Clear Creek Final Monitoring Report
Year 3 of 5 (2006)

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

January 2007

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 2006 for this year 3 monitoring report. During the late growing season, KHA assessed four (4) vegetation quads. Combined stem count density for all the quads equaled approximately 464 stems per acre for planted stems: exceeding year 3 success criteria. Vegetation on the left side is performing better than vegetation on the right side of the stream. A small area of Kudzu remains near the bottom of the stream. Isolated areas of invasives such as 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. Several isolated sections showed bank erosion and a few structures were stressed or failing. Most of the project reach continues to be stable. The geomorphic measurements are within the ranges of the design parameters.

Table of Contents

Tables

Figures

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, the 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. Table I shows a summary of the project structure and objectives.

Table I: Project Mitigation Structure and Objectives Table

Table I. Project Restoration Components
Clear Creek Stream Restoration Site (EEP Project #19)

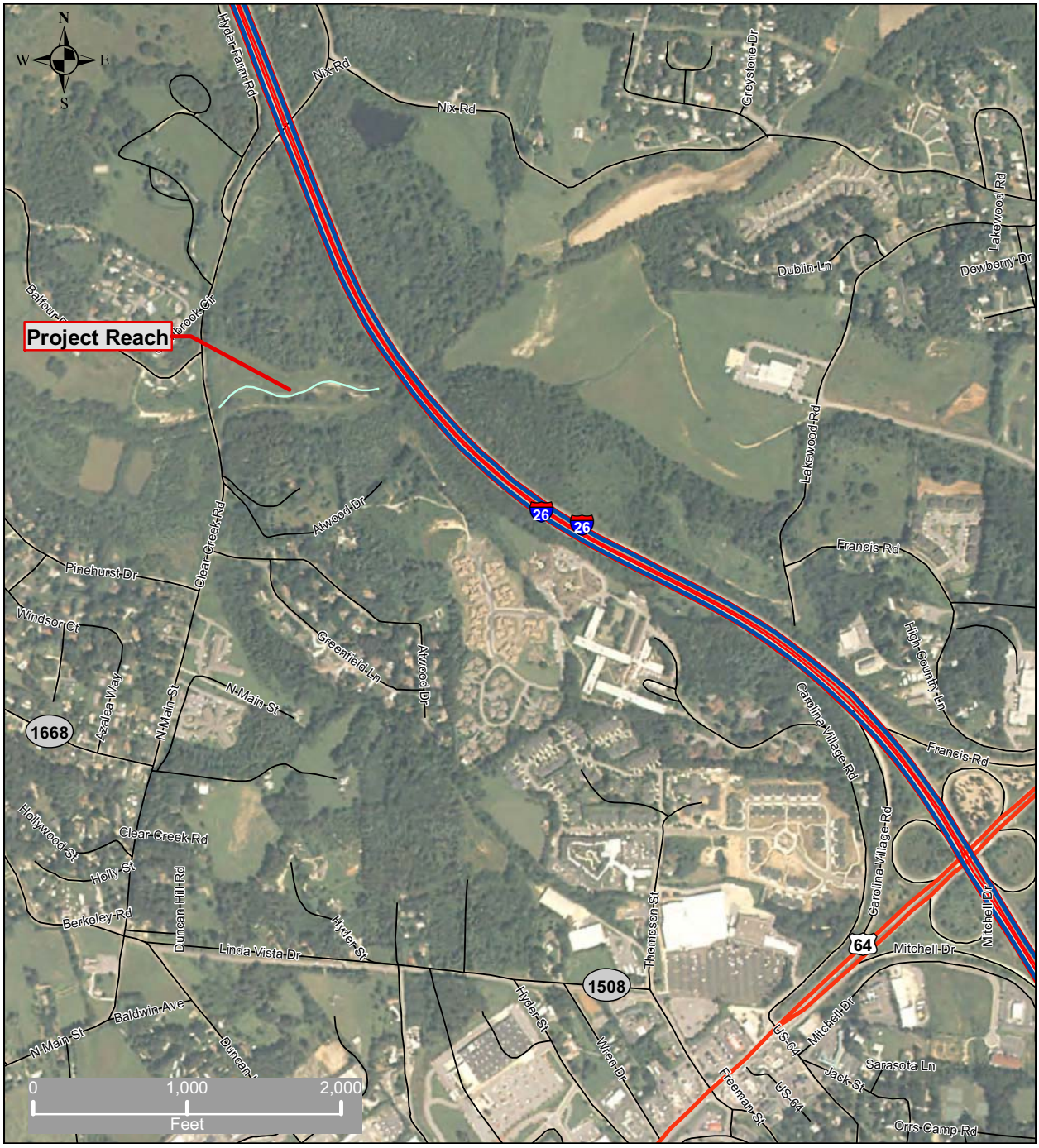
Project Segment or Reach ID	Existing Feet / Acres	Type	Approach	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Main	1,300	R	PI	1,300 lf	1:1	1,300	0+00.0 - 13+00.0	

