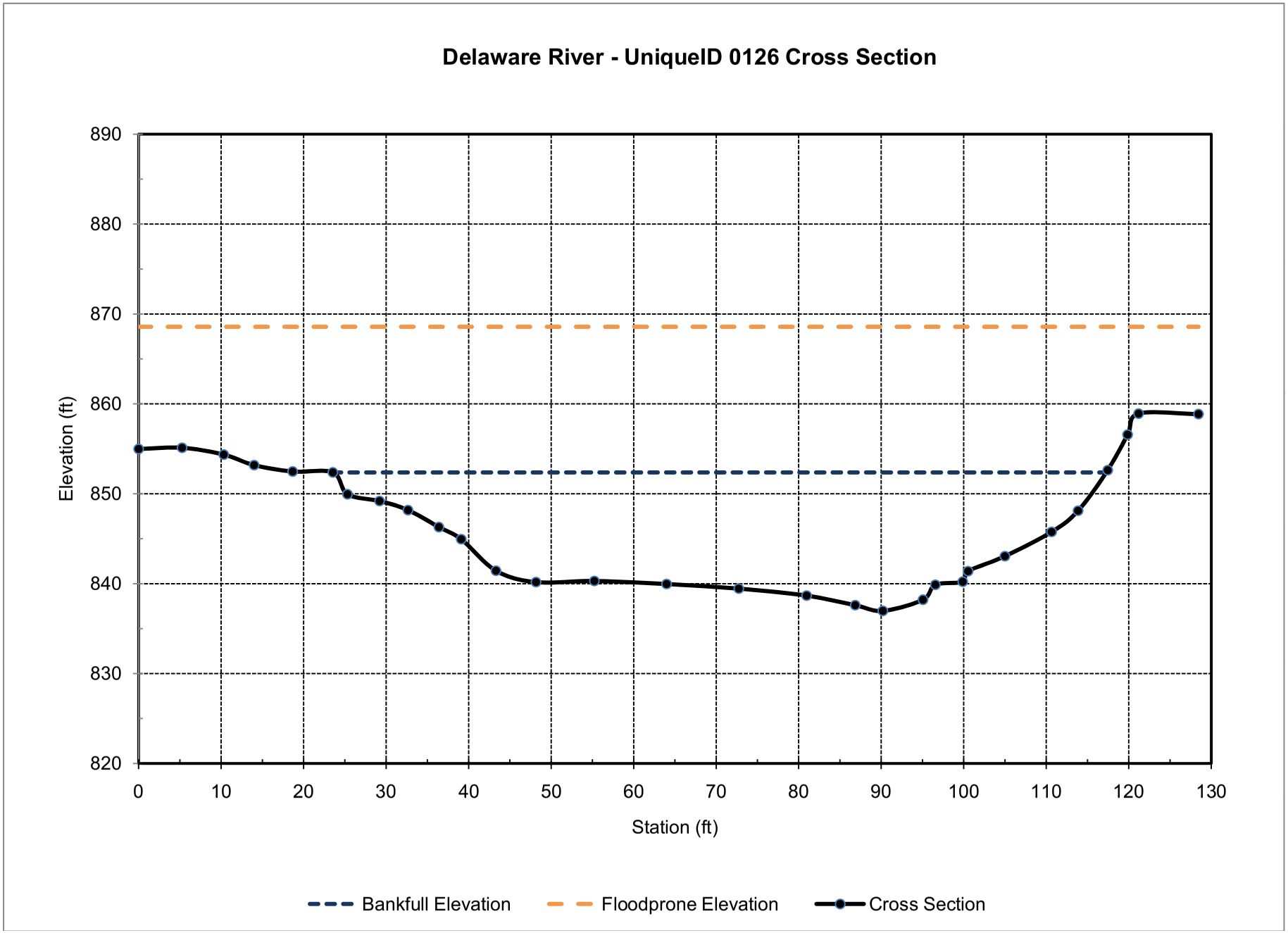
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	High
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		34.9

