ASHOKAN WATERSHED STREAM MANAGEMENT PROGRAM

6375 State Rt. 28, Phoenicia, NY 12464 ♦ (845) 688-3047 ♦ www.ashokanstreams.org

November 2011

Project Report:

Using Bank Assessment for Non-point source Consequences of Sediment (BANCS) model to prioritize potential stream bank erosion on Birch Creek, Shandaken, New York.

Graham Markowitz[1]
Sara Newton[2]

[1]**Ulster County Soil & Water Conservation District**
[2]**Student Conservation Association**

Lead authors contact details:
graham.markowitz@ashokanstreams.org
sara.newton@ashokanstreams.org

SOIL & WATER Conservation District

sca

NYC Environmental Protection

Executive Summary

An internship project was initiated with the purpose of assisting the Ashokan Watershed Stream Management Program (AWSMP) by evaluating the propensity of streambank erosion along Birch Creek within Catskill State Park in New York. The project goals that were designed to supplement Birch Creek's Steam Management Plan include: 1) establish a baseline dataset to predict an annual stream bank erosion rate of Birch Creek; 2) rank and prioritize site specific potential erosion; and 3) produce reach specific erosion ratings. Rosgen's BANCS (Bank Assessment for Non-point source Consequences of Sediment) model was used as a quantitative tool for estimating erosion. The BANCS model employs both Bank Erosion Hazard Index (BEHI) and Near-Bank Stress (NBS).

We obtained an inventory of stream bank conditions on Birch Creek from July 2011 through October 2011. A total of 144 bank locations throughout 6.3 miles of stream were assessed by completing a rapid cross-section, NBS, and BEHI evaluations. Nine monumented stream bank cross-sections were installed and measured pre and post Hurricane Irene and Tropical Storm Lee flood events. BEHI ratings, NBS ratings, and the erosion rates were evaluated. Similar BEHI and NBS ratings produced a range of streambank erosion rates. No apparent trend was observed out of our nine data points but upon further inspection, the discrepancy lied within the NBS ratings. BEHI ratings were plotted against material removed, independently of NBS, which consequently produced a correlated trend line. The monumented cross-sectional data points show that a significant amount of erosion was observed at 5.06 ft2/yr for the highest BEHI rating, the moderate BEHI data points ranged from erosion up to 2.7ft2/yr to minor deposition at .33ft2/yr, and the low BEHI ratings ranged from minor erosion of 1ft2/yr to deposition of 1.7ft2/yr.

The discrepancies within the NBS rating may be attributed to the lack of sufficient data points, applicability within the Birch Creek Watershed, or by solely employing a single method from seven possible alternatives to calculate NBS score. Other minor discrepancies within the BEHI ratings may be attributed to channel constrictions from infrastructure, non-alluvial boundary conditions such as revetment, glacial till, and lake clays, and by exceeding bankfull conditions during extreme flood events due Tropical Storms Irene and Lee. Future research that may potentially reduce scatter in the data would be employing various NBS methods, expanding sampling locations to different streams within the same hydro-physiographic region, and continuing assessments for multiple years to accurately account for average annual erosion rates. A comprehensive management strategy for Birch Creek would suggest that BEHI ratings rather than NBS ratings are an accurate predictor of stream bank erosion for that particular watershed.

Acknowledgements

We are grateful for the assistance and services of:

- Ulster County Soil and Water Soil and Water Conservation District Stream Project Manager Cory Ritz.
- Ashokan Watershed Stream Management Program Staff.
- New York City Department of Environmental Protection Project Managers; Danny Davis and Mark Vian.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

A practical method for computing stream bank erosion rates and consequent sediment loading is the Bank Assessment for Non-point source Consequences of Sediment (BANCS) model, which encompasses two quantitative tools for estimating erosion: Bank Erosion Hazard Index (BEHI) and Near-Bank Stress (NBS) (Rosgen, 2006). The purpose of this investigation was to: 1) establish a baseline dataset to predict an annual stream bank erosion rate of Birch Creek using Rosgen's BANCS model; 2) rank and prioritize site specific potential erosion; and 3) produce reach specific erosion ratings. The ultimate goal of this research was to assist the Ashokan Watershed Stream Management Program in formulating stream management strategies by completing extensive monitoring and assessment of stream bank erosion. Inventories of stream bank condition were obtained using quantitative measurements of BEHI and NBS which allowed for the prioritization of future bank stabilization efforts. The use of the BANCS model was applied to a total of 6.3 stream miles of Birch Creek. This project was intended to compliment the Birch Creek stream management plan.

1.1 Background

Stream Erosion and Water Quality Impact

Stream bank stability may influence rates of erosion which consequently can accelerate rates of sedimentation and contaminants entering water resources. Stream bank erosion is a natural process; however when excessive accelerated erosion can be a major cause of non-point source pollution from suspended sediment (NYC DEP, 2007). Increased suspended sediment supply affects water quality, physical and biological functions of a stream (Dudley and Karr, 2002). In the Ashokan Reservoir watershed, suspended sediment often contains clayey material negatively effecting water quality in continuous high concentrations. Watershed management practices in the Ashokan Reservoir watershed attempt to determine the volume, source, and rate of stream bank erosion to assist in stream, riparian and habitat restoration, and management recommendations.

Geographic Location

Located at the eastern edge of the Catskill Mountains, New York, the upper Esopus Watershed encompasses 330 stream miles, in which 6.3 miles of that is composed of the Birch Creek tributary (Figure 1). Birch Creek's drainage area of 12.8 square miles represents a 6.7% portion of the 192 square miles draining the upper Esopus Creek Watershed into the Ashokan Reservoir (Figure 2).

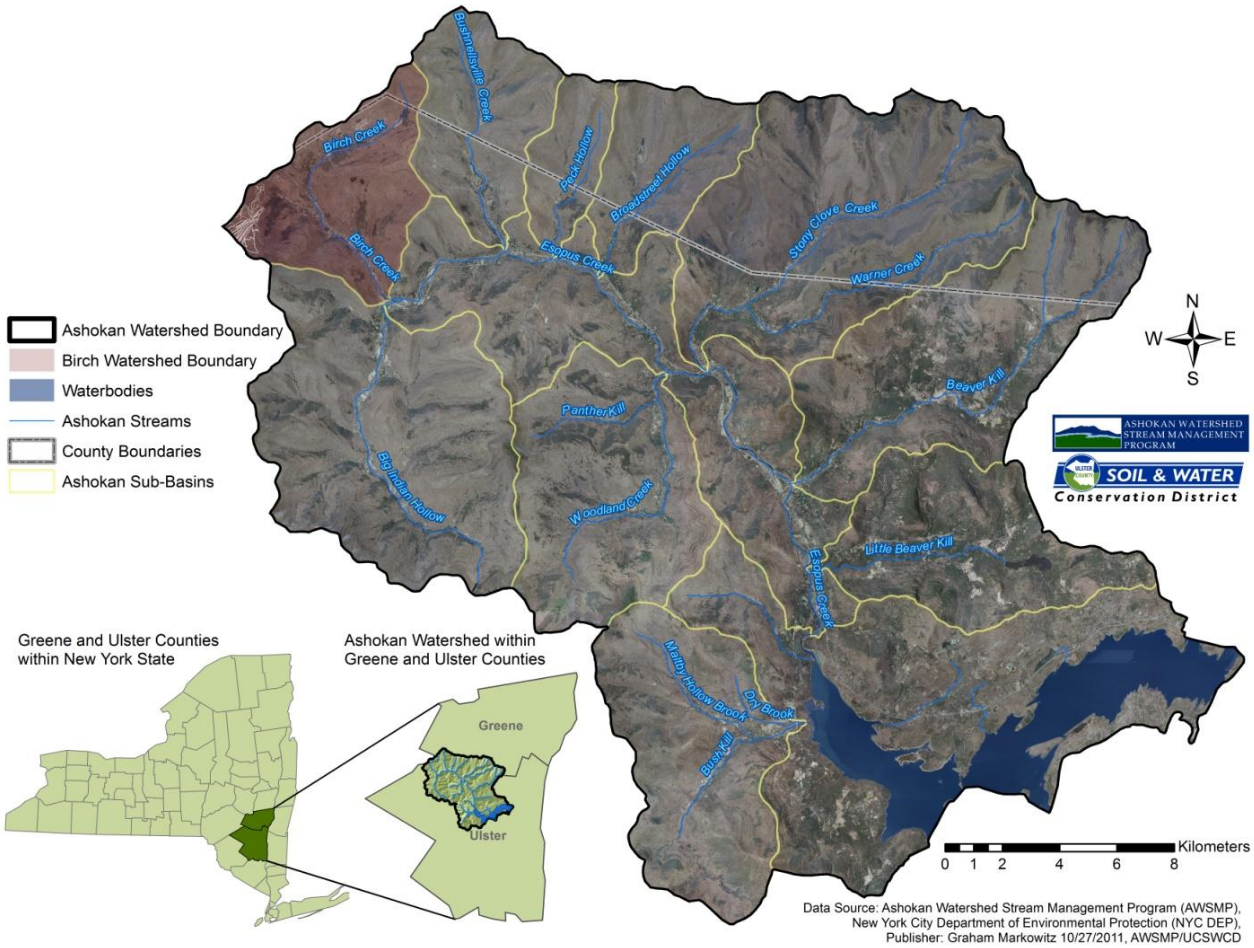


Figure 1: Ashokan Reservoir watershed map and location within the New York State. Birch Creek watershed is highlighted in red. The yellow lines represent subwatershed boundaries and the blue lines represent streams.

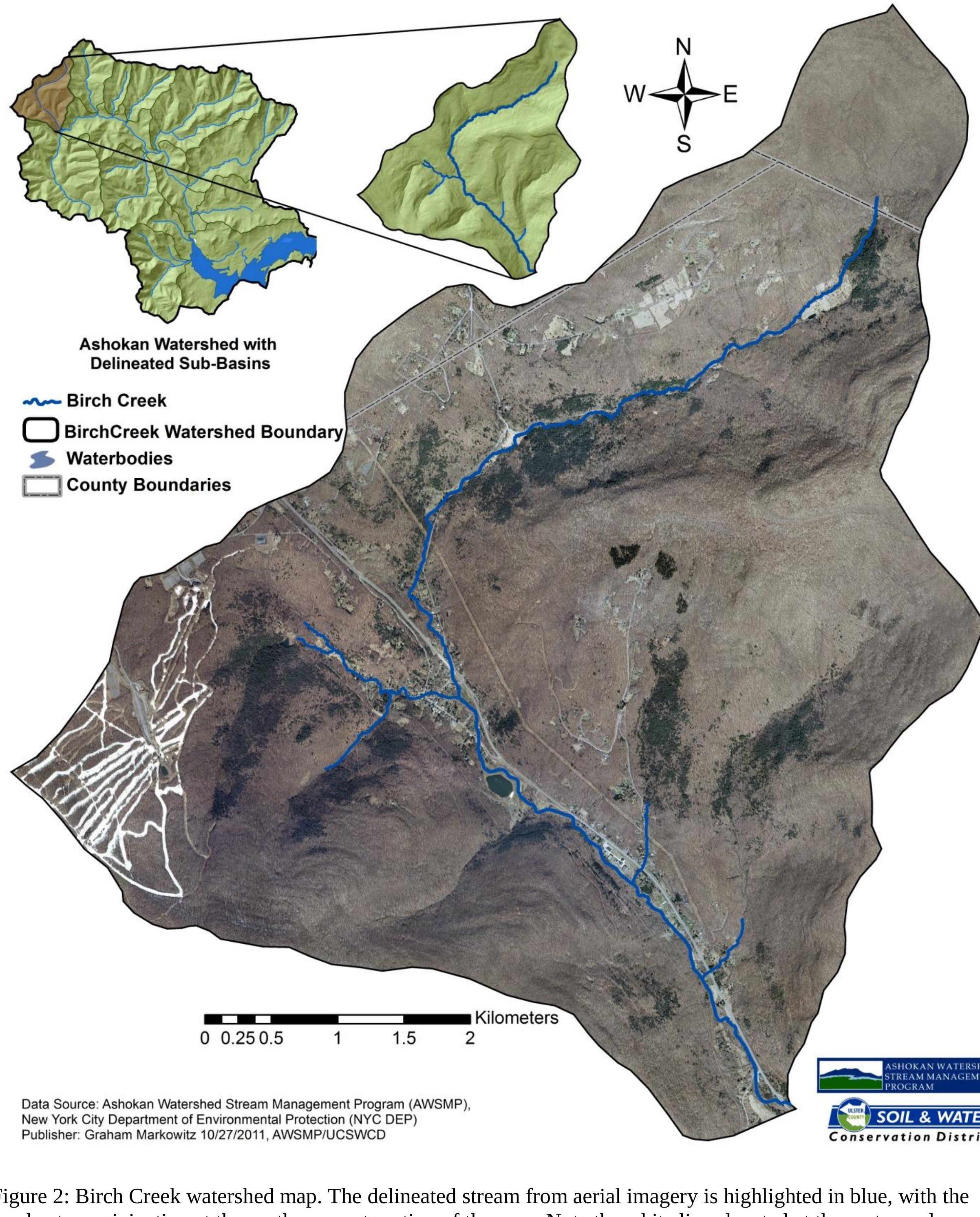


Figure 2: Birch Creek watershed map. The delineated stream from aerial imagery is highlighted in blue, with the headwaters originating at the northern most section of the map. Note the white lines located at the eastern edge are Belleayre Mountain ski slopes.

Basin Characteristics

The Catskill region is underlain by sedimentary siltstones, mudstones, and sandstone bedrock of the Oneonta and Walton formations that were deposited in a delta setting of the Devonian Period (Fisher et al., 1970). These formations are structurally part of the Northeastern extent of the Alleghany plateau, a physiographic province extending to the Southwestern border of the Appalachians (Rich, 1934). Much of the current topographic relief of the Catskills resulted from glacial and melt water erosion during the Wisconsinan glaciations, 10,000 to 25,000 years ago during the Pleistocene ice age (Titus, 2003). In this region, 21 peaks higher than 3000 feet asl. conveys strong hydraulic forces onto the landscape, often increasing surficial erosion and the transportation of sediment down slope.

Repeated advances and retreats of the Laurentide ice sheet left behind a legacy of glacial deposits ranging from over-consolidated clay-rich bouldery till, thick sequences of glacial silt and clay layers, and glacial outwash from meltwater streams (Rich, 1935). All of these depostis contain significant amount of fine-grained sediment, especially the lacustrine sediments. Stream erosion into these glacial deposits is of high concern to stream managers because of the streams ability to entrain fine-grained sediment that results in suspended sediment inducing turbidity and thereby decreasing water quality and ecosystem habitat throughout the watershed (NYC DEP, 2007). The upper Esopus provides a cold water sink for aquatic life and natural trout reproduction along its entire length (Figure 4) (NYC DEC, 2009). In addition to erosion, these cold-water habitats can become impaired due to sedimentation redistribution after flood events and increased embeddedness from siltation reducing macroinvertibrate habitat (NYC DEP, 2007).

Figure 3(left): A healthy wild Brown Trout from upstream of the Shandaken aqueduct.

Figure 4(right): Exposed glacio-lacustrine clay deposits such as this are located throughout the upper Esopus watershed. Notice the increased turbidity once disturbed.

Hydrologic Characteristics

Birch Creek is located in a steep gradient mountain setting. The landscape experiences snow melt runoff, flashy storm dominated runoff, and a combination of storm and snow melt runoff. Figure 5 illustrates the flashy character of the Birch Creek system. The Birch Creek watershed receives a mean annual precipitation of 50.1 inches and of that, 30.9 inches occur as runoff annually (USGS Stream Stats, 2011).

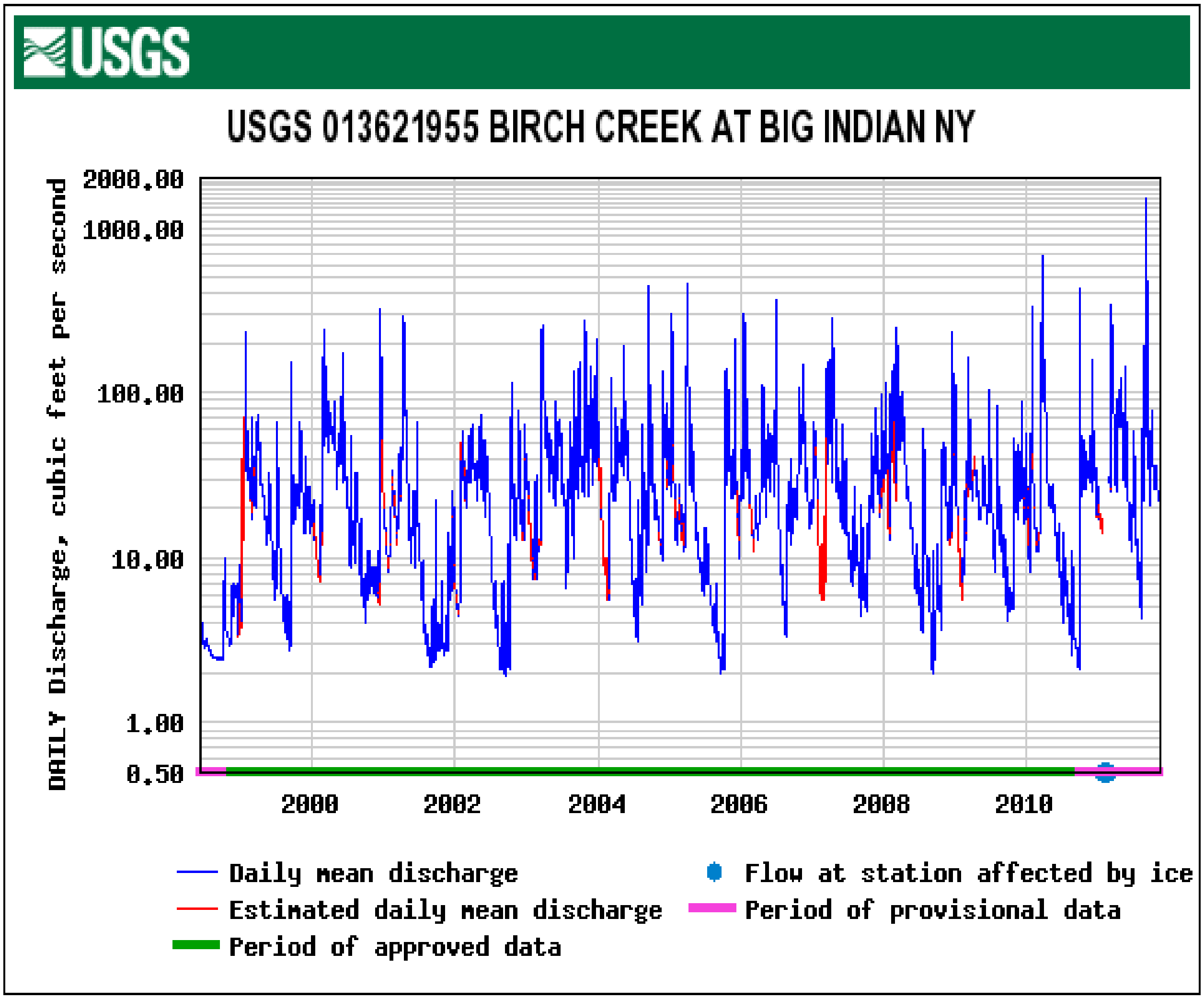


Figure 5: This hydrograph represents the continuous record from 1999 to the present at the USGS gauging station located on Birch Creek. The blue line represents real-time data with sharper increases and decreases in discharge (flashiness) as opposed to the red line representing daily mean discharge.