Mitigation Unit Summaries

Stream (lf)	Riparian Wetland (Ac.)	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

Figure 1: Project Setting



Prepared For	Project	Clear Creek Stream Restoration Monitoring Year 3 (2006) Henderson, North Carolina	Prepared By
Ecosystem Enhancement Program			Kimley-Horn and Associates, Inc.
	Date	Project Number	
	1/22/07	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. 2006 served as Year 3 of monitoring. Table II provides additional details regarding the timeline of the project.

Table II: Project Activity and Reporting History

Table II. Project Activity and Reporting History Clear Creek Stream Restoration Site (EEP Project #19)				
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 – baseline)			October-02	
Year 1 Monitoring	December-04			
Year 2 Monitoring	December-05	November-05	December-05	
Year 3 Monitoring	December-06	November-06	January-07	
Year 4 Monitoring	December-07			
Year 5 Monitoring	December-08			

The project was designed by EcoLogic Associates. The construction contractor is unknown. KHA performed monitoring work for Year 3. Table III provides additional information regarding contractors.

Table III: Project Contact Table

Table III. Project Contact Table Clear Creek Stream Restoration Site (EEP Project #19)		
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	Andrew Kiley	(919) 678-4150
Vegetation Monitoring POC	Andrew Kiley	(919) 678-4150

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. Table IV provides additional information regarding the stream.

Table IV: Project Background Table

Table IV. Project Background Table Clear Creek Stream Restoration Site (EEP Project #19)	
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%

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 provide for a visual comparison of key site features through time. The monitoring plan uses four (4) randomly placed vegetation quads to assess riparian buffer restoration. KHA performed channel material sampling at each cross section. Figures 2 and 3 show the locations of the monitoring features.