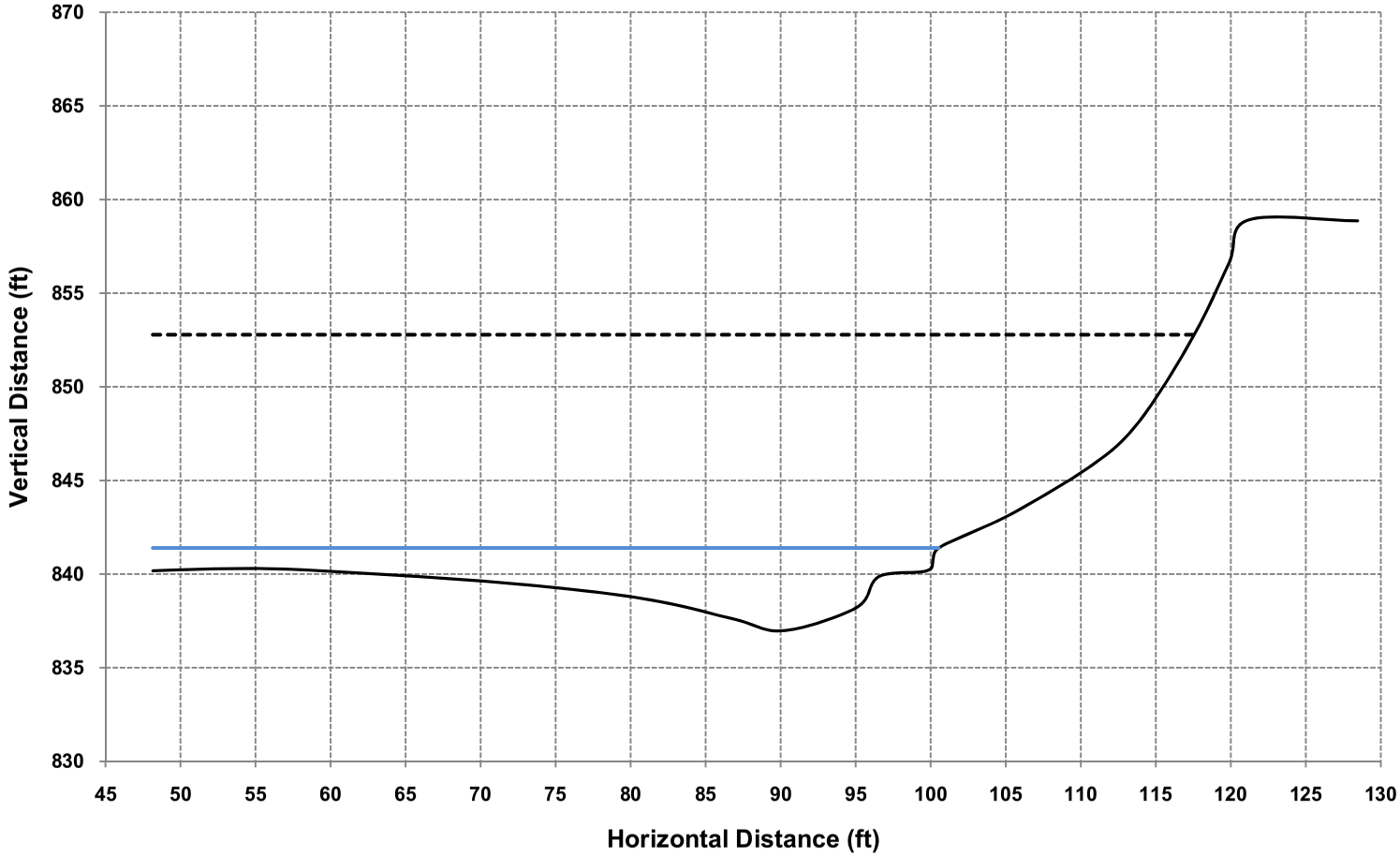




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0126 Cross Section
890
880
870
860
850
840
830
820
Elevation (ft)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


