Hanging Rock Creek and Tributary Stream Restoration

NCEEP Project Number: 165

Monitoring Year 5

2008 Final Report

Submitted to
North Carolina Ecosystem Enhancement Program
North Carolina Department of Environment and Natural Resources
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Raleigh, NC 27699

Hanging Rock Creek and Tributary Stream Restoration – 2008 Monitoring Report (MY 5)

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1.0 EXECUTIVE SUMMARY / PROJECT ABSTRACT

The Hanging Rock Creek and Tributary Stream Restoration Site is located in Avery County, North Carolina, within the Watauga River Basin. The North Carolina Department of Transportation (NCDOT), in consultation with Buck Engineering (now Michael Baker Corporation), completed the Mitigation Plan in November 2001. Stream restoration construction was completed in September 2003 with final re-vegetation completed in the spring of 2004. Based on available data, the actual restored length is approximately 2,499 linear feet for Hanging Rock Creek and 240 linear feet for the unnamed tributary. Prior to the Baseline / Year 1 monitoring effort (MY 1), structural maintenance and bank re-vegetation was conducted to repair damage associated with high rainfall events in September of 2004. The first geomorphological measurement point was generated in 2004 Monitoring Year 1 (MY 1) with 2008 representing Monitoring Year 5 (MY 5).

Geomorphology and vegetation data collected in 2008 were repeated for those locations monitored in 2007. Due to differences in cross-section nomenclature between monitoring years, the nomenclature established in MY 1 was reinstated for MY 5. Additionally, differences in bankfull elevation calls between monitoring years resulted in what appeared as morphological variability between years. Bankfull elevations as determined from the 2008 survey were applied to all previous monitoring data sets and dimension computations were re-calculated.

Based on the available data, stream dimension and profile have remained relatively stable between years along the mainstem. The dimension and profile data for the unnamed tributary indicates variability between years and is likely the result of annual changes in sediment deposition and transport capacities.

The two main issues on the project mainstem had to do with scour areas associated with structures and root wads. All other metrics for the mainstem indicated performance percentages averaging between 88 and 100%. Issues for the unnamed tributary reach included riffle and pool impacts primarily associated with sediment deposition upstream of a beaver dam. Performance percentages for the additional tributary metrics averaged between 80 and 100%. While the aforementioned stability metrics appear to have shifted substantially from previous monitoring years, field observations and discussions with the North Carolina Ecosystem Enhancement Program (NCEEP) made it apparent that these differences may have been more an artifact of data compilation discrepancies in prior submissions and differences in visual thresholds between performers as opposed to a sudden shift in project performance variables. With the exception of increased fining within some riffle reaches associated with recent beaver activity and upstream sediment sources, the local instances of bank scour and structural observations appear to have occurred earlier in the projects history before the onset of vegetation, possibly in relation to the large events of 2004, and based on discussions with NCEEP it is unlikely that they advanced appreciably since that time..

The MY 5 vegetation monitoring indicates that the project does not meet the established criteria for planted stem density, which is a minimum survival of 260 stems per acre at the end of Year 5 of the monitoring period. Average stem density for planted stems in MY 5 was approximately 222 stems per acre. However, when planted and natural stems are combined the average stem

density was 455 stems per acre, which is well above the minimum established criteria. Discrepancies in previous data collection efforts as well as unauthorized mowing between MY 3 and MY 4 have limited comparisons between monitoring years. However, based on the MY 5 data, there appears to have been a 26% increase in stem density since MY 4. Vegetation problem areas consisted of bare bench and floodplain areas as well as isolated patches of invasive/exotic species that span the project extent.

2.0 PROJECT BACKGROUND

2.1 Project Objectives

The Hanging Rock Creek Mitigation Plan (NCDOT, 2001) stated the following project objectives:

- Restore the channel to a natural stable form;
- Improve floodplain and functionality;
- Reduce the sediment load discharged to the Elk River;
- Restore native floodplain vegetation through a forested riparian buffer;
- Improve the trout fishery and natural aesthetics of the stream corridor; and
- Acquire mitigation credits for other unavoidable impacts to streams within the same Cataloging Unit (06010103).

2.2 Project Structure, Restoration Type, and Approach

Prior to restoration, both Hanging Rock Creek and the unnamed tributary were characterized as Rosgen C4 channels. Hanging Rock Creek had high width to depth ratios, streambank erosion throughout the reach, and was likely straightened in the past. The riparian zone and floodplain vegetation was maintained as active pasture land. The unnamed tributary was maintained as a drainage ditch through straightening, bank grading, and channel bed widening. While streambank vegetation was minimal, bank erosion was primarily confined to hoof shear at cattle crossings along the unnamed tributary.

The Mitigation Plan indicates the pre-restoration reach lengths were approximately 2,311 linear feet for Hanging Rock Creek and 817 linear feet for the unnamed tributary with proposed restoration lengths of 2,808 linear feet for Hanging Rock Creek and 879 linear feet for the unnamed tributary. Based on the 2008 survey, the actual restored length is approximately 2,499 linear feet for Hanging Rock Creek and 240 linear feet for the unnamed tributary. The Mitigation Plan indicated that a section of stream above Dobbins Road was proposed for restoration, but not included in the actual work, explaining differences between the proposed and restored length for Hanging Rock Creek. The large discrepancy between the proposed length and the actual length for the unnamed tributary appears to be related to a change in the acquired easement area between design and construction. The Mitigation Plan indicated the restoration reach for the unnamed tributary extended to the tree line to the southeast of the existing easement area. Based on visual assessment of 1998 NCDOT aerial photos, the actual restored reach is located a significant distance downstream from the referenced tree line.

The Mitigation Plan for Hanging Rock Creek included construction of a C4 type channel, including the use of j-hooks or single rock vanes within the meander bends. Additionally, root wad complexes were planned for the apex of meander bends with the addition of cover logs for habitat. Cross veins were included between glides and riffles for grade control. The restoration approach for the unnamed tributary primarily involved improving stream dimension and creating a bankfull bench to provide access to the floodplain. Riparian buffer restoration through planting of native herbaceous and woody vegetation was included for both the mainstem and the unnamed tributary. Additionally, three ford crossings on Hanging Rock Creek and two on the unnamed

tributary were proposed. The Mitigation Plan indicated that one or more of the crossings on Hanging Rock Creek may be converted to a footbridge. Currently, the project site includes a footbridge on Hanging Rock Creek and a wooden bridge on the unnamed tributary. The completed restoration included approximately 2,739 linear feet of stream restoration and 9.8 acres of riparian re-vegetation (Table 1a and 1b).

Table 1a. Project Components
Hanging Rock Creek / Project No. 165

Project Component or Reach ID	Existing Feet	Restoration Level	Approach	Footage or Acreage	Stationing	Buffer Acres	BMP Elements	Comment
Reach I	-	R	P1	2,499 lf	0+00 - 24+99	9.8		Included riparian re-vegetation
Reach II -Trib	-	R	-	240 lf	0+00 - 02+40			Included riparian re-vegetation

- Information unavailable.

Table 1b. Component Summations
Hanging Rock Creek / Project No. 165

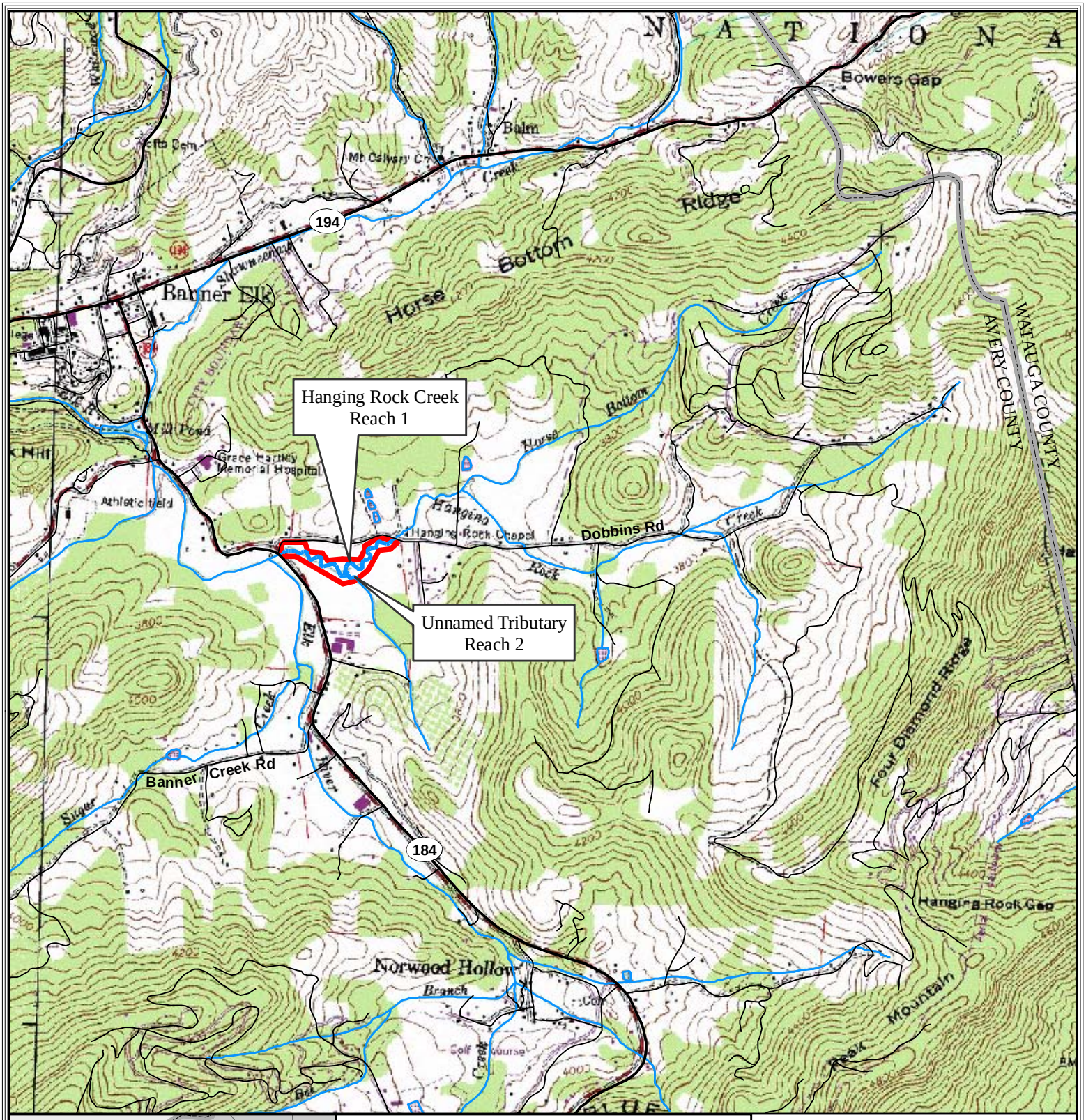
Restoration Level	Stream (lf)	Riparian Wetland (Ac)		Non-Ripar (Ac)	Upland (Ac)	Buffer (Ac)	BMP
		Riverine	Non-Riverine				
Restoration	2,739						
Enhancement							
Enhancement I							
Enhancement II							
Creation							
Preservation							
HQ Preservation							
		0	0				
Totals	**2,739**	0		0	0	9.8	0

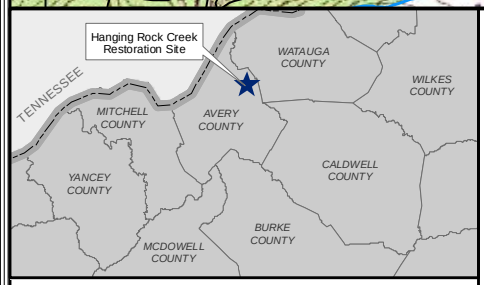
Non-Applicable

2.3 Location and Setting

Hanging Rock Creek and the unnamed tributary are located in Avery County, North Carolina within the Watauga River Basin. The project is located within Cataloging Unit (USGS 8-digit Hydrologic Unit) 06010103 and the NCDWQ sub-basin 8-22-5. The project site is located 0.8 miles southeast of downtown Banner Elk (Figure 1).

The headwaters of Hanging Rock Creek originate along the Avery and Watauga County line and drain west to the project site. The drainage area for Hanging Rock Creek is 3.0 square-miles and consists of a mix of pasture, forest, and low-density development. The unnamed tributary has a drainage area of 0.26 square-miles with current land use including pasture, forest, and low-density development.





Directions: From Banner Elk, take NC Hwy 184 East for approximately 0.8 miles. Approximately 160 feet south of Dobbins Road, an unimproved road accesses the project site on the left immediately after crossing Hanging Rock Creek.

Figure 1 - Vicinity Map

Hanging Rock Creek & Tributary
Restoration Site
Project No. 165

Avery County, North Carolina
May 2009

N

EQUINOX ENVIRONMENTAL
CONSULTATION & DESIGN

Ecosystem Enhancement
PROGRAM

0 1,000 2,000 3,000 4,000 Feet

7.5 Minute Series Elk Park &
Valle Crucis Quadrangles

2.4 Project History and Background

The NCDOT in consultation with Buck Engineering completed the Mitigation Plan for the Hanging Rock Creek project in November 2001. Stream restoration construction was completed in September 2003 with final riparian re-vegetation completed in the spring of 2004. In September of 2004 the remnants of Hurricanes Frances and Ivan caused stream bank erosion and structure damage. Structural maintenance and bank re-vegetation were completed prior to the Baseline / Year 1 monitoring effort (MY 1) in 2004.

The project activity and reporting history from 2001 to 2008 is presented in Table 2. Project personnel and contact information for the design and monitoring components are presented in Table 3. Table 4 presents background information for the project site and the reference sites utilized for design.

Table 2. Project Activity and Reporting History
Hanging Rock Creek / Project No. 165

Activity or Report	Data Collection Complete	Actual Completion or Delivery
Mitigation / Restoration Plan *	June 2001	Nov 2001
Final Design - 90%	-	-
Construction	N/A	Sep 2003
Temporary S&E Mix Applied to Project Area	N/A	Sep 2003
Live Stakes and Bare Root Trees Planted	N/A	Spring 2004
Structural maintenance (Streambank repair and revegetation)	N/A	2004
Baseline / Year 1 Monitoring	Oct 2004	March 2005
Year 2 Monitoring	Sep 2005	April 2006
Year 3 Monitoring	Dec 2006	April 2007
Year 4 Monitoring	Dec 2007	April 2008
Year 5 Monitoring	Oct 2008	May 2009

* The 2001 Report is titled as a Mitigation Plan.

- Information unavailable.

N/A - Item does not apply.

Table 3. Project Contacts Hanging Rock Creek / Project No. 165	
Designer	Buck Engineering (Michael Baker Corporation) 8000 Regency Parkway, Suite 200 Cary, North Carolina 27518
Primary Project Design POC	William A. Harmon (919) 463-5488
Construction Contractor	North State Environmental 2889 Lowery Street Winston-Salem, NC 27101
Primary Project Design POC	Darrell T. Westmoreland (336) 725-2010
Planting Contractor	Unknown
Planting Contractor POC	Unknown
Seeding Contractor	Unknown
Seeding Contractor POC	Unknown
Seed Mix Sources	Unknown
Nursery Stock Suppliers	Unknown
Monitoring Performers (Y1) - 2004	Mulkey Engineers and Consultants Office Location Unknown
Stream Monitoring POC	Unknown
Vegetation Monitoring POC	Unknown
Monitoring Performers (Y2) - 2005	Ecologic Associates, P.C. 4321-A South Elm-Eugene Greensboro, NC 27406
Stream Monitoring POC	Kyle Hoover (336) 335-1108
Vegetation Monitoring POC	Moni Bates (336) 335-1108
Monitoring Performers (Y3) - 2006	MACTEC Engineering and Consulting, Inc. 3301 Atlantic Avenue Raleigh, North Carolina 27604
Stream Monitoring POC	Richard Harmon (919) 876-0416
Vegetation Monitoring POC	Lori Saal (919) 876-0416
Monitoring Performers (Y4)- 2007	MACTEC Engineering and Consulting, Inc. 3301 Atlantic Avenue Raleigh, North Carolina 27604
Stream Monitoring POC	Richard Harmon (919) 876-0416
Vegetation Monitoring POC	Jim Cutler (336) 294-4221
Monitoring Performers (Y5)- 2008	Equinox Environmental Consultation & Design, Inc. 37 Haywood Street, Suite 100 Asheville, North Carolina 28801
Stream Monitoring POC	Steve Melton (828) 253-6856
Vegetation Monitoring POC	Sarah Marcinko (828) 253-6856

Unknown - Information was unknown at time of report submittal.

Table 4. Project Background Hanging Rock Creek / Project No. 165	
Project County	Avery
Drainage Area	Hanging Rock Creek - 3.0 square miles
	Unnamed Tributary - 0.26 square miles
Drainage Impervious Cover Estimate (%)	Hanging Rock Creek <3%
	Unnamed Tributary <3%
Stream Order	Hanging Rock Creek - 3rd order
	Unnamed Tributary - 1st order
Physiographic Region	Blue Ridge
Ecoregion	High Mountain (66i)
Rosgen Classification of As-built	Hanging Rock Creek - C4
	Unnamed Tributary - E4
Cowardin Classification	N/A
Dominant Soil Types	Hanging Rock Creek - Cullowhee
	Unnamed Tributary - Cullowhee
Reference Site ID	Hanging Rock Creek - North Fork New River
	Unnamed Tributary - Mill Branch (Surry County)
USGS HUC	Hanging Rock & Unnamed Tributary - 06010103
	North Fork New River - 05050001
	Mill Branch - 03040101
NCDWQ Sub-basin	Hanging Rock & Unnamed Tributary 8-22-5
	North Fork New River 10-2-[1]
	Mill Branch - Unknown
NCDWQ Classification	Hanging Rock Creek - C Tr
	North Fork New River - C Tr +
	Mill Branch - Unknown
Any Portion of Project Segment 303d Listed	No
Any Portion of Project Segment Upstream of a 303d	No
Reasons for 303d Listing or Stressor	N/A
% of Project Easement Fenced	50% (one side)

Unknown - Information was unknown at time of report submittal.
N/A - Item does not apply.

2.5 Monitoring Plan View

See Figure 2 – Monitoring Plan View.

Figure 2: Monitoring Plan View

Prepared for Ecosystem Enhancement Program	**Project:** Hanging Rock Creek & Tributary Restoration Year 5 Monitoring Avery County, North Carolina	Notes: 1) Base Map from CAD file "HR_proposed.dgn" Provided by NCEEP 2) 2005 Aerial Photo
	Sheet 1 of 1	
	Date May 2009	Project Number NCEEP # 165
		Prepared by EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN

3.0 Project Condition and Monitoring Results

The MY 5 vegetation and stream data collection occurred between June and September 2008. The constraints and results of the vegetation and stream assessment are discussed in the following sections and referenced figures and tables.

3.1 Vegetation Assessment

Vegetation monitoring conducted on August 1, 2008 indicated that the project does not successfully meet the established criteria for planted stem density, which is a minimal survival of 260 stems per acre at the end of Year 5. Average stem density for planted stems in MY 5 was approximately 222 stems per acre. However, when planted and natural stems are combined the average stem density was 455 stems per acre, which is well above the minimum criteria.

In general, the low planted stem density observed is likely due to soil compaction during construction, extensive loss of vegetation cover as a result of unauthorized mowing between MY 3 and MY 4, chronic drought, competition from invasive exotic species, and, to a lesser extent, stem damage due to beaver activity. Unauthorized mowing in 2007 impacted vegetation monitoring plots 1, 2, 3, 4, 5, 7, and 8 which has likely been a contributing factor associated with the site not meeting established criteria. The species most negatively affected by these stressors include Sycamore (*Platanus occidentalis var. occidentalis*), Black walnut (*Juglans nigra*), and Sweet birch (*Betula lenta var. lenta*).