Figure 2: Monitoring Plan View Sheet 1

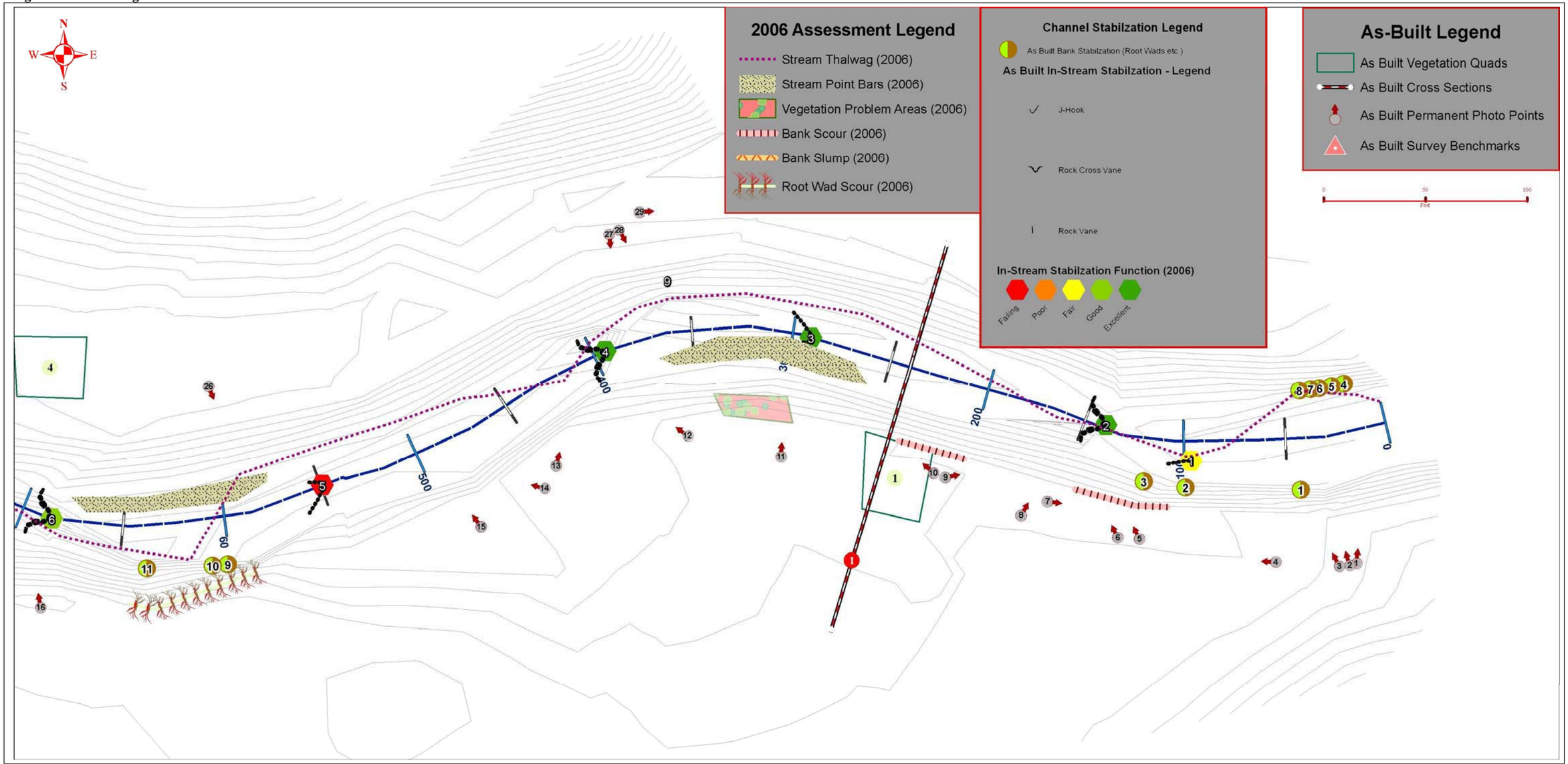


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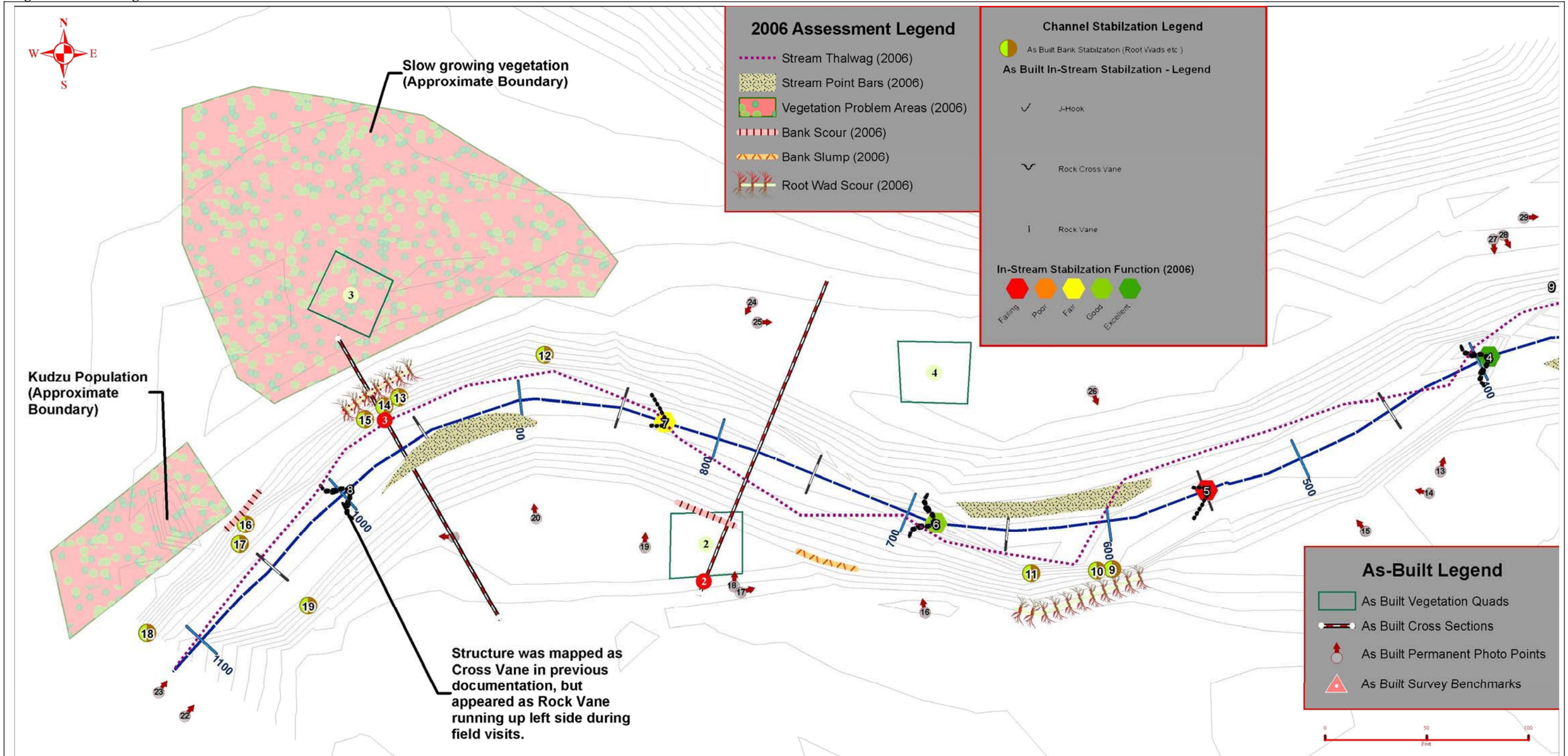
Figure 3: Monitoring Plan View Sheet 2