870
865
860
855
850
845
840
835
830
Vertical Distance (ft)
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
125
130
Horizontal Distance (ft)

PERRY LAKE RESERVOIR WATERSHED HOTSPOT 0127

A-50 Delaware Hot-Spot UniqueID: 0127

Location of Stream Segment: Delaware River

BEHI EROSION POTENTIAL SUMMARY

Unique ID	BEHI Score	BEHI Rating	NBS Ratio	Predicted Erosion (tons/foot/year)
0127	27.8	Moderate	1.53	1.03

Description of Survey Site: There is one row of wooded riparian vegetation along to of bank. Many trees have fallen into the channel area. At the bank toe, there are seeps daylighting throughout the meander.

Length of Bank (feet): 652

Recommended BMPs for Erosion Hotspot: Bank Shaping, Riparian Plantings, LPSTP, and Rock Vanes.

	Year 1 - 3	Year 4 - 10
BMP Estimated Percent Reduction:	50%	82%
Reduction of Rate of Erosion (tons/foot/year):	0.52	0.84
Cost of BMP Per Linear Foot:	80	80
Cost to Install BMP in Reach:	$52,160	$52,160
Total Soil Reduction Resulting from BMP Implementation (tons/reach/year):	336	551
***Cost of Soil Reduction Per Ton:**	**$15.53**	**$9.47**
***Cost of Soil Reduction Per Cubic Yard:**	**$20.19**	**$12.31**

*Costs are distributed over a 10-year period and assumes the BMP is fully functional and reduces erosion at the estimated rate over the 10-year period. Assume that 1 cubic yard of soil weighs 1.3 tons.

Field Assessment Form

Site Location

Stream Name: Delaware River **Date:** 2-Sep-09
14 Digit HUC: 10270103030080
Person(s) Filling out Form: Emmert, McCurdy, Kolian
Affiliation(s): Gulf South Research Corporation, Watershed Institute, Inc.

Location: Site Number: 0127
County: Atchison County
Legal Description: NW1/4 Sec 29 T6S R17E

Above Public Water Supply: Yes X No
If yes, provide name of reservoir or water body: Perry Lake

Site Inventory

Stream Type:	Perennial	X		Comments	
	Intermittent				
	Ephemeral				
Riparian Condition:	Width	40	Feet	Pasture	
	Crop field			Rangeland	
	Timber				
Adjacent Landuse:	Pasture			Urban	
	Timber			Residential	
	Cropland	X		Industrial	

Channel Width:	Top of Bank to Top of Bank	212.8	Feet
	Edge of Water to Edge of Water	41.1	Feet
Water Depth:	Thalweg	1.2	Feet

Livestock access to Riparian Area **Yes** ____ **No** X
If yes, what is the duration in months per year? ____

Debris or Channel Blockages **Yes** ____ **No** X

Buildings or Structures Threatened **Yes** ____ **No** X
If yes, what is their distance from the streambank? ____ Feet

Bank Erosion Inventory

Average Bank Height: 25.4 Feet (Measure)
Root Depth of Riparian Vegetation: 15.0 Feet

Bank Slope:	Undercut		Comments: Average bank angle is 24 degrees.
	Vertical		
	1H:1V		
	2H:1V	X	

Bank Erosion Inventory (con't)

	Check All That Apply				
Bank Materials:	Silt/Clay	X	<.062 mm dia.		
	Sand		.062-2 mm dia		
	Gravels		.08 - 2.5 inches		
Streambed Materials:	Silt/Clay	X	<.062 mm	Cobbles	2.5 - 10.1 in. dia.
	Sand	X	.062-2 mm	Boulders	10.1 - 80 in. dia.
	Gravels	X	.08 - 2.5 in.	Bedrock	
Eroding Bank Length:		494	Feet		

Erosion History (i.e. Aerial Photography and Landowner Communication)

Erosion Rate: 0.85 Average Feet / year

Comments on Erosion:

View of the left bank.