Bankfull Discharge Determination

The BANCS model is dependent on an accurate assessment of bankfull discharge stage at each study bank location. The bankfull stage in alluvial channels is associated with the approximate 1.5yr discharge determined from flood frequency analysis. It is a surrogate discharge that is assumed to be accountable for formation and maintenance of the stream channel dimensions, platform patterns, and longitudinal profile as the volume of water reaches the point of incipient flooding (Leopold et al. 1964). Bankfull indicators such as considerable slope breaks, depositional features such as the top of point bars, crest of bank adjacent to active flood plain, and base of woody vegetation developed along the stream banks at the bankfull stage. To ensure accurate determination of the bankfull stage all bankfull calls made by field practitioners were checked with the Catskill Mountain hydraulic geometry regional curves (Miller and Davis 2003) and gage station data.

Bankfull discharge was obtained at the USGS Birch Creek gauging station by selecting the site specific gage location, drainage area, instantaneous peak discharge record, and a rating table for stage and discharge relationships. The USGS Birch Creek peak discharge record was sorted in descending order and then ranked for a flood frequency analysis to determine bankfull discharge (Table 1). The exceedance probability was calculated by dividing the rank by the number of years on record plus *1 (m/(n+1))*, where *m* represents rank of discharges and *n* represents the number of years on record. A return interval was obtained by corresponding the interval to peak discharges (Figure 4). To further insure accuracy of bankfull discharge, a Log Pearson Type III method was performed in Rivermorph[1] with the same peak discharge data. Bankfull determination was recorded at approximately 410cfs from annual peak discharges based on USGS discharge data 1999-2011 (Figures 3 and 4).

Date	Peak Discharge (cfs)	Gage Height (ft.)	Rank (m)	Exceedance Probability m/(n+1)	Percent Exceedance 100(m/(n+1))	Return Interval (RI) RI=(1/P)*100
8/28/2011	3710	7.18	1	0.0769	7.69	13.00
3/23/2010	1360	5.8	2	0.1538	15.38	6.50
4/2/2005	1130	7.12	3	0.2308	23.08	4.33
12/17/2000	857	6.32	4	0.3077	30.77	3.25
9/18/2004	844	6.28	5	0.3846	38.46	2.60
6/28/2006	710	5.86	6	0.4615	46.15	2.17
9/16/1999	518	5.21	7	0.5385	53.85	1.86
3/8/2008	427	4.96	8	0.6154	61.54	1.63
12/12/2008	398	4.85	9	0.6923	69.23	1.44
4/16/2007	336	4.6	10	0.7692	76.92	1.30
9/23/2003	321	4.47	11	0.8462	84.62	1.18
2/28/2000	304	4.4	12	0.9231	92.31	1.08
3/27/2002	121	3.57	13	1.0000	100.00	1.00

Table 1: Peak discharges recorded at USGS gage station from 1999-2011 data. The highlighted return interval of 1.5

[1] Rivermorph, LLC 10509 Timberwood Circle, Suite 100Louisville, Kentucky

year was used to determine bankfull discharge. A corresponding discharge of around 410cfs can be approximated for the 1.5 year return interval (bankfull flow). The discharge during tropical storms Irene and Lee (3710 cfs) were significantly larger than the bankfull discharge.

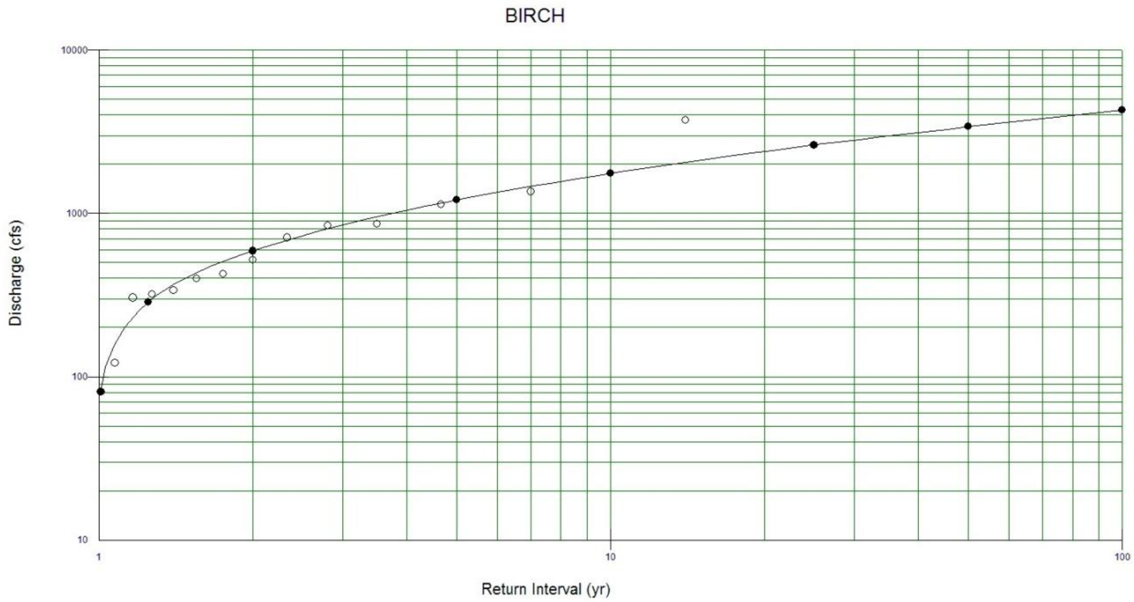


Figure 6: Log Pearson Type III distribution curve for reoccurrence intervals of peak annual discharges. Bankfull discharge (approx. 1.5 year interval) can be located on this distribution curve. The largest flow (Tropical Storm Irene) is located above the distribution curve because of the uncharacteristically (within the data set) large discharge with only 13 of record.

Flow Duration Curves

Figure 3 illustrates the daily flow-duration of Birch Creek from 1999 to 2010. A general trend depicting a uniform steepened slope was observed after flows exceed approximately 3 cfs. Flows below 3 cfs were depicted as a less steepened slope. The steeper slope above 3 cfs indicated a tendency for flashiness and smaller base flows. The flashiness may be attributed to rapid runoff in a steep gradient high relief mountain setting with limited shallow groundwater storage capacity. The less steepened slope or plateau below 3 cfs was observed less than 95% of the time, may be attributed to groundwater input during drought conditions. Flows equaling or exceeding 3 cfs occur at least 95% of the time.

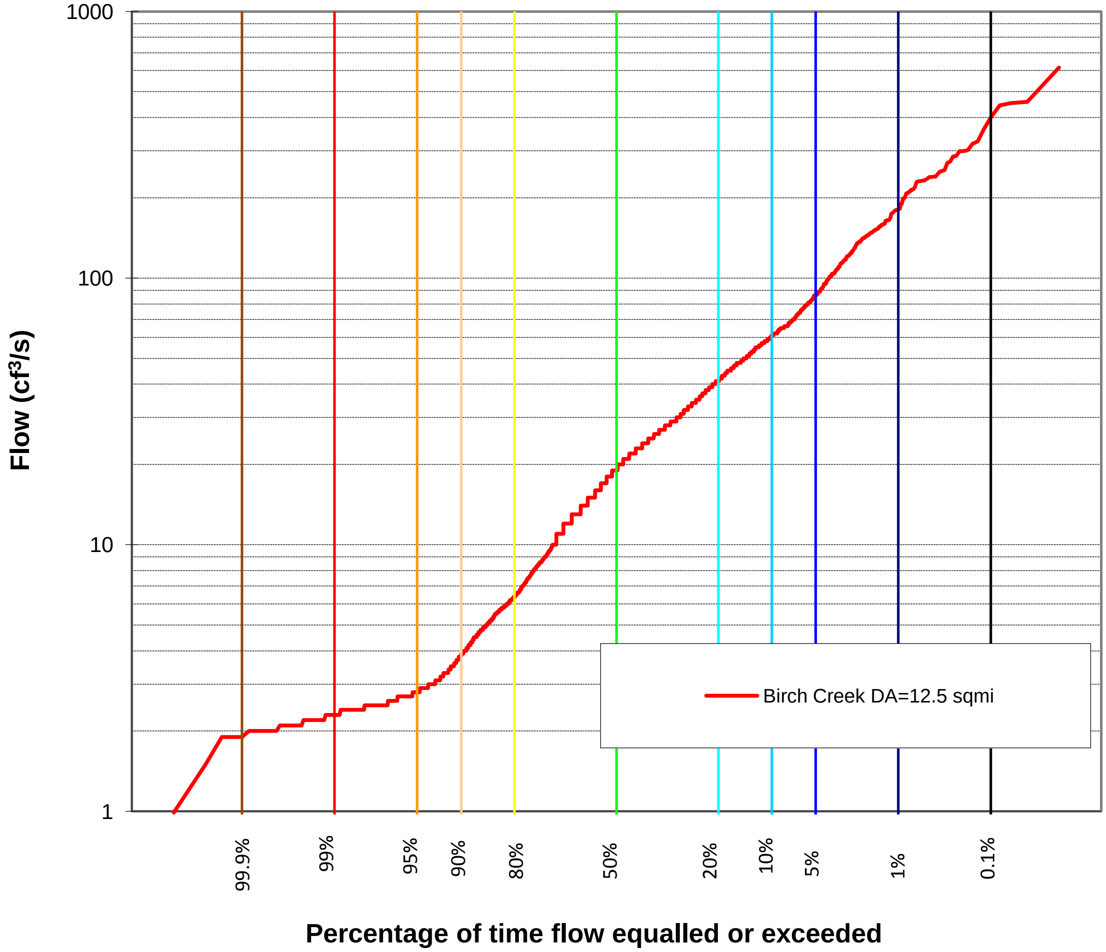


Figure 7: Daily flow-duration curves for Birch Creek based on USGS discharge data 1999-2010.

Study Period

Increased localized precipitation and runoff rates were observed during the months of August and September 2011 by the occurrence of two tropical storms (Irene and Lee) passing through the Catskills region (Figure 7). Bankfull flows were exceeded approximately three times, with the largest being 3710 cfs (Figure 8). A proposal was developed in the spring of 2011 for the field season of July 2011 – October 2011. The first portion of fieldwork provided a baseline dataset was gathered pre-tropical storms Irene and Lee. Post flood assessments resumed late September to document geomorphologic changes after flood inundation.

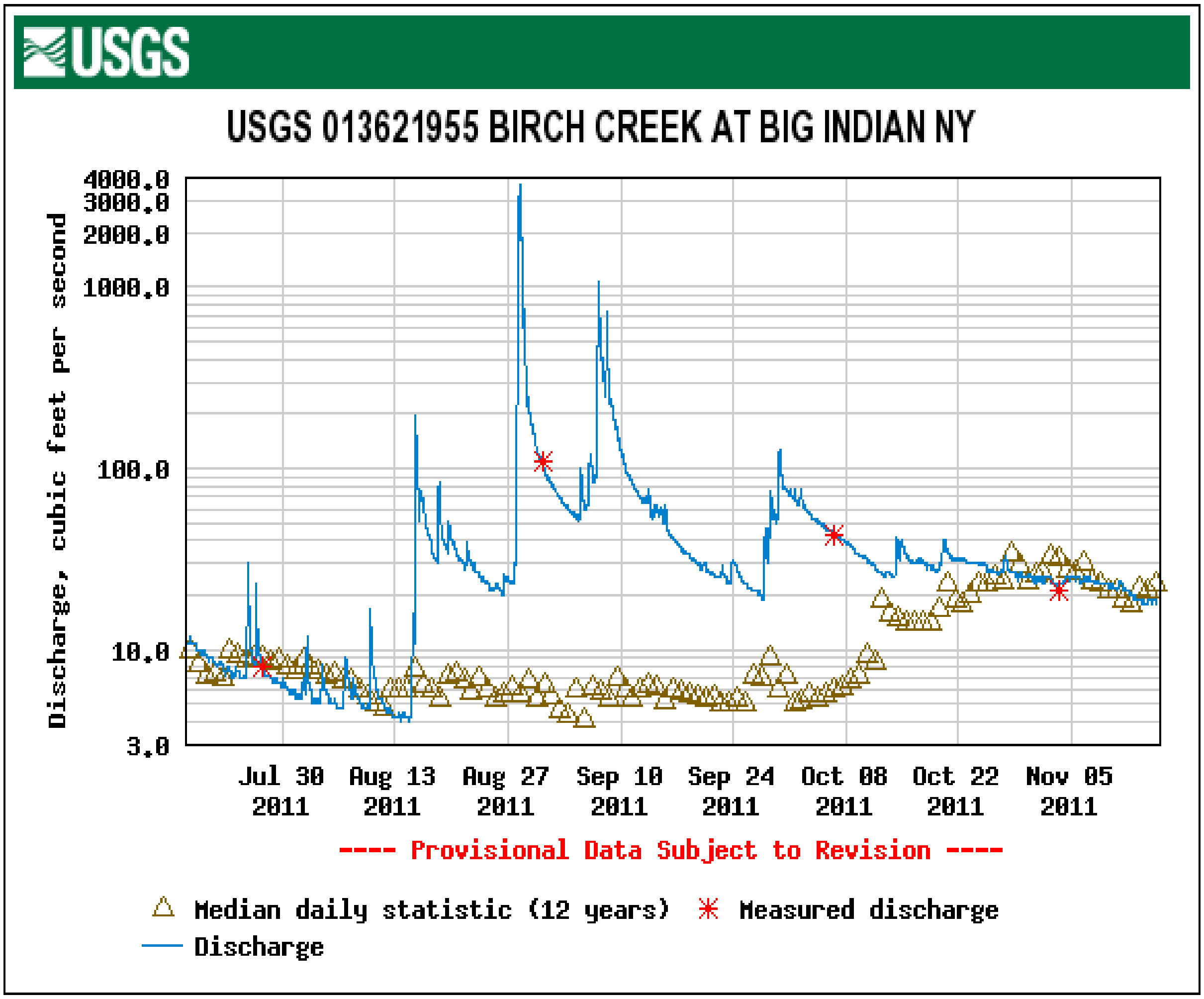


Figure 8: Hydrograph represents study period. The two largest discharges (3710cfs and 1060cfs) are representative of tropical storms Irene and Lee.

2.0 Data Collection Protocols/Methodology

BANCS Model

The BANCS (Bank Assessment for Non-point source Consequence of Sediment) model was developed by Dr. Dave Rosgen to help stream practitioners to quantitatively evaluate and estimate streambank erosion rates (Rosgen 2001). Based on stream bank erosion variables and energy dispersal within the stream systems, the BEHI and NBS ratings were used in the BANCS model to predict annual stream bank erosion rates. Rosgen (2001) based the annual erosion rates off of one of two previously assessed hydo-physiographic regions. Streams found in metamorphic and/or sedimentary geologic regions are applicable to the Colorado dataset (Rosgen 2001). Streams found in volcanism and/or alpine glaciation geologic regions are applicable to the Yellowstone National Park dataset (Rosgen 2001). The framework for determining erosion rates is provided by these studies but the particular erosion rates may not be applicable with all alluvial streams (Rosgen 2008a). The Birch Creek dataset was applied to the BANCS framework and compared to Rosgen's previously determined Colorado and Yellowstone erosion rates.

2.1 Pre Field Analytical Methods

Reach Break Determination

A fluvial geomorphic evaluation of Birch Creek watershed was performed by AWSMP field personnel in the summer of 2011. For this study stream reaches are defined as relatively geomorphically homogenous sections of the stream corridor. According to the AWSMP, the geomorphic variables associated with reach breaks are determined by stream confinement (or valley width), valley slope, dominant channel materials and major tributary influences (VA, 2003). Certain physical parameters for each reach may be further investigated as a contributing mechanism for the amount of erosion occurring in a given reach. Birch Creek was divided into 11 total reaches (Figure 7).

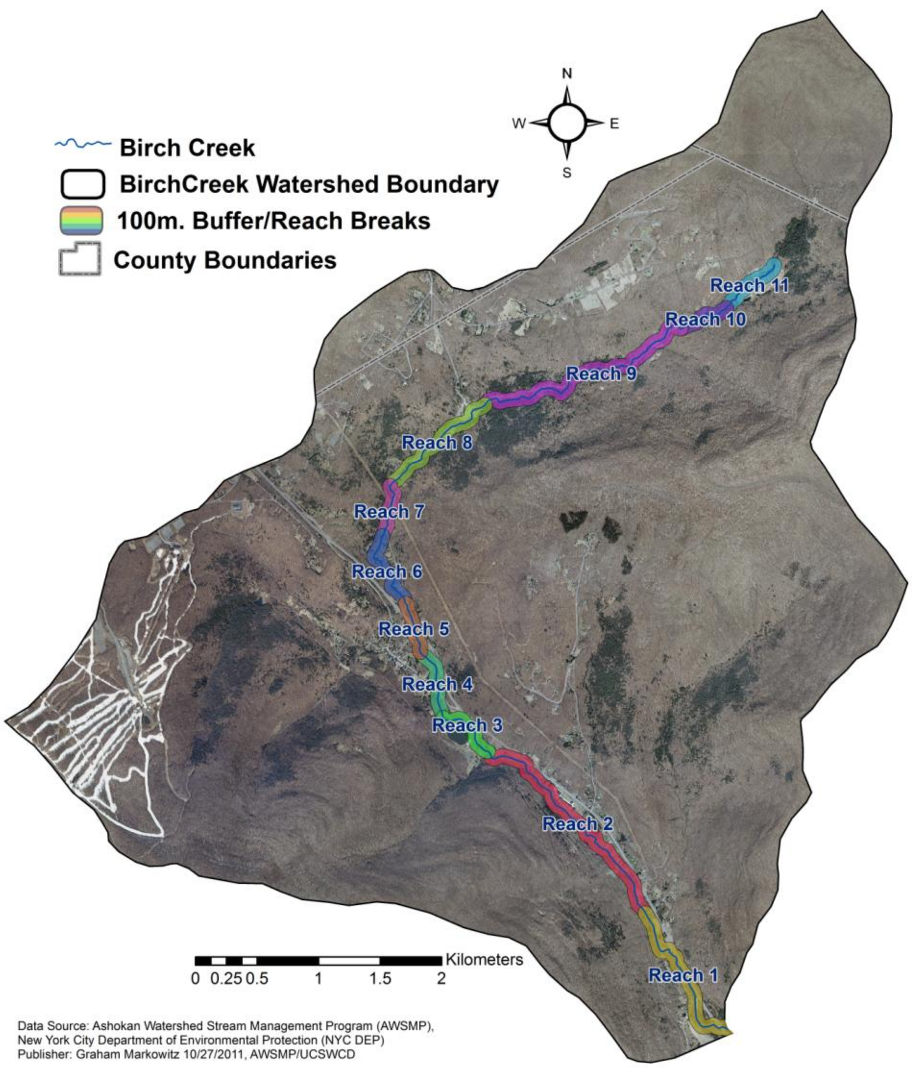


Figure 9: Locations of Birch Creek reach breaks. Reach 11 is the headwaters of Birch Creek and reach 1 is at the confluence with the Esopus Creek.