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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 288 live stems per acre within the restoration area during year 3 of a 5-year monitoring period.

The Kudzu 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.

Appendix A provides representative photos of problem areas and sampling areas. Figures 2 and 3 show the problem areas.

KHA conducted a vegetation assessment during the early fall of 2006. 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, *Betula nigra* is rapidly colonizing.

2.2 Stream Assessment

KHA assessed the stream channel during the spring and fall of 2006. Several isolated sections exhibited bank scour. Excessive shear stresses and possibly historic flood flows may have a role in the scour. Back eddy currents immediately below a structure may be causing bank slumping along a section of the left bank. Some structures seemed to exhibit signs of stress including partial to complete structure collapse; excessive arm scour; and missing header rock. Several root wads along the middle and lower section of the reach have experienced scour behind the root balls and may be unstable. The bottommost structure was mapped as a cross vane in the MY2 2005 monitoring report, but appeared as a rock vane running up the right bank during the 2006 field visits. Figures 1 and 2 show the location of the stream problem areas and table B1 in appendix B summarizes the stream problem areas.

KHA performed a database search and document review to locate information concerning measurement of bankfull events. The research did not find functional gauges within the project catchment. An older, retired gauge lies within a segment of stream immediately upstream of the site reach. A possible surrogate gauge was found in a similar catchment that like the site reach drains into the French Broad. USGS operates the gauge and has identified it as Mill's River near Mill's River NC with an identification number of 03446000. The period of record runs from 1924 to the present. Without the opportunity to visit the site to estimate bankfull geometry, KHA used a flood frequency analysis of annual peak flows to derive an estimate bankfull discharge. Bankfull discharge was set to a two (2) year recurrence interval. Table V provides a listing of bankfull events based on the estimated bankfull discharge.

Table V: Verification of Bankfull Events

Table V. Verification of Bankfull Events Clear Creek Stream Restoration Site (EEP Project #19)			
Collection	**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)	

KHA did not find documentation of bank erosion estimates from previous site assessments. EEP will schedule a bank erosion assessment for a later date. Table VI that is intended to summarize sediment export estimates has no values, but has been included in this section as a placeholder for future completion.

Table VI: BEHI and Sediment Export Estimates

Table VI. BEHI and Sediment Export Estimates																	
Clear Creek Stream Restoration Site (EEP Project #19)																	
Time Point	Date of Assessment	Segment/ Reach	Linear Feet	Extreme		Very High		High		Moderate		Low		Very low		Sed. Export	
				ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	Ton/y	
Pre Construction[1]																	
Total																	
Post Construction[2]																	
Total																	

[1] Data missing or unavailable

[2] Assessment planned for later monitoring year

Table VII provides a categorical view of the stream visual stability assessment. The visual assessment shows an apparent decrease in stability related to riffles, thalweg, meanders, and in-stream structures. Bank stabilization structures did not show a decrease in stability, but they also did not improve. Meander instability relates to floodplain relief and point bar slope. All four (4) of the point bars appear to be overly steep and may not provide adequate floodplain relief. Each meander shows active, likely slow, lateral migration evidenced by outer bank erosion with coincident point bar formation and expansion. The thalweg appears to be actively shifting and mobile. In some locations the alignment of the thalweg appeared to out of place. Also, 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.