While the average stem density was not explicitly stated in the MY 4 monitoring report, Equinox calculated an approximately 26% increase in planted stem density (±176 stems/acre) between MY 4 and MY 5. This increase is principally attributed to the accounting in MY 5 of natural stems and five additional species that were not counted in MY 4 (NCEEP 2007). These species included Silky dogwood (*Cornus amomum*), Buttonbush (*Cephalanthus occidentalis*), Black willow (*Salix nigra*), Black cherry (*Prunus serotina var. serotina*), and Northern maleberry (*Lyonia ligustrina var. ligustrina*). Taxonomic nomenclature follows Weakley (2008).

Due to differences in monitoring methodologies between MY 4 and MY 5, several assumptions and modifications were made in MY 5. First, plot corners previously marked with PVC pipe were re-established as the plot origin. Reference photographs were taken at the origin facing the opposite diagonal corner and GPS coordinates were taken. For each plot, x and y coordinates and other required data were recorded for all stems in accordance with the CVS-EEP Protocol (Lee *et al.* 2006). Second, several different colors of flagging tape were previously used to mark plant stems, but the significance of the colors was unknown. Plant stems marked with red and white flagging were, on average, well-established, larger caliper trees and were therefore assumed to be planted. These were re-marked with pink flagging and all previous flagging was left in place. Plant stems previously marked with blue and white flagging were, on average, shorter, smaller caliper trees and were assumed to be natural stems. In addition, several of these unmarked stems were re-sprouting from damaged stems and were denoted in MY 5 with blue flagging tape. Any previously un-marked stems that occurred in the plot were flagged with orange and black tape and were assumed to be new recruits since the past monitoring year.

See Appendix A for vegetation data tables.

3.1.1 Vegetation Problem Areas

Vegetation problem areas identified in MY 5 included bare bench and floodplain areas as well as some invasive/exotic species throughout the easement area (Appendix A – Table A6). Vegetative growth at two stream bench locations was stunted and appeared to be related to poor soil substrate. The bare floodplain areas were the result of unauthorized mowing outside hiking paths sanctioned in the easement. NCDOT and NCEEP readdressed these restrictions with adjacent landowners in 2007. Based on the MY 4 Current Condition Plan View (NCEEP 2007), the extent of mowed hiking trails had been minimized in MY 5.

3.1.2 Vegetation Problem Area Plan View

See Appendix D – Integrated Current Condition Plan View.

3.2 Stream Assessment

3.2.1 Morphometric Criteria

Morphological assessments of the Hanging Rock Creek and unnamed tributary reaches were conducted on September 4 and 18, 2008. Longitudinal profiles were surveyed for the entire project reach on both Hanging Rock Creek and the tributary. Cross-sectional data were collected for six locations on Hanging Rock Creek and one on the tributary. Wetted perimeter pebble counts were conducted at cross-section locations on both reaches.

Due to discrepancies in annual monitoring plan views and the loss of cross-section 6 between MY 2 and MY 3, cross-section nomenclature and locations have altered over the course of the annual monitoring efforts. Based on NCEEP guidance, the original MY 1 cross-section identification numbers (NCEEP 2005) were used for the 2008 monitoring. Additionally, all previous data collected were corrected to reference the MY1 cross section nomenclature.

Differences in bankfull elevation calls between years resulted in what appeared to be morphological variability. Bankfull elevations as determined in 2008 were applied to all previous monitoring data sets and dimension computations were recalculated.

With the exception of some minor cross-section dimensional changes along the mainstem, the morphologic data collected in MY 5 indicated similar results from previous monitoring years, indicating that bed form has remained within the variability and sensitivity tolerances expected. Bed form and cross sectional area for the unnamed tributary have varied between monitoring years. Bed form changes appeared to be a result of annual differences in sediment inputs from upstream landuse practices and transport capacity. The significant change in cross-sectional area between MY 4 and MY 5 for the tributary reach is likely attributed to the MY 4 data collected at a different angle than previous years.

3.2.2 Hydrologic Criteria

Hydrologic data to document bankfull events during MY 5 incorporated the existing crest gauge and documentation of wrack lines within the floodplain area (Table 5). Evidence of two bankfull events was documented during the 2008 monitoring period. Old wrack lines within the bankfull bench were identified during the initial site visit on June 25, 2008. These old wrack lines were likely the result of a flow event that occurred on March 4 and 5, 2008. On these two days flows

at the U.S. Geological Survey (USGS) stream gage on the Watauga River near Sugar Grove, NC (Station # 03479000) registered 7,950 cubic feet per second (cfs) and 4,780 cfs, respectively. The crest gauge was checked on September 4, 2008 and indicated an additional bankfull event had occurred. This event was likely the result of an event that registered 2,060 cfs on August 27, 2008 at the Sugar Grove gage.

Table 5. Verification of Bankfull Events
Hanging Rock Creek / Project No. 165

Date of Data Collection	Date of Occurrence	Method	Photo # (if available)
2004	August 2004	USGS Gage Station 03479000	
2004	August 2004	USGS Gage Station 03479000	
2004	August 2004	USGS Gage Station 03479000	
April 2007	1/14/2005	USGS Gage Station 03479000	
April 2007	11/29/2005	USGS Gage Station 03479000	
April 2007	1/18/2006	USGS Gage Station 03479000	
April 2007	11/16/2006	USGS Gage Station 03479000	
6/25/2008	3/4/2008	Wrack lines	
9/4/2008	8/27/2008	Crest Gauge	

3.2.3 Bank Stability Assessments
A comprehensive pre-construction Bank Erosion Hazard Index (BEHI) was not performed on this site and therefore does not provide a pre-construction baseline for meaningful comparison.

3.2.4 Current Condition Plan View
See Appendix D – Integrated Current Condition Plan View.

3.2.5 Stream Problem Areas
The majority of the stream problem areas identified during the MY 5 visual assessment had been identified during previous monitoring years. Problem areas were primarily associated with stressed or failing engineered structures, which have resulted in areas of bank erosion and stream aggradation. These local instances of bank scour and structural problems appear to have occurred earlier in the project history before the onset of vegetation and may be related to the large stream flow events in 2004. Based on discussions with NCEEP it is unlikely that these areas have advanced appreciably over the five year monitoring period. Minimal evidence of beaver activity was identified during the initial site assessment in June. However, during the final site assessment in September beaver activity had increased and consisted of two beaver dams on Hanging Rock Creek and one on the unnamed tributary. The beaver dams have resulted in an increase of fining over the upstream riffle reaches on both Hanging Rock Creek and the tributary. Table B1 in Appendix B provides categorical feature issues by station, the suspected cause, and denotes the number of a representative photo.

3.2.6 Numbered Issue Photos
See Appendix B for photo examples of stream problem areas.

3.2.7 Fixed Station Photos
See Appendix B for fixed photo station photos.

3.2.8 Stream Stability Assessment
A visual stability assessment was conducted for both the Hanging Rock Creek reach and the tributary reach during the initial site assessment on June 25, 2008 and again on September 23, 2008. While the 2008 visual morphological stability tables illustrate significant declines in performance for some feature categories, this change from previous monitoring years may be associated with data compilation discrepancies in prior reports as well as visual assessment thresholds between monitoring performers rather than a sudden shift in stream stability. Additionally, there were discrepancies between the numbers of structures and root wads assessed in previous years as compared to those presented in the plan views for those years. The MY 5 structure and root wad assessment was based on field verification of those structures presented in previous monitoring reports.

The primary issues identified on the mainstem involved scour associated with structures and root wads. Scour and structure problems along the mainstem appear to have occurred early on in the project history prior to vegetation establishment and do not appear to have appreciably during the five year monitoring efforts. Riffle and pool impacts associated with sediment deposition comprised the primary concerns on the unnamed tributary. However, all other performance percentage metric means ranged from 88 to 100% on the mainstem and 80 to 100% on the unnamed tributary.

Data collected during the visual stability assessment for Hanging Rock Creek and the tributary reaches are included in Table 6 below and in Appendix B - Table B.2. Table 6 below provides the categorical stream feature summary for MY 2 through MY 5.

Table 6. Categorical Stream Feature Visual Stability Assessment
Hanging Rock Creek / Project No. 165
Hanging Rock Creek / Reach 1

Feature	Initial	MY-01	MY-02*	MY-03*	MY-04*	MY-05
A. Riffles	-	-	100%	100%	100%	95%
B. Pools	-	-	98%	98%	100%	90%
C. Thalweg	-	-	100%	100%	100%	100%
D. Meanders	-	-	100%	100%	100%	88%
E. Bed General	-	-	100%	100%	100%	97%
F. Bank Condition	-	-	100%	100%	100%	93%
G. Vanes / J Hooks etc.	-	-	100%	100%	100%	79%
H. Wads and Boulders	-	-	100%	100%	100%	75%

*Percentages not representative based on information contained within the reports.
- Information unavailable.

Table 6 Continued. Categorical Stream Feature Visual Stability Assessment Hanging Rock Creek / Project No. 165 Unnamed Tributary / Reach 2						
Feature	**Initial**	**MY-01**	**MY-02***	**MY-03***	**MY-04***	**MY-05**
A. Riffles	-	-	100%	100%	100%	76%
B. Pools	-	-	100%	100%	100%	78%
C. Thalweg	-	-	100%	100%	100%	100%
D. Meanders	-	-	100%	100%	100%	100%
E. Bed General	-	-	100%	100%	100%	80%
F. Bank Condition	-	-	100%	100%	100%	100%
G. Vanes / J Hooks etc.	-	-	100%	100%	100%	100%
H. Wads and Boulders	-	-	100%	100%	100%	100%

*Percentages not representative based on information contained within the reports.

- Information unavailable.

3.2.9 Quantitative Measures Summary

Quantitative stream monitoring data are summarized in Tables 7 and 8. As-built geomorphological data is unavailable because of non-standard deliverables associated with NCDOT practices prior to transfer. The associated cross-sectional, longitudinal, and substrate assessment plots are located in Appendix B.

Table 7. Baseline Morphology and Hydraulic Monitoring Summary
Hanging Rock Creek / Project No. 165
Hanging Rock Creek / Reach 1 (2,499 feet)

Parameter	USGS Gauge Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**
BF Width (ft)	-	-	-	-	-	-	-	-	28	-	-	52	-	-	22	-	-	-
Floodprone Width (ft)	-	-	-	-	-	-	-	-	300	-	-	235	-	-	300	-	-	-
BF Cross Sectional Area (ft^2)	-	-	-	-	-	-	-	-	41	-	-	169	-	-	41	-	-	-
BF Mean Depth (ft)	-	-	-	-	-	-	-	-	1.4	-	-	3.2	-	-	1.9	-	-	-
BF Max Depth (ft)	-	-	-	-	-	-	-	-	2.9	-	-	4.5	-	-	2.3	-	-	-
Width/Depth Ratio	-	-	-	-	-	-	-	-	20	-	-	16	-	-	12	-	-	-
Entrenchment Ratio	-	-	-	-	-	-	-	-	11	-	-	4.5	-	-	14	-	-	-
Bank Height Ratio	-	-	-	-	-	-	-	-	1.3	-	-	1.0	-	-	1.0	-	-	-
Wetted Perimeter (ft)	-	-	-	-	-	-	-	-	23.3	-	-	-	-	-	24.7	-	-	-
Hydraulic Radius (ft)	-	-	-	-	-	-	-	-	1.4	-	-	-	-	-	1.5	-	-	-
Pattern																		
Channel Beltwidth (ft)	-	-	-	-	-	-	-	-	< 120	192	300	-	74	120	-	-	-	-
Radius of Curvature (ft)	-	-	-	-	-	-	-	-	100	42	69	-	40	66	-	-	-	-
Meander Wavelength (ft)	-	-	-	-	-	-	-	-	600	-	-	640	200	350	-	-	-	-
Meander Width Ratio	-	-	-	-	-	-	-	-	-	3.7	5.7	-	3.4	5.5	-	-	-	-
Profile																		
Riffle Length (ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Riffle Slope (ft/ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pool Length (ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pool Spacing (ft)	-	-	-	-	-	-	-	-	-	-	-	320	100	200	-	-	-	-
Substrate																		
d50 (mm)		-			-			30			75			-			-	
d84 (mm)		-			-			52			-			-			-	
Additional Reach Parameters																		
Valley Length (ft)		-			-			1687			-			1687			-	
Channel Length (ft)		-			-			1826			1500			2808			-	
Sinuosity		-			-			1.4			1.5			1.5			-	
Water Surface Slope (ft/ft)		-			-			0.0064			0.0048			0.0059			-	
BF Slope (ft/ft)		-			-			0.006			-			-			-	
Rosgen Classification		-			-			C4			C3			C4			-	
Habitat Index		N/A			N/A			-			-			N/A			-	
Macrobenthos		N/A			N/A			Good			-			N/A			-	

- Information unavailable.
N/A - Information does not apply.

Table 7 Continued. Baseline Morphology and Hydraulic Monitoring Summary
Hanging Rock Creek / Project No. 165
Unnamed Tributary / Reach 2 (240 feet)

Parameter	USGS Gauge Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**
BF Width (ft)	-	-	-	-	-	-	-	-	10.4	-	-	13.7	-	-	7	-	-	-
Floodprone Width (ft)	-	-	-	-	-	-	-	-	300	-	-	415	-	-	300	-	-	-
BF Cross Sectional Area (ft^2)	-	-	-	-	-	-	-	-	7	-	-	28	-	-	7	-	-	-
BF Mean Depth (ft)	-	-	-	-	-	-	-	-	0.4	-	-	2.1	-	-	0.9	-	-	-
BF Max Depth (ft)	-	-	-	-	-	-	-	-	1.4	-	-	3.6	-	-	1.4	-	-	-
Width/Depth Ratio	-	-	-	-	-	-	-	-	24	-	-	6.6	-	-	8	-	-	-
Entrenchment Ratio	-	-	-	-	-	-	-	-	29	-	-	30	-	-	42	-	-	-
Bank Height Ratio	-	-	-	-	-	-	-	-	1.6	-	-	1.0	-	-	1.0	-	-	-
Wetted Perimeter (ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydraulic Radius (ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pattern																		
Channel Beltwidth (ft)	-	-	-	-	-	-	-	-	-	23	54	-	-	-	40	-	-	-
Radius of Curvature (ft)	-	-	-	-	-	-	-	-	-	23	126	-	13	22	-	-	-	-
Meander Wavelength (ft)	-	-	-	-	-	-	-	-	-	95	108	-	-	-	140	-	-	-
Meander Width Ratio	-	-	-	-	-	-	-	-	-	2	4	-	-	-	5.7	-	-	-
Profile																		
Riffle Length (ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Riffle Slope (ft/ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pool Length (ft)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pool Spacing (ft)	-	-	-	-	-	-	-	-	-	73	76	-	50	80	-	-	-	-
Substrate																		
d50 (mm)		-			-			-			-			-			-	
d84 (mm)		-			-			-			-			-			-	
Additional Reach Parameters																		
Valley Length (ft)		-			-			-			-			-			-	
Channel Length (ft)		-			-			817			224			879			-	
Sinuosity		-			-			1.2			1.7			1.4			-	
Water Surface Slope (ft/ft)		-			-			0.0017			0.008			0.0017			-	
BF Slope (ft/ft)		-			-			-			-			-			-	
Rosgen Classification		-			-			C4			E4			C4/E4			-	
Habitat Index		N/A			N/A			-			-			N/A			-	
Macrobenthos		N/A			N/A			Good/Fair			-			N/A			-	

- Information unavailable.

N/A - Information does not apply.

Table 8. Morphology and Hydraulic Monitoring Summary
Hanging Rock Creek / Project No. 165
Hanging Rock Creek / Reach 1 (2,499 feet)

Parameter	Cross Section 1 Riffle					Cross Section 2 Pool					Cross Section 3 Riffle					Cross Section 4 Pool					Cross Section 5 Pool					Cross Section 7 Riffle				
Dimension	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	33.9	30.1	27.1	31.4	31.3	35.4	34.6	37.0	38.1	37.5	25.3	27.7	24.1	29.8	21.9	32.8	-	38.3	36.2	34.2	37.6	39.9	36.2	36.8	38.0	25.3	26.7	28.7	25.9	27.6
Floodprone Width (ft)	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	-	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100	>100
BF Cross Sectional Area (ft^2)	50.0	45.1	46.5	47.4	45.1	96.8	87.9	93.0	81.9	82.1	31.2	29.0	26.3	33.5	39.0	69.1	-	73.9	66.9	67.0	60.4	69.1	63.8	60.6	67.9	39.2	43.7	40.3	39.1	40.5
BF Mean Depth (ft)	1.5	1.5	1.7	1.5	1.4	2.7	2.5	2.5	2.1	2.2	1.2	1.0	1.1	1.1	1.8	2.1	-	1.9	1.8	2.0	1.6	1.7	1.8	1.6	1.8	1.6	1.6	1.4	1.5	1.5
BF Max Depth (ft)	3.1	3.1	2.9	3.0	3.0	5.9	5.1	5.2	4.8	5.1	2.6	2.1	1.8	2.6	3.2	4.8	-	4.7	4.1	4.7	4.9	5.1	4.7	4.5	5.0	2.3	2.6	2.5	2.3	2.4
Width/Depth Ratio	23.0	20.0	15.8	20.7	21.7	12.9	13.6	14.7	17.7	17.1	20.4	26.5	22.1	26.4	12.2	15.6	-	19.9	19.6	17.4	23.4	23.0	20.6	22.3	21.2	16.3	16.3	20.4	17.2	18.8
Entrenchment Ratio	>2.9	>3.3	>3.7	>3.2	>3.2	>2.8	>2.9	>2.7	>2.6	>2.7	>4.0	>3.6	>4.2	>3.4	>4.6	>3.0	-	>2.6	>2.8	>2.9	>2.7	>2.5	>2.8	>2.7	>2.6	>4.0	>3.7	>3.5	>3.9	>3.6
Bank Height Ratio	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Wetted Perimeter (ft)	34.8	31.0	28.3	32.7	33.8	38.2	36.8	41.1	40.9	40.2	26.6	28.4	27.7	31.1	25.4	36.0	-	41.4	40.2	43.2	41.4	42.4	39.6	40.0	48.9	26.2	27.4	29.6	26.6	28.4
Hydraulic Radius (ft)	1.4	1.5	1.6	1.5	1.3	2.5	2.4	2.3	2.0	2.0	1.2	1.0	0.9	1.1	1.5	1.9	-	1.8	1.7	1.6	1.5	1.6	1.6	1.5	1.4	1.5	1.6	1.4	1.5	1.4
Substrate																														
d50 (mm)	25.0	27.7	33.7	29.1	17.0	8.7	25.3	11.5	< 2	6.0	19.0	23.1	26.5	14.9	20.0	11	29.6	16.4	20.3	5.7	13	22.6	29.3	35.7	42.0	29.0	36.5	22.5	30.0	27.0
d84 (mm)	43.0	58.8	71	69.2	62.0	40.0	74.8	32.0	72.8	43.0	36.0	45.0	54.0	46.3	55.0	39	67.7	43.0	66.2	55.0	35	46.7	51.0	86.6	150	57.0	61.6	69.0	66.3	57.0

Parameter	MY-01 (2004)			MY-02 (2005) *			MY-03 (2006)			MY-04 (2007)			MY-05 (2008)		
Pattern	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**
Channel Beltwidth (ft)	-	-	-	57.0	230.0	120.0	56.5	234.0	145.3	56.0	234.0	145.0	43.0	207.2	130.8
Radius of Curvature (ft)	-	-	-	26.0	86.0	55.0	25.0	86.0	55.5	25.0	86.0	55.0	25.0	77.7	44.3
Meander Wavelength (ft)	-	-	-	170.0	350.0	203.0	170.0	348.5	202.0	170.0	350.0	202.0	180.9	351.3	231.3
Meander Width Ratio	-	-	-	1.6	6.6	3.4	1.6	6.5	3.4	1.6	6.5	3.4	3.1	5.6	3.5
Profile															
Riffle Length (ft)	-	-	-	15.8*	97.0	15.0*	18.5	89.8	42.7	18.1	98.9	38.0	19.8	102.5	45.7
Riffle Slope (ft/ft)	-	-	-	0.005	0.003	0.001	0.001	0.020	0.007	0.003	0.019	0.005	0.003	0.014	0.011
Pool Length (ft)	-	-	-	13.2	97.0	43.5	22.5	215.2	75.3	25.0	190.0	70.0	32.6	219.9	82.2
Pool Spacing (ft)	-	-	-	44.0	211.0	112.0	26.0	205.8	113.4	40.0	205.0	110.0	33.2	252.3	111.9
Additional Reach Parameters															
Valley Length (ft)	-			1685			1700			1700			1670		
Channel Length (ft)	-			2583			2531			2526			2583		
Sinuosity	-			1.5			1.5			1.5			1.5		
Water Surface Slope (ft/ft)	-			0.0054			0.0054			0.0054			0.0053		
BF Slope (ft/ft)	-			0.0052			0.0050			0.0053			0.0052		
Rosgen Classification	-			B			B/C			B/C			C4		
Habitat Index	N/A			N/A			N/A			N/A			N/A		
Macrobenthos	N/A			N/A			N/A			N/A			N/A		

*The minimum riffle length and slope data reported for MY 2 are greater than the median numbers reported.

