Clear Creek
Monitoring Report
Year 5 of 5 (2008)

Henderson County, North Carolina

USGS HUC: 06010105
Project ID No. 92

Prepared for:

NCDENR-Ecosystem Enhancement Program
1652 Mail Service Center
Raleigh, North Carolina 27699-1652

May 2009

Executive Summary

The Clear Creek Stream Restoration project falls within USGS hydrologic unit **06010105.** The project lies within a rural setting that includes pasture, farmland, and low density residential areas. Prior to restoration work, the project stream had been destabilized though channelization and hoof-shear.

EcoLogic Associates designed the restoration plans and restoration was completed in 2002. Kimley-Horn and Associates (KHA) performed stream and riparian monitoring during 2008 for this year 5 monitoring report. During the late growing season, KHA assessed four (4) vegetation quads. Combined stem count density for all the quads equaled approximately 400 stems per acre for planted stems: exceeding year 5 success criteria. A small area of Kudzu remains near the downstream section of the stream. This area has not expanded since 2006. Isolated areas of invasive species such as Russian Olive are also present.

The stream assessment that included a visual assessment and geomorphic survey indicated that the project reach was performing mostly within established success criteria ranges. Most of the project reach continues to be stable. The geomorphic measurements are within the ranges of the design parameters.

Table of Contents

Figures

Project Tables

Appendices

1.0 Project Background

1.1 Location and Setting

The Clear Creek stream restoration project is located between I-26 and Clear Creek Road in Henderson County, NC. The site, a fourth order tributary to Mud Creek in the French Broad River Basin, is located in a relatively low slope mountain valley.

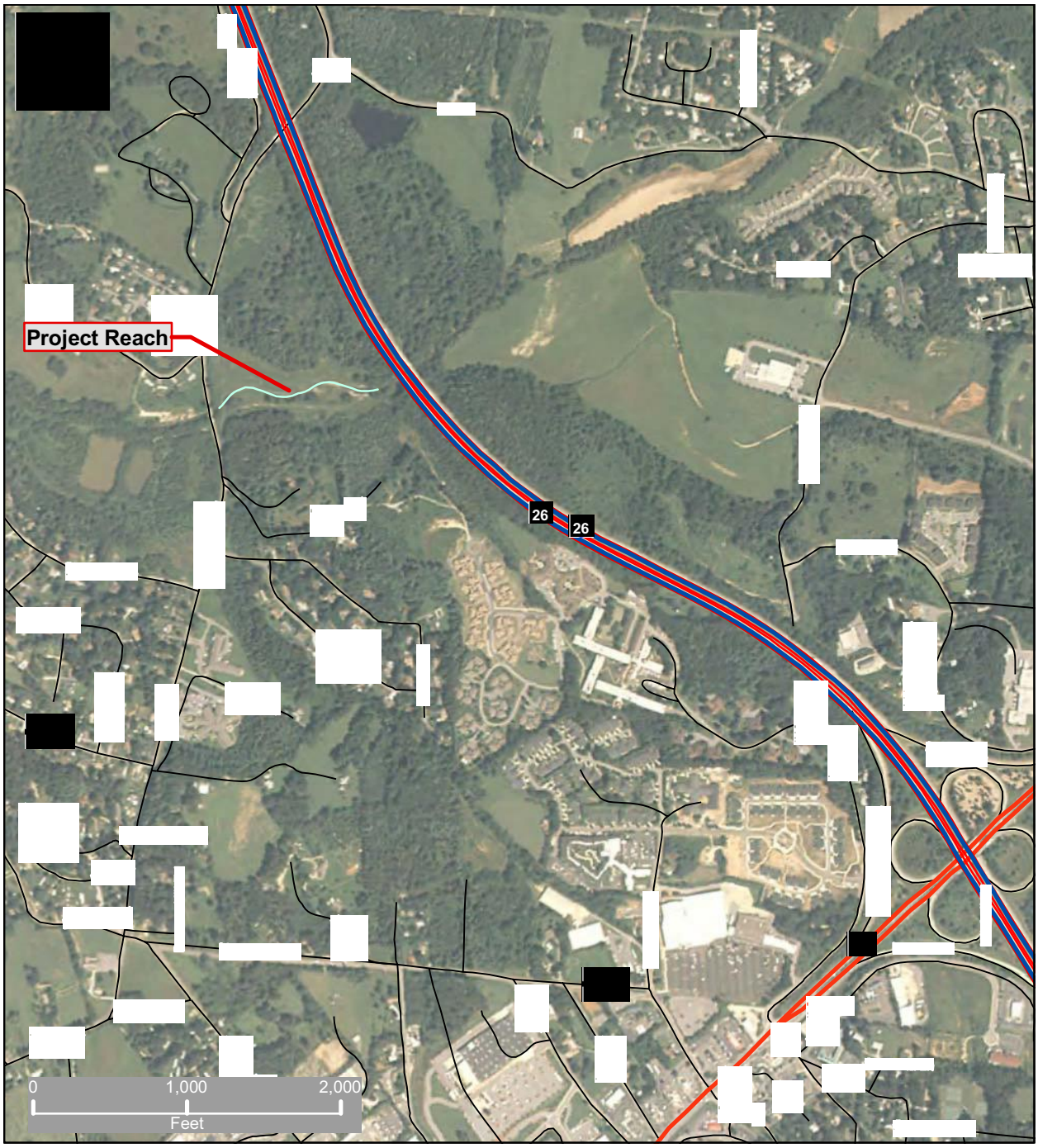
Figure 1 shows the project vicinity and mitigation features.

1.2 Project Structure, Mitigation Type, Approach and Objectives

Prior to restoration, a majority of the reach's stream banks were nearly vertical and exposed, with minimal vegetative cover. As a result, the banks were actively eroding, subsequently slumping and promoting lateral channel migration and meander creation. The degraded channel was classified as an "F" type channel under the Rosgen Stream Classification System. Some sections of channel were incised and had limited access to their historic flood plain during large flood flows, but not during bankfull events that typically occur as a result of the 1.5 to 2 year storm event.

The project included 1,300 linear feet of stream restoration. Project Table I shows a summary of the project structure and objectives.

Figure 1: Project Setting



Prepared For	Project	Clear Creek Stream Restoration Monitoring Year 5 (2008) Henderson, North Carolina	Prepared By
Ecosystem Enhancement Program			Kimley-Horn and Associates, Inc.
	Date	Project Number	
	05/27/2009	92	