2.2 Field Methods

Bank Erosion Hazard Index (BEHI) and Near-Bank Stress (NBS) are two stream bank erosion factors used to estimate bank erosion (Rosgen, 2006). All data was recorded in the field on Trimble Geo-XH explorers with sub-meter horizontal accuracy.

Bank Erosion Hazard Index (BEHI)

Rosgen (2006) described BEHI as a fluvial geomorphic assessment procedure to evaluate the susceptibility of stream bank erosion on a section of stream, based on a combination of several erodibility variables. The BEHI assessment assigned a numerical value which corresponds to an overall BEHI rating (very low, low, moderate, high, very high, extreme) for a particular stream bank. The rating was based on the following parameters:

1. Study bank height / bankfull height ratio
2. Root depth / study bank height ratio
3. Weighted root density (percentage)
4. Bank angle (degrees)
5. Bank surface protection
6. Bank material adjustment
7. Stratification adjustment

See Rosgen, 2006 for detailed description of each variable and rationale for BEHI rating values. A brief summary is provided below.

<u>Ratio of stream bank height to bankfull height:</u>
Because the bank height ratio is independent of stream size, the total bank height was divided by bankfull height to compensate for the localized differences in stream sizes. The bank height was measured from the toe of the bank to the top of the bank. The bankfull height was measured from the toe of the bank to the bankfull stage. The ratio obtained was converted to a BEHI rating. The closer the ratio was to 10, the higher the risk of bank erosion.

<u>Ratio of riparian root depth to stream bank height:</u>
The average root depth of plants divided by the study bank height was calculated to estimate the adherence of bank material by vegetation. Failure of the bank due to undercutting can occur if the root depth does not reach the bank height. The ratio obtained was converted to a BEHI rating. High ratios resulted in lower BEHI scores.

<u>Weighted Root density:</u>
This was a visual assessment of the amount of bank composed of root material, expressed as a percentage. The root density was estimated and then multiplied by the root depth to stream bank height ratio, which yields the weighted root density of the bank height. Higher weighted root density percentages correspond with low BEHI scores.

Bank angle:
The bank angle was the angle from the lower bank at the waterline during base flow to the top of the bank. Steeper bank angles were estimated to have a higher risk of mass failure of the bank due to gravitational force and shear stresses.

Surface protection:
This was the amount of stream bank covered and protected by woody debris, vegetation, revetment etc. This was measured as the percentage of streambank not exposed to erosive forces, for example more surface protection on a bank, the lower the risk of erosion. For example easily erodible material such as sand or silt sized sediment increased the points thus raising the BEHI score.

Bank material adjustment
The composition of the bank material was noted in order to account for erosive variables that occur due to differential erosion susceptibilities attributable to sediment size. Points were subtracted, added, or not applied to the BEHI score depending on sediment composition.

Stratification adjustment:
Stratification adjustments were made to account for zones of preferential erosion that occur within banks that have more than one strata. BEHI score adjustments were made if the strata exist specifically near the bankfull stage height.

Near Bank Stress (NBS)

Near Bank Stress variables indicate disproportionate energy acting on banks at bankfull stage flow. Higher near bank stress often indicated a higher erosion rate along the bank. Seven ways to assess near bank stress were possible, however only one was chosen which was dependent on the different onsite stream characteristics. The seven possible assessments that assign a rating of very low, low, moderate, high, very high or extreme to NBS follows:

1. Channel pattern, transverse bar or split channel / central bar creating NBS or 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 near-bank shear stress to bankfull shear stress (will not use)
7. Velocity profiles / Isovels / Velocity gradients (will not use)

See Rosgen, 2006 for detailed description of each variable and rationale for NBS rating values. To maintain consistency, the ratio of near-bank maximum depth to the bankfull mean depth method for determining NBS was used. To avoid errors in bankfull determination cross sections were taken at each assessed bank along a riffle. The data was then entered into Rivermorph which calculates the NBS score. A brief summary of the method used is provided below:

Ratio of near-bank maximum depth to bankfull mean depth:
This ratio was obtained by measuring the maximum bankfull depth near the bank and dividing that value by the bankfull average depth from a riffle cross section. Values calculated correspond to NBS ratings ranging from very low to extreme.

Cross section procedures

Cross sectional surveys were used quantify to morphological features such as bankfull width, depth, area, and entrenchment ratio. Seven monumented cross sections along riffles were installed at four different sites. Installation of monumented cross sections were chosen based off of lack of stream confinement due to revetment, presence of bankfull indicators, erosive potential, and various drainage areas (upper, mid, and lower portion of the watershed). In order to document erosion rates, pre and post flood surveys were compared to determine bank retreat. The site specific erosion rate was then compared to both BEHI and NBS ratings.

Monumented installation

The following monumented cross section procedures from *River Morphology and Applications* by Dr. David Rosgen were used to maintain consistency cross section set up and data collection (Rosgen, 2010). An automatic optical level was used to perform cross section surveys.

1. Setup the surveying instrument in a location where the entire cross section can be viewed. The instrument should be placed at a higher elevation than the highest feature required for the survey.
2. Stretch the tape across the channel (zero on the left bank) making sure the tape is perpendicular to the direction of flow.
3. Backsight (BS) a benchmark or permanent feature used for relocation or resurvey of cross section.
4. Obtain rod reading at major breaks in bed elevation and key features, such as left bankfull (LBF), left edge water (LEW), thalweg (THL), right edge water (REW) and right bankfull (RBF).
5. Record the distance on the bank (station), the corresponding rod height and feature notes.
6. Measure the flood prone area width (width of the channel that is two times the maximum bankfull depth).
7. Plot cross- section and calculate the bankfull cross-sectional area.
8. Calculate mean depth, width/depth ratio and entrenchment ratio.
9. Using the appropriate regional curves, check to make sure the cross-sectional area, bankfull width and depth were reasonable.
10. Record all data in Trimble Geo-XH

Rapid survey procedure of assessed banks

Given the time constraints and to maintain consistency in the data collection process, the following procedure was adopted to perform rapid cross sections at assessed banks.

1. Stretch the tape across the channel (zero on the left bank) making sure the tape was perpendicular to the direction of flow. Measure from water surface to the tape on both left and right edge of water ensuring the tape was level.
2. Obtain rod reading at the intersection of the rod and the transect tape at major breaks in bed elevation and key features, such as left bankfull (LBF), left edge water (LEW), thalweg (THL), right edge water (REW) and right bankfull (RBF).
3. Plot cross- section and calculate the bankfull cross-sectional area in RiverMorph.
4. Calculate mean depth, width/depth ratio and entrenchment ratio (RiverMorph)
5. Using the appropriate regional curves, check to make sure the cross-sectional area, bankfull width and depth were reasonable.
6. Record all data in Trimble Geo-XH

2.3 Post Field Analytical Methods

BEHI-NBS Calibration

Cross sectional area measurements from monumented cross sections were measured pre and post flood events and were overlaid in Rivermorph to calculate amount of material removed. As noted above, the flood events in all cross sectional data were considerably above bankfull due to tropical storm occurrences between pre and post measurements. A correlation between data points should illustrate the rate of material was removed as compared to the corresponding BEHI/NBS value.

Various computer programs were used to analyze erosional data sets during the data processing phases. Arc GIS 9.3 (Environmental Systems Research Institute, Redlands, Califorinia), Rivermorph, and Excel (Microsoft Office 2010) were all utilized to compute and convey spatial and quantitative data sets. The following operations were performed:

- In Rivermorph field data including BEHI, NBS, and Cross Sections were uploaded and cross sectional area, bankfull width, depth, and area, were computed.

- GPS data points of erosional features were uploaded, differentially corrected then imported into an Arc GIS dataset as a shapefile.

- Once imported, the coordinates and attribute data were plotted and attached to particular reference point on an aerial photograph of the watershed.

- GIS layers including digitized streams, watershed boundaries, digital elevation models, soil map units, digital orthoimagery, and erosion locations were overlain and potential erosion area was quantified.
- To determine erosion potential for each assessed bank location, separate shapefiles were produced by extrapolating boundaries of the digitized length of indexed bank.
- In Arc GIS an erosion analyses spreadsheet was exported to Excel to compute reach specific statistics for, area of indexed banks, reach overlap, and material removed.
- In Arc GIS, site and reach specific BEHI and NBS index values were classified into an erosion potential rating.
- Maps were produced via Arc GIS of BEHI and NBS Ratings.

3.0 Assumptions and Limitations

Bankfull Discharge

In our study the assumption was made that the bankfull reoccurrence interval is 1.5 years as predicted by Rosgen (1996), however, bankfull recurrence interval as stated by Mulvilhill, 2009 is reported to be approximately 1.77 years. In order to predict the 1.5 year reoccurrence interval (bankfull discharge), a minimum record of ten years is required. Our bankfull calculations were based upon 12 years of record from the Birch Creek USGS gaging station. The amount of measured erosion that occurred at the monumented cross sections was a direct result of the discharges that Birch Creek experienced during tropical storms Irene and Lee. Bankfull flows were exceeded approximately three times, with the largest being 3710 cfs. (figure 8). The discharge during tropical storms Irene and Lee were significantly larger than the bankfull (1.5 year) discharge. The erosion rates during those flows may not be representative of an average annual year.

BEHI and NBS Variations

As this is a study that evaluates a model's predictive capacity, it is important to understand and state the necessary limitations and assumptions implicit in the model. Bank erosion processes and rates are affected by many interconnected variables such as annual and seasonal precipitation rates , frequency and duration of freeze thaw period, soil moisture levels, vegetation type and density of root systems, land drainage, reservoir development and channelization projects (Sass, 2011). Field work after flooding has potential user bias due to variables appearing more severe. BEHI ratings may be influenced by loss of vegetation, excessive aggradation and degradation, bank exposure, channel avulsions, geotechnical failures and alterations to infrastructure post tropical storms Irene and Lee. Therefore the application of monumenting cross sections was utilized in order to reduce potential observer bias and seasonality of events.

Inconsistent Alluvial Boundary Conditions

The BANCS model erosion rates were developed in intermountainous alluvial settings, tailored for Southern Colorado and Yellowstone. The relations developed from Colorado and Yellowstone are not intended to be universal for alluvial streams (Rosgen 2008a). It was unclear if no-alluvial boundary conditions such as glacial till and/or glaciolacustrine lake clays observered in the Catskill region may influence the erosion rates in ways that may not be predicted by the BANCS model. Mass failures are thought to be initiated by the presence of clayey bank material because of the clays ability to retain water, causing an increased mass and concurrent decrease in shear strength (Abbott, 2004) (Figure 5). In particular, banks composed of glacial till and/or glaciolacustrine lake clays have been observed to experience geotechnical failures, in which the bank slumps but maintains a vertical profile creating shelf typically being exposed even at base flow elevation. This shelf can skew the amount of material removed (deposition as opposed to erosion) and off-set the corresponding high BEHI rating. These exposed glacial deposits yield suspended sediment at flows that would not normally entrain alluvial material.

Figure 10: High erosive variability was observed in this type of non-alluvial boundary condition. Decreased shear strength after saturation from storms and removal of toe support initiated this geotechnical failure that created a shelf exposed below bankfull elevation. The red circle illustrates the section of vegetated-glaciolacustrine clay layer that slumped near the water surface.

Channel Constrictions Due to Infrastructure

Many locations throughout the upper Esopus Creek have been treated by mitigation and restoration efforts. The most common reasons for installing revetment are decrease flood and erosion hazards around private property or public infrastructure. Armoring the bank can often cause changes in stream geometry. The highest velocity within the stream can be displaced elsewhere such as upstream and more frequently downstream, often causing channel scour and bank erosion. During peak discharges of tropical storms Irene and Lee, many of the undersized conveying or contributing bridges and culverts created channel constrictions or blockage upstream of the infrastructure. These structures created depositional environments for large woody debris and sediment and in turn, experienced increased amounts of erosion and or channel avulsions, which may not be accurately assessed with the BANCS model. Once stream banks have been armored the erosive potential of the bank cannot be predicted when applying the given variables in the BANCS.

Figure 11: The observable section of stream has been straighted and constricted, conveying flow through a culvert and stacked rock walls to protect roadway infrastructure.

4.0 Results

We applied Birch Creek data to both Southern Colorado and Yellowstone prediction curves to determine predicted erosion rates from our 9 banks assessed at the 7 monumented cross section locations (Table 2) (Rosgen 2008a). The Birch Creek data set, including BEHI ratings, NBS ratings, and material removed have been plotted to determine if an erosion rating curve can be developed from a total of nine data points (Figure 13). In addition, BEHI and NBS ratings were plotted separately against material removed (Figures 14 and 15). Furthermore, all 144 assessed sites including the monumented cross sections were projected for a watershed analysis of both BEHI and NBS ratings; comparisons of each erosive potential ratings can be observed in Figure 16.

Monumented Cross Sections	NBS Rating	BEHI Rating	Length of bank (ft)	Observed Erosion Rates (ft2/yr)	Observed Erosin Rates (ft3/yr)	Predicted Erosion Rates (ft3/yr) Colorado Dataset	Predicted Erosion Rates (ft3/yr) Yellowstone Dataset
Reach 11_ 2 M (right)	**Moderate**	**Low**	**20**	**1.7**	**34 (Deposition)**	**4.86**	**6.48**
Reach 7_ 2M	**High**	**Low**	**60**	**-1**	**60**	**54.54**	**83.97**
Reach 11_1 M (left)	**High**	**Low**	**20**	**1.1**	**22 (Deposition)**	**7.83**	**11.88**
Reach 11_ 1 M (right)	**High**	**Moderate**	**20**	**-0.09**	**1.8**	**30.51**	**52.11**
Reach 2_17 M	**Low**	**Moderate**	**20**	**-2.7**	**54**	**7.29**	**14.31**
Reach 11_2 M (left)	**Moderate**	**Moderate**	**20**	**0.33**	**6.6 (Deposition)**	**18.9**	**34.02**
Reach 7_1 M	**Moderate**	**Moderate**	**30**	**-2.4**	**72**	**21.06**	**102.06**
Reach 2_ 18 M	**Moderate**	**Moderate**	**15**	**-0.4**	**6**	**28.62**	**51.03**
Reach 11_ 7 M	**Moderate**	**High**	**30**	**-5.06**	**151.8**	**21.06**	**1050.03**

Table 2: Observed erosion rates at monumented cross sections. Negative values indicated erosion and positive values indicate deposition. Yellowstone and Colorado erosion rates at each monumented cross section was calculated in RiverMorph. The observed erosion rates were recorded in square feet/yr and were converted to an area measurement by multiplying the bank retreat by the length of assessed bank.

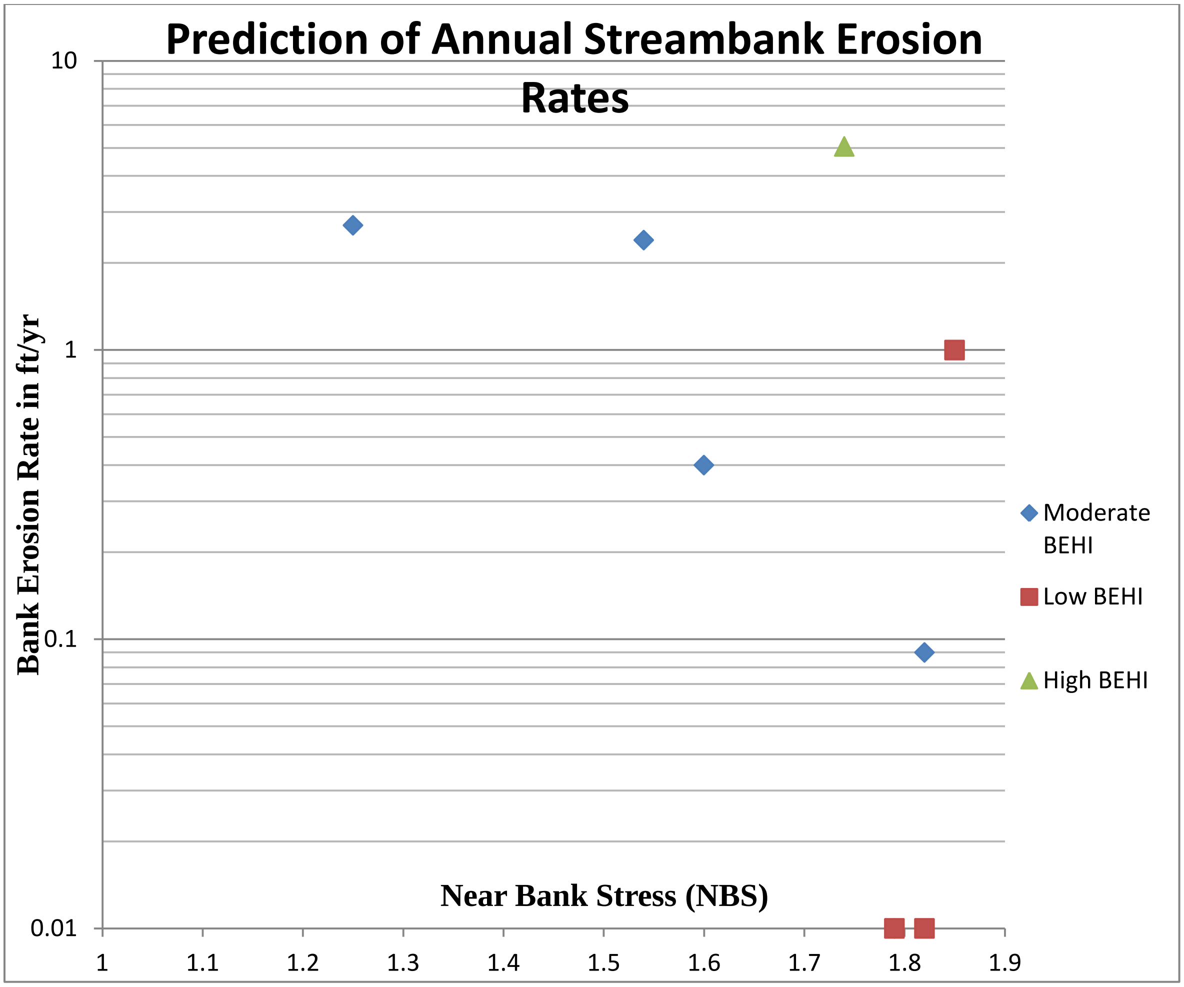


Figure 12: The Birch Creek NBS and BEHI ratings are plotted against measured erosion rates. Areas that experienced deposition were plotted as 0.01 because negative values could not be plotted on a logarithmic scale. Birch Creek did not produce a curve to plot measured bank erosion rates respective to their BEHI and NBS ratings.