- Information unavailable.

N/A - Item does not apply.

Table 8 Continued. Morphology and Hydraulic Monitoring Summary
Hanging Rock Creek / Project No. 165
Unnamed Tributary / Reach 2 (240 feet)

Parameter	Cross Section 8 Run																											
Dimension	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
BF Width (ft)	10.6	12.5	6.7	17.4	9.1																									
Floodprone Width (ft)	>100	>100	>100	>100	>100																									
BF Cross Sectional Area (ft^2)	7.6	10.1	5.2	13.0	7.4																									
BF Mean Depth (ft)	0.7	0.8	0.8	0.7	0.8																									
BF Max Depth (ft)	1.6	1.7	1.8	1.9	1.9																									
Width/Depth Ratio	15.0	15.4	8.7	23.3	11.3																									
Entrenchment Ratio	>9.4	>8.0	>14.8	>5.7	>11.0																									
Bank Height Ratio	1.2	1.2	1.3	1.3	1.3																									
Wetted Perimeter (ft)	11.3	13.2	10.7	18.1	10.5																									
Hydraulic Radius (ft)	0.7	0.8	0.5	0.7	0.7																									
Substrate																														
d50 (mm)	1.8	13.0	-	-	9.0																									
d84 (mm)	22	30.3	-	-	28.0																									

Parameter	**MY-01 (2004)**			**MY-02 (2005)**			**MY-03 (2006)**			**MY-04 (2007)**			**MY-05 (2008)**		
Pattern	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**
Channel Beltwidth (ft)	-	-	-	45	45	45	45	47	46	45	47	46	44.8	45.3	44.9
Radius of Curvature (ft)	-	-	-	20	30	28	20	30	28	20	30	28	20.3	32.0	27.5
Meander Wavelength (ft)	-	-	-	145	145	145	145	145	145	145	145	145	140.0	140.0	140.0
Meander Width Ratio	-	-	-	-	-	19.3	-	-	19.3	-	-	19.3	2.7	2.7	2.7
Profile															
Riffle Length (ft)	-	-	-	3.2	17.7	6.8	2.0	12.0	6.0	15.0	70.0	32.0	2.7	19.4	7.8
Riffle Slope (ft/ft)	-	-	-	0.012	0.047	0.027	0.010	0.039	0.025	0.007	0.042	0.007	0.013	0.032	0.023
Pool Length (ft)	-	-	-	7.5	27.0	13.0	12.0	21.0	16.5	2.0	10.0	8.0	11.7	34.1	18.1
Pool Spacing (ft)	-	-	-	20.0	76.0	37.0	13.0	76.0	32.0	65.0	120.0	90.0	16.4	55.6	30.7
Additional Reach Parameters															
Valley Length (ft)	-			210			221			221			207		
Channel Length (ft)	-			238			238			238			222		
Sinuosity	-			1.1			1.1			1.1			1.1		
Water Surface Slope (ft/ft)	-			0.0068			0.0060			0.006			0.0099		
BF Slope (ft/ft)	-			0.0130			0.0130			0.013			0.0031		
Rosgen Classification	-			E			E			E			E4		
Habitat Index	N/A			N/A			N/A			N/A			N/A		
Macrobenthos	N/A			N/A			N/A			N/A			N/A		

- Information unavailable.

N/A - Item does not apply.

3.3 Wetland Assessment

There was no direct wetland monitoring components for the Hanging Rock Creek Restoration Site.

4.0 Methodology

The stream monitoring methodologies utilized in 2008 were intended to replicate those employed during previous monitoring years and are based on standard guidance and procedures documents (Rosgen 1996 and USACOE 2003). Vegetation monitoring followed the standard CVS-EEP Protocol for Recording Vegetation, Level I (Lee *et al*. 2006). Any deviations from MY 4 vegetation monitoring methodologies are stated in Section 3.1, Vegetation Assessment.

5.0 References

Lee, M.T; Peet, R.K.; Roberts, S.D.; and T.R. Wentworth. 2006. CVS-EEP Protocol for Recording Vegetation. Version 4.0. http://cvs.bio.unc.edu/methods.htm.

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USACOE 2003. Stream Mitigation Guidelines. USACOE, USEPA, NCWRC, NCDENR-DWQ.

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Appendix A
Hanging Rock Creek
Vegetation Data

Table A1. Vegetation Metadata Hanging Rock Creek / Project No. 165	
Report prepared by	Sarah Marcinko
Date prepared	9/16/2008 11:42
Database name	cvs-eep-entrytool-v2.2.5.mdb
Database location	Z:\Equinox Projects\EEP Monitoring\Hanging Rock Creek\Vegetation Data\hangingrock-2008vmd-Equinox
Computer name	D16TNK71
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT	
Metadata	This worksheet, which is a summary of the project and the project data.
Proj, planted	The number of living planted stems per acre, excluding live stakes.
Proj, total stems	The number of total stems per acre, including live stakes and natural stems.
Plots	List of plots surveyed.
Vigor	Frequency distribution of vigor classes.
Vigor by species	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by species	Damage values tallied by type for each species.
Damage by plot	Damage values tallied by type for each plot.
All stems by plot and species	Count of total living stems of each species; dead and missing stems are excluded.
PROJECT SUMMARY	
Project code	165
Project name	Hanging Rock Creek
Description	Monitoring Year 5
River basin	Watauga
Length (ft)	N/A
Stream-to-edge width (ft)	N/A
Area (sq m)	N/A
Required plots (calculated)	N/A
Sampled plots	8

Table A2. Vegetation Vigor by Species Hanging Rock Creek / Project No. 165								
	Species	**4**	**3**	**2**	**1**	**0**	**Missing**	**Unknown**
	Cephalanthus occidentalis	1						
	Cornus amomum	5						
	Diospyros virginiana	7	1					
	Juglans nigra	20	1	1				
	Salix nigra	1						
	Betula lenta var. lenta	11	2			3		
	Lyonia ligustrina var. ligustrina	1						
	Platanus occidentalis var. occidentalis	18	14					
	Prunus serotina var. serotina	4						
Total	**9**	**68**	**18**	**1**		**3**		

Table A3. Vegetation Damage by Species Hanging Rock Creek / Project No. 165								
	Species	**All damage categories**	**No damage**	**Other damage**	**Beaver**	**Drought**	**Insects**	**Mowing**
	Betula lenta	16	9		2	2	1	2
	Cephalanthus occidentalis	1	1					
	Cornus amomum	5	4				1	
	Diospyros virginiana	8	6				1	1
	Juglans nigra	22	15	1			3	3
	Lyonia ligustrina var. ligustrina	1	1					
	Platanus occidentalis var. occidentalis	32	11				9	12
	Prunus serotina var. serotina	4	4					
	Salix nigra	1	1					
Total	**9**	**90**	**52**	**1**	**2**	**2**	**15**	**18**

Table A4. Vegetation Damage by Plot Hanging Rock Creek / Project No. 165								
	Plot	**All damage categories**	**No damage**	**Other damage**	**Beaver**	**Drought**	**Insects**	**Mowing**
	00165-01-0001-year:5	11	6				4	1
	00165-01-0002-year:5	19	13	1			2	3
	00165-01-0003-year:5	12	7				2	3
	00165-01-0004-year:5	6	4					2
	00165-01-0005-year:5	12	7		2	2	1	
	00165-01-0006-year:5	10	3				4	3
	00165-01-0007-year:5	14	6				2	6
	00165-01-0008-year:5	6	6					
Total	**8**	**90**	**52**	**1**	**2**	**2**	**15**	**18**

Table A5. Stem Count by Plot and Species Hanging Rock Creek / Project No. 165												
	Species	**Total stems**	**No. plots**	**Avg. no. stems**	**00165-01-0001-year:5**	**00165-01-0002-year:5**	**00165-01-0003-year:5**	**00165-01-0004-year:5**	**00165-01-0005-year:5**	**00165-01-0006-year:5**	**00165-01-0007-year:5**	**00165-01-0008-year:5**
	Cephalanthus occidentalis	1	1	1					1			
	Cornus amomum	5	2	2.5	4				1			
	Diospyros virginiana	8	5	1.6		1			1	1	2	3
	Juglans nigra	22	7	3.14	1	5	3	1	1	4	7	
	Salix nigra	1	1	1					1			
	Betula lenta var. lenta	16	6	2.67	1	8	1	1	4		1	
	Lyonia ligustrina var. ligustrina	1	1	1	1							
	Platanus occidentalis var. occidentalis	32	7	4.71	4	5	8	4		5	4	2
	Prunus serotina var. serotina	4	2	2.5					3			1
Total	**9**	**90**			**11**	**19**	**12**	**6**	**12**	**10**	**14**	**6**

Table A6. Vegetation Problem Areas Hanging Rock Creek / Project No. 165			
Feature Issue	**Station Numbers**	**Suspected Cause**	**Photo Number**
Bare Bench	00+00	Poor soil substrate	VPA 1
	07+50	Poor soil substrate	
Bare Floodplain	See CCPV	Unauthorized mowing	VPA 2
	See CCPV	Unauthorized mowing	VPA 3
Invasive / Exotic Populations	See CCPV	*Rosa multiflora*: On site seed source	VPA 4
	See CCPV	*Lolium arundinaceum*: Encroachment from outside	

Vegetation Problem Area (VPA 1) – Bare bench
Monitoring Year 5 – June 25, 2008

Vegetation Problem Area (VPA 2) – Mowed floodplain
Monitoring Year 5 – June 25, 2008

Vegetation Problem Area (VPA 3) – Mowed path
Monitoring Year 5 – June 25, 2008

Vegetation Problem Area (VPA 4) – *Rosa multiflora*
Monitoring Year 5 – June 25, 2008

Vegetation Monitoring Plot #1
Monitoring Year 5 – August 1, 2008

Vegetation Monitoring Plot #2
Monitoring Year 5 – August 1, 2008

Vegetation Monitoring Plot #3
Monitoring Year 5 – August 1, 2008

Vegetation Monitoring Plot #4
Monitoring Year 5 – August 1, 2008

Vegetation Monitoring Plot #5
Monitoring Year 5 – August 1, 2008

Vegetation Monitoring Plot #6
Monitoring Year 5 – August 1, 2008

Vegetation Monitoring Plot #7
Monitoring Year 5 – August 1, 2008

Vegetation Monitoring Plot #8
Monitoring Year 5 – August 1, 2008

Appendix B
Hanging Rock Creek
Geomorphologic Data

Table B1. Stream Problem Areas
Hanging Rock Creek / Project No. 165
Hanging Rock Creek / Reach 1 (2,499 feet)

Feature Issue	Station Numbers	Suspected Cause	Photo Number
Aggradation / Bar Formation	00+82	Thalweg migration	SPA 1 SPA 2
	01+72	Thalweg migration associated with failing structure	
	06+00	Downstream beaver dam causing sediment deposition	
	10+24	Thalweg migration associated with failing structure	
Bank Scour	01+78	Thalweg migration associated with failing structure	SPA 3
	02+45	Downstream structure set at high angle	
	03+60	Undercutting causing bank to slump	
	04+97	Thalweg migration associated with failing structure	
	07+50	Structure set at high angle	
	10+00	Thalweg migration associated with failing structure	
	12+00	Structure set at high angle	
	14+10	Structure set at high angle	
	14+36	Structure set at high angle	
	14+68	Structure set at high angle	
	16+46	Thalweg migration associated with stressed structure	
	17+50	Structure set at high angle	
Engineered Structures	01+80	Structure slump possibly due to piping	SPA 4 SPA 5
	02+60	Structure set at high angle causing back scour	
	03+77	Structure set at high angle causing back scour	
	04+87	Structure set at high angle causing back scour	
	05+05	Structure slump possibly due to piping	
	06+51	Structure slump possibly due to piping	
	07+44	Structure set at high angle causing back scour	
	07+70	Structure set at high angle causing back scour	
	10+11	Structure slump possibly due to piping	
	12+04	Structure set at high angle causing back scour	
	14+08	Structure set at high angle causing back scour	
	14+42	Structure set at high angle causing back scour	
	16+44	Structure slump possibly due to piping	
	17+35	Structure set at high angle causing back scour	
	17+45	Structure set at high angle causing back scour	
	17+62	Structure set at high angle causing back scour	
	17+98	Structure piping	
	20+69	Structure slump possibly due to piping	
	21+72	Structure slump possibly due to footer rock shift	

Table B1. Stream Problem Areas
Hanging Rock Creek / Project No. 165
Unnamed Tributary / Reach 2 (240 feet)

Feature Issue	Station Numbers	Suspected Cause	Photo Number
Aggradation / Bar Formation	00+50	Downstream beaver dam causing sediment deposition	SPA 6

Stream Problem Area (SPA 1) – Beaver dam causing upstream aggradation
Monitoring Year 5 – September 18, 2008

Stream Problem Area (SPA 2) – Mid channel bar associated with failing structure
Monitoring Year 5 – June 25, 2008

Stream Problem Area (SPA 3) – Bank scour
Monitoring Year 5 – June 25, 2008

Stream Problem Area (SPA 4) – Failed engineered structure
Monitoring Year 5 – June 25, 2008

Stream Problem Area (SPA 5) – Stressed engineered structure
Monitoring Year 5 – June 25, 2008

Stream Problem Area (SPA 6) – Mid channel bar within unnamed tributary
Monitoring Year 5 – June 25, 2008

Photo Station Photo #1
Monitoring Year 5 – September 23, 2008

Photo Station Photo #2
Monitoring Year 5 – September 23, 2008

Photo Station Photo #3
Monitoring Year 5 – September 23, 2008

Photo Station Photo #4
Monitoring Year 5 – September 23, 2008

Photo Station Photo #5
Monitoring Year 5 – September 23, 2008

Photo Station Photo #6
Monitoring Year 5 – September 23, 2008

Table B2. Visual Morphological Stability Assessment
Hanging Rock Creek / Project No. 165
Hanging Rock Creek / Reach 1 (2,499 feet)

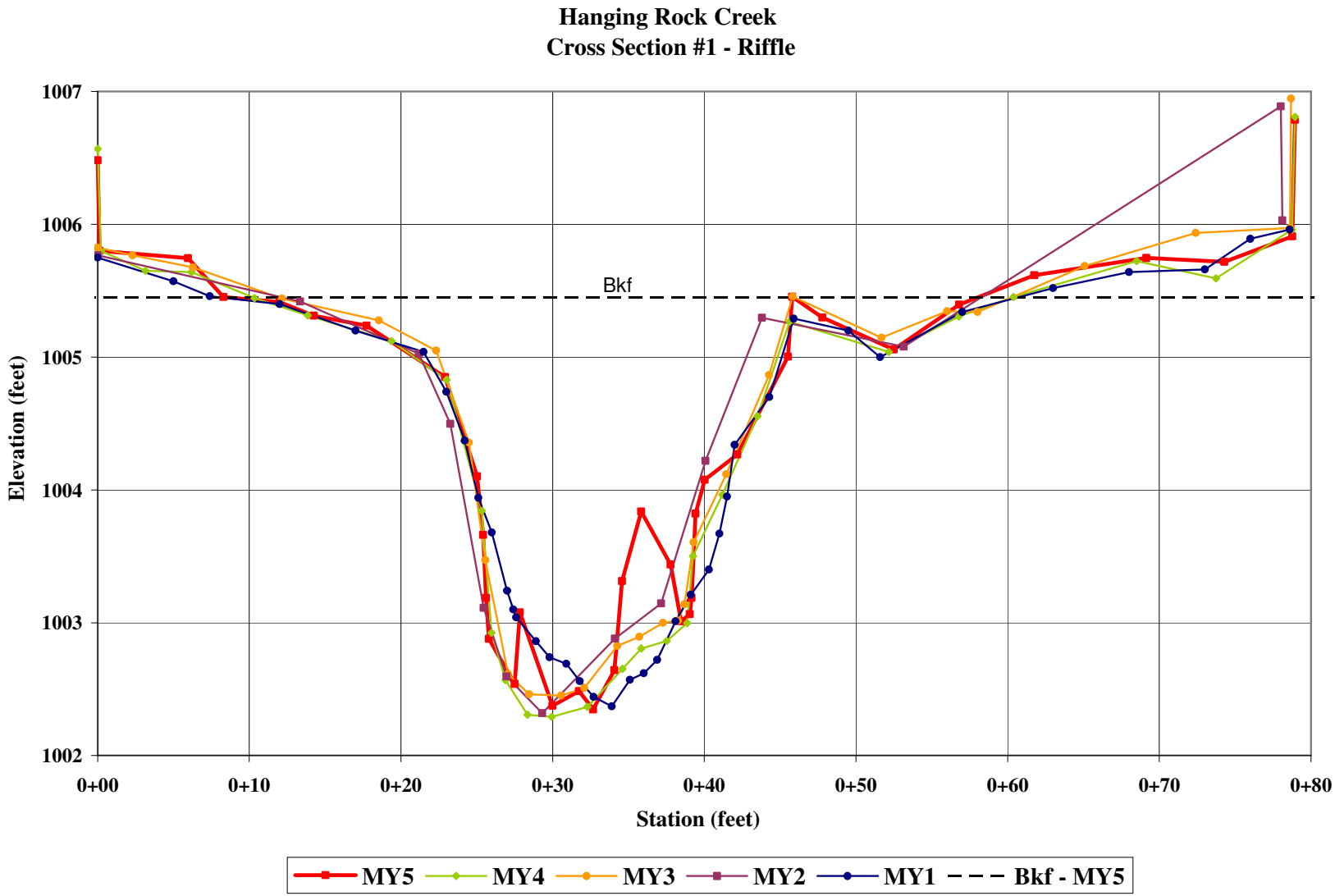
Feature Category	Metric (Per As-built and Reference Baselines)	(# Stable) Number Performing as Intended	Total Number per As-built	Total Number / Feet in Unstable State	% Perform. in Stable Condition	Feature Perform. Mean or Total
A. Riffles	1. Present?	19	20	N/A	95%	
	2. Armor stable (e.g. no displacement)?	20	20	N/A	100%	
	3. Facet grade appears stable?	20	20	N/A	100%	
	4. Minimal evidence of embedding/fining?	18	20	N/A	90%	
	5. Length appropriate?	18	20	N/A	90%	**95%**
B. Pools	1. Present? (e.g. not subject to severe aggrad. or migrat.?)	16	16	N/A	100%	
	2. Sufficiently deep (Max Pool D : Mean Bkf >1.6)	11	16	N/A	69%	
	3. Length appropriate?	16	16	N/A	100%	**90%**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	20	20	N/A	100%	
	2. Downstream of meander (glide/inflection) centering?	20	20	N/A	100%	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	8	16	N/A	50%	
	2. Of those eroding, # w/ concomitant point bar formation?	0	N/A	N/A	100%	
	3. Apparent Rc within spec?	16	16	N/A	100%	
	4. Sufficient floodplain access and relief?	16	16	N/A	100%	**88%**
E. Bed General	1. General channel bed aggradation areas (bar formation)?	N/A	N/A	4 / 164	93%	
	2. Channel bed degradation - areas of increasing down cutting or head cutting?	N/A	N/A	0 / 0	100%	**97%**
F. Bank	1. Actively eroding, wasting, or slumping bank?	N/A	N/A	12 / 352	93%	**93%**
G. Vanes / J-Hooks	1. Free of back or arm scour?	26	38	N/A	68%	
	2. Height appropriate?	34	38	N/A	89%	
	3. Angle and geometry appear appropriate?	28	38	N/A	74%	
	4. Free of piping or other structural failures?	32	38	N/A	84%	**79%**
H. Wads/Boulders	1. Free of scour?	5	8	N/A	63%	
	2. Footing stable?	7	8	N/A	88%	**75%**

N/A - Item does not apply.