View of the left bank.

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Delaware River - UniqueID 0127**	Location:	**Atchison County**
Station:	**Streambank Assessment**	Observers:	**GSRC, TWI**
Date: **09/02/09**	Stream Type: **-**	Valley Type:	**VIII**

						BEHI Score (Fig. 5-19)
Study Bank Height / Bankfull Height (C)						
Study Bank Height (ft) =	25.4 (A)	Bankfull Height (ft) =	14.5 (B)	(A) / (B) =	1.8 (C)	6.7
Root Depth / Study Bank Height (E)						
Root Depth (ft) =	15 (D)	Study Bank Height (ft) =	25.4 (A)	(D) / (A) =	0.6 (E)	3.5
Weighted Root Density (G)						
		Root Density as % =	20 (F)	(F) x (E) =	11.8 (G)	8.2
Bank Angle (H)						
				Bank Angle as *Degrees* =	24 (H)	2.2
Surface Protection (I)						
				Surface Protection as % =	20 (I)	7.2

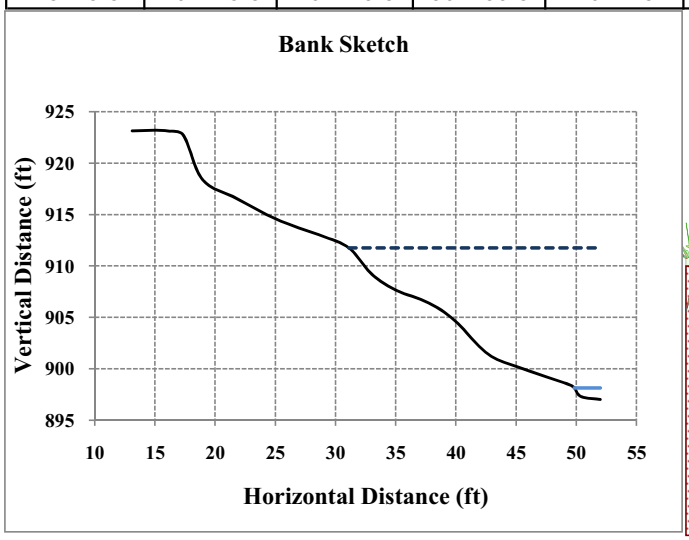
Bank Material Adjustment:

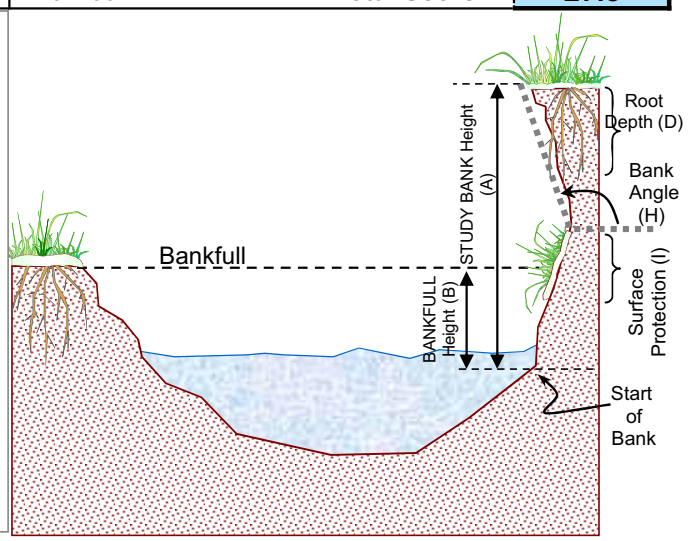
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment 0