Table VII: Categorical Stream Features Visual Stability Assessment

Table VII. Categorical Stream Feature Visual Stability Assessment Clear Creek Stream Restoration Site (EEP Project #19)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	--	--	90%	80%	--	--
B. Pools	--	--	100%	100%	--	--
C. Thalweg	--	--	100%	50%	--	--
D. Meanders	--	--	100%	75%	--	--
E. Bed General	--	--	100%	100%	--	--
F. Bank Condition	--	--	98%	93%	--	--
G. Vanes / J Hooks etc.	--	--	85%	75%	--	--
H. Wads and Boulders	--	--	63%	65%	--	--

Tables VII and IX summarize the site 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. 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 previous year's 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 or area compared to last year. Appendix B provides raw data, photographs, and graphing for geomorphic data.

Table VIII: Baseline Morphology and Hydraulic Summary

Table VIII. Baseline Morphology and Hydraulic Summary
Clear Creek Stream Restoration Site (EEP Project #19)

Reach																			
Parameter		**USGS Gage Data**			**Regional Curve**			**Pre-Existing Condition**			**Project Reference Stream**			**Design**			**As-built**		
	Units	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**	**Min**	**Max**	**Med**
Dimension																			
BF Width	ft	*	*	*	*	*	*	*	*	53	*	*	69	*	*	73	*	*	*
Floodprone Width	ft	*	*	*	*	*	*	*	*	129	*	*	220	*	*	275	*	*	*
BF Cross Sectional Area	ft^2	*	*	*	*	*	*	*	*	246	*	*	199	*	*	339	*	*	*
BF Mean Depth	ft	*	*	*	*	*	*	*	*	4.64	*	*	2.9	*	*	4.66	*	*	*
BF Max Depth	ft	*	*	*	*	*	*	*	*	7.7	*	*	5.2	*	*	7	*	*	*
Width/Depth Ratio		*	*	*	*	*	*	*	*	11.4	*	*	23.9	*	*	15.6	*	*	*
Entrenchment Ratio		*	*	*	*	*	*	*	*	2.4	*	*	3.2	*	*	3.8	*	*	*
Bank Height Ratio		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Wetted Perimeter	ft	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Hydraulic radius	ft	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Pattern																			
Channel Beltwidth	ft	*	*	*	*	*	*	67	100	*	*	*	*	*	*	131	*	*	*
Radius of Curvature	ft	*	*	*	*	*	*	*	*	69	*	*	*	90	150	*	*	*	*
Meander Wavelength	ft	*	*	*	*	*	*	*	*	230	*	*	*	*	*	763	*	*	*
Meander Width ratio		*	*	*	*	*	*	*	*	1.6	*	*	*	*	*	1.8	*	*	*
Profile																			
Riffle length	ft	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Riffle slope	ft/ft	*	*	*	*	*	*	*	*	0.008	*	*	0.022	*	*	0.003	*	*	*
Pool length	ft	*	*	*	*	*	*	*	*	87	133	285	*	*	*	80	*	*	*
Pool spacing	ft	*	*	*	*	*	*	235	393	*	250	631	*	300	420	*	*	*	*
Substrate																			
d50	mm	*	*	*	*	*	*	*	*	3	*	*	45	*	*	3	*	*	*
d84	mm	*	*	*	*	*	*	*	*	20	*	*	425	*	*	20	*	*	*
Additional Reach Parameters																			
Valley Length	ft	*			*			*			*			*			*		
Channel Length	ft	*			*			*			*			*			*		
Sinuosity		*			*			1.09				1.2			1.17			*	
Water Surface Slope	ft/ft	*			*			0.002				0.004			0.002			*	
BF slope	ft/ft	*			*			*				*			*			*	
Rosgen Classification		*			*			C4				C4/1			C4			*	
*Habitat Index		*			*			*				*			*			*	
*Macrobenthos		*			*			*				*			*			*	

Location of substrate sampling is unknown

Table IX: Morphology and Hydraulic Monitoring Summary

Table IX. Morphology and Hydraulic Monitoring Summary
Clear Creek Stream Restoration Site (EEP Project #19)