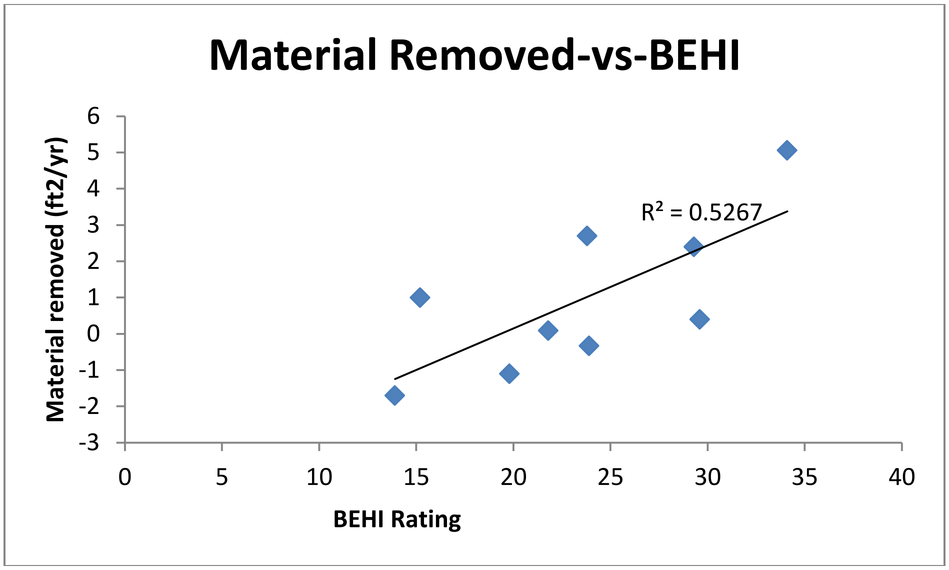


Figure 13: BEHI ratings from all monumented cross sections were plotted separately against material removed. Negative values on the y-axis represent deposition. Some scatter was observed. An overall correlation between material removed and BEHI was graphed (r^2=0.5267).

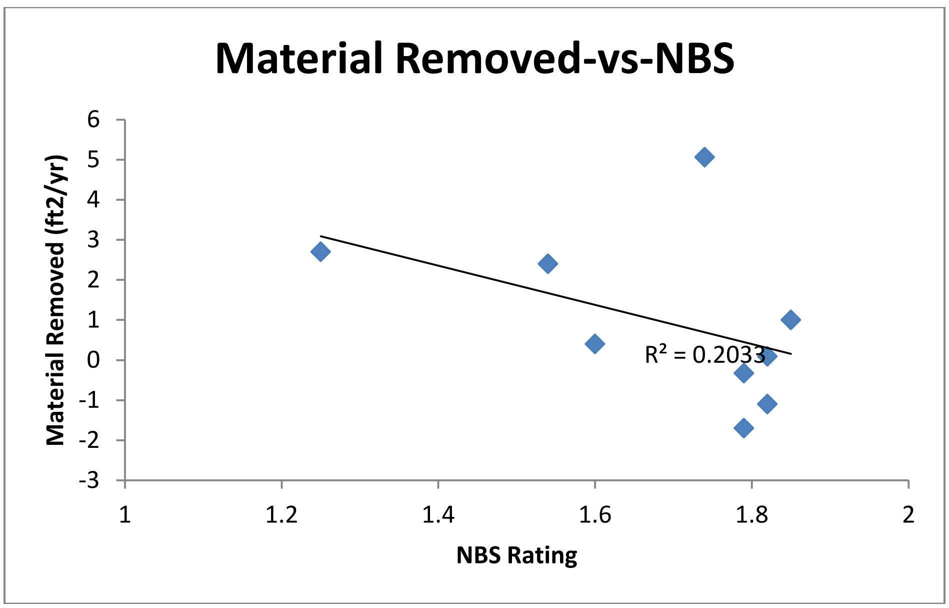


Figure 14: NBS rating from all monumented cross sections were plotted separately against material removed. Negative values on the y-axis represent deposition. Considerable scatter was observed. An overall correlation between material removed and NBS was graphed (r^2=0.2033).

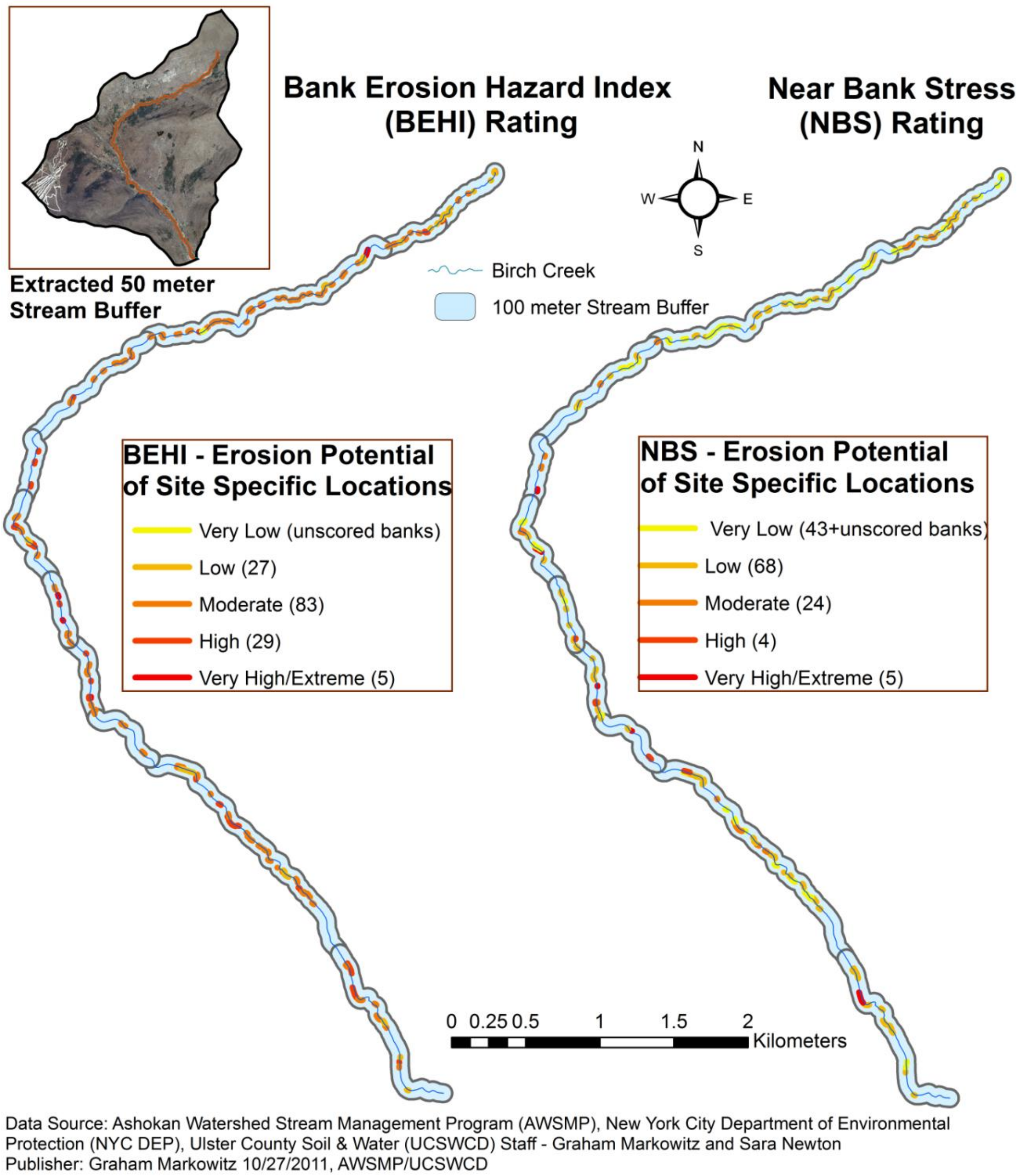


Figure15: Stream Buffer layout of Birch Creek erosion analysis indicating site specific BEHI and NBS ratings. A total of 144 sites were assessed. All banks that were not assessed during this study were considered stable and would have reflected very low BEHI and NBS ratings. Outline (grey line) represents a buffered zone surrounding the entire length of Birch Creek (blue line), Colored areas represent BEHI and NBS scores respectively.

Reach Specific Stream Statistics:

Eleven stream reaches were assessed using Rosgen's level II protocol to classify and monitor these stream reaches according to measured morphological characteristics: cross-sections at both pool and riffle facets, sinuosity measurements, width/depth ratio, entrenchment ratio, bankfull cross sectional area (Table 3). Reach specific geomorphic stream variables were calculated using remotely sensed data, Catskill Mountain hydraulic geometry regional curves (Miller and Davis 2003), and USGS stream stats. Reach characteristics, morphological descriptions and erosion potential according to Rosgen's Yellowstone and Colorado datasets are noted in Table 4.

Reach	Length (ft.)	Assessed Bank Length (ft)	Drainage Area	Bankfull Area	Sinuosity	Width/ Depth Ratio	Entrenchment Ratio
1	4523	1265	12.8	130.98	1.19	22.08	1.01
2	6641	2096	10.2	109.72	1.1	17.28	1.07
3	1726	180	7.93	90.16	1.16	14.43	1.00
4	1976	550	7.62	87.40	1.07	16.08	1.02
5	1395	295	4.84	61.34	1.03	15.68	1.10
6	2312	700	4.54	58.36	1.21	19.10	1.10
7	1474	228	4	52.87	1.09	18.70	1.50
8	3591	2086	3.88	51.63	1.08	16.12	1.10
9	6544	2260	2.96	41.80	1.17	16.84	1.12
10	1427	392	1.44	23.83	1.07	16.62	1.13
11	1887	695	1.21	20.80	1.1	16.27	1.24
Total	33496	10747					

Table 3. Reach specific analysis of Birch Creek. Notice, drainage area was proportionate to proposed bankfull area because the channel dimensions of the lower reaches are representative of larger discharges.

Reach	Length (ft)	Total erosion (yds^3/yr) Yellowstone Dataset	Total erosion (tons/yr) Yellowstone Dataset	Total erosion (yds^3/yr) Colorado Dataset	Total erosion (tons/yr) Colorado Dataset
1	1265	131.99	171.6	75.83	98.58
2	2096	142.08	184.72	67.08	87.21
3	180	2.28	2.96	1.24	1.61
4	550	16.42	21.35	8.6	11.19
5	295	14.44	18.78	7.1	9.23
6	700	23.4	30.41	10.99	14.28
7	228	18.51	24.06	10.61	13.79
8	2086	33.32	43.21	18.95	24.63
9	2260	104.98	136.49	54.43	70.77
10	392	21.01	27.32	13.36	17.38
11	695	82.6	107.4	37.2	48.36
Total	10747	591.03	768.3	305.39	397.03

Table 4: All 144 site specific erosion locations were assigned to their respective reaches. BEHI, NBS, study bank height, and length were used to calculate the sum of eroded material in each reach. Notice Rosgen's previously assessed erosion rates vary up to 75 yds3/yr or 97.5 tons/yr in between reaches.

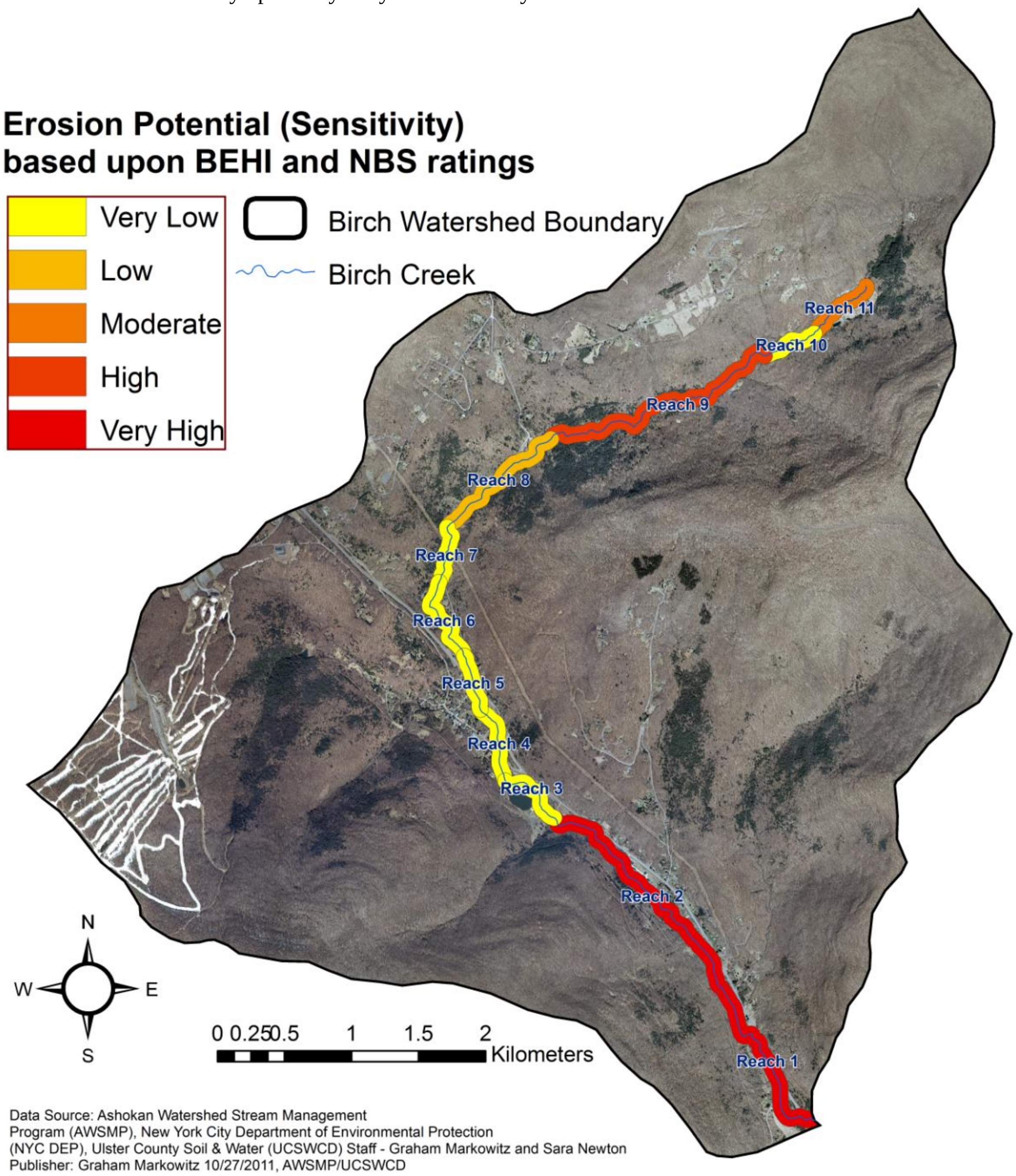


Figure 16: Birch Creek Erosion Potental Map (erosion sensity rating). Reaches 1, 2, and 9 are the most erosive reaches of Birch Creek according to the BANCS model. Both BEHI and NBS rating were incorporated in the reach ratings.

5.0 Discussion

Monumented Cross Sections and Site Specific Analysis

The majority of the upper watershed (Reach 11) showed limited erosion to no erosion at the monumented cross sections and limited erosion at the rapidly assessed stream banks. Three of the four banks assessed at the monumented cross sections in reach 11 experienced overall deposition. Minor erosion of 0.09 ft^3 occurred on the right bank of cross section 1 with a corresponding moderate BEHI rating and high NBS. At the rapidly assessed sites, the most significant amount of erosion was measured at the downstream portions of reach 11, corresponding with a high BEHI rating and a moderate NBS rating. General observations indicated a possible pre-existing mass failure occurred on the right bank of this location. A slumping of permeable sand within a clay matrix occurred during the flooding events of Irene and Lee, which was deposited at the toe of the study bank that became entrained, eroding 5.06 ft^2 of material from the bank (appendix A).

The monumented cross sections located in the upper portions of reach 7 in Birch Creek experienced moderate amounts of erosion (Table 2). Increased amounts of erosion (2.4 ft^2) occurring at the upstream monumented cross section can be partially due to the hydraulic constrictions upstream, high study bank, and steepened angle, which corresponds with both moderate BEHI and NBS values. Similar geomorphic features were observed at the downstream cross section, however less erosion (1 ft^2) occurred primarily due to access of a wider channel and the stream being able to disperse its energy.

The monumented cross sections installed at the downstream extent of Reach 2 displayed varying amounts of erosion. The upstream cross section experienced minor amounts of erosion of 0.4 ft^2 which was reflected in the assigned moderate BEHI and NBS values. This can be related to a moderately entrenched segment (entrenchment ratio 1.31) with access to floodplain. Erosion increased downstream to 2.7ft^2 at the second cross section with the assigned moderate BEHI and Low NBS rating. This can be partially attributed to a higher entrenchment ratio of 1.78 and limited access to a floodplain.

BEHI ratings, NBS ratings, and erosion rates from the monumented cross sections were plotted in order to observe any trend in the erosion rates (Rosgen 2008a). An appropriate erosion rating curve would illustrate a stratification based upon low, medium, and high BEHI ratings. The Birch Creek dataset of 9 BEHI scores illustrate high variability within the dataset and was not sufficient in attaining an appropriate best fit line of on BEHI ratings (Figure 12). Similar BEHI and NBS ratings produced various streambank erosion rates. Material removed associated with moderate BEHI ratings decreased as the corresponding NBS increased. The only high BEHI rating and high NBS data point illustrated the most amount of material removed, which would be expected from high BEHI and NBS ratings. The majority of the low BEHI scores that corresponded with high NBS ratings illustrated deposition; only one illustrated erosion. The ratings associated with BEHI data points appeared to fit closer to our predictions as opposed to NBS ratings.

Reach Specific Analysis

Erosion processes may differ significantly in reaches possessing certain geomorphic variables. The components reflecting the importance of dominant erosion process(es) have been described by the following reach based analysis. As noted by Rosgen's predicted erosion rates in table 4, reaches 1,2, and 9 are predicted to experience the most erosion. Reaches 1 and 2 are more sinuous, ranging from 1.1 to 1.19, which can be associated with higher NBS scores indicating increased hydraulic stress on the banks laterally. High erosion rates and corresponding BEHI ratings in reach 1 may also be contributed to lack of substantial riparian vegetation, banks composition primarily of lacustrine clay and glacial till, and stream re-routing into loosely compacted alluvial sediments. Increased erosion rates occurred in reaches 2 and 9 primarily due to channel constrictions from revetment, undersized culverts and bridges. Several areas of reach 9 were straightened by revetment due to the close proximity to the roadway, which increased velocity and limited the natural channel planform. Other reaches were observed as relatively stable sections exhibiting varying degrees of access to floodplains and lack of anthropogenic channel constrictions. Site specific erosion rates per reach may be further assessed in appendix B.