1.3 Project History and Background

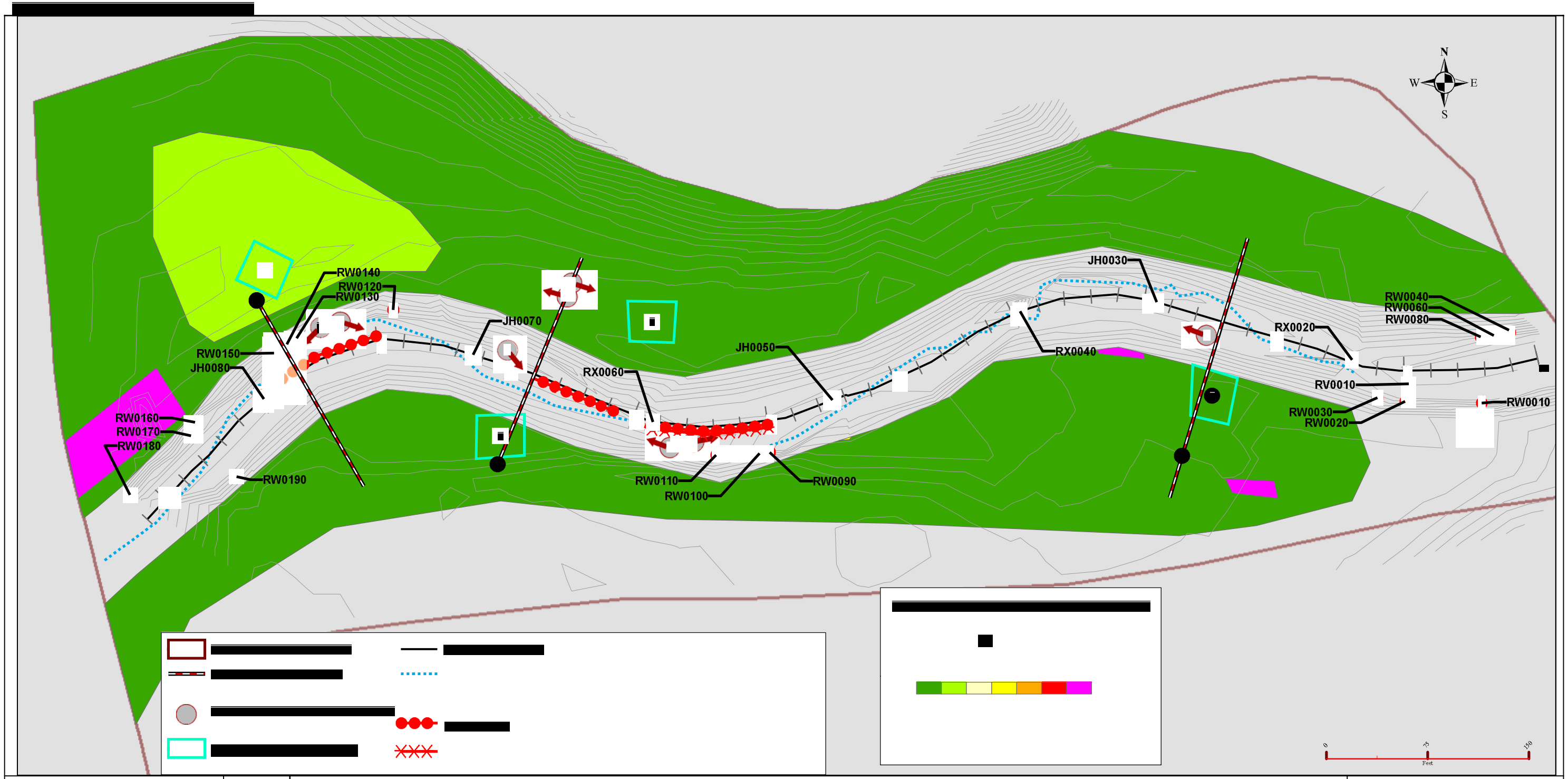
Construction of the Clear Creek Stream Restoration began in early 2002 with construction ending in the fall of 2002. The As-built survey was completed in early 2003. 2008 served as Year 5 of monitoring. Project Table II provides additional details regarding the timeline of the project.

The project was designed by EcoLogic Associates. The construction contractor is unknown. KHA performed monitoring work for Year 5. Project Table III provides additional information regarding contractors.

The project is located within Henderson County, portions of which are located within the Blue Ridge Belt of the Mountains of North Carolina. The site is located within a moderately rural area. Project Table IV provides additional information regarding the stream.

1.4 Monitoring Plan View

The monitoring plan assesses the project stream's geomorphology using a set of three (3) cross sections located throughout the project reach. The longitudinal profile and pattern assessment covered the entire reach. Twenty-nine (29) permanent photo points had been used to provide for a visual comparison of key site features through time. During 2007, KHA modified the number and location of the photo points to reduce redundancies and streamline comparison points. The monitoring plan uses four (4) randomly placed vegetation quads to assess riparian buffer restoration. KHA performed channel material sampling at each cross section. Figure 2 shows the locations of the monitoring features.



Ecosystem Enhancement Program

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2.0 Project Conditions and Monitoring Results

2.1 Vegetation Assessment

The Clear Creek site consists of two vegetative zones: riparian buffer and stream banks. The riparian buffer zone begins at the top of the bank and continues out perpendicular from the stream. The planted stream bank begins at the normal base flow elevation and extends to the top of bank or interface with the flood plain. Success criteria require 260 live stems per acre within the restoration area during year 5 of a 5-year monitoring period.

The kudzu (*Pueraria montana*) population reported during the MY2 2005 monitoring report remains on site. The population falls within an isolated area near Clear Creek Road and does not appear be spreading. A small riparian area upstream of the kudzu population along the right bank does not appear to be thriving. Vegetation growth in this area is more scattered and less vigorous than the rest of the site. Russian olive (*Elaegnus pungens*) grows in isolated populations (3-4 specimens) throughout the site. The larger populations are shown on Figure 2.

Appendix A provides representative photos of problem areas and sampling areas. Figure 2 shows the problem areas.

KHA conducted a vegetation assessment during the early fall of 2008. Appendix A summarizes the results of the vegetation sample. Three (3) of the four (4) plots met success criteria for planted stem counts. Plot 3 contains less planted stems than required, but total stems including volunteers exceed success criteria. The plot summary also shows that in the plots on the left side of the stream, river birch (*Betula nigra*) is rapidly colonizing.

2.2 Stream Assessment

Events in 2004 and 2005 generated several isolated instances of bank scour, which have advanced little over the monitoring period. The percentage of bank exhibiting scour has maintained levels between 8% and 10% since that time, with little advancement. In between the large storms related to the remnant hurricanes of 2004, the bank was hardened near the old channel plug at the top of the project. The flow vectors coming into the project under the I-26 bridge led to concerns after the first event that the forecasted, second event might re-enter or avulse into the abandoned channel on stream left. This hardening is observable in photos PS1. As per EEP, it was always intended to re-grade and replant that area once additional observation provided confidence that the vectors and conditions would not lead to an avulsion. This was carried out in winter of 2008/2009 and while equipment was already on site, another area between station 9+00 and 10+00 on stream right was repaired as well. This area did not seem to completely arrest its advancement as with the other areas of bank scour. This included resloping, root wrap installation, and plantings. Three structures designed to provide bank protection exhibited some loss of structural integrity or did not provide complete bank protection as intended. These conditions did not noticeably advance after their initial onset.

EEP installed a crest gage near permanent cross section XS-2. During the October field visit, the gage indicated that bankfull events had occurred since the last reading. A listing of bankfull events based on the estimated bankfull discharge from a proximate USGS gauge and on-site crest gauge is provided in Project Table V.

Project Table VI provides a categorical view of the stream visual stability assessment. The visual assessment shows maintenance of stability related to bank condition. Riffles, thalweg, meanders have maintained or improved function compared to the previous year. The initial stresses and functional losses experienced by a few structures did not change in any significant way over the monitoring period. Meander instability relates to floodplain relief and point bar slope. The meanders do not exhibit classic, well developed point bars of C channels. The project's dimension represents an E/C channel and exhibits steep inner meanders, which can represent pressure on the outer meander. Some meanders have exhibited modest, slow, lateral migration, but this appears to be at a sustainable rate such that the inner meander builds at a complementary modest rate. The area between station 900 and 1000 appears to have been the most pronounced and was addressed as part of the aforementioned remediation. The thalweg appears to be actively shifting and mobile. In opposition to 2007, the alignment of the thalweg appeared to be more appropriate. In some locations multiple thalweg lines were present within a section of channel. The riffles appeared to be short and this may be related to the shifting thalweg. Table B2 in Appendix B provides a breakdown of the visual assessment.