Table B2. Visual Morphological Stability Assessment
Hanging Rock Creek / Project No. 165
Unnamed Tributary / Reach 2 (240 feet)

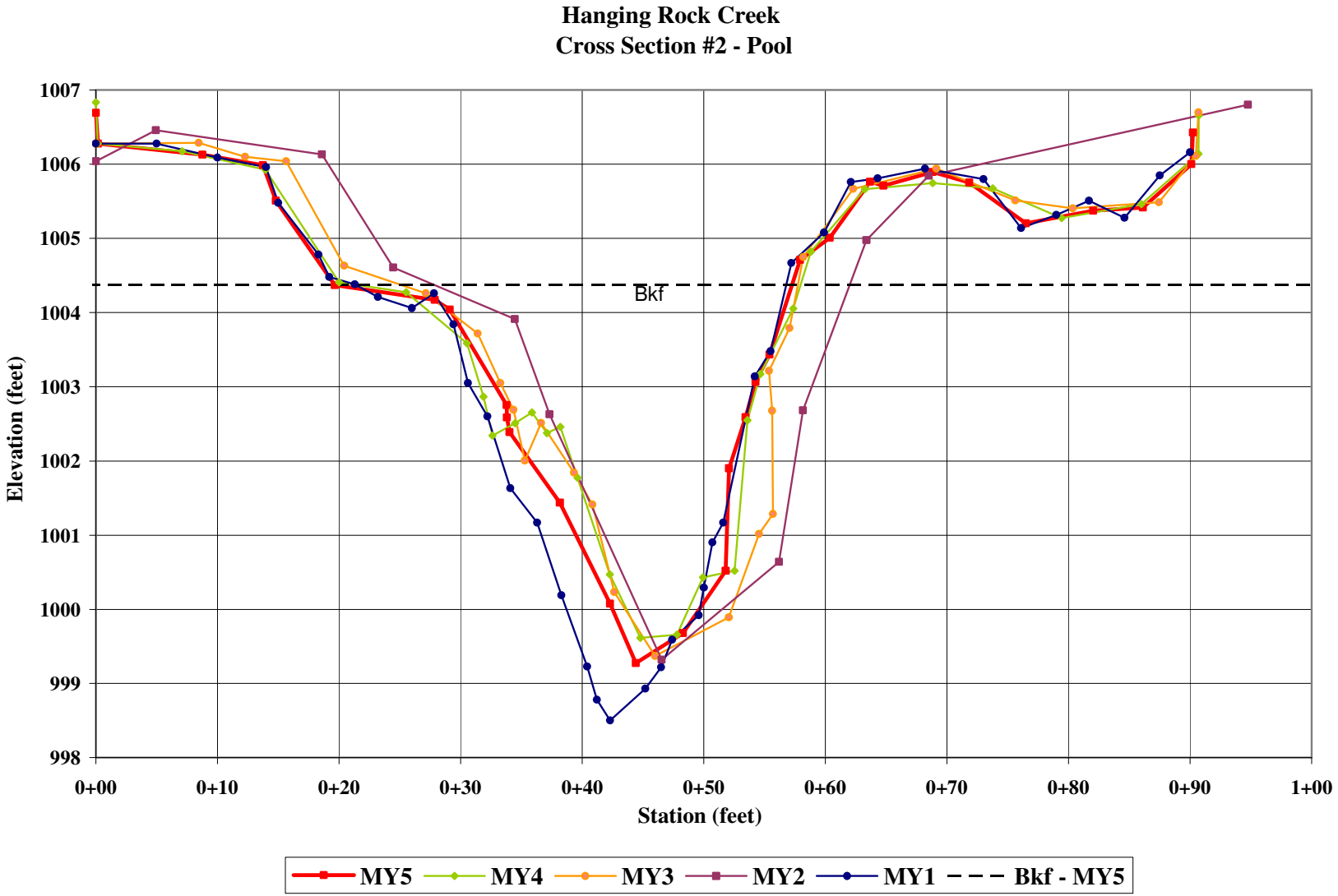
Feature Category	Metric (Per As-built and Reference Baselines)	(# Stable) Number Performing as Intended	Total Number per As-built	Total Number / Feet in Unstable State	% Perform. in Stable Condition	Feature Perform. Mean or Total
A. Riffles	1. Present?	3	5	N/A	60%	
	2. Armor stable (e.g. no displacement)?	5	5	N/A	100%	
	3. Facet grade appears stable?	5	5	N/A	100%	
	4. Minimal evidence of embedding/fining?	3	5	N/A	60%	
	5. Length appropriate?	3	5	N/A	60%	**76%**
B. Pools	1. Present? (e.g. not subject to severe aggrad. or migrat.?)	4	6	N/A	67%	
	2. Sufficiently deep (Max Pool D : Mean Bkf >1.6)	4	6	N/A	67%	
	3. Length appropriate?	6	6	N/A	100%	**78%**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	6	6	N/A	100%	
	2. Downstream of meander (glide/inflection) centering?	6	6	N/A	100%	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	3	3	N/A	100%	
	2. Of those eroding, # w/ concomitant point bar formation?	0	N/A	N/A	100%	
	3. Apparent Rc within spec?	3	3	N/A	100%	
	4. Sufficient floodplain access and relief?	3	3	N/A	100%	**100%**
E. Bed General	1. General channel bed aggradation areas (bar formation)?	N/A	N/A	1 / 103	60%	
	2. Channel bed degradation - areas of increasing down cutting or head cutting?	N/A	N/A	0 / 0	100%	**80%**
F. Bank	1. Actively eroding, wasting, or slumping bank?	N/A	N/A	0 / 0	100%	**100%**
G. Vanes / J-Hooks	1. Free of back or arm scour?	6	6	N/A	100%	
	2. Height appropriate?	6	6	N/A	100%	
	3. Angle and geometry appear appropriate?	6	6	N/A	100%	
	4. Free of piping or other structural failures?	6	6	N/A	100%	**100%**
H. Wads/Boulders	1. Free of scour?	3	3	N/A	100%	
	2. Footing stable?	3	3	N/A	100%	**100%**

N/A - Item does not apply.


Hanging Rock Creek
Cross Section #1 - Riffle
1007
1006
1005
1004
1003
1002
Elevation (feet)
Bkf
0+00
0+10
0+20
0+30
0+40
0+50
0+60
0+70
0+80
Station (feet)
MY5
MY4
MY3
MY2
MY1
Bkf - MY5

Hanging Rock Creek – Cross Section #1 – Riffle
(Looking Downstream)
Monitoring Year 5 – September 4, 2008

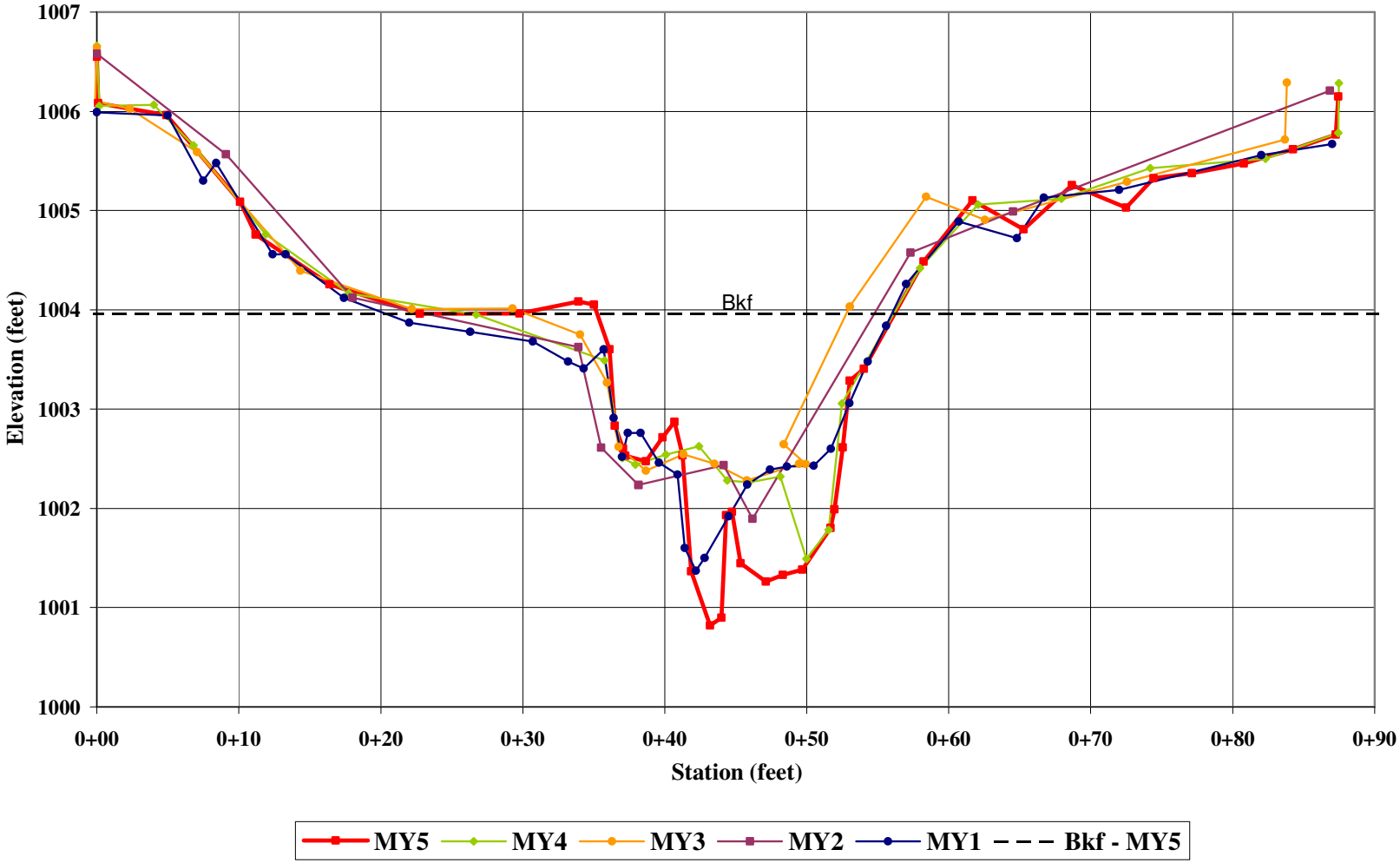
Hanging Rock Creek – Cross Section #1 – Riffle
(Looking Upstream)
Monitoring Year 5 – September 4, 2008


Hanging Rock Creek
Cross Section #2 - Pool
Elevation (feet)
1007
1006
1005
1004
1003
1002
1001
1000
999
998
Bkf
0+00
0+10
0+20
0+30
0+40
0+50
0+60
0+70
0+80
0+90
1+00
Station (feet)
MY5
MY4
MY3
MY2
MY1
Bkf - MY5

Hanging Rock Creek – Cross Section #2 – Pool
(Looking Downstream)
Monitoring Year 5 – September 4, 2008

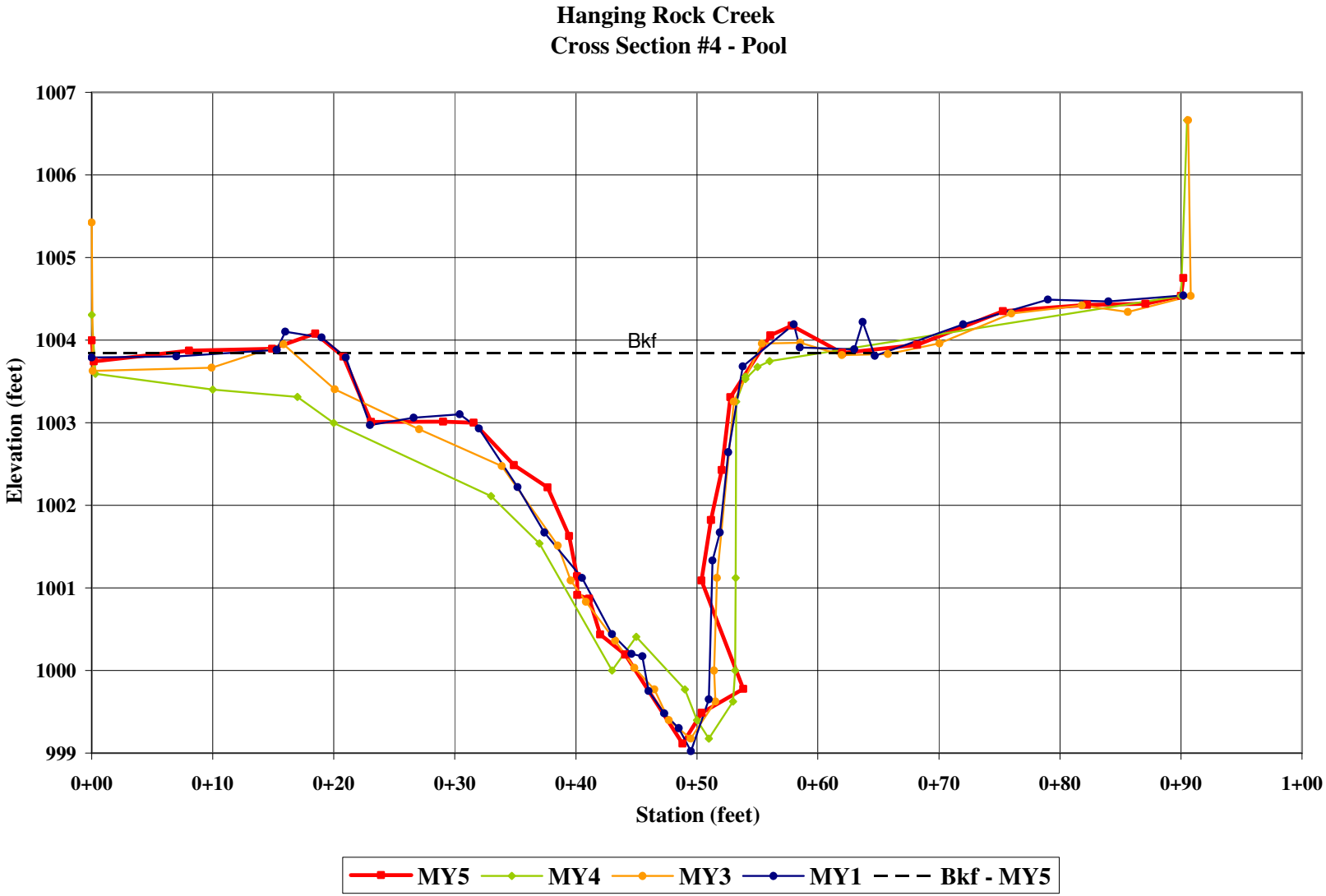
Hanging Rock Creek – Cross Section #2 – Pool
(Looking Upstream)
Monitoring Year 5 – September 4, 2008

Hanging Rock Creek
Cross Section #3 - Riffle



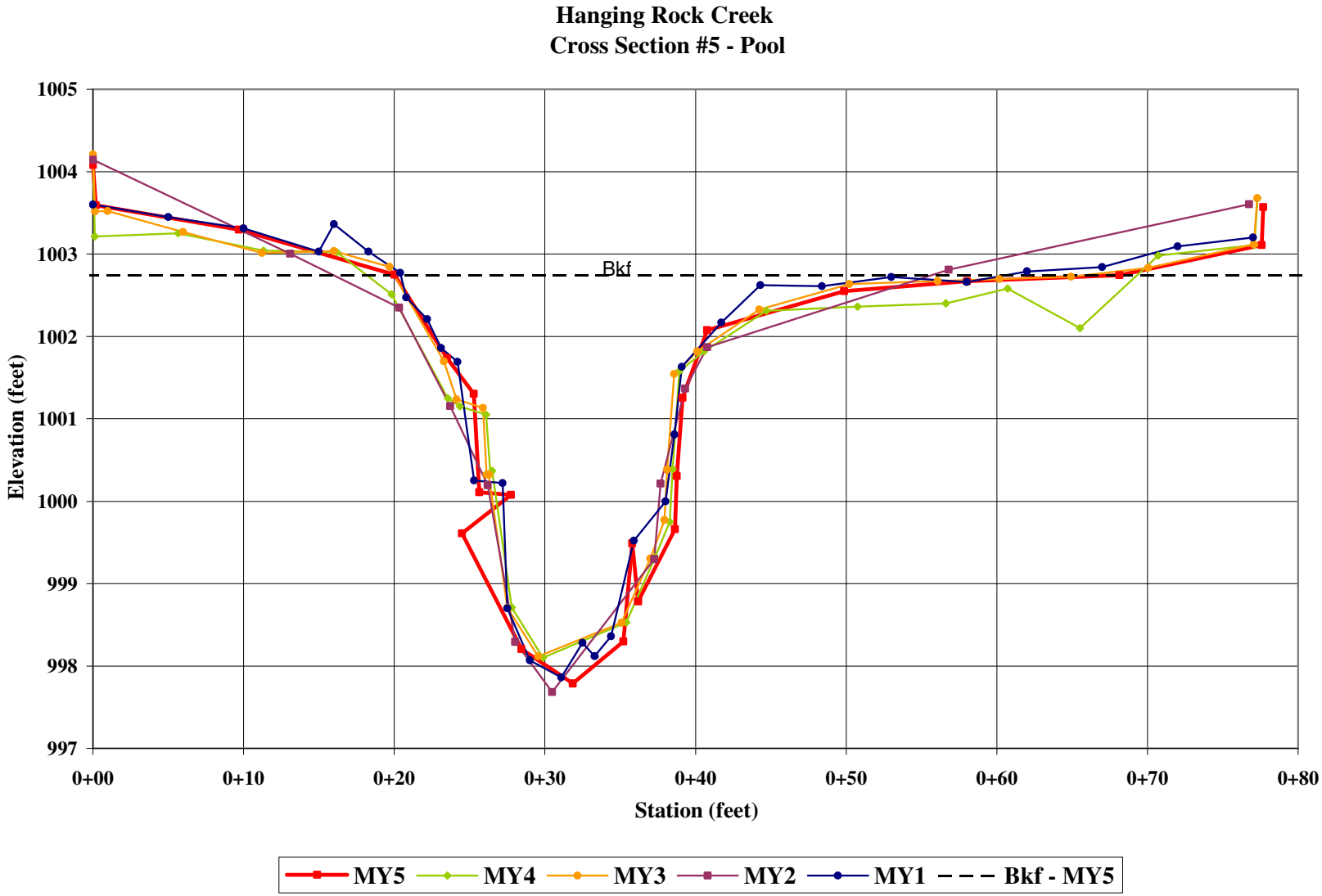
Hanging Rock Creek – Cross Section #3 – Riffle
(Looking Downstream)
Monitoring Year 5 – September 4, 2008