BEHI and NBS analysis

BEHI and NBS ratings were plotted separately against material removed to identify any correlated trends in the data. No trend was observed in the NBS graph, suggesting as measured in the field, NBS was potentially not a sound erosion predictive model for the Birch Creek watershed for our study. For this project to assess Birch Creek, one method was employed to calculate NBS for all of Birch Creek. The NBS method and numerical ratings were based solely on Rivermorph for NBS calculations. There were seven possible ways to assess near bank stress, however only one was chosen to encompass all geomorphic characteristics of Birch Creek. The ratio of near-bank maximum depth to the bankfull mean depth method for determining NBS was the only method used in order to maintain consistency.

Higher near bank stress ratings often indicate a higher erosion rate along the bank (Rosgen, 2001), which was not observed in table 2 and figure 15. For instance, the assessed banks at the upstream monumented cross section in reach 11 corresponded with a high NBS rating, as the thalweg was observed in the center of the channel and no apparent shear stress was on the banks. This particular method, which used the ratio of max bankfull depth to mean bankfull depth, may have been a better predictor for areas that were not steeply sloped or uniformly entrenched such as reaches 11 or 2. Because the same cross section was often used to assess adjacent stream banks, the NBS ratio was therefore applied to both banks. In some cases both stream banks along the channel were scored and rated with independent BEHI ratings but given the NBS rating. Other NBS methods may have produced a more accurate rating for the observed erosion rates because that particular method was independent of thalweg location within the stream channel.

6.0 Conclusion

An inventory of stream bank conditions have been documented and quantitative measurements of BEHI and NBS have been recorded in order to prioritize future bank stabilization efforts. Throughout this research, a total of 144 banks have been classified and documented for an annual baseline dataset. The use of the BANCS model has been applied to a total of 6.3 stream miles of Birch Creek. This project was intended to compliment the Birch Creek stream management plan. This project 1) established a baseline dataset to predict an annual stream bank erosion rate of Birch Creek, 2) prioritized site specific potential erosion, and 3) produced a reach specific erosion rating.

The BANCS model is a multiple variable model that accounts for many erosion related processes. These processes may differ in non alluvial boundary conditions such as glacial till and/or glacio-lacustrine lake clays, and revetment as observed in the Ashokan Reservoir watershed. These boundary conditions may influence the erosion rates in ways not predicted by the BANCS model. No apparent trend was observed out of our nine data points but upon further inspection, the discrepancy appeared to lie within the NBS method used. Only one out of the seven methods were applied to all geomorphic conditions along Birch Creek. When graphed separately it became apparent that the variables associated with the BEHI rating was a much more effective predictor of bank erosion than NBS.

A comprehensive management strategy for Birch Creek would suggest that the BEHI rating system is an accurate predictor of stream bank erosion. It would be recommended to include the BEHI rating assessment as an accurate predictor of bank erosion and should be continued and monitored along Birch Creek and possibly other Ashokan Reservoir streams. A second recommendation is the other NBS methods be applied to further assess in order to determine if NBS rating system is applicable in the Ashokan Reservoir watershed. A final recommendation suggests BEHI methods be applied to other tributaries during stream assessments and incorporated into the “erosion” category of the data dictionary as an “active/non active” erosion option.

Future Studies

A field based study, such as the one completed for Birch Creek should be monitored and re-measured for as long as possible so the data points will be closer to an average for the natural range of conditions. Additional time studying Birch Creek’s erosion rates and corresponding BEHI and NBS ratings will enhance this study's dataset and our understanding, accuracy, and application of the BANCS model in this watershed. Considering the variability in the Catskills climate, soils, and riparian vegetation in comparison to Colorado and Yellowstone datasets, some modifications to the BANCS model could be made in order to incorporate multiple hydro physiographic regions. Additional data points from other watersheds within the same physiographic region as well as Birch Creeks re-referenced cross sections would also be required to accurately predict erosion rates within the Catskills. Long term studies of the Catskills hydro physiographic streams would also assist in accurately predicting an average/annual streambank erosion curve for this area.

7.0 References

Abbott, P,L., 2004, Natural Disasters, New York, McGraw-Hill Companies, Inc., 460 p.

Beck, J.M., Cotter, A.S., Formica, S.J., Morris, T.L., Van Eps, M.A. 2002. Arkansas Department of Environmental Quality, Environmental Preservation Division, Little Rock, Arkansas.

Davis, W.D., Miller, S.J. Optimizing Catskill Mountain Regional Bankfull Discharge and Hydraulic Geometry Relationships. AWRA 2003 International Congress June 29 - July 2, 2003. New York City Department of Environmental Protection (NYCDEP) Stream Management Program.

Davis, W.D., Knuepfer, P., Miller, N., Vian, M. 2007. Fluvial Geomorphology of the Upper Esopus Creek Watershed and Implications for Stream Management. Stream Management Program, New York City Department of Environmental Protection, Kingston, NY. Department of Geological Sciences and Environmental Studies, Binghamton University, NY.

Dudley, D.R., Karr, J.R. 2002. Ecological perspective on water quality goals. Environmental Management Volume 5, Number 1, 55-68. Springer, New York.

Fisher, D.W., Isachen, Y.W., and Rickard, L.V., 1970, Geologic Map of New York State: Hudson-Mohawk Sheet: New York State Museum, Map and Chart Series no. 15, Scale 1:250,000

Mulvihill, C.I., Baldigo, B.P., Miller, S.J., DeKoskie, D., DuBois, J. 2009. Bankfull Discharge and Channel Characteristics of Streams in New York State. U. S. Geological Survey (USGS) Scientific Investigations Report 2009-5144.

Nelson, C., Flagor, B., Keith, K., Herron, T., 2009. Lower Coeur d'Alene Riverbank Stabilization Prioritization. Kootenai-Shoshone Soil and Water Conservation District and Idaho Department of Environmental Quality, Coeur d'Alene, Idaho

New York State Department of Environmental Conservation (NYCDEC). 2009. Public Fishing Rights Map Esopus/Woodland Valley? Stony Clove Creek. Accessed November 22, 2011. http://www.dec.ny.gov/docs/fish_marine_pdf/pfresopusck.pdf.

New York City Department of Environmental Protection (NYCDEP), US Army Engineer Research Development Center, Cornell Cooperative – Ulster Country. 2007. Upper Esopus Creek Management Plan. Volume I-III.

Rich, J.L. 1934. Glacial Geology of the Catskills. New York State Museum Bulletin. Published by the University of the State of New York, Albany, N.Y. No 299. pg 85.

Rosgen, D.L. (2001). A practical method of computing streambank erosion rate. Wildland Hydrology, Pagosa Springs, Colorado. Proceedings of the Seventh Federal Interagency Sedimentation Conference. March 25-29, 2001, Reno, NV. Vol. 2.

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

Rosgen, D.L. 2008a. River Stability Field Guide. Wildland Hydrology, Fort Collins, Colorado.

Rosgen, D.L. 2008b. River Stability Forms and Worksheets. Wildland Hydrology, Fort Collins, CO.

Rosgen, D.L. 2010. River Morphology and Applications, Asheville, North Carolina. Wildland Hydrology, Fort Collins, Colorado

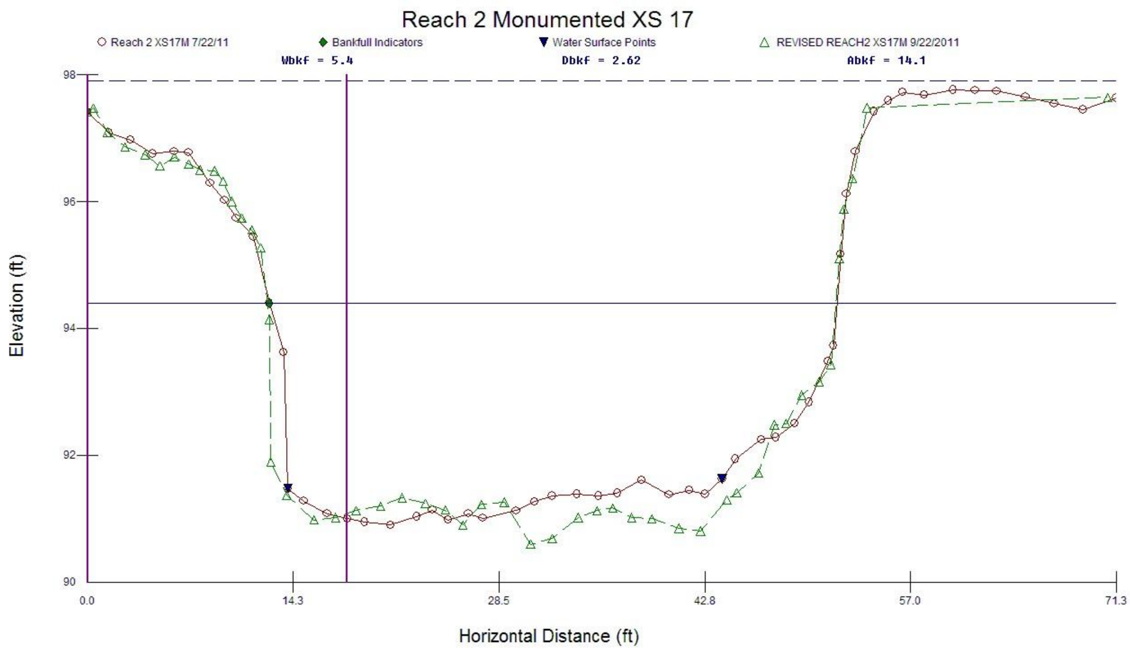
Sass, C.K. 2011. Evaluation and Development of Predictive Streambank Erosion Curves for Northeast Kansas using Rosgen's "BANCS" Methodology. Dissertation for Doctor of Philosophy, Kansas State University, Manhattan, Kansas.

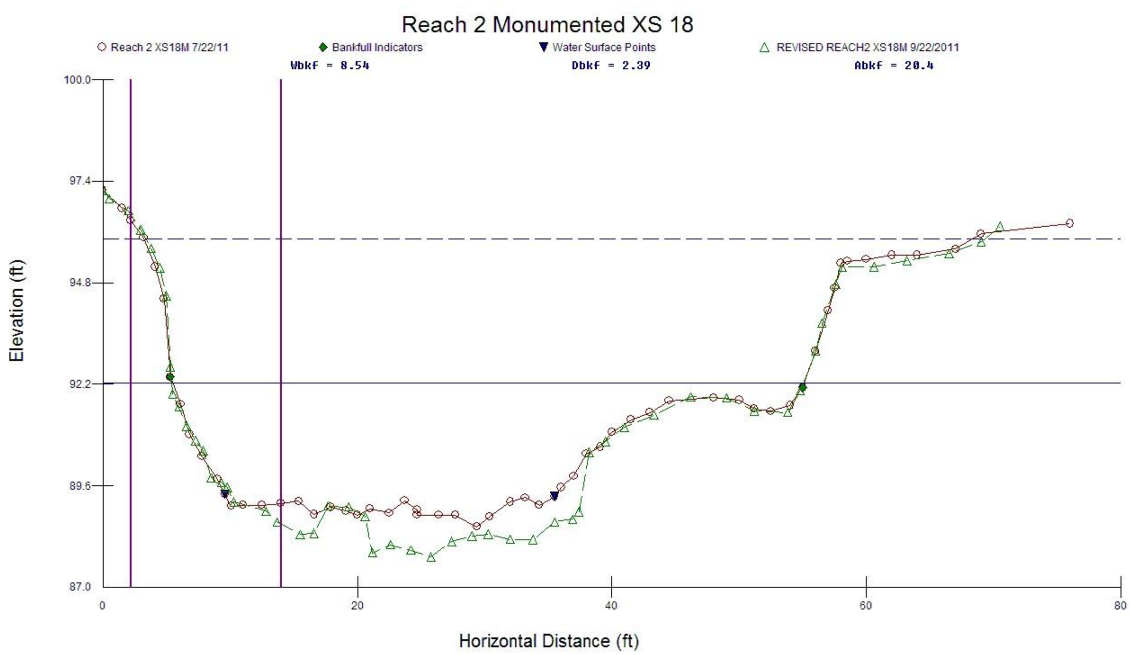
Titus, R. 2003. The Catskills in the Ice Age: Revised Edition. Purple Mountain Press New York.

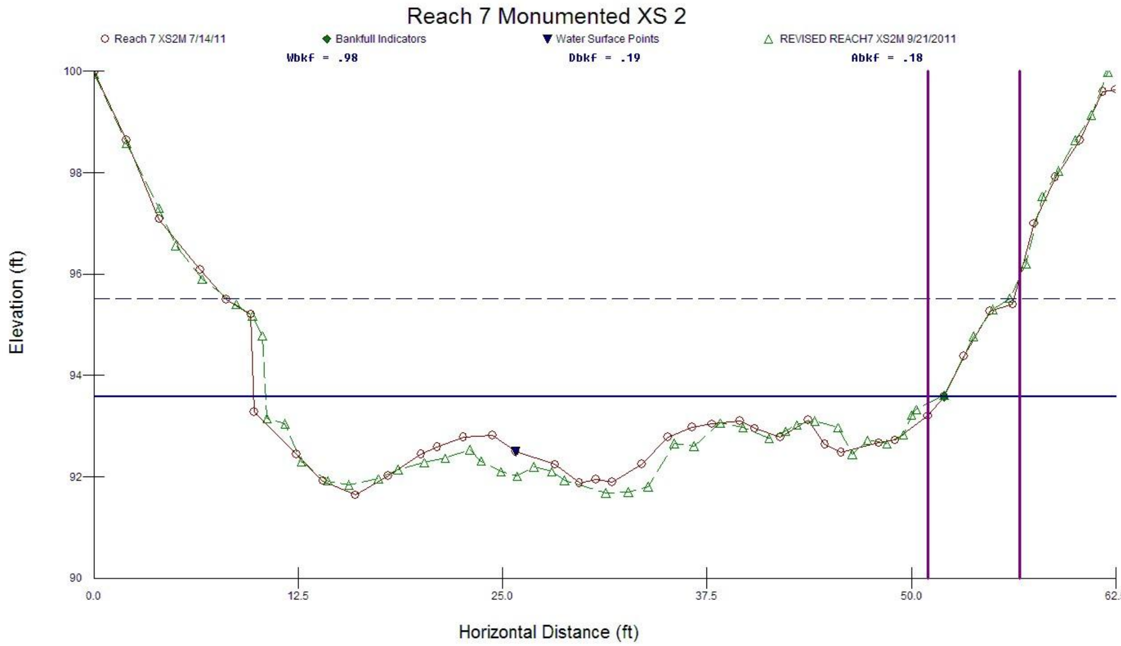
U. S. Geological Survey (USGS). 2011a. Birch Creek, New York Hydrograph (website). http://waterwatch.usgs.gov/new/index.php?id=ww_current . Accessed June 2011.

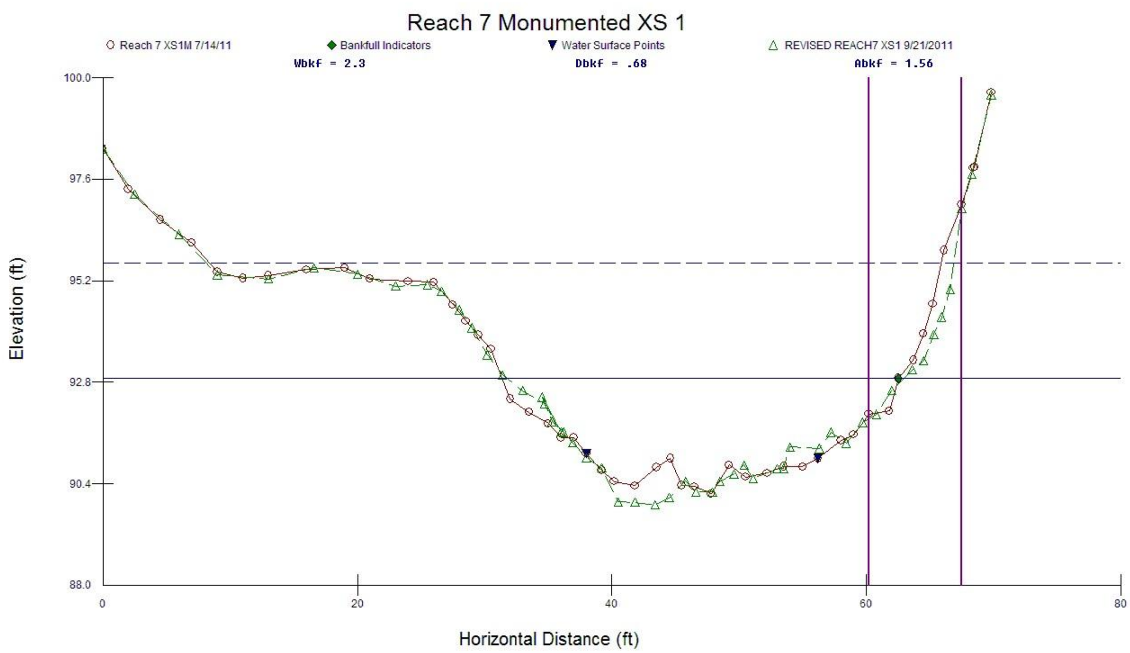
U.S. Geological Survey (USGS). 2011b. Stream Stats for Ashokan Sub-Watersheds. Last modified Aug. 2, 2011. http://streamstats.usgs.gov. Accessed June 2011.