Project Tables VII and VIII summarize the sites geomorphic assessment. The longitudinal profile utilizes bankfull measurements based on observations in the field. Bankfull indicators for cross sections align with the previous years' data to allow direct comparison. In the past, the field investigators had difficulty identifying and/or isolating cross section benchmarks in the field; therefore, some of the cross sections had a slightly different alignment than the previous years' cross sections. The difference in alignment negates a very fine comparison between years for a cross section but does allow for the identification of significant changes in cross section. The cross sections did not show a significant change in the shape compared to last year. Appendix B provides photographs and graphing for geomorphic data.

3.0 Methodology

Monitoring methods for 2008 were similar to those used during the 2007 effort.

PROJECT TABLES

Table I. Project Restoration Components
Clear Creek Stream Restoration Site (EEP Project #92)

Project Segment or Reach ID		[redacted]					Stationing	Comment
Main	1,300	R	PI	1,300 lf	1:1	1,300	0+00.0 - 13+00.0	

Mitigation Unit Summaries

Stream (lf)	Riparian Wetland	Non-Riparian Wetland (Ac.)	Total Wetland (Ac.)	Buffer (Ac.)	Comment
1,300	0.0	0.0	0.0		

R = Restoration
EI = Enhancement
EII = Enhancement
S = Stabilization
P1 = Priority I
P2 = Priority II
P3 = Priority III
SS = Stream Bank stabilization

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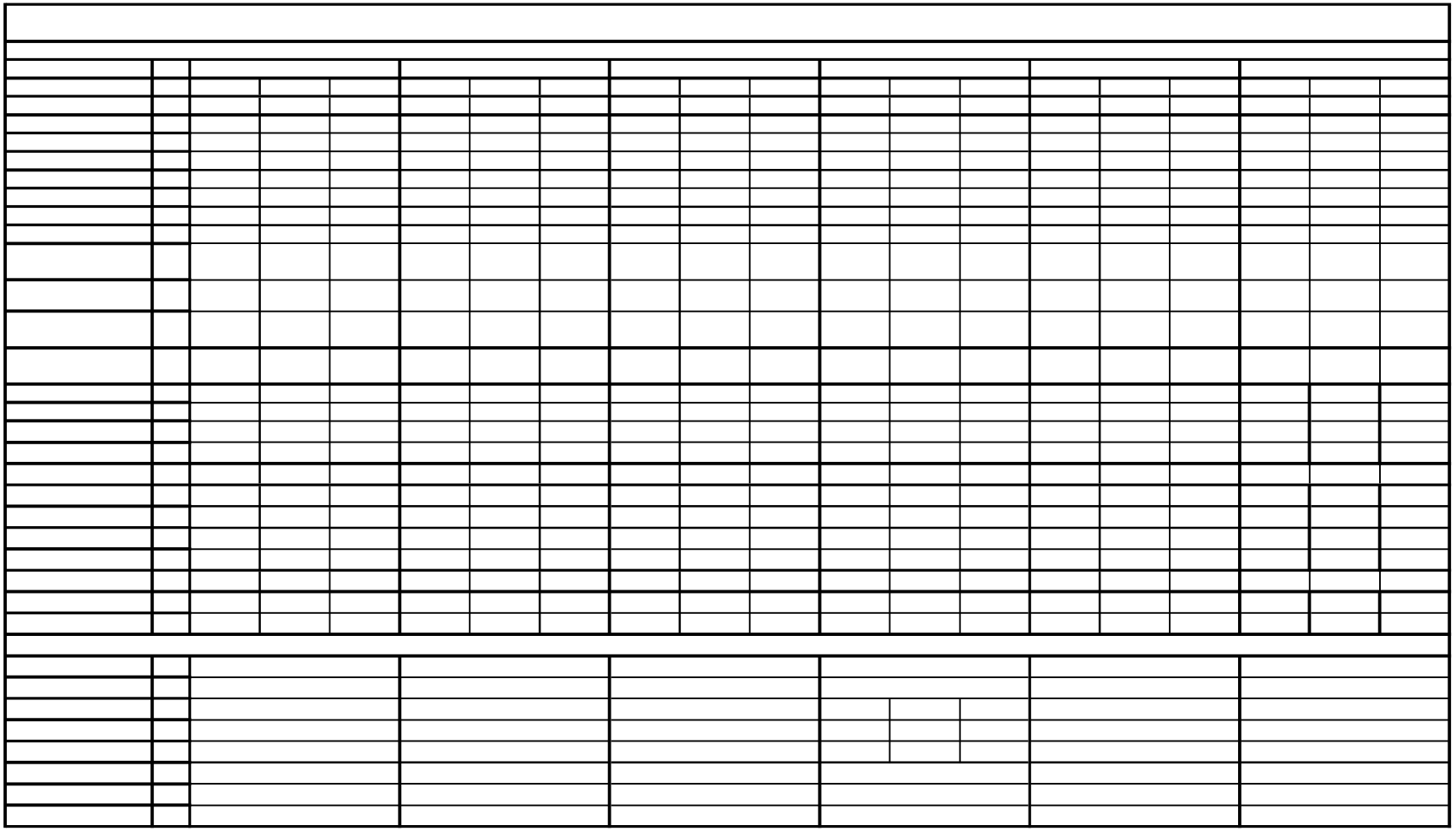
Table II. Project Activity and Reporting History Clear Creek Stream Restoration Site (EEP Project #92)				
Activity or Report	**Scheduled Completion**	**Data Collection Complete**	**Actual Completion or Delivery**	**Comments**
Restoration Plan		December-01	March-02	
Final Design – 90%				
Construction			Fall 2002	
Temporary S&E mix applied to entire project area				
Permanent seed mix applied				
Containerized and B&B plantings for reach/segments 1&2				
Mitigation Plan / As-built (Year 0 Monitoring –			October-02	
Year 1 Monitoring	December-04			
Year 2 Monitoring	December-05	November-05	December-05	Performed by Soil and Environmental Consultants, PA
Year 3 Monitoring	December-06	November-06	January-07	Performed by Kimley - Horn and Associates, Inc.
Year 4 Monitoring	December-07	Novermber-07	February-08	Performed by Kimley - Horn and Associates, Inc.
Year 5 Monitoring	December-08	October-08		Performed by Kimley - Horn and Associates, Inc.