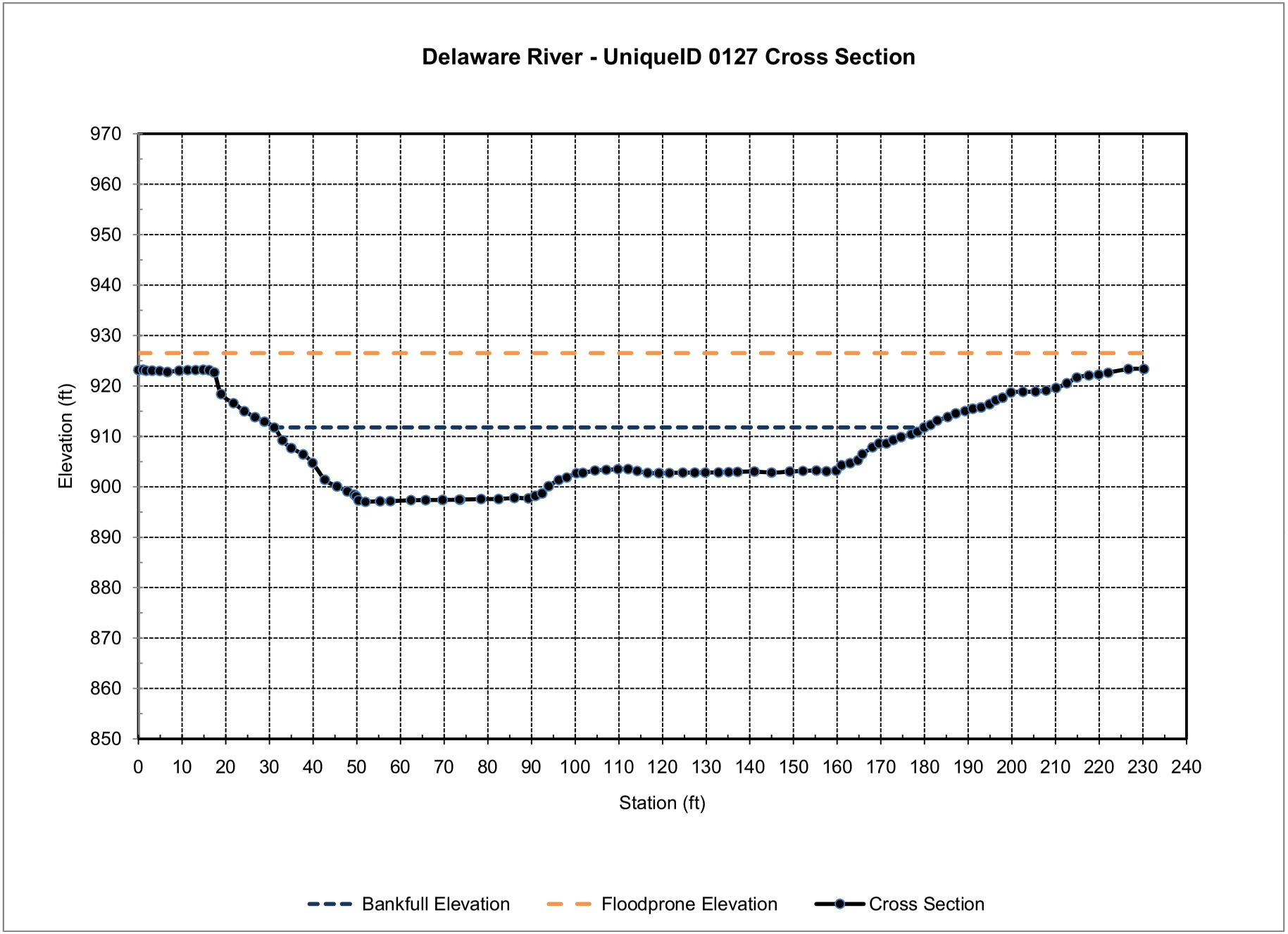
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating and Total Score	Moderate
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		27.8