Hanging Rock Creek – Cross Section #3 – Riffle
(Looking Upstream)
Monitoring Year 5 – September 4, 2008


Hanging Rock Creek
Cross Section #4 - Pool
1007
1006
1005
1004
1003
1002
1001
1000
999
Elevation (feet)
Bkf
0+00
0+10
0+20
0+30
0+40
0+50
0+60
0+70
0+80
0+90
1+00
Station (feet)
MY5
MY4
MY3
MY1
Bkf - MY5

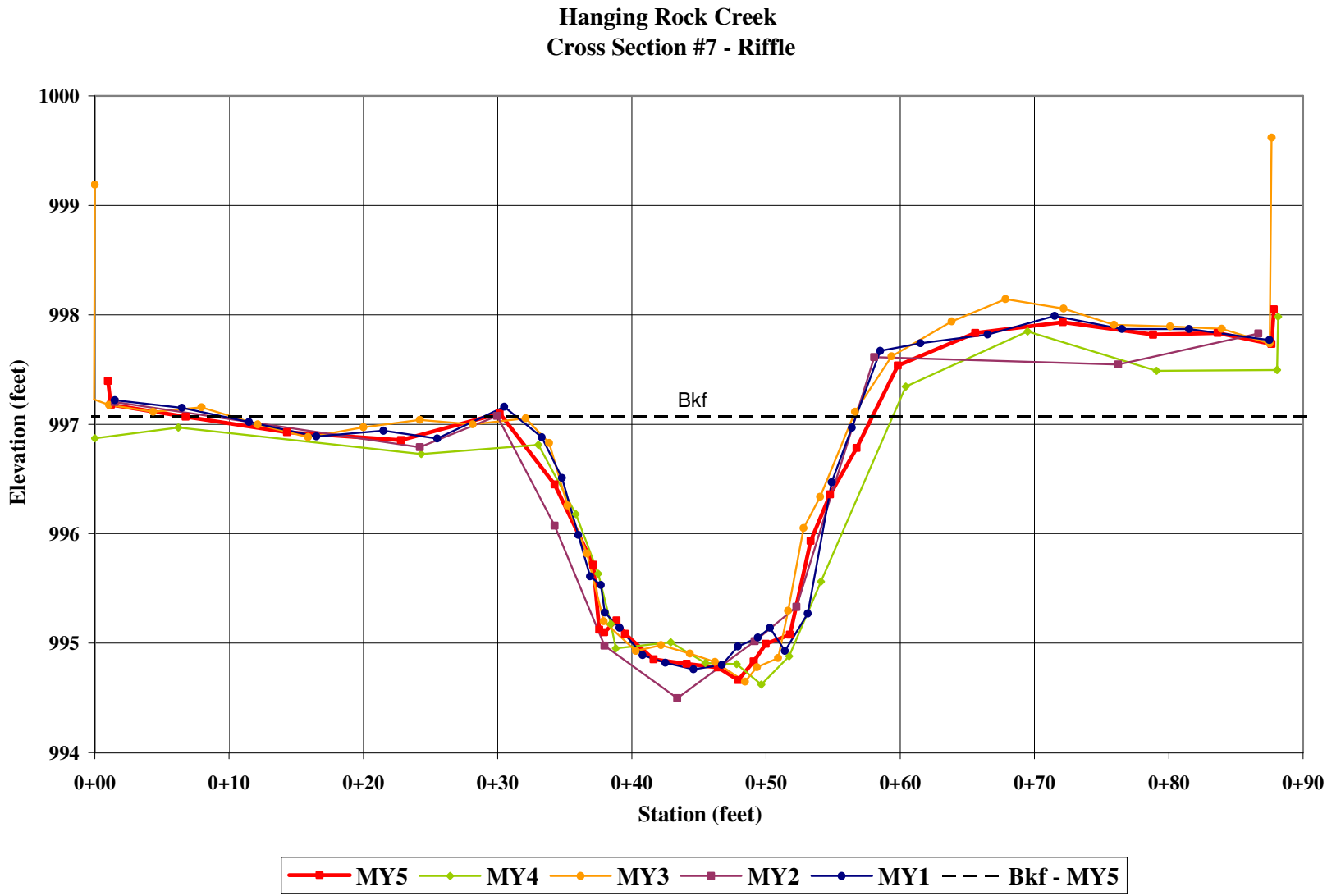
Hanging Rock Creek – Cross Section #4 – Pool
(Looking Downstream)
Monitoring Year 5 – September 4, 2008

Hanging Rock Creek – Cross Section #4 – Pool
(Looking Upstream)
Monitoring Year 5 – September 4, 2008


Hanging Rock Creek
Cross Section #5 - Pool
1005
1004
1003
1002
1001
1000
999
998
997
Elevation (feet)
Bkf
0+00
0+10
0+20
0+30
0+40
0+50
0+60
0+70
0+80
Station (feet)
MY5
MY4
MY3
MY2
MY1
Bkf - MY5

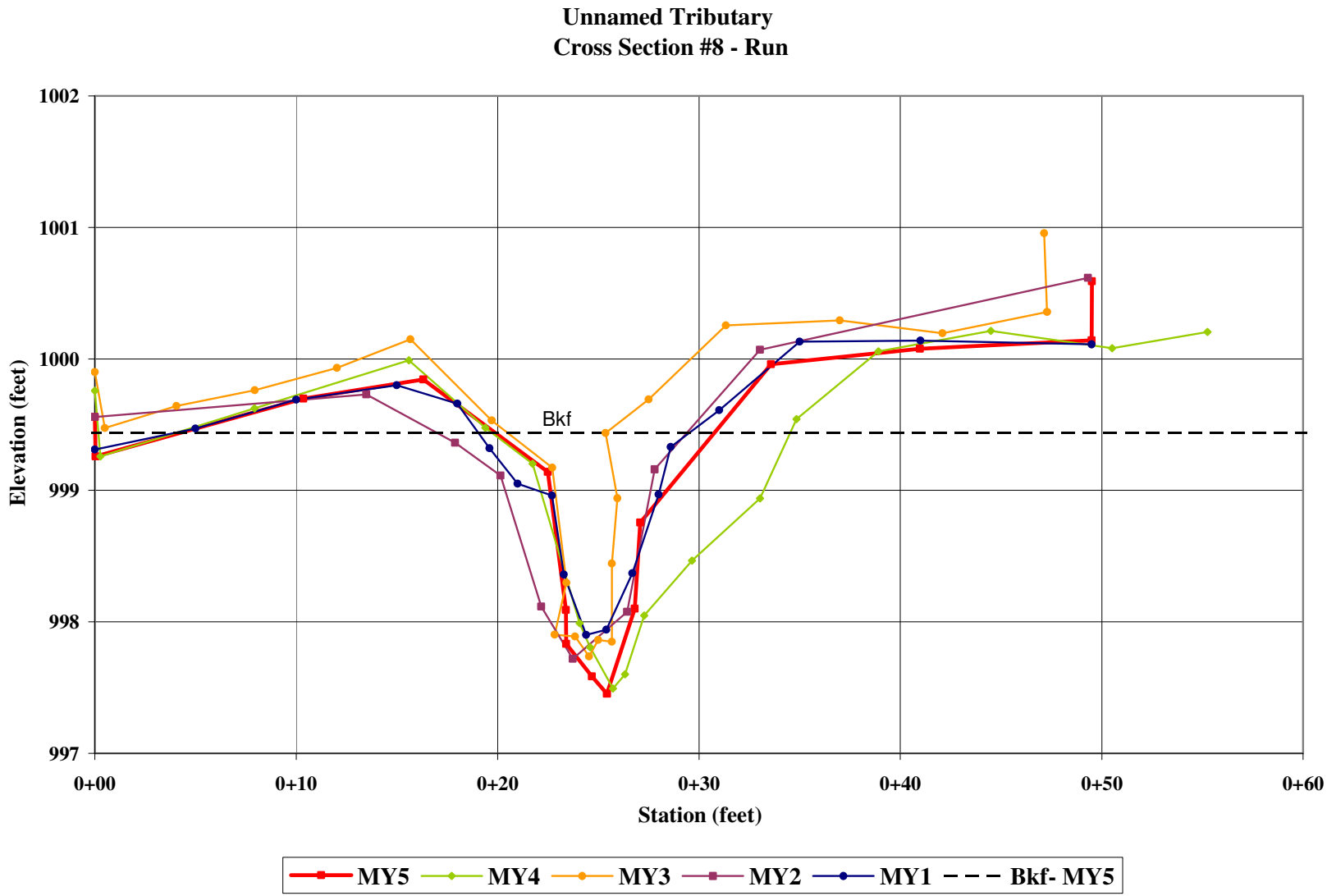
Hanging Rock Creek – Cross Section #5 – Pool
(Looking Downstream)
Monitoring Year 5 – September 4, 2008

Hanging Rock Creek – Cross Section #5 – Pool
(Looking Upstream)
Monitoring Year 5 – September 4, 2008


Hanging Rock Creek
Cross Section #7 - Riffle
1000
999
998
997
996
995
994
Elevation (feet)
Bkf
0+00
0+10
0+20
0+30
0+40
0+50
0+60
0+70
0+80
0+90
Station (feet)
MY5
MY4
MY3
MY2
MY1
Bkf - MY5

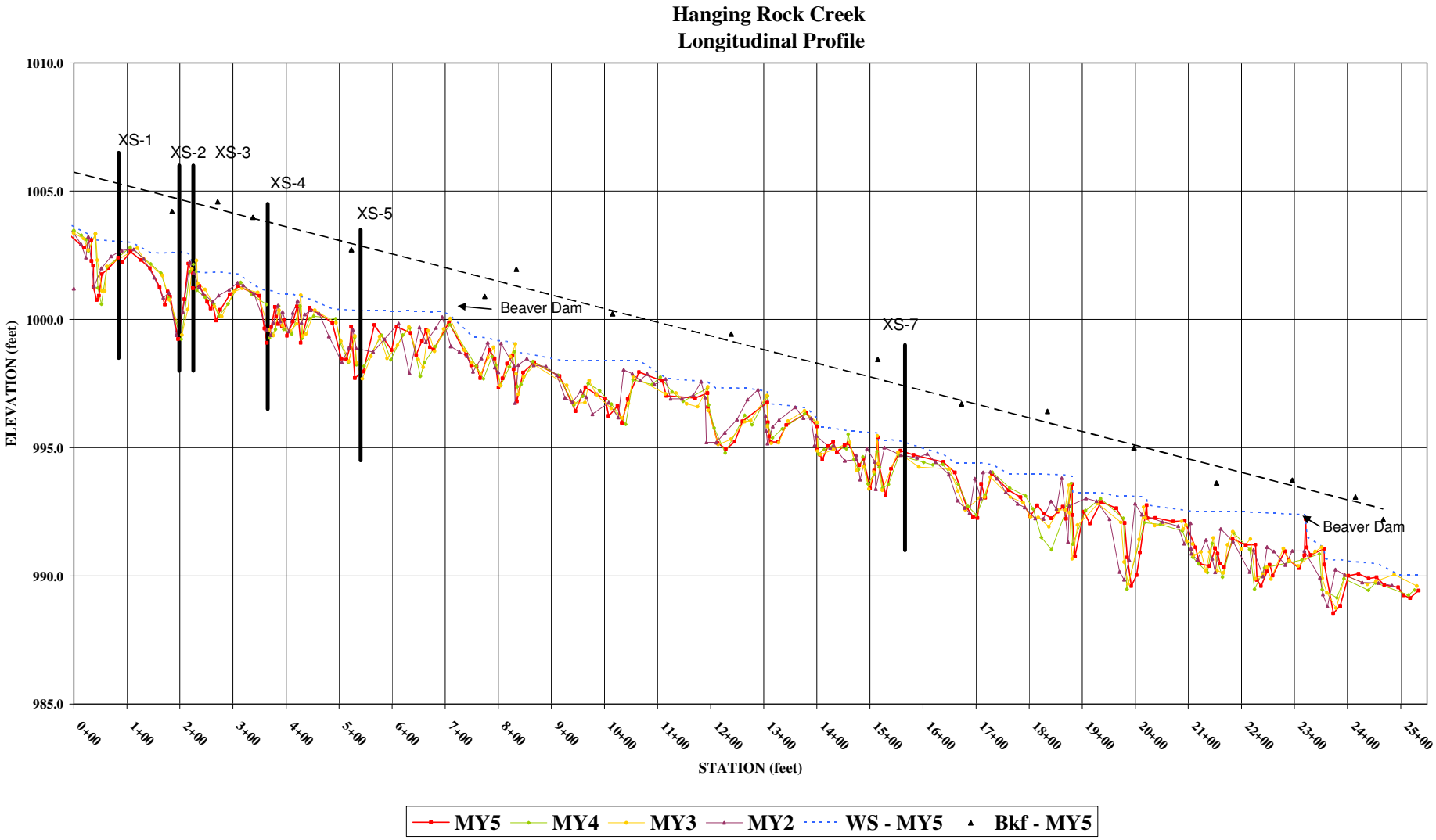
Hanging Rock Creek – Cross Section #7 – Riffle
(Looking Downstream)
Monitoring Year 5 – September 18, 2008

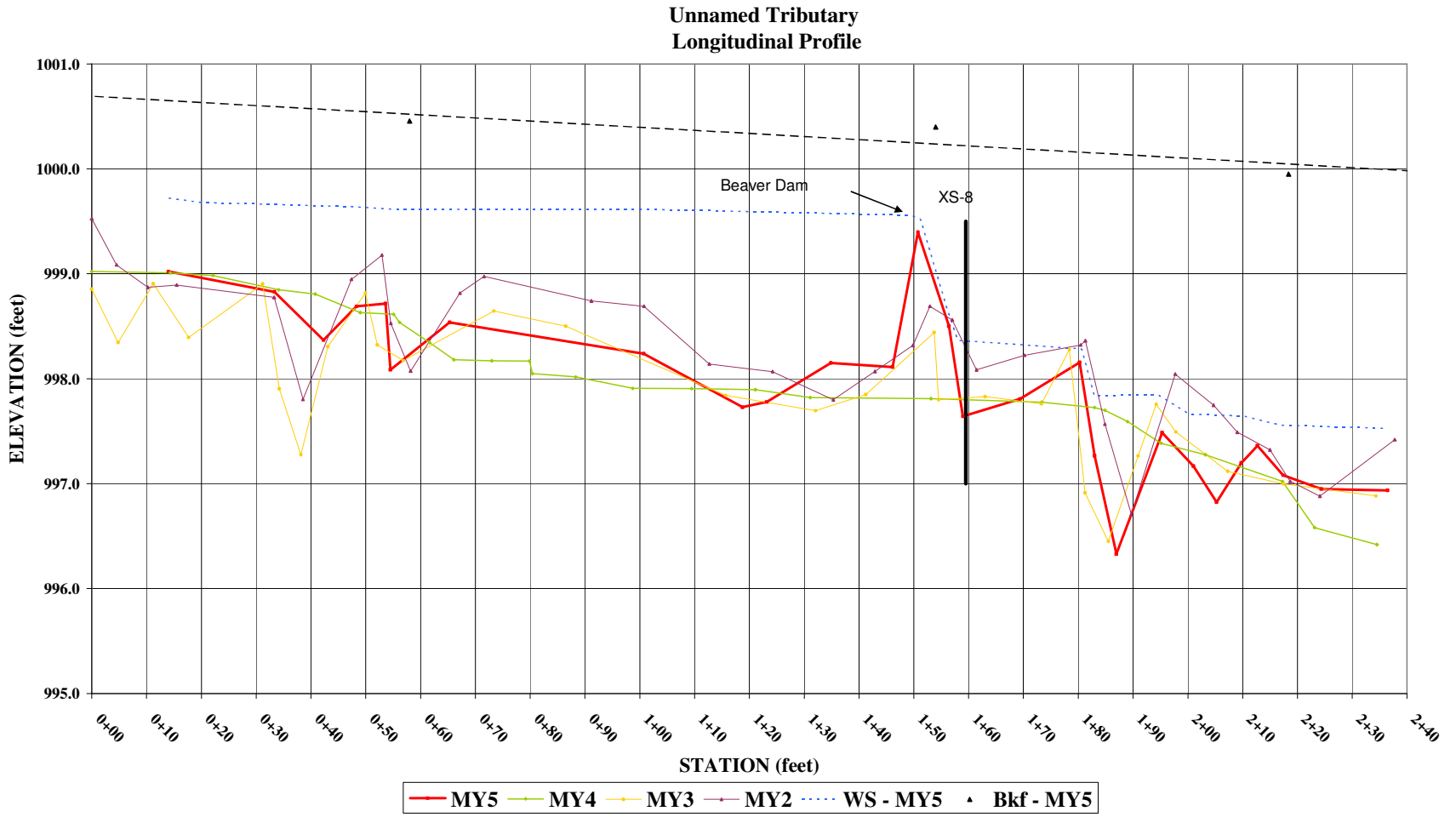
Hanging Rock Creek – Cross Section #7 – Riffle
(Looking Upstream)
Monitoring Year 5 – September 18, 2008


Unnamed Tributary
Cross Section #8 - Run
1002
1001
1000
999
998
997
Elevation (feet)
Bkf
0+00
0+10
0+20
0+30
0+40
0+50
0+60
Station (feet)
MY5
MY4
MY3
MY2
MY1
Bkf- MY5

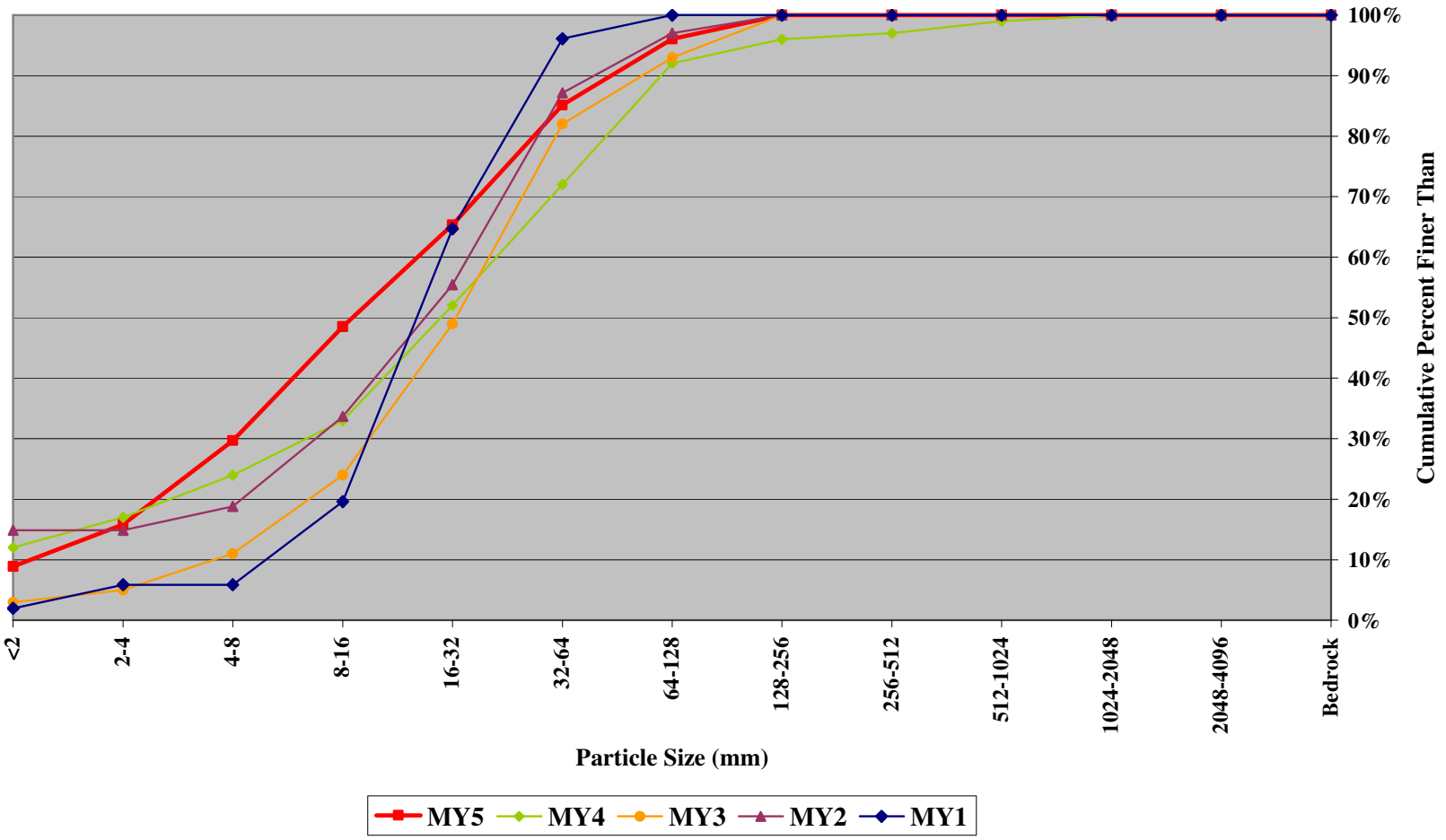
Hanging Rock Creek – Cross Section #8 – Run
(Looking Downstream)
Monitoring Year 5 – September 4, 2008