Table III. Project Contact Table Clear Creek Stream Restoration Site (EEP Project #92)		
Designer		
EcoLogic Associates	Greensboro, NC	
Primary Designer POC		
Construction Contractor		
Primary Contractor POC		
Planting Contractor		
Planting contractor POC		
Seeding Contractor		
Planting contractor POC		
Seed Mix Sources		
Nursery Stock Suppliers		
Monitoring Performers	PO Box 33068	
	Raleigh, NC	
Stream Monitoring POC	Daren Pait, P.E.	(919) 678-4155
Vegetation Monitoring POC	Daren Pait, P.E.	(919) 678-4155

Table IV. Project Background Table Clear Creek Stream Restoration Site (EEP Project #92)	
Project County	Henderson
Drainage Area	44 mi^2
Drainage impervious cover estimate (%)	20%
Stream Order	4^{th}
Physiographic Region	Mountains
Ecoregion	Blue Ridge Belt
Rosgen Classification of As-built	C4
Cowardin Classification	N/A
Dominant soil types	Codorus
Reference site ID	N/A
USGS HUC for Project and Reference	06010105
NCDWQ Sub-basin for Project and Reference	04-03-02
NCDWQ classification for Project and Reference	C
Any portion of any project segment 303d listed?	No
Any portion of any project segment upstream of a 303d listed segment?	No
Reasons for 303d listing or stressor	N/A
% of project easement fenced	0%

Table V. Verification of Bankfull Events Clear Creek Stream Restoration Site (EEP Project #92)			
Date of Data	**Date of Occurrence**	**Method**	**Photo #**
7/2/2003	7/2/2003	Proximal USGS Gauge (ID#03446000)	
9/8/2004	9/8/2004	Proximal USGS Gauge (ID#03446000)	
10/13/2008	10/13/2008	Crest Gauge	

Table VI. Categorical Stream Feature Visual Stability Assessment Clear Creek Stream Restoration Site (EEP Project #92)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	--	--	90%	80%	80%	80%
B. Pools	--	--	100%	100%	100%	75%
C. Thalweg	--	--	100%	50%	50%	71%
D. Meanders	--	--	100%	75%	75%	94%
E. Bed General	--	--	100%	100%	100%	100%
F. Bank Condition	--	--	98%	93%	90%	90%
G. Vanes / J Hooks etc.	--	--	85%	75%	75%	66%
H. Wads and Boulders	--	--	63%	65%	65%	85%



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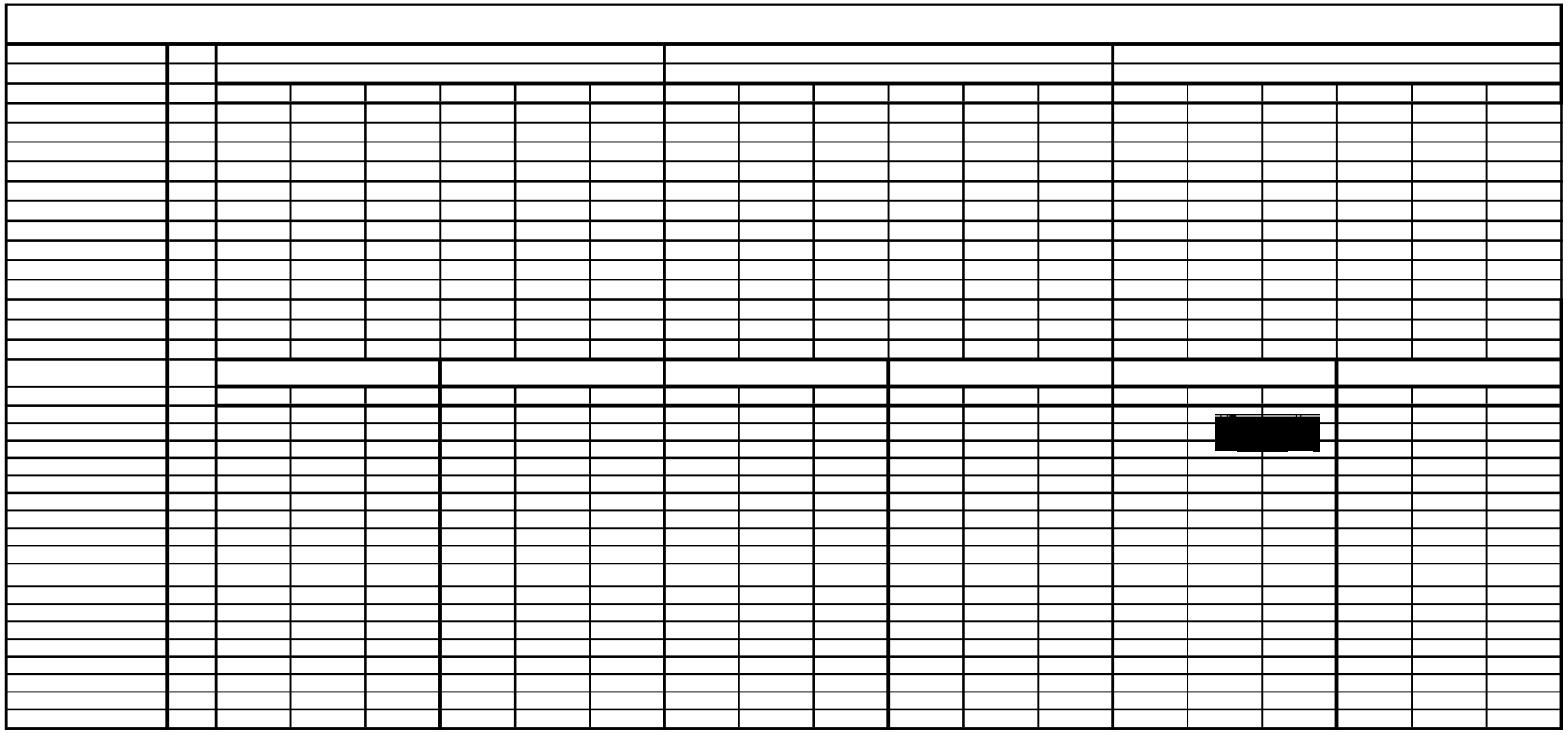
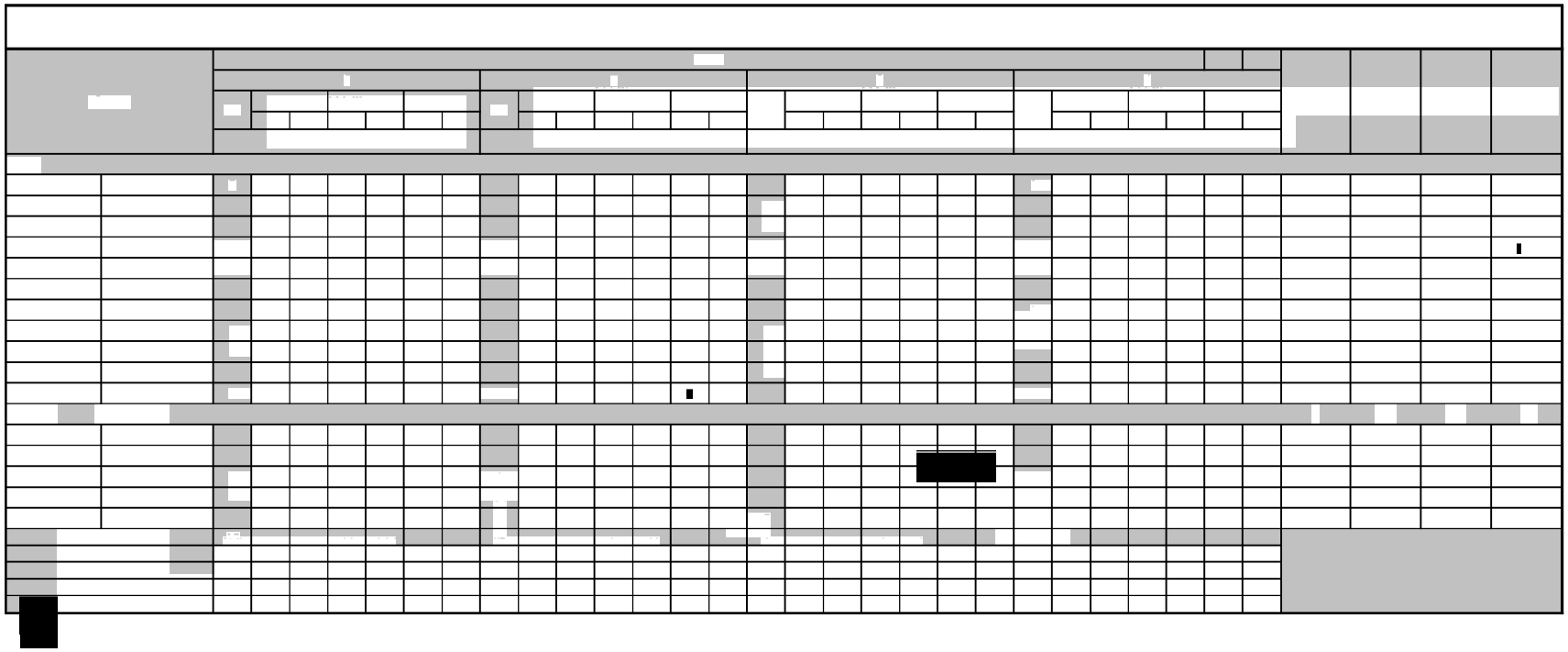