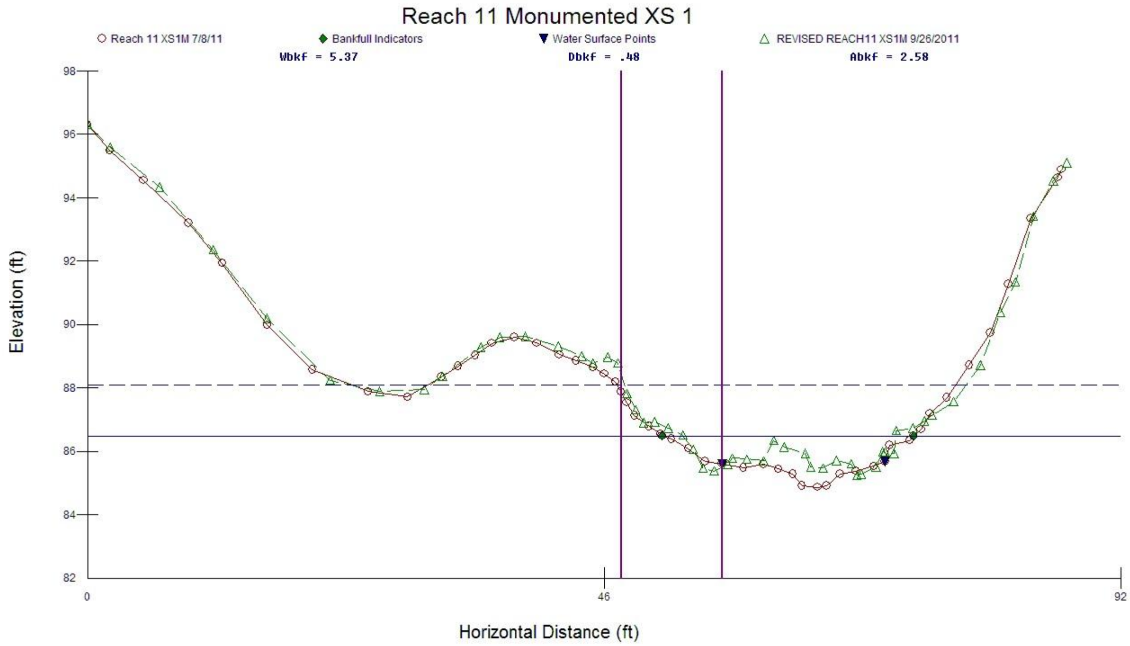
8.0 Appendix A: Monumented Cross Sections

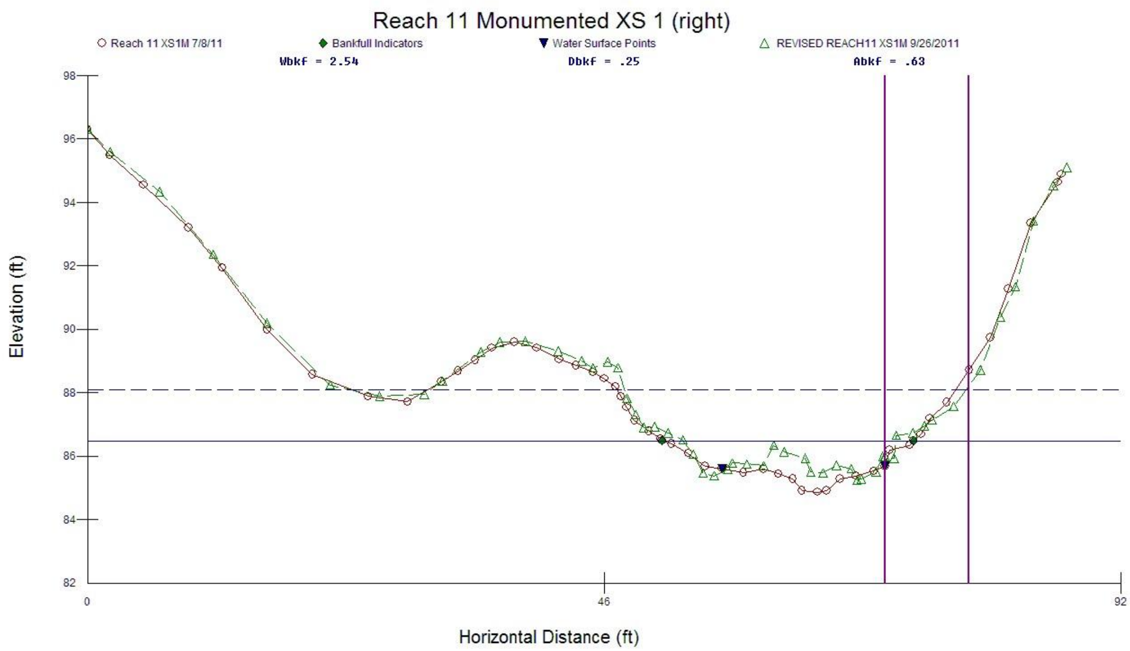


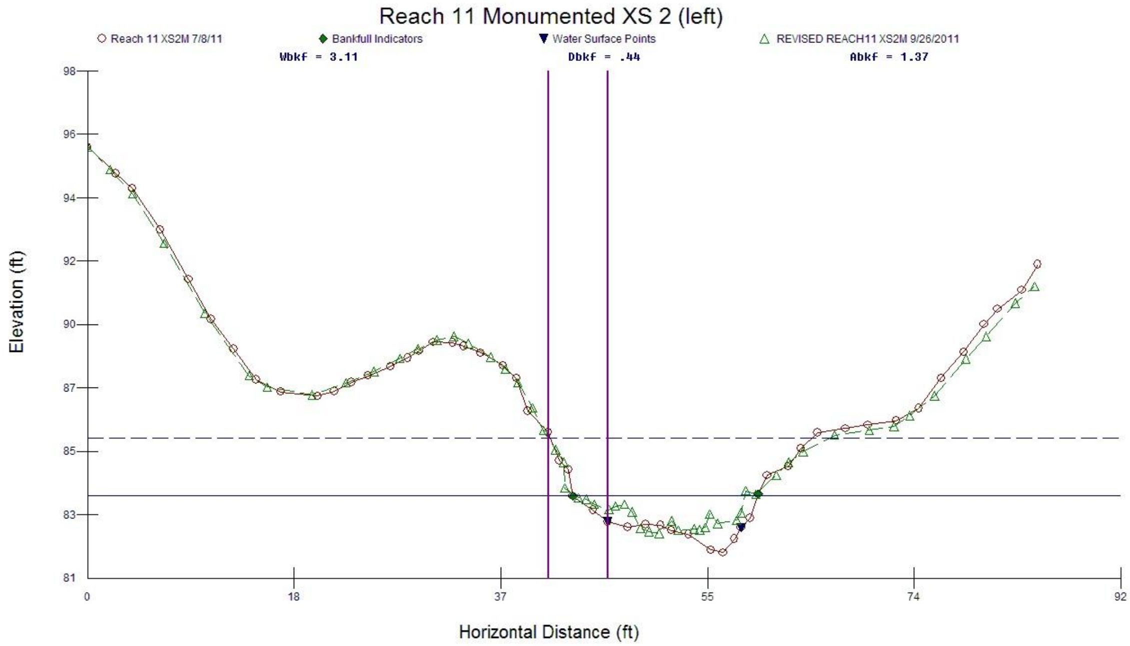


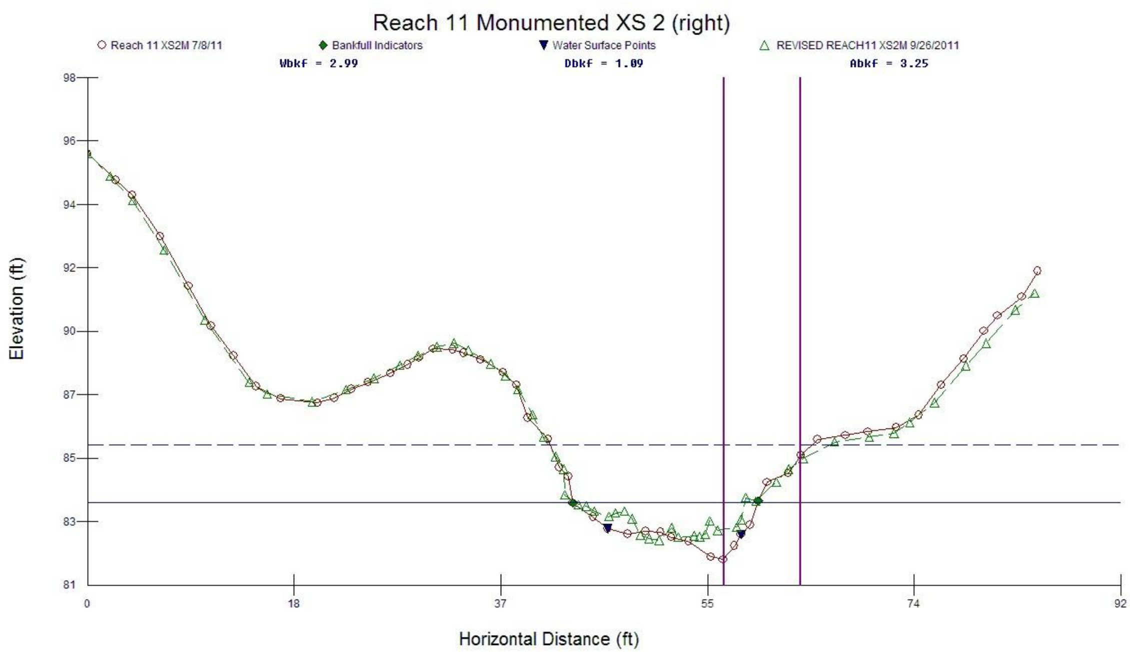

Reach 7 Monumented XS 2
Reach 7 XS2M 7/14/11
Bankfull Indicators
Water Surface Points
REVISED REACH7 XS2M 9/21/2011
Wbkf = .98
Dbkf = .19
Abkf = .18
Elevation (ft)
Horizontal Distance (ft)
100
98
96
94
92
90
0.0
12.5
25.0
37.5
50.0
62.5

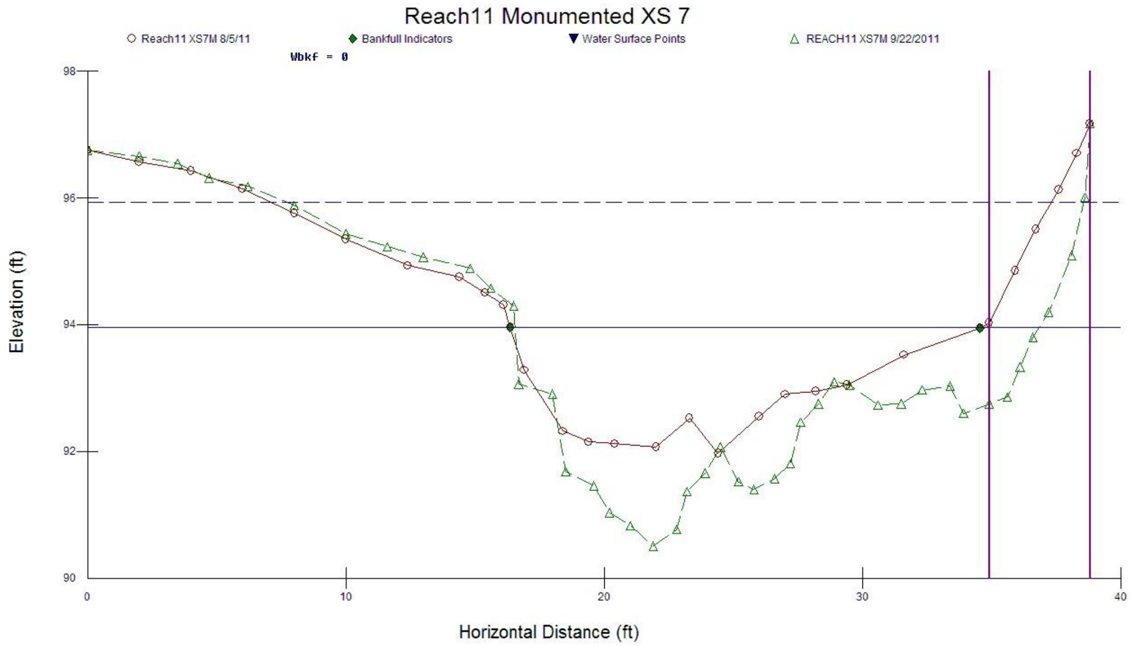

Reach 7 Monumented XS 1
Reach 7 XS1M 7/14/11
Bankfull Indicators
Water Surface Points
REVISED REACH7 XS1 9/21/2011
Wbkf = 2.3
Dbkf = .68
Abkf = 1.56
Elevation (ft)
Horizontal Distance (ft)
100.0
97.6
95.2
92.8
90.4
88.0
0
20
40
60
80


Reach 11 Monumented XS 1
Reach 11 XS1M 7/8/11
Bankfull Indicators
Water Surface Points
REVISED REACH11 XS1M 9/26/2011
Wbkf = 5.37
Dbkf = .48
Abkf = 2.58
Elevation (ft)
Horizontal Distance (ft)


Reach 11 Monumented XS 1 (right)
Reach 11 XS1M 7/8/11
Bankfull Indicators
Water Surface Points
REVISED REACH11 XS1M 9/26/2011
Wbkf = 2.54
Dbkf = .25
Abkf = .63
Elevation (ft)
Horizontal Distance (ft)


Reach 11 Monumented XS 2 (left)
Reach 11 XS2M 7/8/11
Bankfull Indicators
Water Surface Points
REVISED REACH11 XS2M 9/26/2011
Wbkf = 3.11
Dbkf = .44
Abkf = 1.37
Elevation (ft)
Horizontal Distance (ft)


Reach 11 Monumented XS 2 (right)
Reach 11 XS2M 7/8/11
Bankfull Indicators
Water Surface Points
REVISED REACH11 XS2M 9/26/2011
Wbkf = 2.99
Dbkf = 1.09
Abkf = 3.25
Elevation (ft)
Horizontal Distance (ft)


Reach11 Monumented XS 7
Reach11 XS7M 8/5/11
Bankfull Indicators
Water Surface Points
REACH11 XS7M 9/22/2011
Wbkf = 0
Elevation (ft)
Horizontal Distance (ft)
98
96
94
92
90
0
10
20
30
40

9.0 Appendix B: BEHI/NBS Data Collection Forms

Stream: **Birch Creek** Location: **Reach 1**

Graph Used: Total Bank Length (ft): **1987** Date: **9/28/2011**

Observers: **Graham M Sara N** Valley Type: Stream Type:

(1) Station (ft)	(2) BEHI rating (Worksheet 5-8) (adjective)	(3) NBS rating (Worksheet 5-9) (adjective)	(4) Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. REACH1_XS9R_9/26/1	Moderate	High	0.6499286	140	5	454.95	0.16
2. REACH1_XS8L_9/26/11	Low	Moderate	0.0916071	80	3.5	25.65	0.02
3. REACH1_XS10L_9/26/1	Extreme	Moderate	1.2	60	6	432	0.35
4. REACH1_XS11R_9/26/	Extreme	Low	0.4201071	120	7	352.89	0.14
5. REACH1_XS12R_9/26/	High	Moderate	0.699975	250	8	1399.95	0.27
6. REACH1_XS13L_9/26/1	Moderate	Low	0.18009	250	4	180.09	0.03
7. REACH1_XS14R_9/26/	Low	Low	0.0324	50	1.5	2.43	0.00
8. REACH1_XS1L_9/26/11	Very High	Moderate	0.7	90	3	189	0.10
9. REACH1_XS2R_9/26/1	High	High	1.2	45	2.5	135	0.14
10. REACH1_XS3R_9/26/1	High	High	1.20015	40	5	240.03	0.29
11. REACH1_XS4R_9/26/1	Moderate	Moderate	0.3394286	35	1.5	17.82	0.02
12. REACH1_XS5F_9/26/11	Moderate	Moderate	0.3402	25	2	17.01	0.03
13. REACH1_XS6L_9/26/11	Moderate	Low	0.1793571	20	7	25.11	0.06
14. REACH1_XS7R_9/26/1	Moderate	Moderate	0.34	60	4.5	91.8	0.07
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total erosion (ft^3/yr)	3563.73	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					Total erosion (yds^3/yr)	131.99	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					Total erosion (tons/yr)	171.59	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					Total erosion (tons/yr/ft)	0.0864	

Stream:	Birch Creek			Location:		Reach 2	
Graph Used:		Total Bank Length (ft):		6641		Date:	9/29/2011
Observers:	Graham M. Sara N.		Valley Type:			Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-8) (adjective)**	**NBS rating (Worksheet 5-9) (adjective)**	**Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. REACH2_XS1R_9/26/1	Moderate	Low	0	1	5	0	0.00
2. REACH2_XS2L_9/26/11	High	High	1.1998636	110	6	791.91	0.35
3. REACH2_XS3R_9/26/1	High	Low	0.45	40	6	108	0.13
4. REACH2_XS4L_9/26/11	Low	Low	0.033	30	3	2.97	0.00
5. REACH5_XS5R_9/26/1	Moderate	Moderate	0	80	3.5	0	0.00
6. REACH2_XS6L_9/26/11	High	High	1.19988	100	5	599.94	0.29
7. REACH2_XS7R_9/26/1	High	High	1.1999221	110	3.5	461.97	0.20
8. REACH2_XS8R_9/29/1	Moderate	Low	0.18	30	3.5	18.9	0.03
9. REACH2_XS9L_9/29/11	Moderate	Low	0.1793571	40	3.5	25.11	0.03
10. REACH2_XS10R_9/29/	High	Moderate	0.69975	120	3	251.91	0.10
11. REACH2_XS11R_9/29/	High	Moderate	0.6998906	80	8	447.93	0.27
12. 12l	Moderate	Low	0.18036	50	5	45.09	0.04
13. 13r	Low	Low	0.034	45	3	4.59	0.00
14. 14r	Low	Low	0.0332308	65	4	8.64	0.01
15. 15r	Very High	Moderate	0.300375	60	4	72.09	0.06
16. 16r	Moderate	Low	0.18	75	4	54	0.03
17. 17LM	Moderate	Low	0.178875	20	4	14.31	0.03
18. 18LM	Moderate	Moderate	0.3402	15	10	51.03	0.16
19. 19l	Low	Low	0.0347143	35	2	2.43	0.00
20. 20r	High	Moderate	0.7000714	200	3.5	490.05	0.12
21. 21l	Low	Low	0.032625	80	3	7.83	0.00

Stream:	Birch Creek			Location:	Reach 2 (pg 2)		
Graph Used:		Total Bank Length (ft):	6641			Date:	9/29/2011
Observers:	Graham M. Sara N.		Valley Type:			Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI rating (Worksheet 5-8) (adjective)	NBS rating (Worksheet 5-9) (adjective)	Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
22. 22r	Low	Low	0.033	45	6	8.91	0.01
23. 23r	Low	Low	0.033	60	6	11.88	0.01
24. 24l	Low	Low	0.0324	30	5	4.86	0.01
25. 25r	Low	Low	0.0327857	40	3.5	4.59	0.01
26. 26l	Moderate	Low	0.1798022	65	7	81.81	0.06
27. 27r	Moderate	Low	0.1799289	230	5.5	227.61	0.05
28. 28l	Low	Low	0.0330545	150	5.5	27.27	0.01
29. 29r	Low	Low	0.0334286	90	3.5	10.53	0.01
30.							
31.							
32.							
33.							
34.							
35.							
36.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total erosion (ft^3/yr)	3836.16	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					Total erosion (yds^3/yr)	142.08	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					Total erosion (tons/yr)	184.7	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					Total erosion (tons/yr/ft)	0.1253	

Stream: **Birch Creek**				Location: **Reach 3**			
Graph Used:		Total Bank Length (ft): **1726**				Date: **10/28/2011**	
Observers: **Graham M. Sara Newton**			Valley Type:			Stream Type:	
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Station (ft)	**BEHI rating (Worksheet 5-8) (adjective)**	**NBS rating (Worksheet 5-9) (adjective)**	**Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **1L_10/12/11**	**Moderate**	**Low**	**0.18**	**90**	**3.5**	**56.7**	**0.03**
2. **2L_10/12/11**	**Low**	**Low**	**0.0315**	**30**	**2**	**1.89**	**0.00**
3. **3R_10/12/11**	**Low**	**Low**	**0.033**	**60**	**1.5**	**2.97**	**0.00**
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total erosion (ft^3/yr)**	**61.56**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					**Total erosion (yds^3/yr)**	**2.28**	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					**Total erosion (tons/yr)**	**2.96**	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					**Total erosion (tons/yr/ft)**	**0.0017**	