Parameter		Cross Section 1						Cross Section 2						Cross Section 3					
		Riffle						Pool						Riffle					
Dimension	**Units**	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
BF Width	ft	*	*	60.67	54.4	*	*	*	*	66.3	65.3	*	*	*	*	56.8	55.0	*	*
Floodprone Width	ft	*	*	202.15	200.6	*	*	*	*	169.72	132.5	*	*	*	*	168.11	135.3	*	*
BF Cross Sectional Area	ft	*	*	287.43	264.4	*	*	*	*	298.3	296.1	*	*	*	*	281.43	239.6	*	*
BF Mean Depth	ft	*	*	4.74	4.9	*	*	*	*	4.5	4.5	*	*	*	*	4.95	4.4	*	*
BF Max Depth	ft	*	*	5.91	6.4	*	*	*	*	7.99	8.2	*	*	*	*	7.7	7.4	*	*
Width/Depth Ratio		*	*	12.81	11.2	*	*	*	*	14.74	14.4	*	*	*	*	11.46	12.6	*	*
Entrenchment Ratio		*	*	3.33	3.7	*	*	*	*	2.56	2.0	*	*	*	*	2.96	2.5	*	*
Bank Height Ratio		*	*	1.4	1.3	*	*	*	*	*	*	*	*	*	*	1.3	1.2	*	*
Wetted Perimeter	ft	*	*	65.66	59.1	*	*	*	*	71.09	69.8	*	*	*	*	61.38	59.1	*	*
Hydraulic radius	ft	*	*	4.38	4.5	*	*	*	*	4.2	4.2	*	*	*	*	4.59	4.1	*	*
Substrate																			
d50	mm	*	*	*	0.28	*	*	*	*	*	0.5	*	*	*	*	*	0.33	*	*
d84	mm	*	*	*	13.45	*	*	*	*	*	7.91	*	*	*	*	*	20.45	*	*
Parameter		**AB (2003)**			**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**	**Min**	**Max**	**Med**
Channel Beltwidth	ft	*	*	*	*	*	*	131	153	143	122	198	148	*	*	*	*	*	*
Radius of Curvature	ft	*	*	*	*	*	*	89	105	97	124	194	183	*	*	*	*	*	*
Meander Wavelength	ft	*	*	*	*	*	*	497	576	536	511	541	526	*	*	*	*	*	*
Meander Width ratio		*	*	*	*	*	*	2.2	2.6	2.4	2.0	3.3	2.5	*	*	*	*	*	*
Profile																			
Riffle length	ft	*	*	*	*	*	*	15	89	38	15	23	21	*	*	*	*	*	*
Riffle slope	ft/ft	*	*	*	*	*	*	0.0007	0.0019	0.0014	0.0040	0.0040	0.0040	*	*	*	*	*	*
Pool length	ft	*	*	*	*	*	*	28	135	65	131	290	182	*	*	*	*	*	*
Pool spacing	ft	*	*	*	*	*	*	260	291	311	227	360	279						
Additional Parameters																			
Valley Length	ft	*	*	*	*	*	*	*	*	1115	*	*	1115	*	*	*	*	*	*
Channel Length	ft	*	*	*	*	*	*	*	*	1228	*	*	1228	*	*	*	*	*	*
Sinuosity		*	*	*	*	*	*	*	*	1.11	*	*	1.11	*	*	*	*	*	*
Water Surface Slope	ft/ft	*	*	*	*	*	*	*	*	0.0015	0.0002	0.0014	0.0009	*	*	*	*	*	*
BF slope	ft/ft	*	*	*	*	*	*	*	*	*	*	*	0.0009	*	*	*	*	*	*
Rosgen Classification		*	*	*	*	*	*	*	*	C4	*	*	C4	*	*	*	*	*	*
Habitat Index*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Macrobenthos*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

3.0 Methodology

Monitoring methods and practice for 2006 differed slightly from the previous year. Surveyed cross sections differed slightly from previous year's cross sections because the field team had difficulty locating benchmarks or distinguishing which benchmarks corresponded to a cross section. KHA set up additional benchmarks to aid in setting up total station survey and locating cross sections. The longitudinal profile was aligned with the stream centerline to allow a more direct comparison between monitoring years.

Click on the Desired Link Below

Appendix A

Appendix B