Hanging Rock Creek – Cross Section #8 – Run
(Looking Upstream)
Monitoring Year 5 – September 4, 2008

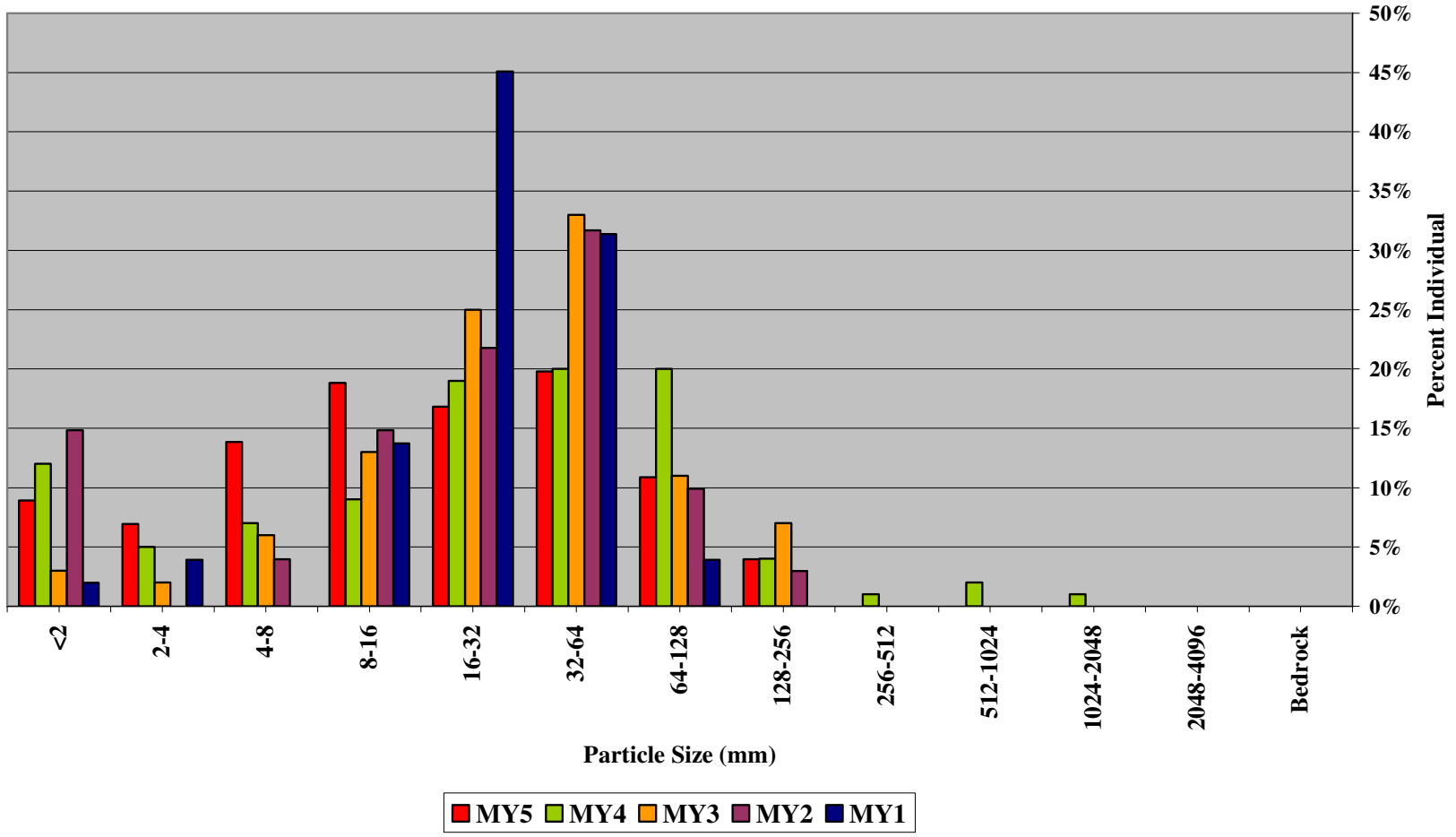

Hanging Rock Creek
Longitudinal Profile
ELEVATION (feet)
1010.0
1005.0
1000.0
995.0
990.0
985.0
XS-1
XS-2
XS-3
XS-4
XS-5
XS-7
Beaver Dam
Beaver Dam
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00
19+00
20+00
21+00
22+00
23+00
24+00
25+00
STATION (feet)
MY5
MY4
MY3
MY2
WS - MY5
Bkf - MY5


Unnamed Tributary
Longitudinal Profile
ELEVATION (feet)
1001.0
1000.0
999.0
998.0
997.0
996.0
995.0
Beaver Dam
XS-8
0+00
0+10
0+20
0+30
0+40
0+50
0+60
0+70
0+80
0+90
1+00
1+10
1+20
1+30
1+40
1+50
1+60
1+70
1+80
1+90
2+00
2+10
2+20
2+30
2+40
STATION (feet)
MY5
MY4
MY3
MY2
WS - MY5
Bkf - MY5

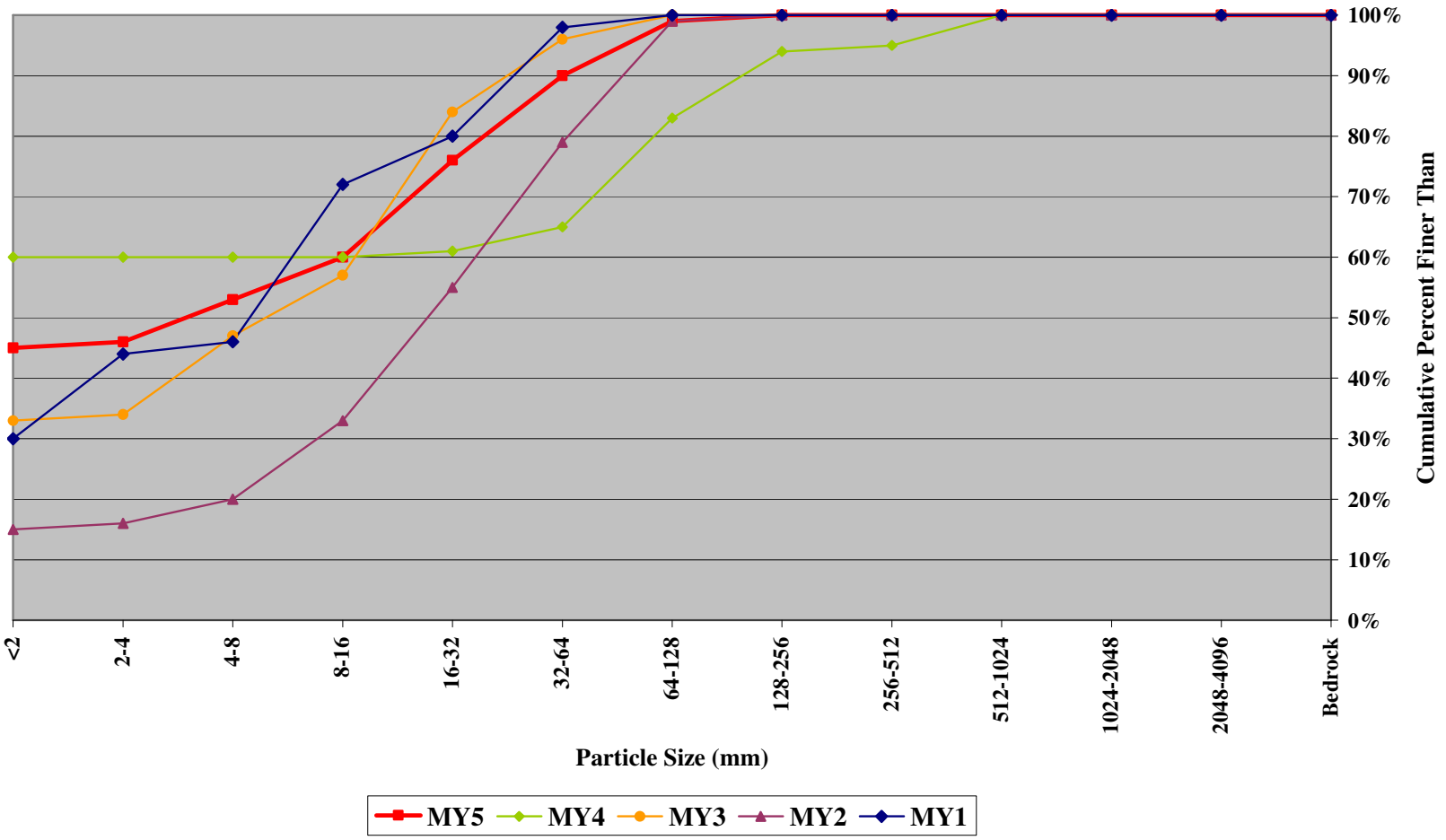
Hanging Rock Creek
Pebble Count - Percent Cumulative
Cross Section #1 - Riffle



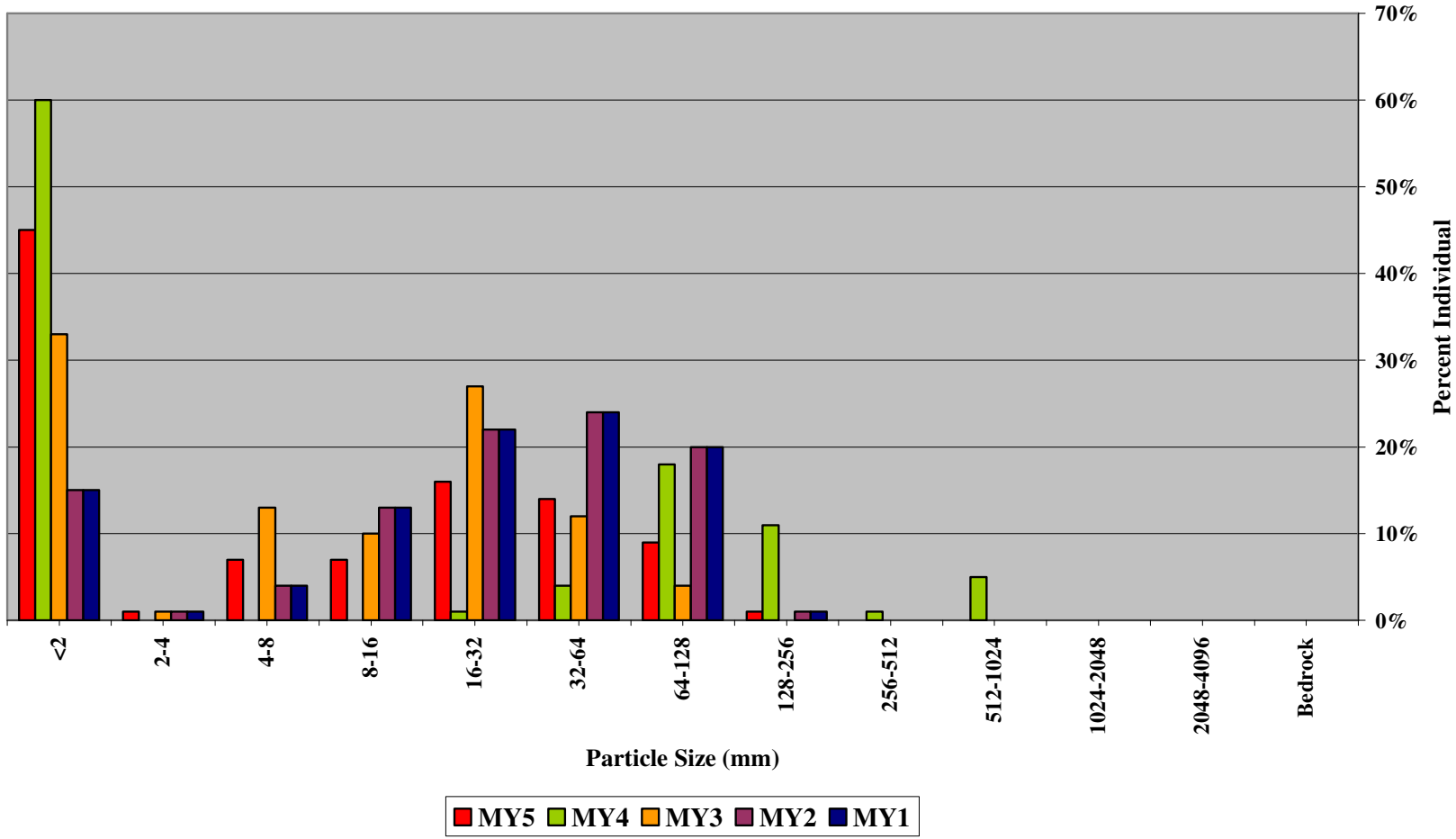
Hanging Rock Creek
Pebble Count - Percent Individual
Cross Section #1 - Riffle