Stream:	Birch Creek			Location:		Reach 4	
Graph Used:		Total Bank Length (ft): **1976**				Date: **10/18/2011**	
Observers:	Graham M, Sara N.		Valley Type:			Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI rating (Worksheet 5-8) (adjective)	NBS rating (Worksheet 5-9) (adjective)	Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. 1r	Moderate	Moderate	0.33975	60	6	122.31	0.10
2. 2l	Moderate	Low	0.1809	25	4	18.09	0.03
3. 3l	Moderate	Low	0.18	55	4.5	44.55	0.04
4. 4r	Moderate	Low	0.18	170	3	91.8	0.03
5. 5l	Moderate	Moderate	0.339	15	6	30.51	0.10
6. 6l	Moderate	Low	0.18	30	4	21.6	0.03
7. 7r	Moderate	Low	0.18036	50	5	45.09	0.04
8. 8r	Low	Low	0.0324	50	2	3.24	0.00
9. 9r	Moderate	Low	0.1803214	70	4	50.49	0.03
10. 10l	Moderate	Low	0.1789714	25	3.5	15.66	0.03
11.							
12.							
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total erosion (ft^3/yr)	443.34	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					Total erosion (yds^3/yr)	16.42	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					Total erosion (tons/yr)	21.35	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					Total erosion (tons/yr/ft)	0.0108	

Stream: Birch Creek				Location: Reach 5			
Graph Used:		Total Bank Length (ft): 1395				Date: 10/18/2011	
Observers: Graham M Sara N			Valley Type:			Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI rating (Worksheet 5-8) (adjective)	NBS rating (Worksheet 5-9) (adjective)	Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. 1l	Moderate	Low	0.18	75	10	135	0.09
2. 2r	Moderate	Low	0.18	60	4	43.2	0.03
3. 3l	Moderate	Low	0.180225	40	10	72.09	0.09
4. 4l	Moderate	Moderate	0.3408	25	4.5	38.34	0.07
5. 5l	High	Low	0.45	20	6	54	0.13
6. 6r	Moderate	Low	0.18	75	3.5	47.25	0.03
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total erosion (ft^3/yr)	389.88	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					Total erosion (yds^3/yr)	14.44	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					Total erosion (tons/yr)	18.77	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					Total erosion (tons/yr/ft)	0.0135	

Stream:	Birch Creek			Location:		Reach 6	
Graph Used:		Total Bank Length (ft): 2312				Date: 10/18/2011	
Observers:	Graham M. Sara N.		Valley Type:			Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI rating (Worksheet 5-8) (adjective)	NBS rating (Worksheet 5-9) (adjective)	Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. 1l	Moderate	Low	0.1804091	55	4	39.69	0.03
2. 2r	Moderate	Low	0.1805625	40	4	28.89	0.03
3. 3l	Moderate	Low	0.1802769	65	5	58.59	0.04
4. 4r	Low	Low	0.036	15	2	1.08	0.00
5. 5l	High	Low	0.45	100	6	270	0.13
6. 6l	Low	Low	0.0331579	95	3	9.45	0.00
7. 7l	Moderate	Low	0.18	110	3	59.4	0.03
8. 8r	Moderate	Low	0.1798676	170	4	122.31	0.03
9. 9l	Moderate	Moderate	0.33912	50	2.5	42.39	0.04
10.							
11.							
12.							
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total erosion (ft^3/yr)	631.8	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					Total erosion (yds^3/yr)	23.4	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					Total erosion (tons/yr)	30.42	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					Total erosion (tons/yr/ft)	0.0132	

Stream:	Birch Creek			Location:		Reach 7	
Graph Used:			Total Bank Length (ft): 1474			Date: 10/18/2011	
Observers:	Sara N, Graham M.		Valley Type:			Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-8) (adjective)**	**NBS rating (Worksheet 5-9) (adjective)**	**Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **1ML**	**Moderate**	**Moderate**	**0.3402**	**30**	**10**	**102.06**	**0.16**
2. **2ML**	**Low**	**High**	**0.1999286**	**60**	**7**	**83.97**	**0.07**
3. **3L**	**High**	**Moderate**	**0.7007143**	**18**	**7**	**88.29**	**0.24**
4. **4L**	**Moderate**	**High**	**0.6499286**	**60**	**7**	**272.97**	**0.22**
5. **5R**	**Moderate**	**Low**	**0.18**	**60**	**2.5**	**27**	**0.02**
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total erosion (ft^3/yr)**	**574.29**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					**Total erosion (yds^3/yr)**	**21.27**	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					**Total erosion (tons/yr)**	**27.65**	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					**Total erosion (tons/yr/ft)**	**0.0188**	

Stream: Birch Creek				Location: Reach 8			
Graph Used:		Total Bank Length (ft): 3591				Date: 10/18/2011	
Observers: Graham M, Sara N		Valley Type:				Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI rating (Worksheet 5-8) (adjective)	NBS rating (Worksheet 5-9) (adjective)	Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. BEHI_XS1R _9/30/11	High	Moderate	0.6994286	35	3	73.44	0.10
2. 2l	Moderate	Moderate	0.34	30	4.5	45.9	0.07
3. 3l	High	Moderate	0.7008	25	4.5	78.84	0.15
4. 4r	Moderate	Low	0.1797429	70	5	62.91	0.04
5. 5r	Moderate	High	0.6498151	85	3.5	193.32	0.11
6. 6l	Low	Low	0.03297	1601	2	105.57	0.00
7. 7r	High	Low	0.4496727	50	5.5	123.66	0.12
8. 8r	Moderate	High	0.6494026	55	3.5	125.01	0.11
9. 9l	Moderate	Low	0.18	75	3.5	47.25	0.03
10. 10r	Moderate	Low	0.17955	50	4	35.91	0.03
11. 11l	Moderate	Low	0.18	10	3	5.4	0.03
12.							
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total erosion (ft^3/yr)	897.21	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					Total erosion (yds^3/yr)	33.23	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					Total erosion (tons/yr)	43.2	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					Total erosion (tons/yr/ft)	0.012	

Stream:	Birch Creek			Location:	Reach 9		
Graph Used:		Total Bank Length (ft):		6541		Date:	10/18/2011
Observers:	Graham M, Sara N.		Valley Type:			Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI rating (Worksheet 5-8) (adjective)	NBS rating (Worksheet 5-9) (adjective)	Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. 1L	Moderate	Moderate	0.3399796	140	3.5	166.59	0.06
2. 2R	Low	Low	0.0339429	35	2.5	2.97	0.00
3. 3L	Moderate	Low	0.18	60	7	75.6	0.06
4. 4R	Low	Low	0.0324	50	2.5	4.05	0.00
5. 5L	Moderate	Low	0.18	120	3	64.8	0.03
6. 6L	Moderate	Low	0.1806545	55	2.5	24.84	0.02
7. 7R	Moderate	Moderate	0.3397091	75	5.5	140.13	0.09
8. 8L	Moderate	Moderate	0.3405	45	4	61.29	0.07
9. 9R	Moderate	Moderate	0.3402353	85	4.5	130.14	0.07
10. 10L	Moderate	Low	0.18	55	4.5	44.55	0.04
11. 11R	Moderate	Moderate	0.3402	50	6	102.06	0.10
12. 12R	Moderate	Low	0.1805143	50	3.5	31.59	0.03
13. 13R	Moderate	Low	0.1798875	200	4	143.91	0.03
14. 14L	Moderate	Low	0.1809	40	2.5	18.09	0.02
15. 15R	Low	Low	0.03375	20	6	4.05	0.01
16. 17R	Moderate	Moderate	0.3402	50	6	102.06	0.10
17. 16R	High	Low	0.4497429	70	5	157.41	0.11
18. 18L	High	Moderate	0.7000714	70	4	196.02	0.13
19. 19R	High	Low	0.44982	100	5	224.91	0.11
20. 20L	Moderate	Low	0.18	80	6	86.4	0.05
21. 21R	Moderate	Moderate	0.3405306	35	7	83.43	0.11

Stream:	**Birch Creek**			Location:		**Reach 9 (pg 2)**	
Graph Used:		Total Bank Length (ft):	**6541**			Date:	**12/30/1999**
Observers:	**Graham M, Sara N.**		Valley Type:			Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-8) (adjective)**	**NBS rating (Worksheet 5-9) (adjective)**	**Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
22. **22L**	**High**	**Low**	**0.45**	**70**	**3**	**94.5**	**0.07**
23. **23L**	**Moderate**	**Low**	**0.17928**	**50**	**2.5**	**22.41**	**0.02**
24. **24L**	**Low**	**Low**	**0.033**	**180**	**3.5**	**20.79**	**0.01**
25. **25R**	**Moderate**	**Low**	**0.1797429**	**50**	**7**	**62.91**	**0.06**
26. **26L**	**Moderate**	**High**	**0.6495**	**60**	**3**	**116.91**	**0.09**
27. **27R**	**Moderate**	**High**	**0.65025**	**60**	**4**	**156.06**	**0.13**
28. **28R**	**Moderate**	**High**	**0.650025**	**80**	**5**	**260.01**	**0.16**
29. **29L**	**Moderate**	**Low**	**0.1797429**	**70**	**5**	**62.91**	**0.04**
30. **30L**	**Moderate**	**Low**	**0.1797188**	**80**	**4**	**57.51**	**0.03**
31. **31R**	**Moderate**	**Low**	**0.18**	**15**	**5**	**13.5**	**0.04**
32. **32L**	**Moderate**	**Moderate**	**0.3402**	**60**	**5**	**102.06**	**0.08**
33.							
34.							
35.							
36.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total erosion (ft^3/yr)**	**2834.46**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					**Total erosion (yds^3/yr)**	**104.98**	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					**Total erosion (tons/yr)**	**136.47**	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					**Total erosion (tons/yr/ft)**	**0.0209**	

Stream:	Birch Creek			Location:		Reach 10	
Graph Used:		Total Bank Length (ft): 1427				Date: 10/18/2011	
Observers:	Graham M. Sara N		Valley Type:			Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI rating (Worksheet 5-8) (adjective)	NBS rating (Worksheet 5-9) (adjective)	Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. 1R	Low	Moderate	0.0925714	35	4	12.96	0.02
2. 2L	Moderate	Moderate	0.3405	45	4	61.29	0.07
3. 3R	Very Low			1	0	0	0.00
4. 4L	Moderate	Moderate	0.3394286	30	3.5	35.64	0.06
5. 5R	High	Very High	1.7002286	25	3.5	148.77	0.29
6. 6L	High	Low	0.4505455	45	5.5	111.51	0.12
7. 7R	Moderate	Low	0.1803956	35	6.5	41.04	0.06
8. 8L	Moderate	Low	0.18	40	3	21.6	0.03
9. 9R	Moderate	Low	0.1793571	35	4	25.11	0.03
10. 10R	Moderate	Low	0.1807347	35	3.5	22.14	0.03
11. 11L	Moderate	Low	0.18	7	3	3.78	0.03
12. 12R	High	Low	0.4493571	40	3.5	62.91	0.08
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total erosion (ft^3/yr)	546.75	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					Total erosion (yds^3/yr)	20.25	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					Total erosion (tons/yr)	26.33	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					Total erosion (tons/yr/ft)	0.0184	

Stream: Birch Creek				Location:		Reach 11	
Graph Used:		Total Bank Length (ft): 1987				Date: 12/30/1999	
Observers: Sara N. , Graham M.		Valley Type:				Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-8) (adjective)**	**NBS rating (Worksheet 5-9) (adjective)**	**Bank erosion rate (Figure 5-38 or 5-39) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. Reach 11_XS1M_1	Moderate	High	0.651375	20	4	52.11	0.13
2. Reach 11_XS1M_1	Low	High	0.198	20	3	11.88	0.03
3. Reach 11_XS2M_2	Moderate	Moderate	0.3402	20	5	34.02	0.08
4. Reach11_XS2M_2R_8/	Low	Moderate	0.0925714	20	3.5	6.48	0.02
5. Reach 11_3L_8/8/1	Moderate	Moderate	0.33975	20	6	40.77	0.10
6. Reach11_4L_8/8/11	Moderate	Low	0.18	15	4.5	12.15	0.04
7. Reach 11_6R_8/8/1	High	Moderate	0.69975	60	6	251.91	0.20
8. Reach 11_XS7M_7	High	Moderate	0.70002	100	15	1050.03	0.51
9. 8R_10/13/11	Low	Low	0.03348	100	2.5	8.37	0.00
10. 9L_10/13/11	Moderate	Moderate	0.34	45	4.5	68.85	0.07
11. Reach11_5L_8/8/11	High	Moderate	0.7002	30	5	105.03	0.17
12. 10R_10/13/11	High	High	1.1998125	120	4	575.91	0.23
13. 11L_10/13/11	Low	Low	0.032625	80	3	7.83	0.00
14. 12R	Moderate	Low	0.18	10	3	5.4	0.03
15. 13R	Moderate	Low	0.1793571	35	4	25.11	0.03
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total erosion (ft^3/yr)	2255.85	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}					Total erosion (yds^3/yr)	83.55	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}					Total erosion (tons/yr)	108.62	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					Total erosion (tons/yr/ft)	0.0547	

BEHI_ID	BEHI_Date	Location	Bkfl_Ht	Bank_Ht	RootDpth	%RootDen	Bank_Angle	%Cover	BankLength	BankMatrl	Stratified	Bank_Area	BEHI_Score	NBS_Score
Reach10_XS10R	10/13/2011	Right Bank	1.5	3.5	3.5	40.0	80.0	65.0	35.0	Cobbles	False	122.5	23.4	1.18
Reach10_XS11L	10/13/2011	Left Bank	1.5	3.0	3.0	25.0	90.0	55.0	7.0	Cobbles	False	21	27.2	1.18
Reach2_XS8R	9/29/2011	Right Bank	2.8	3.5	3.0	55.0	90.0	50.0	30.0	Cobbles	True	105	28.3	1.19
Reach8_XSL6		Left Bank	2.9	2.0	2.0	80.0	90.0	85.0	160.0	Boulder	FALSE	320	12.2	1.2
Reach2_XS9R	9/29/2011	Left Bank	2.6	3.5	3.5	70.0	115.0	20.0	40.0	Cobbles	False	140	24.9	1.2
Reach3XS_2L	10/12/2011	Left Bank	2.3	2.0	2.0	90.0	80.0	40.0	30.0	Cobbles	False	60	13.5	1.22
Reach2XS_29R	10/12/2011	Right Bank	3.4	3.5	3.5	80.0	95.0	65.0	90.0	Cobbles	False	315	15.3	1.22
Reach2XS_28L	10/12/2011	Left Bank	3.4	5.5	5.5	65.0	70.0	80.0	140.0	Cobbles	False	770	16.9	1.22
Reach9_XS2L	10/13/2011	Right Bank	2.4	2.5	2.5	40.0	75.0	65.0	35.0	Cobbles	False	87.5	14.2	1.23
Reach9_XS3L	10/13/2011	Left Bank	2.4	7.0	7.0	35.0	85.0	55.0	60.0	Cobbles	False	420	27.2	1.23
Reach2_XS17LM	10/6/2011	Left Bank	2.8	4.0	3.5	45.0	75.0	40.0	20.0	Cobbles	False	80	23.8	1.25
Reach9_XS6L	10/13/2011	Left Bank	1.2	2.5	2.5	60.0	90.0	20.0	55.0	Cobbles	False	137.5	27.6	1.25
Reach1_XS_11L	9/27/2011	Left Bank	3.3	7.0	2.5	20.0	90.0	10.0	120.0	Clay	True	840	53	1.25
Reach8_XS10R	9/30/2011	Right Bank	2.2	4.0	3.5	40.0	80.0	55.0	50.0	Cobbles	False	200	24.3	1.26
Reach8_XS11L	9/30/2011	Left Bank	2.2	3.0	1.0	30.0	75.0	50.0	15.0	Cobbles	False	45	26.7	1.26
Reach2_XS14R	10/6/2011	Right Bank	2.7	4.0	4.0	60.0	85.0	70.0	65.0	Cobbles	False	260	18	1.27
Reach2_XS13R	10/6/2011	Right Bank	2.7	3.0	3.0	45.0	75.0	30.0	45.0	Cobbles	False	135	19.3	1.27
Reach6_XS8R	10/4/2011	Right Bank	1.7	4.0	4.0	65.0	105.0	65.0	160.0	Cobbles	False	640	22.1	1.27
Reach2_XS16R	10/6/2011	Right Bank	2.8	4.0	3.0	50.0	85.0	30.0	60.0	Cobbles	False	240	26.2	1.27
Reach9_XS20L	10/14/2011	Left Bank	1.9	6.0	4.5	55.0	80.0	60.0	80.0	Cobbles	False	480	29.1	1.27
Reach9_XS19R	10/14/2011	Right Bank	1.9	5.0	4.0	55.0	80.0	40.0	100.0	Cobbles	False	500	30.9	1.27
Reach10_XS12R	10/13/2011	Right Bank	1.5	3.5	1.0	25.0	85.0	50.0	40.0	Cobbles	False	140	38.4	1.27
Reach11_XS12LR	10/13/2011	Right Bank	1.5	3.0	3.0	55.0	90.0	70.0	10.0	Cobbles	False	30	17.8	1.28
Reach6_XS7L	10/4/2011	Left Bank	1.7	3.0	3.0	55.0	85.0	45.0	65.0	Cobbles	False	195	21.4	1.28
Reach11_XS11L	10/13/2011	Left Bank	1.5	3.0	3.0	70.0	80.0	75.0	80.0	Cobbles	False	240	38.4	1.28
Reach6_XS2R	10/4/2011	Right Bank	1.9	4.0	3.0	40.0	60.0	50.0	40.0	Cobbles	False	160	24.8	1.3
Reach2_XS12L	10/6/2011	Left Bank	2.4	5.0	2.5	30.0	60.0	50.0	50.0	Cobbles	False	250	28.1	1.32
Reach8_XSR7	9/30/2011	Right Bank	0.0	5.5	2.5	30.0	70.0	30.0	0.0	Cobbles	False	0	33.2	1.32
Reach9_XS15R		Right Bank	1.6	6.0	5.5	50.0	65.0	80.0	20.0	Cobbles	FALSE	120	18.7	1.34
Reach4_XSL10	10/5/2011	Left Bank	2.2	3.5	3.5	50.0	80.0	35.0	25.0	Cobbles	False	87.5	22.8	1.34
Reach9_XS29L	10/14/2011	Left Bank	1.8	5.0	5.0	50.0	75.0	60.0	70.0	Cobbles	False	350	24.2	1.34
Reach4_XSR9	10/5/2011	Right Bank	2.1	4.0	3.5	35.0	75.0	50.0	70.0	Cobbles	False	280	24.9	1.34
Reach8_XSR4	9/30/2011	Right Bank	1.8	5.0	3.5	50.0	80.0	65.0	90.0	Cobbles	False	450	25.4	1.34
Reach9_XS25R	10/14/2011	Right Bank	1.6	7.0	7.0	45.0	85.0	25.0	50.0	Cobbles	False	350	29.1	1.34