APPENDIX A
VEGETATION MONITORING DATA



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VQ1: Vegetation Quad 1
Taken: 2005

VQ1: Vegetation Quad 1
Taken: 10/05/2006

VQ1: Vegetation Quad 1
Taken: 10/11/2007

VQ1: Vegetation Quad 1
Taken: 10/13/2008

VQ2: Vegetation Quad 2
Taken: 2005

VQ2: Vegetation Quad 2
Taken: 10/05/2006

VQ2: Vegetation Quad 2
Taken: 10/11/2007

VQ2: Vegetation Quad 2
Taken: 10/13/2008

VQ3: Vegetation Quad 3
Taken: 2005

VQ3: Vegetation Quad 3
Taken: 10/05/2006

VQ3: Vegetation Quad 3
Taken: 10/11/2007

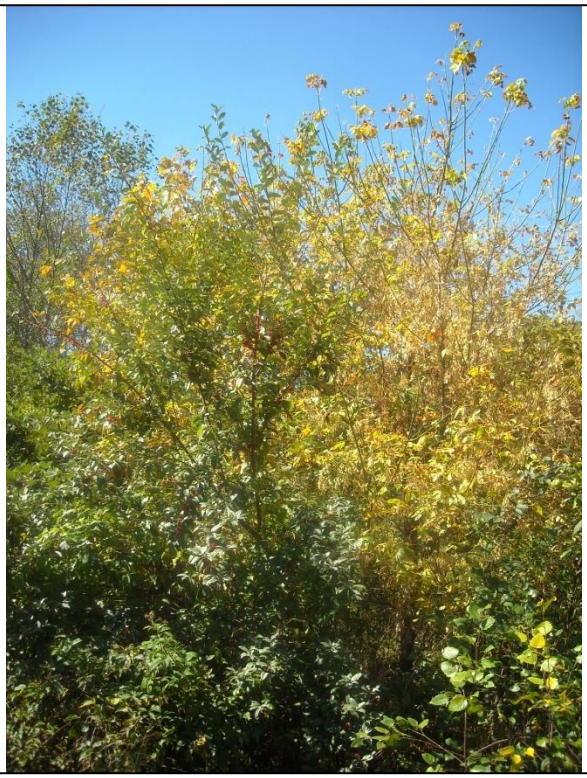
VQ3: Vegetation Quad 3
Taken: 10/13/2008

VQ4: Vegetation Quad 4
Taken: 2005

VQ4: Vegetation Quad 4
Taken: 10/05/2006

VQ4: Vegetation Quad 4
Taken: 10/11/2007

VQ4: Vegetation Quad 4
Taken: 10/13/2008

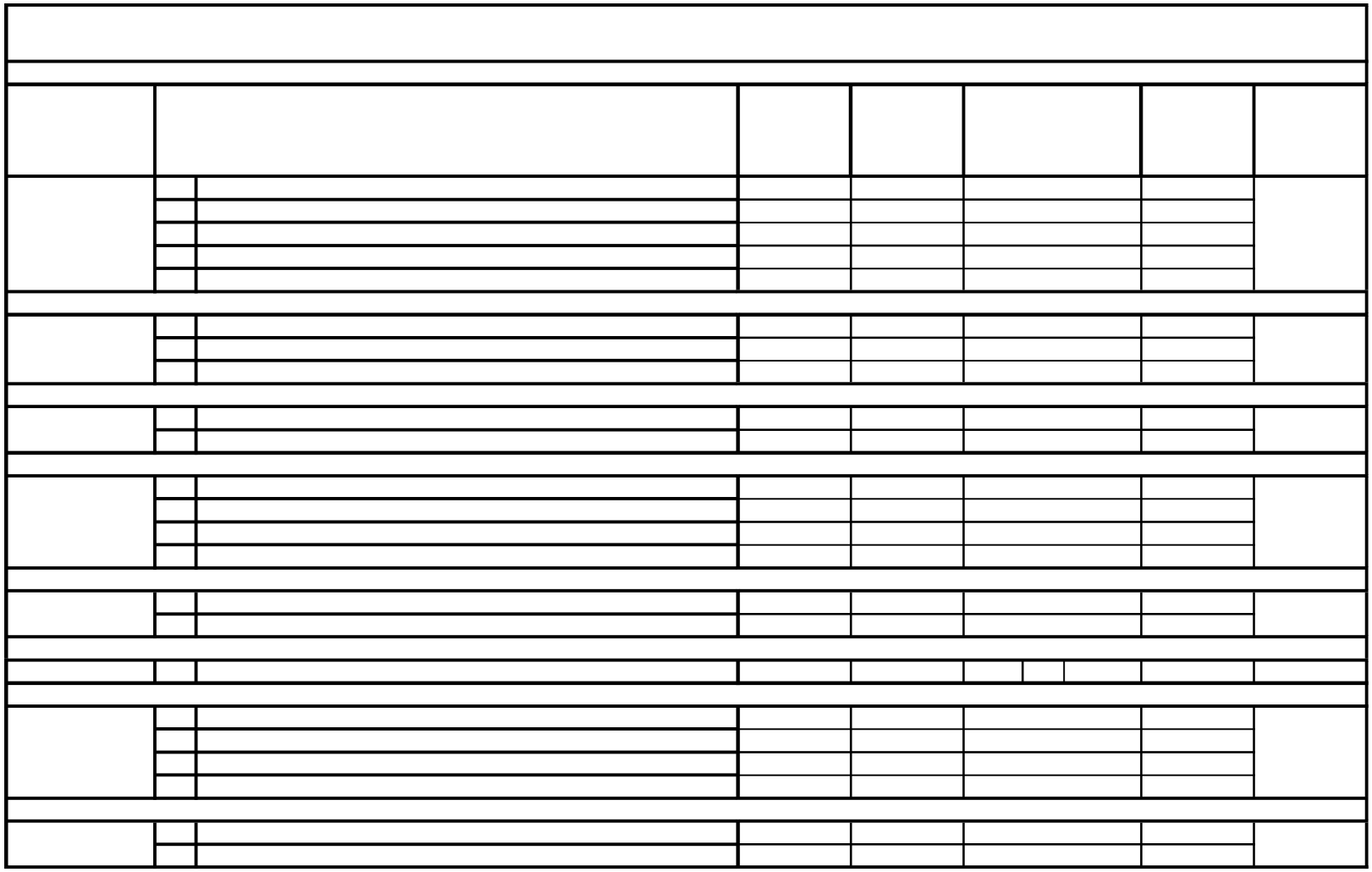


VP1: Stand of Russian Olive. Typical of stands scattered through site.