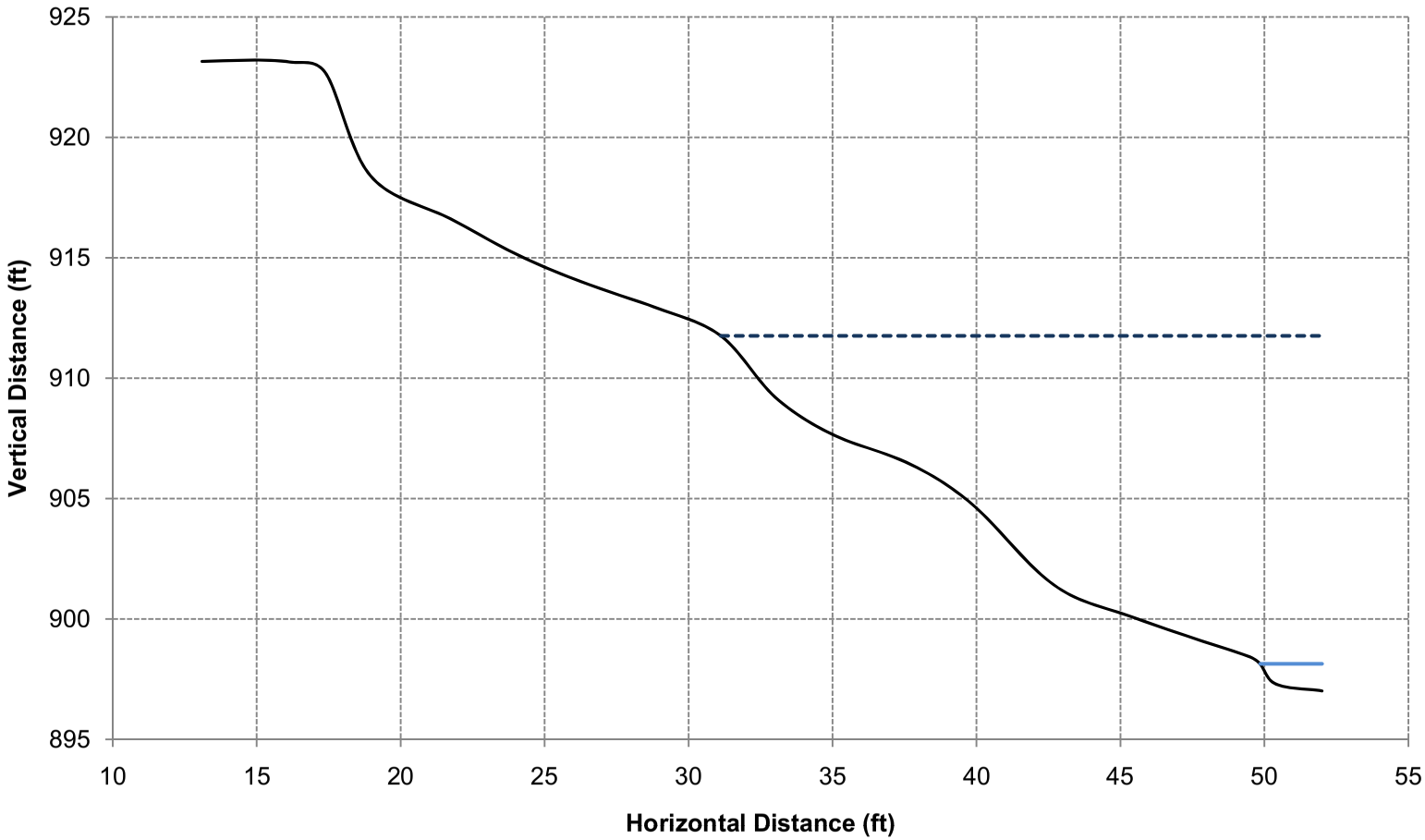




Copyright © 2006 Wildland Hydrology


Delaware River - UniqueID 0127 Cross Section
Elevation (ft)
970
960
950
940
930
920
910
900
890
880
870
860
850
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
Station (ft)
Bankfull Elevation
Floodprone Elevation
Cross Section

Bank Sketch


925
920
915
910
905
900
895
Vertical Distance (ft)
10
15
20
25
30
35
40
45
50
55
Horizontal Distance (ft)