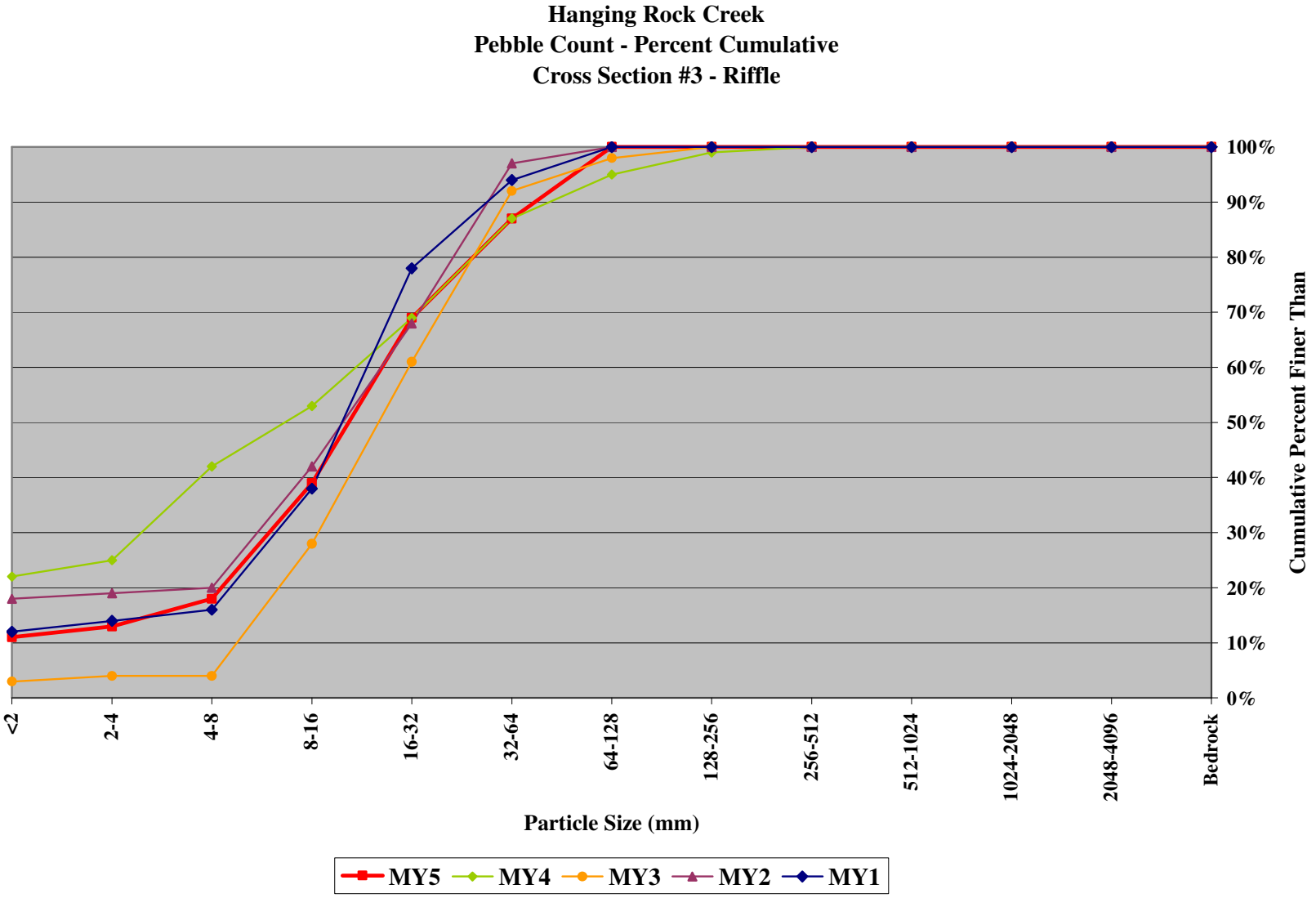


Hanging Rock Creek
Pebble Count - Percent Cumulative
Cross Section #2 - Pool

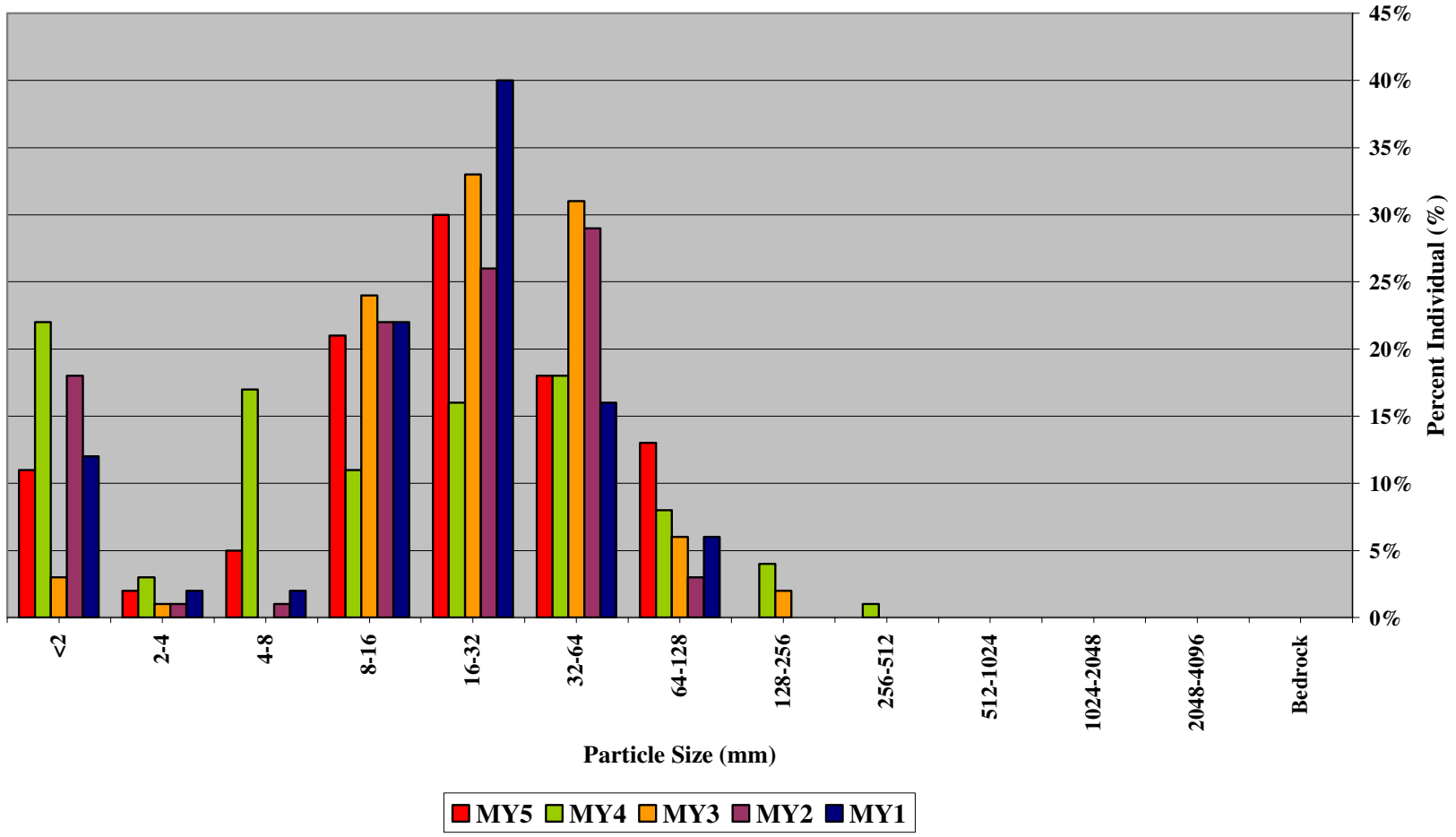


Hanging Rock Creek
Pebble Count - Percent Individual
Cross Section #2 - Pool

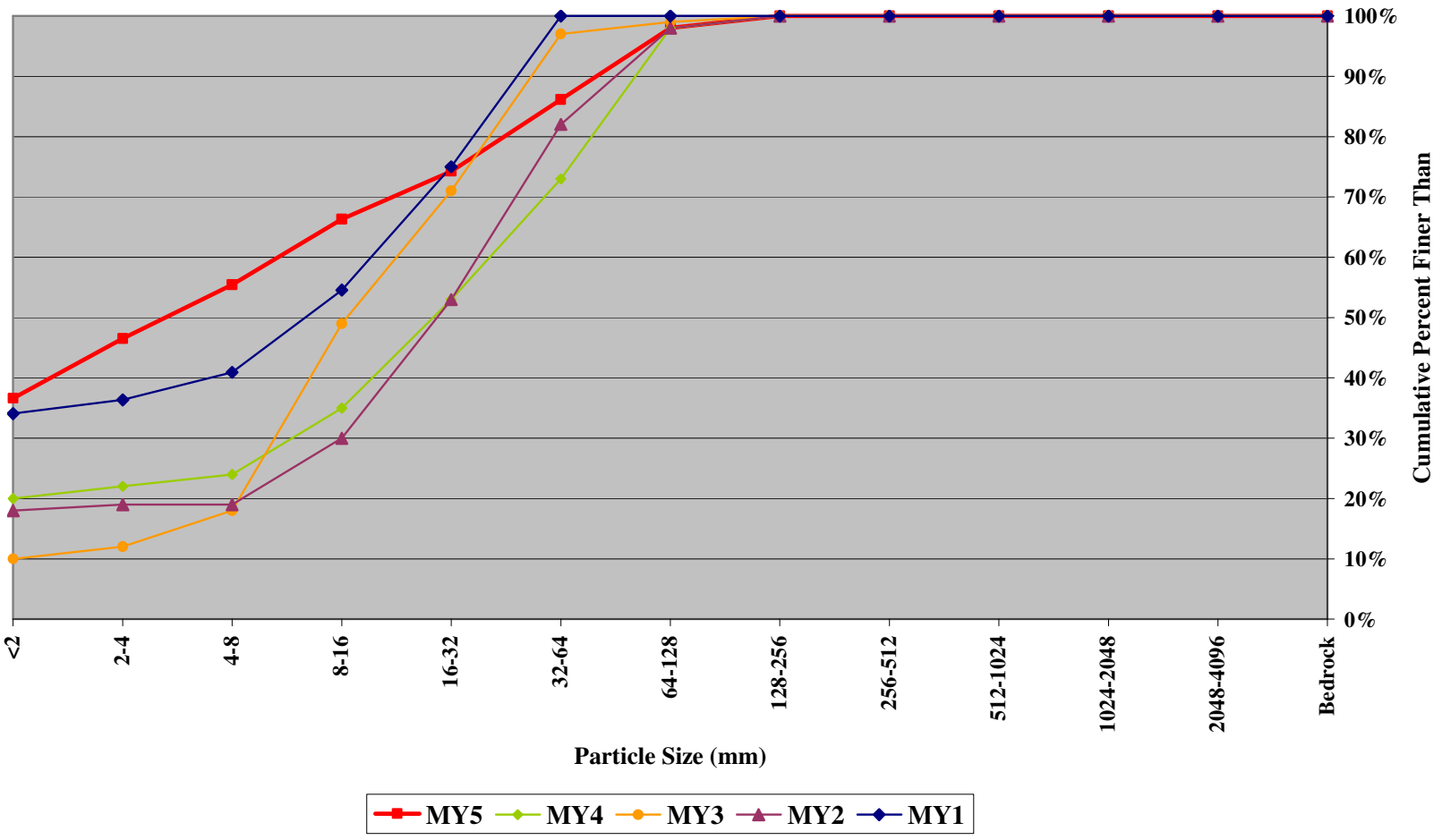



Hanging Rock Creek
Pebble Count - Percent Cumulative
Cross Section #3 - Riffle
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Cumulative Percent Finer Than
<2
2-4
4-8
8-16
16-32
32-64
64-128
128-256
256-512
512-1024
1024-2048
2048-4096
Bedrock
Particle Size (mm)
MY5
MY4
MY3
MY2
MY1

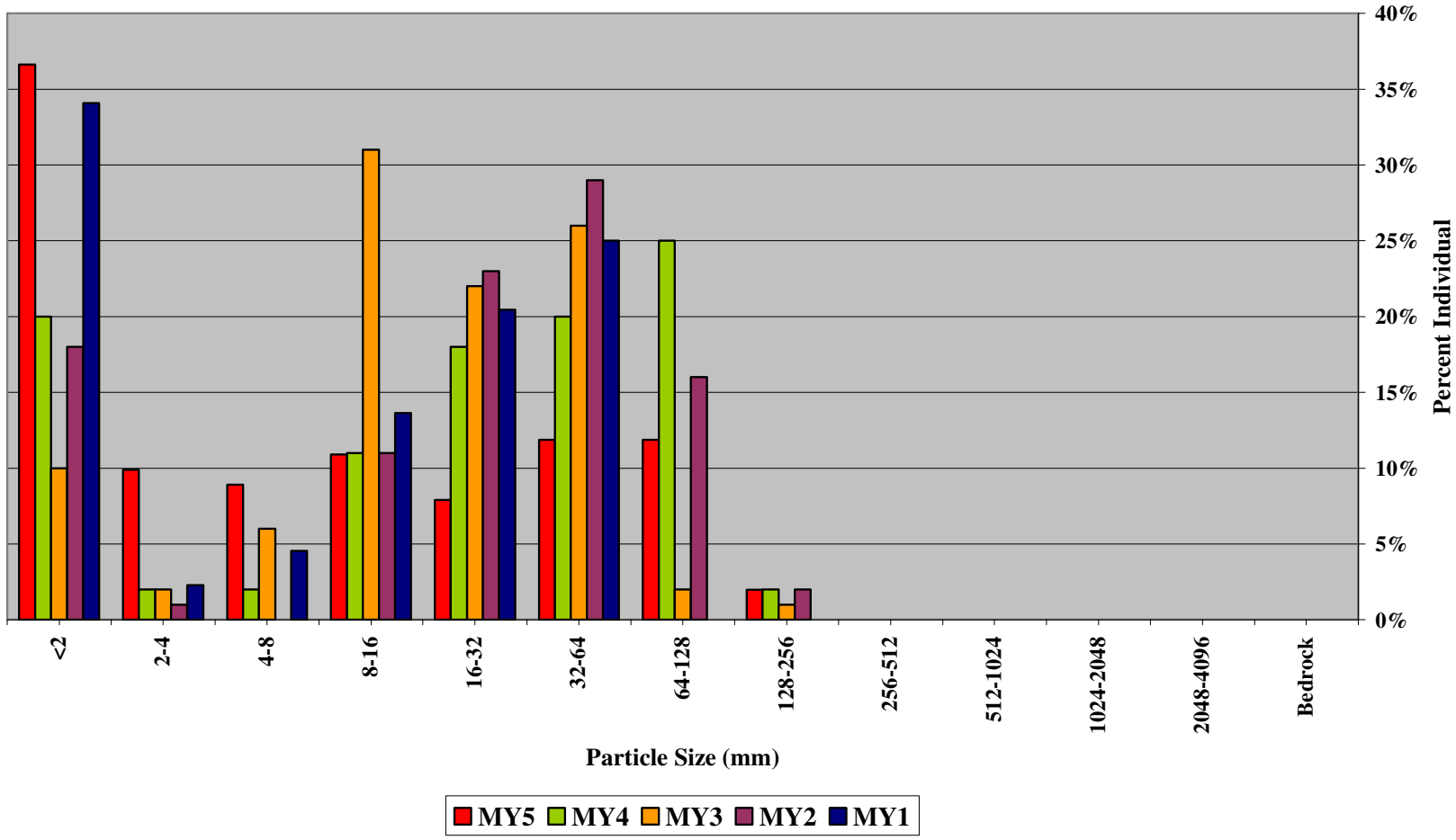
Hanging Rock Creek
Pebble Count - Percent Individual
Cross Section #3 - Riffle



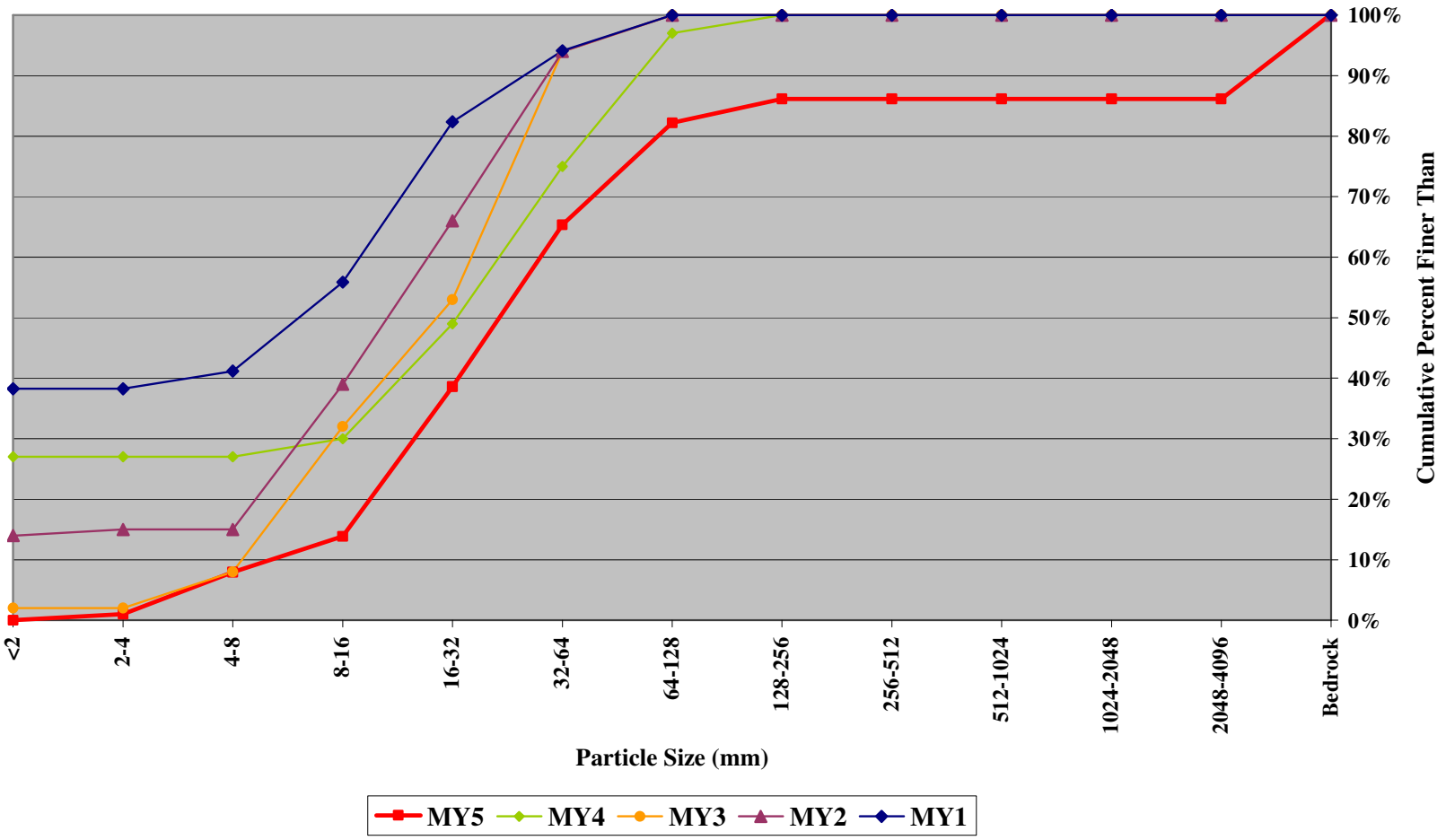
Hanging Rock Creek
Pebble Count - Percent Cumulative
Cross Section #4 - Pool



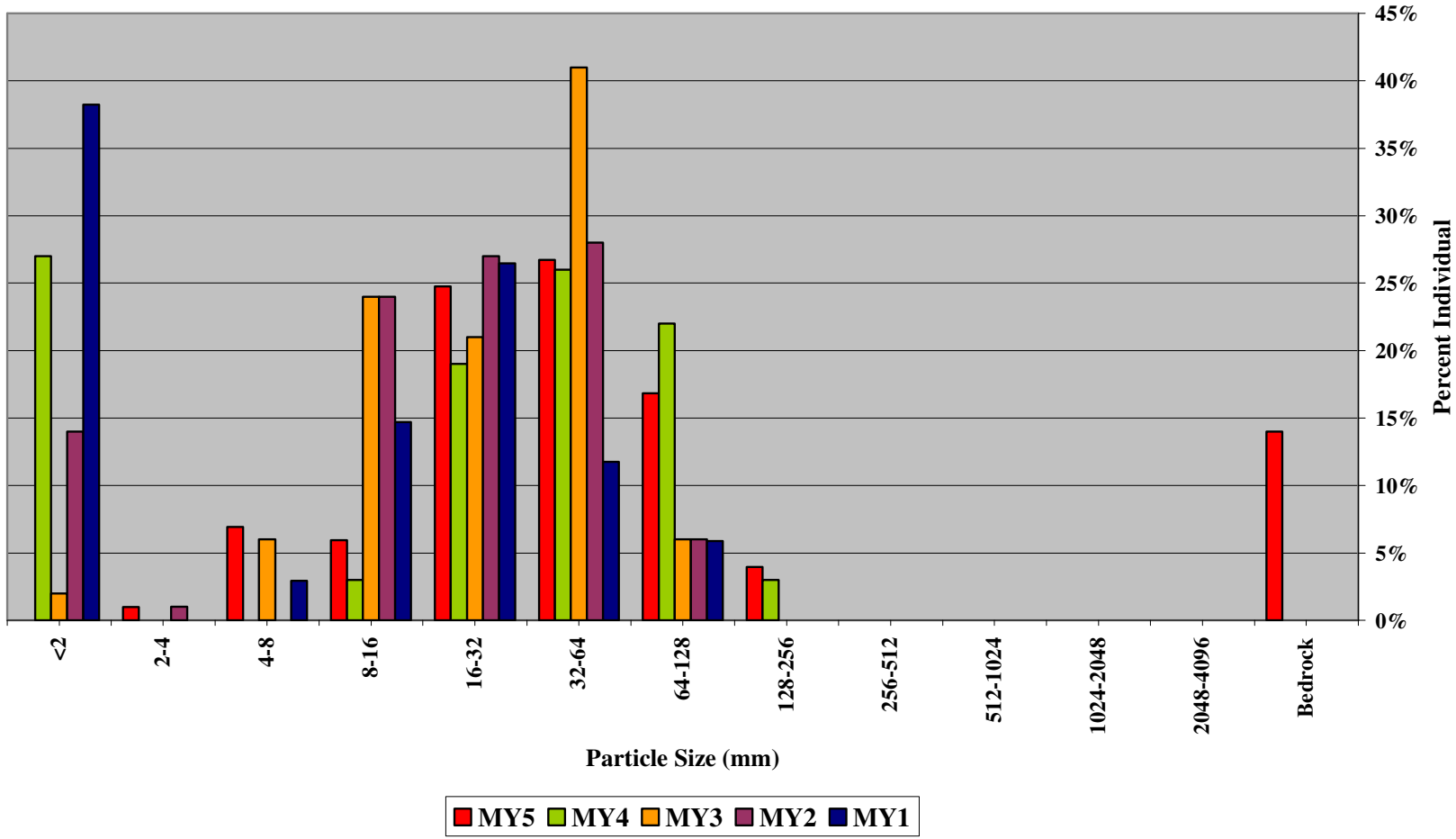
Hanging Rock Creek
Pebble Count - Percent Individual
Cross Section #4 - Pool