APPENDIX B
STREAM MONITORING DATA

Table I. Stream Problem Areas
Clear Creek Stream Restoration Site (EEP Project #92)

Feature Issue	Reach	Station numbers	Description	Suspected Cause	Photo number
2008					
Aggradation/Bar Formation					
Bank scour		600 - 690	Bank Slump/ Bank Scour	Excessive shear stress	SP1
		715 - 780	Bank Scour	Back eddy from upstream in-stream stabilization	SP2
		900 - 1,000	Bank Scour	Excessive shear stress	SP3
Engineered structures – back or arm scour Etc.		545	Structure Collapse	Excessive shear stress	
		690	Excessive Arm Scour	Back eddy due to improper geomerty	
		990	Structure Collapse	Excessive shear stress	
		600 - 650	Rootwad Scour	Excessive shear stress	
		940 - 980	Rootwad Scour	Excessive shear stress	
2007					
Aggradation/Bar Formation					
Bank scour		100 - 150	Bank Scour	Excessive shear stress	
		200 - 240	Bank Scour	Excessive shear stress	
		410 - 430	Bank Scour	Excessive shear stress	
		710 - 750	Bank Slump/ Bank Scour	Back eddy from upstream in-stream stabilization	
		780 - 810	Bank Scour	Excessive shear stress	
		940 - 980	Bank Scour	Excessive shear stress	
		1,020 - 1,050	Bank Scour	Excessive shear stress	
Engineered structures – back or arm scour Etc.		100 - 150	Partial Strucutre Collapse	Excessive shear stress	
		545	Structure Collapse	Excessive shear stress	
		690	Excessive Arm Scour	Back eddy due to improper geomerty	
		810	Missing header rock	Excessive shear stress	
		600 - 650	Rootwad Scour	Excessive shear stress	
		940 - 980	Rootwad Scour	Excessive shear stress	
2006					
Aggradation/Bar Formation					
Bank scour		100 - 150	Bank Scour	Excessive shear stress	
		200 - 240	Bank Scour	Excessive shear stress	
		710 - 750	Bank Slump/ Bank Scour	Back eddy from upstream in-stream stabilization	
		780 - 810	Bank Scour	Excessive shear stress	
		1,020 - 1,050	Bank Scour	Excessive shear stress	
Engineered structures – back or arm scour Etc.		100 - 150	Partial Strucutre Collapse	Excessive shear stress	
		545	Structure Collapse	Excessive shear stress	
		690	Excessive Arm Scour	Back eddy due to improper geomerty	
		810	Missing header rock	Excessive shear stress	
		600 - 650	Rootwad Scour	Excessive shear stress	
		940 - 980	Rootwad Scour	Excessive shear stress	
2005					
Bank Scour		121 - 166		Scour at arm of crossvane	
		212 - 229		Scour at arm of crossvane	
		975 - 1,007		Root wads on outside bend, excessive scour	
Stressed or Failing Structures					
		1,068 - 1,092		Root wads on outside bend (near crossvane), excessive scour	
		975 - 1,007		Root wads on outside bend, excessive scour	
		1,068 - 1,092		Root wads on outside bend (near crossvane), excessive scour	



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Permanent Photo PS01
Taken: 2005

Permanent Photo PS01
Taken: 2006

Permanent Photo PS01
Taken: 2007

Permanent Photo PS01
Taken On: 10/13/2008

Permanent Photo PS02
Taken: 2005

Permanent Photo PS02
Taken: 2006

Permanent Photo PS02
Taken: 2007

Permanent Photo PS02
Taken: 10/13/2008

Permanent Photo PS03
Taken: 2007

Permanent Photo PS03
Taken: 10/13/2008

Permanent Photo PS04
Taken: 2005

Permanent Photo PS04
Taken: 2006

Permanent Photo PS04
Taken: 2007

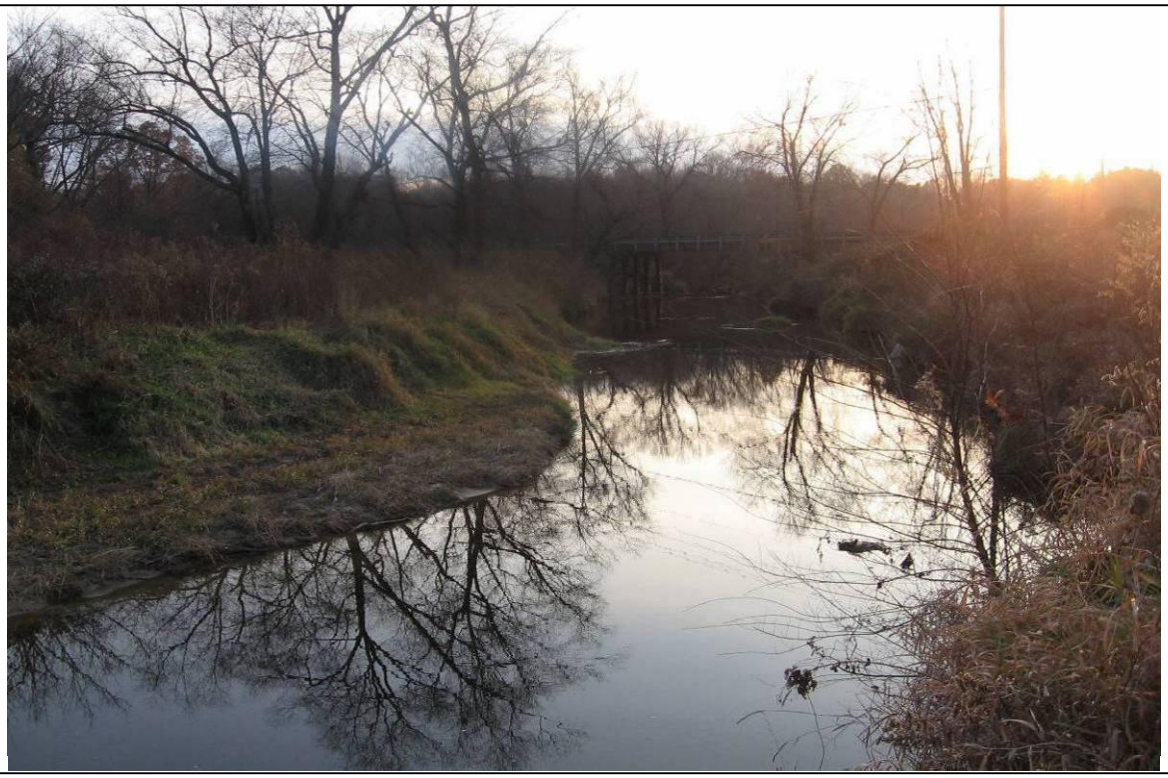
Permanent Photo PS04
Taken: 10/13/2008

Permanent Photo PS05
Taken: 2007

Permanent Photo PS05
Taken: 10/13/2008

Permanent Photo PS06
Taken: 2007

Permanent Photo PS06
Taken: 10/13/2008



Permanent Photo PS07
Taken: 2007

Permanent Photo PS07
Taken: 10/13/2008

Permanent Photo PS08
Taken: 2007

Permanent Photo PS08
Taken: 10/13/2008

Permanent Photo PS09
Taken: 2005

Permanent Photo PS09
Taken: 2006

Permanent Photo PS09
Taken: 2007

Permanent Photo PS09
Taken: 10/13/2008

Permanent Photo PS10
Taken: 2007

Permanent Photo PS10
Taken: 10/13/2008

SP1: Eroding bank
Taken 10/13/2008

SP2: Eroding bank with undercut rootwads
Taken 10/13/2008

SP3: Scour behind rootwads
Taken 10/13/2008

Figure 1. Clear Creek Longitudinal Profile (2008)