Reach9_XS16R	10/14/2011	Right Bank	1.6	5.0	5.0	65.0	110.0	15.0	70.0	Cobbles	False	350	30.7	1.34
Reach6_XS6L	10/4/2011	Left Bank	1.8	3.0	3.0	60.0	95.0	85.0	95.0	Cobbles	False	285	12.1	1.35
Reach2XS_22R	10/12/2011	Right Bank	2.8	6.0	5.0	45.0	75.0	85.0	45.0	Cobbles	False	270	14.7	1.35
Reach2_XS_4L	9/27/2011	Left Bank	3.1	3.0	2.5	75.0	85.0	70.0	30.0	Mixed Till	True	90	16.5	1.35
Reach2XS_21L	10/12/2011	Left Bank	2.8	3.0	3.0	65.0	85.0	50.0	80.0	Cobbles	False	240	16.9	1.35
Reach4_XSR4	10/5/2011	Right Bank	2.3	3.0	3.0	65.0	90.0	35.0	110.0	Cobbles	False	330	22.2	1.35
Reach6_XS3L	10/4/2011	Left Bank	1.9	5.0	4.5	50.0	90.0	35.0	65.0	Cobbles	False	325	28.7	1.35
Reach6_XS1L	10/4/2011	Left Bank	2.0	4.0	4.0	30.0	65.0	70.0	55.0	Cobbles	False	220	21.9	1.37
Reach3XS_1L	10/12/2011	Left Bank	2.2	3.5	3.0	55.0	80.0	60.0	90.0	Cobbles	False	315	21.9	1.38
Reach4_XSL2	10/5/2011	Left Bank	2.0	4.0	3.5	65.0	75.0	40.0	25.0	Cobbles	False	100	24.1	1.38
Reach5_XS1L	10/4/2011	Left Bank	2.3	10.0	10.0	45.0	80.0	40.0	75.0	Cobbles	False	750	26.7	1.38
Reach2_XS_3R	9/27/2011	Right Bank	2.8	6.0	3.0	40.0	80.0	30.0	40.0	Mixed Till	True	240	33	1.38
Reach9_XS5L	10/13/2011	Left Bank	2.0	3.0	2.0	35.0	70.0	70.0	120.0	Cobbles	False	360	23.1	1.39
Reach9_XS30L	10/14/2011	Left Bank	1.5	4.0	4.0	60.0	105.0	35.0	80.0	Cobbles	False	320	27.3	1.39
Reach9_XS31R	10/14/2011	Right Bank	1.5	5.0	1.5	20.0	45.0	65.0	15.0	Cobbles	False	75	29.1	1.39
Reach4_XSR7	10/5/2011	Right Bank	2.5	5.0	5.0	65.0	80.0	25.0	50.0	Cobbles	False	250	26.4	1.4
Reach4_XSL6	10/5/2011	Left Bank	2.5	4.0	2.5	35.0	65.0	20.0	30.0	Cobbles	False	120	27.8	1.4
Reach5_X3L	10/4/2011	Right Bank	2.4	10.0	9.5	45.0	85.0	40.0	40.0	Cobbles	False	400	28.3	1.4
Reach9_XS24L	10/14/2011	Left Bank	2.1	3.5	3.5	60.0	85.0	60.0	180.0	Cobbles	False	630	18.4	1.41
Reach1_XS_14R	9/27/2011	Left Bank	1.9	1.5	0.5	50.0	90.0	50.0	50.0	Cobbles	False	75	19.4	1.41
Reach5_XSR6	10/5/2011	Right Bank	1.8	3.5	3.5	50.0	85.0	40.0	75.0	Cobbles	False	262.5	21.1	1.41
Reach10_XS7R	10/13/2011	Right Bank	1.3	6.5	5.5	35.0	60.0	75.0	35.0	Cobbles	False	227.5	24.3	1.41
Reach9_XS23L	10/14/2011	Left Bank	2.1	2.5	2.5	55.0	105.0	15.0	70.0	Cobbles	False	175	25.4	1.41
Reach9_XS12R	10/13/2011	Right Bank	1.7	3.5	3.5	70.0	90.0	20.0	50.0	Cobbles	False	175	26.8	1.41
Reach1_XS_13L	9/27/2011	Left Bank	1.9	4.0	3.0	65.0	90.0	55.0	250.0	Cobbles	True	1000	28.9	1.41
Reach5_XSL5	10/5/2011	Left Bank	1.8	6.0	4.0	40.0	85.0	45.0	20.0	Cobbles	False	120	30.9	1.41
Reach9_XS22L	10/14/2011	Left Bank	2.1	3.0	2.0	55.0	105.0	15.0	70.0	Cobbles	False	210	32.5	1.41
Reach10_XS6L	10/13/2011	Left Bank	1.3	5.5	4.0	45.0	110.0	25.0	45.0	Cobbles	False	247.5	35.7	1.41
Reach2XS_25R	10/12/2011	Right Bank	3.0	3.5	3.0	60.0	80.0	70.0	40.0	Cobbles	False	140	16.9	1.42
Reach2XS_26L	10/12/2011	Left Bank	3.0	7.0	7.0	75.0	80.0	50.0	65.0	Cobbles	False	455	21.1	1.42
Reach_11_4L	8/8/2011	Left Bank	1.4	4.5	4.0	45.0	85.0	80.0	15.0	Cobbles	False	67.5	22.9	1.43
Reach9_XS13R	10/13/2011	Right Bank	1.8	4.0	4.0	70.0	90.0	45.0	200.0	Cobbles	False	800	24.5	1.43
Reach5_X2R	10/4/2011	Right Bank	2.0	4.0	3.4	45.0	75.0	40.0	60.0	Cobbles	False	240	25.6	1.43
Reach1_XS_6R	9/26/2011	Left Bank	2.6	7.0	2.0	15.0	55.0	65.0	20.0	Cobbles	False	140	29.6	1.43
Reach6_XS5L	10/4/2011	Left Bank	2.1	6.0	3.0	40.0	90.0	45.0	100.0	Cobbles	False	600	33.7	1.43
Reach11_XS10R	10/13/2011	Right Bank	0.9	4.0	2.5	30.0	105.0	20.0	120.0	Cobbles	True	480	25.7	1.44
Reach9	10/14/	Left	1.7	2.5	2.5	50.0	100.0	15.0	40.0	Cobble	False	100	27.1	1.44

_XS14L	2011	Bank								s				
Reach3XS_3R	10/12/2011	Right Bank	2.5	1.5	1.5	90.0	80.0	40.0	80.0	Cobbles	False	120	12.9	1.45
Reach2XS_23R	10/12/2011	Right Bank	2.3	6.0	6.0	75.0	75.0	85.0	60.0	Cobbles	False	360	15.2	1.45
Reach2XS_19L	10/12/2011	Left Bank	2.3	2.0	2.0	75.0	100.0	30.0	35.0	Cobbles	False	70	17.6	1.45
Reach4_XSR8	10/5/2011	Right Bank	2.2	2.0	2.0	70.0	85.0	30.0	50.0	Cobbles	False	100	16.6	1.46
Reach6_XSR4	10/4/2011	Right Bank	1.4	2.0	2.0	60.0	80.0	55.0	15.0	Cobbles	False	30	19.8	1.46
Reach2XS_27R	10/12/2011	Right Bank	2.5	5.5	5.0	70.0	80.0	65.0	320.0	Cobbles	False	1760	22.2	1.46
Reach2_XS_1R	9/27/2011	Right Bank	1.9	5.0	4.0	70.0	85.0	70.0	0.0	Cobbles	True	0	24.7	1.46
Reach10_XS8L	10/13/2011	Left Bank	1.1	3.0	3.0	40.0	80.0	35.0	40.0	Cobbles	False	120	26.4	1.46
Reach10_XS9R	10/13/2011	Right Bank	1.1	4.0	4.0	35.0	75.0	35.0	35.0	Cobbles	False	140	27.4	1.46
Reach_7XS5R	10/3/2011	Right Bank	1.7	2.5	2.0	40.0	105.0	40.0	60.0	Cobbles	False	150	27.4	1.47
Reach2XS_24L	10/12/2011	Left Bank	2.3	5.0	5.0	70.0	70.0	55.0	30.0	Cobbles	False	150	18.6	1.48
Reach8_XSL9	9/30/2011	Left Bank	2.2	3.5	3.5	55.0	80.0	55.0	75.0	Cobbles	False	262.5	20.7	1.49
Reach4_XSL3	10/5/2011	Left Bank	2.4	4.5	4.5	65.0	85.0	40.0	55.0	Cobbles	False	247.5	23.9	1.49
Reach11_XS13R	10/13/2011	Right Bank	1.1	4.0	3.5	55.0	80.0	40.0	35.0	Cobbles	False	140	24.4	1.49
Reach9_XS4R	10/13/2011	Right Bank	1.8	2.5	2.5	65.0	75.0	60.0	50.0	Cobbles	False	125	18.3	1.5
Reach1_XS_8L	9/26/2011	Left Bank	2.4	3.5	3.0	75.0	85.0	80.0	80.0	Cobbles	False	280	19.7	1.51
Reach10_XS3R	10/13/2011	Right Bank	1.3	3.0	3.0	50.0	80.0	65.0	20.0	Cobbles	False	60	20.7	1.51
Reach5_XSR4	10/5/2011	Right Bank	1.9	4.5	4.5	40.0	80.0	30.0	25.0	Cobbles	False	112.5	26.3	1.51
Reach2_XS_5R	9/27/2011	Right Bank	1.8	3.5	3.5	70.0	110.0	30.0	80.0	Cobbles	False	280	26.1	1.52
Reach1_XS_4R	9/26/2011	Right Bank	1.4	1.5	1.5	80.0	115.0	80.0	35.0	Sand	False	52.5	20.1	1.54
Reach4_XSL5	10/5/2011	Left Bank	3.2	6.0	5.5	65.0	100.0	20.0	15.0	Cobbles	False	90	28	1.54
Reach_7XS1ML	10/3/2011	Left Bank	1.8	10.0	4.0	30.0	60.0	50.0	30.0	Boulder	FALSE	300	29.3	1.54
Reach10_XS2L	10/13/2011	Left Bank	1.0	4.0	4.0	50.0	75.0	60.0	45.0	Cobbles	False	180	24.2	1.55
Reach9_XS7R	10/13/2011	Right Bank	1.1	5.5	4.0	55.0	80.0	70.0	75.0	Cobbles	False	412.5	24.5	1.55
Reach10_XS4L	10/13/2011	Left Bank	1.4	3.5	3.5	75.0	110.0	25.0	30.0	Cobbles	False	105	27.2	1.55
Reach1_XS_10L	9/27/2011	Left Bank	1.9	6.0	2.0	25.0	75.0	15.0	60.0	Mixed Till	True	360	50.5	1.55
Reach11_XS9L	10/13/2011	Left Bank	0.9	4.5	4.5	50.0	85.0	60.0	45.0	Cobbles	True	202.5	18.3	1.56
Reach10_XS1R	10/13/2011	Right Bank	1.2	4.0	4.0	55.0	60.0	70.0	35.0	Cobbles	False	140	19.5	1.56
Reach1_XS_12L	9/27/2011	Left Bank	2.1	8.0	4.0	45.0	75.0	65.0	250.0	Cobbles	True	2000	31.3	1.58
Reach2_XS15R	10/6/2011	Right Bank	1.6	4.0	1.0	25.0	85.0	15.0	60.0	Mixed Till	True	240	42.7	1.58
Reach6_XS9L	10/4/2011	Right Bank	1.5	2.5	2.5	55.0	80.0	50.0	50.0	Cobbles	False	125	21.4	1.59
Reach8_XSL3	9/30/2011	Left Bank	1.9	4.5	1.0	25.0	85.0	50.0	25.0	Cobbles	False	112.5	37.4	1.59
Reach8_XSL2	9/30/2011	Left Bank	1.9	3.0	1.0	30.0	70.0	70.0	30.0	Cobbles	False	90	27.7	1.6
Reach2_XS18LM	10/6/2011	Left Bank	2.2	10.0	10.0	40.0	70.0	25.0	15.0	Cobbles	False	150	29.6	1.6
Reach9_XS32L	10/14/2011	Left Bank	3.2	5.0	5.0	65.0	110.0	25.0	60.0	Cobbles	False	300	25.2	1.61

Reach4_XSR1	10/5/2011	Right Bank	2.4	6.0	5.5	60.0	100.0	35.0	60.0	Cobbles	False	360	27.3	1.61
Reach1_XS_5R	9/26/2011	Right Bank	1.7	2.0	1.0	70.0	95.0	70.0	25.0	Sand	False	50	28.2	1.61
Reach_11_3L	8/8/2011	Left Bank	1.4	6.0	6.0	60.0	75.0	80.0	20.0	Cobbles	False	120	21.8	1.62
Reach1_XS_7R	9/26/2011	Left Bank	2.2	4.5	3.8	70.0	80.0	65.0	60.0	Cobbles	False	270	22.9	1.63
Reach9_XS1L	10/13/2011	Left Bank	1.9	3.5	3.0	45.0	105.0	60.0	140.0	Cobbles	False	490	24.5	1.63
Reach9_XS8L	10/13/2011	Left Bank	1.6	4.0	4.0	60.0	85.0	45.0	45.0	Cobbles	False	180	24.7	1.64
Reach9_XS11R	10/13/2011	Right Bank	1.2	6.0	6.0	45.0	80.0	70.0	50.0	Cobbles	False	300	23.3	1.65
Reach2_XS11R	9/29/2011	Right Bank	2.8	8.0	2.0	20.0	50.0	15.0	80.0	Cobbles	True	640	36.9	1.66
Reach_11_5L	8/8/2011	Left Bank	1.0	5.0	4.5	50.0	130.0	50.0	30.0	Sand	False	150	36.9	1.67
Reach9_XS9R	10/13/2011	Right Bank	1.3	4.5	4.5	60.0	90.0	50.0	90.0	Cobbles	False	405	26.7	1.69
Reach9_XS21R	10/14/2011	Right Bank	1.5	7.0	6.5	45.0	80.0	45.0	35.0	Cobbles	False	245	27.2	1.69
Reach_7XS3L	10/3/2011	Left Bank	1.8	7.0	1.0	20.0	60.0	30.0	18.0	Boulder	False	126	35.8	1.69
Reach2XS_20R	10/12/2011	Right Bank	1.9	3.5	3.0	60.0	90.0	30.0	200.0	Cobbles	True	700	30.5	1.73
Reach9_XS17R	10/14/2011	Right Bank	1.4	6.0	6.0	55.0	85.0	15.0	50.0	Cobbles	False	300	29.6	1.74
Reach9_XS18L	10/14/2011	Left Bank	1.4	4.0	4.0	50.0	120.0	20.0	70.0	Cobbles	False	280	32.5	1.74
Reach11_XS7RM	10/13/2011	Right Bank	1.4	15.0	3.5	25.0	55.0	70.0	100.0	Cobblew	FALSE	1500	34.1	1.74
Reach8_XSR1	9/30/2011	Right Bank	1.5	3.0	0.5	30.0	100.0	60.0	35.0	Cobbles	False	105	36.4	1.74
Reach1_XS_1L	9/26/2011	Left Bank	1.6	3.0	2.5	30.0	105.0	15.0	90.0	Sand	False	270	40.9	1.74
Reach_11_2RM	8/8/2011	Right Bank	0.9	3.5	2.5	60.0	35.0	90.0	20.0	Cobbles	False	70	13.9	1.79
Reach_11_2LM	8/8/2011	Left Bank	0.9	5.0	4.0	35.0	50.0	80.0	20.0	Cobbles	False	100	23.9	1.79
Reach_11_6R	8/8/2011	Right Bank	1.3	1.3	4.0	45.0	85.0	60.0	60.0	Sand	False	78	34.7	1.79
Reach11XS_8R	10/13/2011	Right Bank	1.1	2.5	2.5	60.0	70.0	70.0	100.0	Cobbles	False	250	39.5	1.79
Reach8_XSR8	9/30/2011	Right Bank	0.0	3.5	3.5	60.0	85.0	65.0	55.0	Cobbles	False	192.5	21.4	1.81
Reach8_XSR5	9/7/2011	Right Bank	1.3	3.5	3.5	70.0	95.0	70.0	85.0	Cobbles	False	297.5	23.5	1.81
Reach2_XS7R	9/29/2011	Right Bank	1.8	3.5	2.0	65.0	80.0	30.0	110.0	Cobbles	True	385	33.5	1.81
Reach_11_1L	8/8/2011	Left Bank	0.8	3.0	3.0	55.0	25.0	70.0	20.0	Sand	False	60	19.8	1.82
Reach_11_1R	8/8/2011	Right Bank	0.9	4.0	4.0	50.0	40.0	60.0	20.0	Cobbles	False	80	21.8	1.82
Reach2_XS_6L	9/27/2011	Left Bank	1.4	5.0	2.0	15.0	80.0	15.0	100.0	Cobbles	False	500	37.6	1.84
Reach_7XS2ML	10/3/2011	Left Bank	1.1	7.0	7.0	40.0	65.0	70.0	60.0	Boulder	FALSE	420	15.2	1.85
Reach_7XS4L	10/3/2011	Left Bank	1.8	7.0	7.0	40.0	65.0	70.0	60.0	Cobbles	False	420	26.7	1.89
Reach9_XS26L	10/14/2011	Left Bank	1.2	3.0	3.0	65.0	85.0	30.0	60.0	Cobbles	False	180	25.5	1.94
Reach1_XS_9R	9/26/2011	Right Bank	1.5	5.0	4.5	75.0	80.0	40.0	140.0	Cobbles	False	700	25.8	1.95
Reach9_XS27R	10/14/2011	Right Bank	1.2	4.0	4.0	55.0	80.0	50.0	60.0	Cobbles	False	240	25.1	1.99
Reach1_XS_2R	9/26/2011	Right Bank	1.7	2.5	1.5	45.0	95.0	30.0	45.0	Sand	False	112.5	37.3	1.99
Reach2_XS_2L	9/27/2011	Left Bank	1.6	6.0	1.0	15.0	75.0	55.0	110.0	Cobbles	True	660	35.9	2.17

Reach1_XS_3R	9/26/2011	Right Bank	1.3	5.0	2.3	35.0	75.0	40.0	40.0	Mixed Till	True	200	34.6	2.21
Reach2_XS10R	9/29/2011	Right Bank	2.4	3.0	1.0	35.0	60.0	30.0	120.0	Cobbles	True	360	33.9	2.41
Reach9_XS28R	10/14/2011	Right Bank	1.2	5.0	4.0	35.0	75.0	75.0	80.0	Cobbles	False	400	24.3	2.47
Reach10_XS5R	10/13/2011	Right Bank	0.7	3.5	1.5	30.0	85.0	50.0	25.0	Cobbles	False	87.5	33.9	2.84