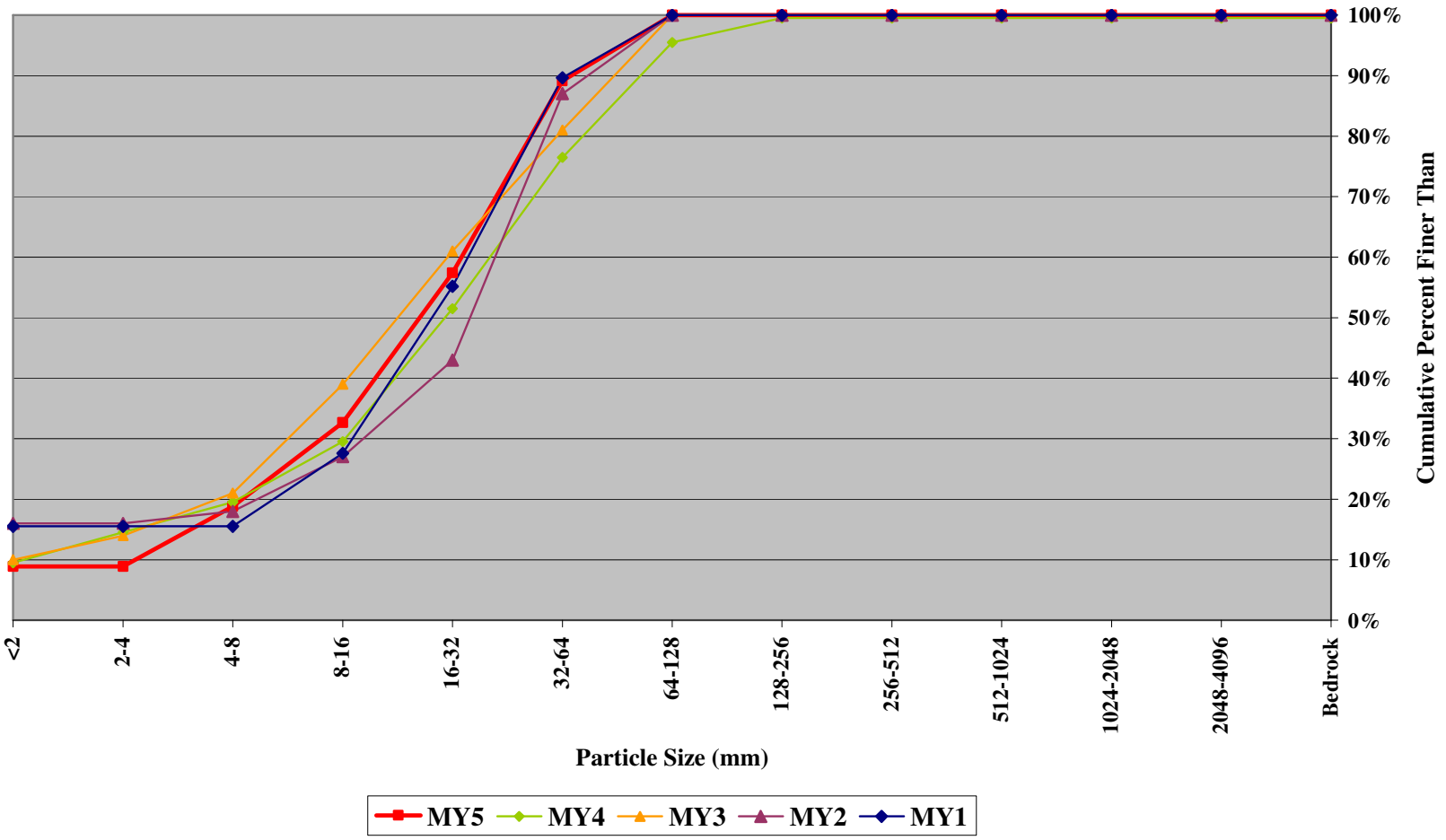
Hanging Rock Creek
Pebble Count - Percent Cumulative
Cross Section #5 - Pool



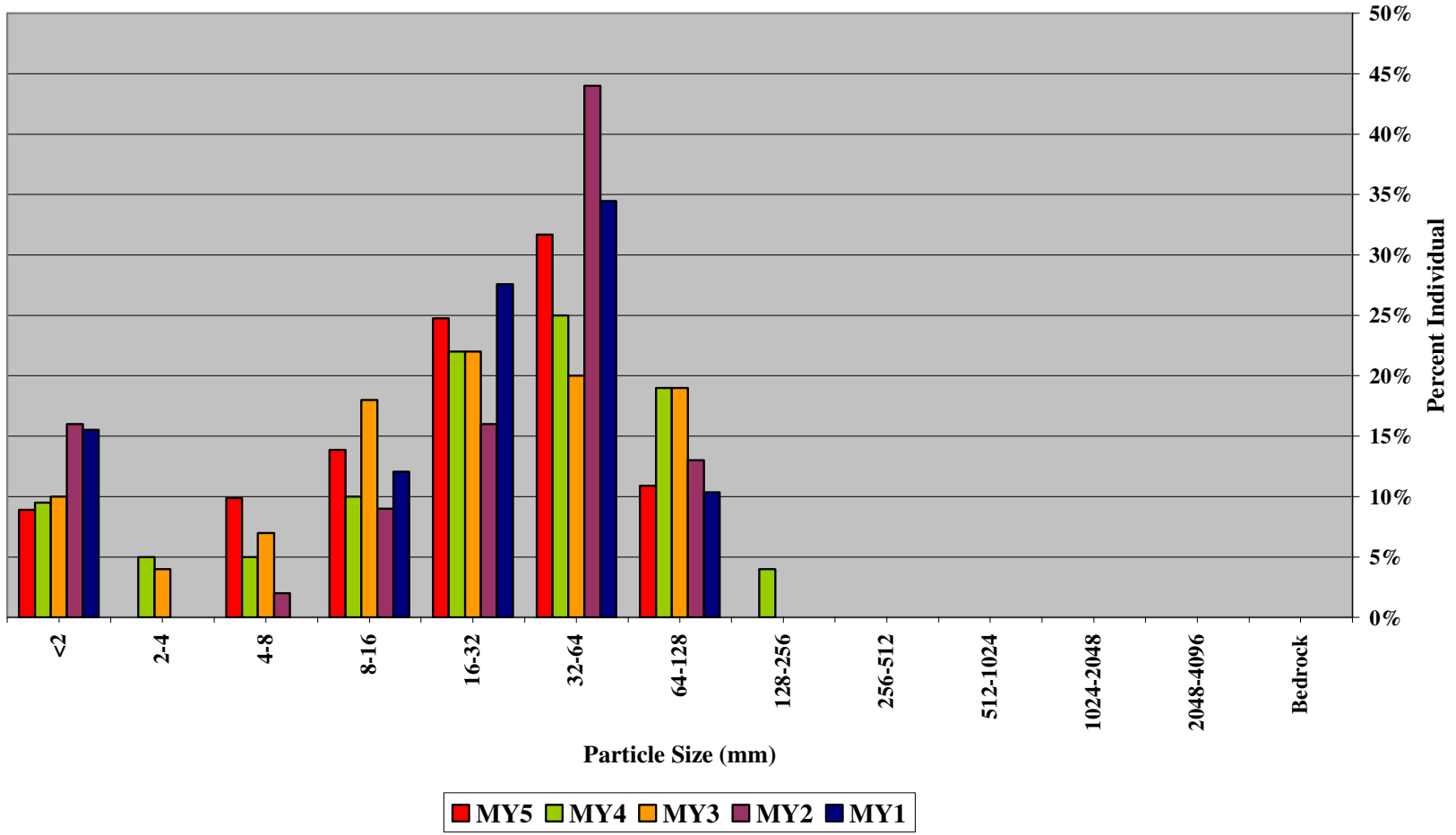
Hanging Rock Creek
Pebble Count - Percent Individual
Cross Section #5 - Pool

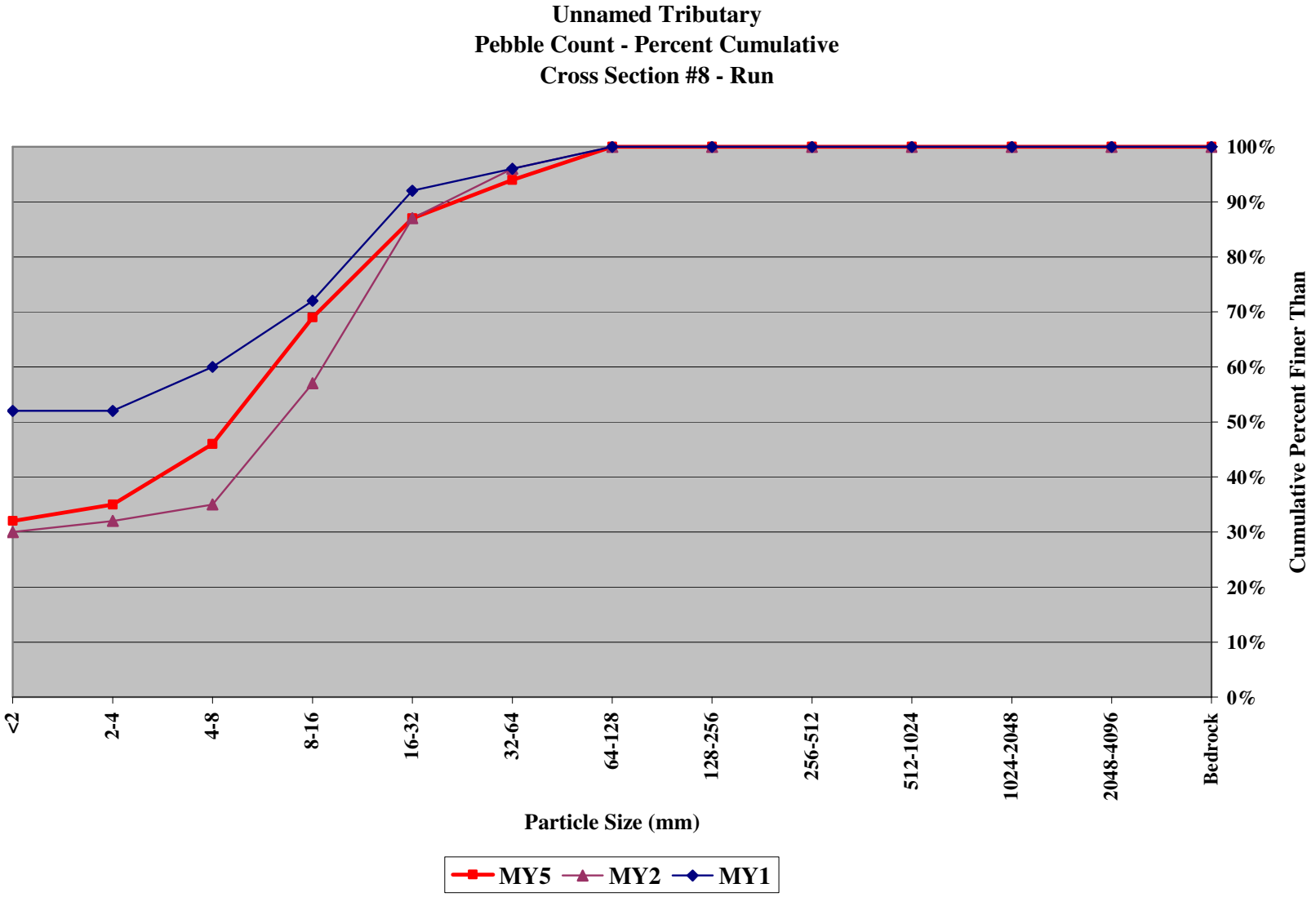


Hanging Rock Creek
Pebble Count - Percent Cumulative
Cross Section #7 - Riffle

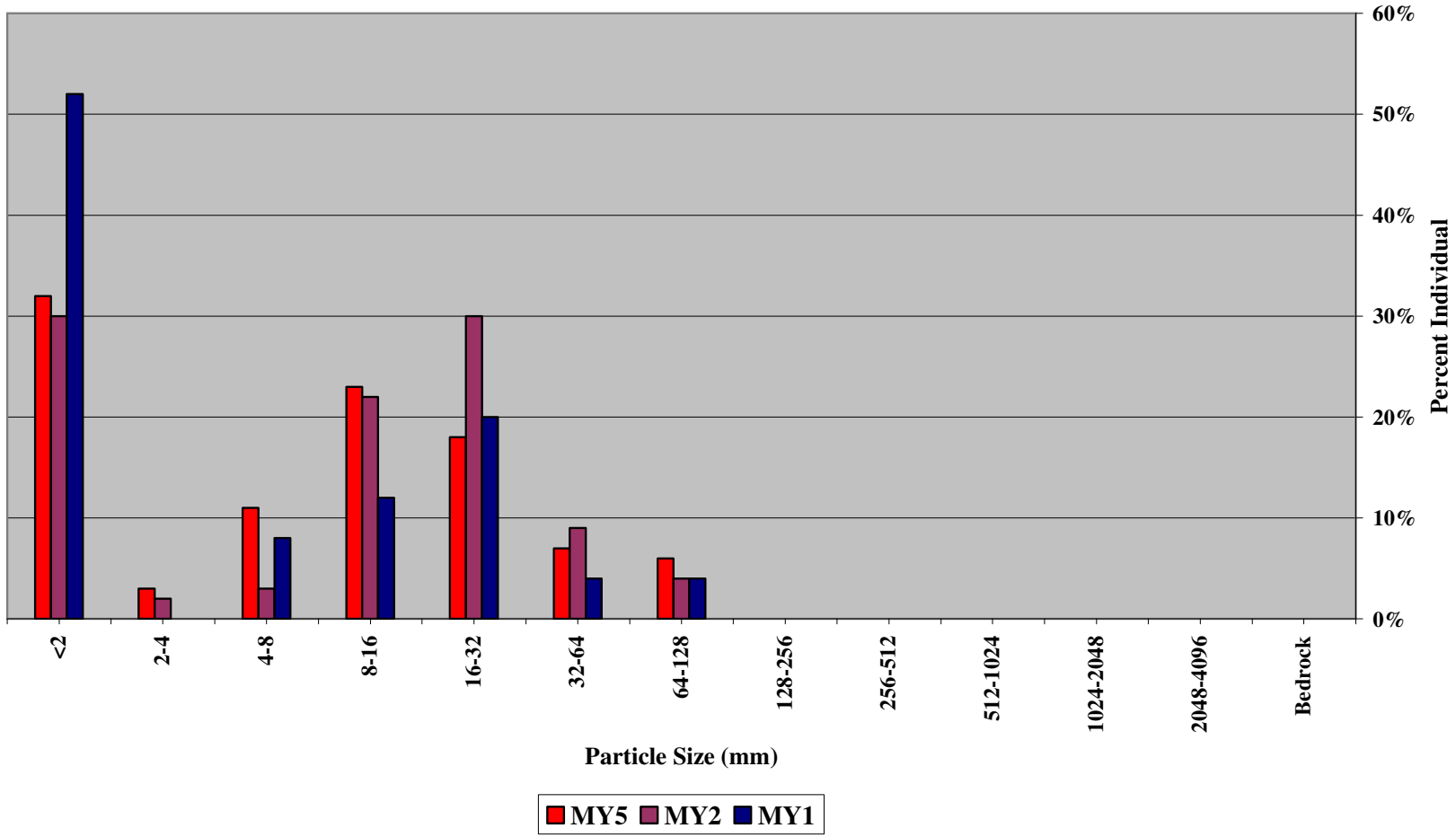


Hanging Rock Creek
Pebble Count - Percent Individual
Cross Section #7 - Riffle




Unnamed Tributary
Pebble Count - Percent Cumulative
Cross Section #8 - Run
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Cumulative Percent Finer Than
<2
2-4
4-8
8-16
16-32
32-64
64-128
128-256
256-512
512-1024
1024-2048
2048-4096
Bedrock
Particle Size (mm)
MY5
MY2
MY1

Unnamed Tributary
Pebble Count - Percent Individual
Cross Section #8 - Run



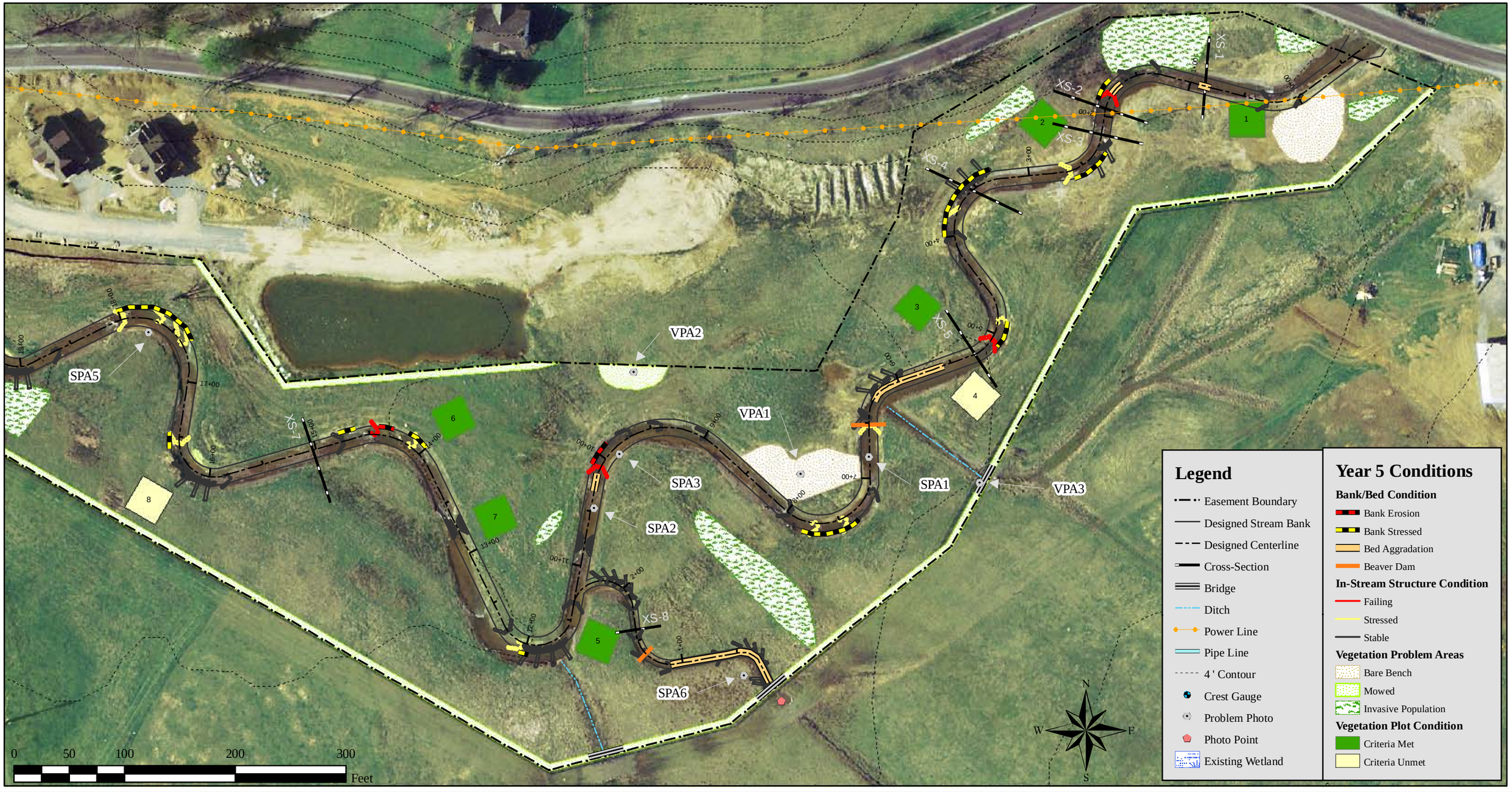
Appendix C
Hanging Rock Creek
Wetland Data
(Not Applicable)

Appendix D
Hanging Rock Creek
Integrated Current Condition Plan View

Intergrated Current Condition Plan View

Prepared for	**Project:** Hanging Rock Creek & Tributary Restoration Year 5 Monitoring Avery County, North Carolina	Notes: 1) Base Map from CAD file "HR_proposed.dgn" Provided By NCEEP 2) 2005 Aerial Photo 3) Invasive/Exotic populations are predominately comprised of *Rosa Multiflora*	Prepared by
Ecosystem Enhancement Program	Sheet 1 of 3		EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN
	Date	Project Number	
	May 2009	NCEEP # 165	

Intergrated Current Condition Plan View



Prepared for	**Project:**	Notes:	Prepared by
Ecosystem Enhancement Program	Hanging Rock Creek & Tributary Restoration Year 5 Monitoring Avery County, North Carolina	1) Base Map from CAD file "HR_proposed.dgn" Provided By NCEEP 2) 2005 Aerial Photo 3) Invasive/Exotic populations are predominately comprised of *Rosa Multiflora*	EQUINOX ENVIRONMENTAL CONSULTATION & DESIGN
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Intergrated Current Condition Plan View

Year 5 Conditions

Bank/Bed Condition
- Bank Erosion
- Bank Stressed
- Bed Aggradation
- Beaver Dam

In-Stream Structure Condition
- Failing
- Stressed
- Stable

Vegetation Problem Areas
- Bare Bench
- Mowed
- Invasive Population

Vegetation Plot Condition
- Criteria Met
- Criteria Unmet

Legend
- Easement Boundary
- Designed Stream Bank
- Designed Centerline
- Cross-Section
- Bridge
- Ditch
- Power Line
- Pipe Line
- 4 ' Contour
- Crest Gauge
- Problem Photo
- Photo Point
- Existing Wetland

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