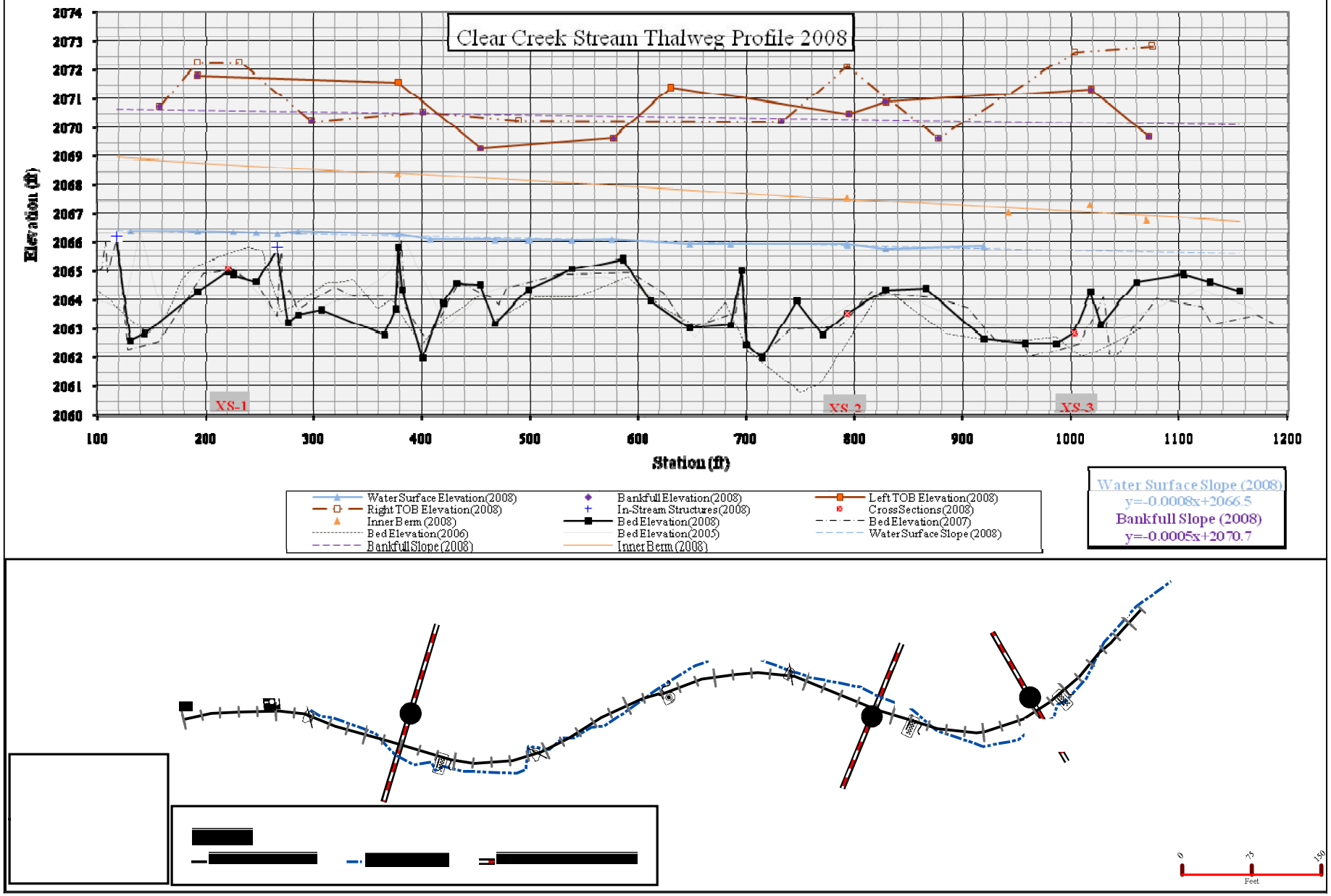
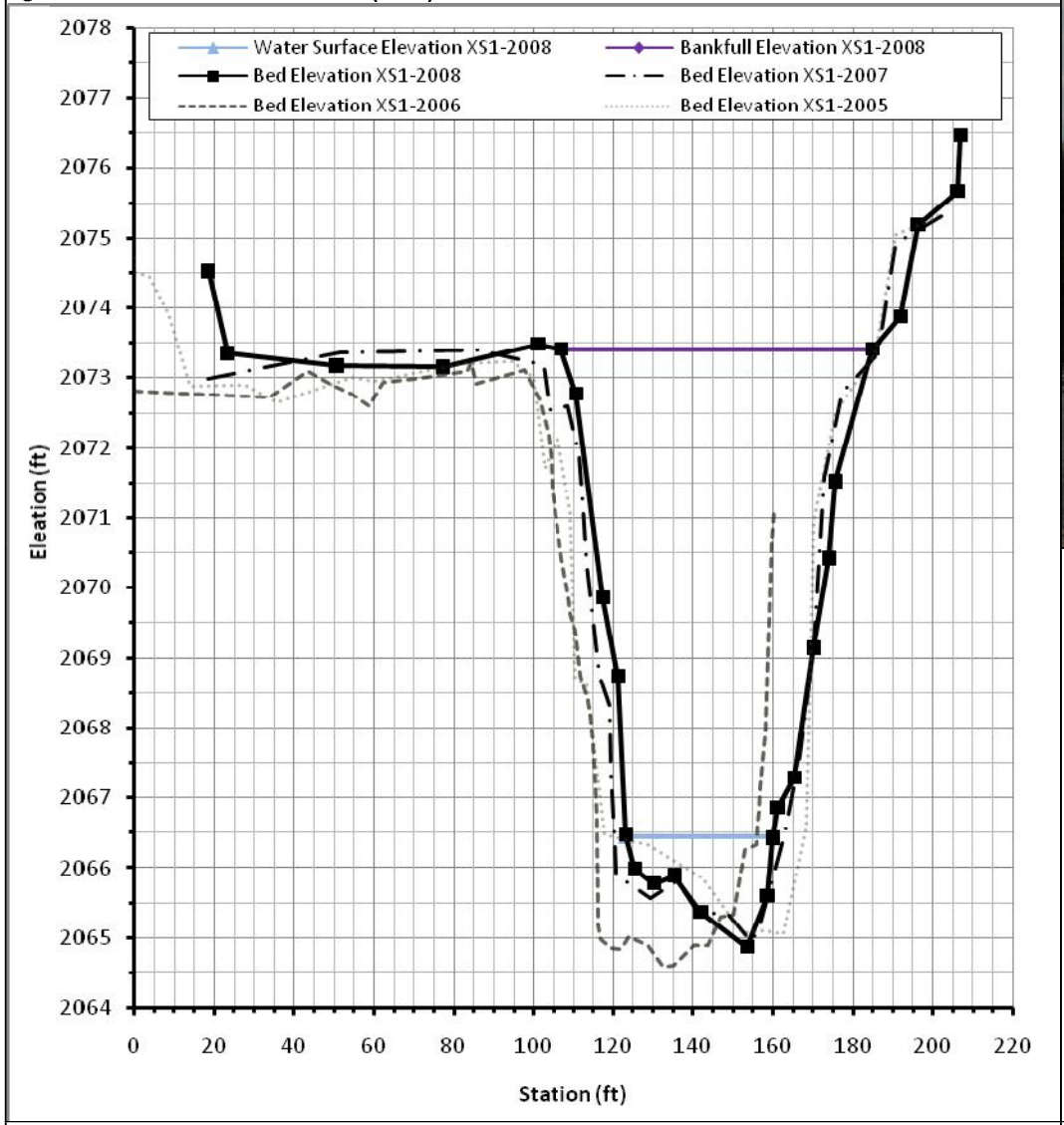


Figure 2. Clear Creek Cross Section 1 (2008)



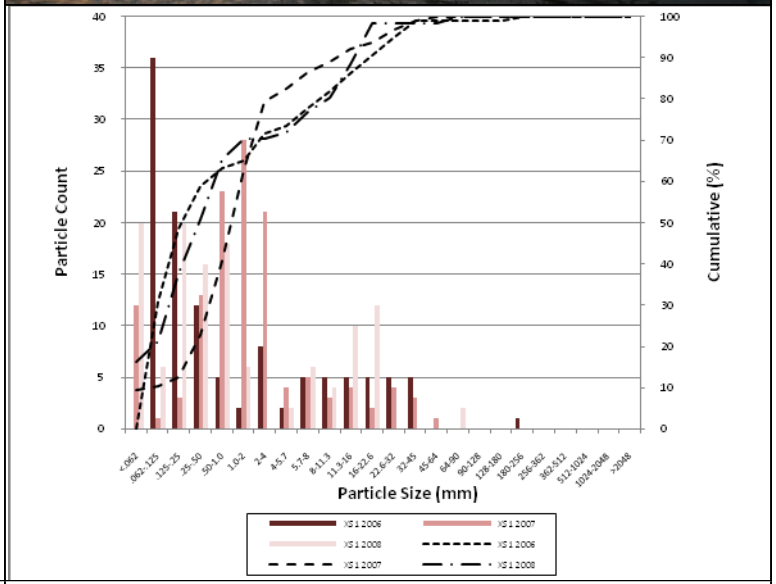
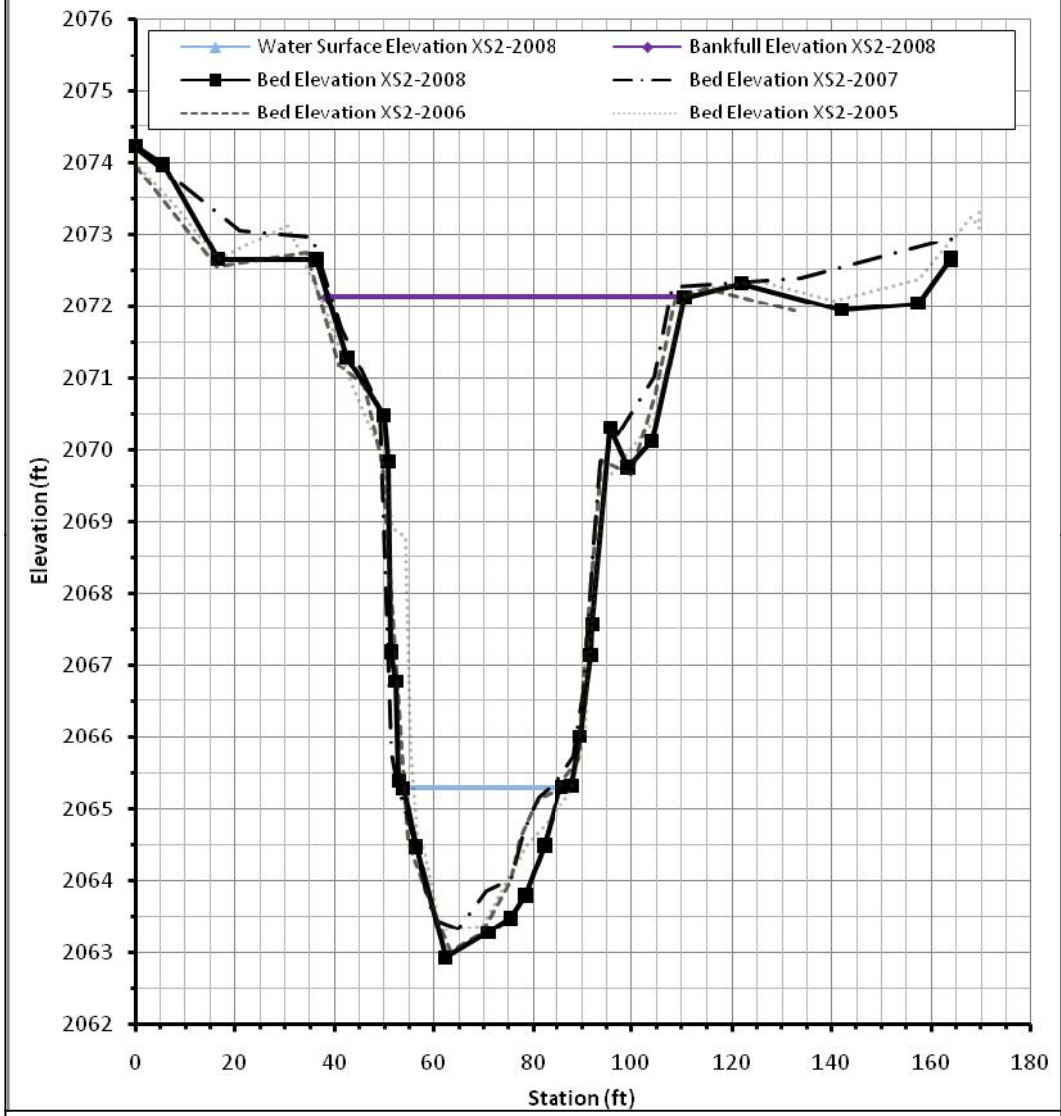


Figure 3. Clear Creek Cross Section 2 (2008)



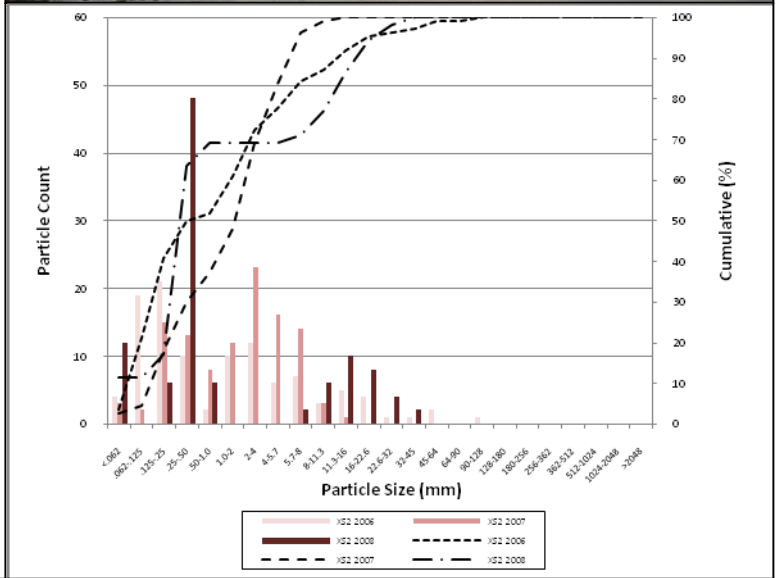


Figure 4. Clear Creek Cross Section 3 (2008)