

**Brush Creek/ Little Pine Creek Stream Restoration – Project #54  
Fourth Year Annual Monitoring Report – November 2007**



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Not Applicable for this project.

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#### **IV. Executive Summary/Project Abstract**

The North Carolina Ecosystem Enhancement Program (EEP) conducted an enhancement/restoration on 1000 feet of Little Pine Creek and 2,640 linear feet of Brush Creek for the purpose of obtaining mitigation credit. The Brush Creek/ Little Pine Creek project is located in Alleghany County, North Carolina and is within the New River Basin. Little Pine Creek, a third-order perennial stream drains a watershed of 4.3 square miles and enters into Brush Creek a fourth-order stream. The Brush Creek watershed comprises 26.3 square miles and is part of the Little River drainage, United States Geologic Survey (USGS) eight-digit hydrologic unit code 05050001 and North Carolina Division of Water Quality (NCDWQ) Subbasin NEW03 10-9-10.

Justification for performing restoration on this stream included an unstable channel configuration, a featureless bed, and a lack of riparian cover. These features were believed to be contributing to poor water quality and poor aquatic habitat. The goals for Little Pine Creek were to establish a stable dimension, pattern, profile, improve habitat, and establish a forested riparian zone surrounding the stream. The goals for Brush Creek were to establish a forested riparian zone surrounding the restored and enhanced section of the stream; restore part of the dimension, pattern, and profile, and enhance channel stability through bank stabilization and reforestation.

A previous, draft, monitoring report completed by Ecologic Associates confirmed that several problem areas found in Brush Creek and Little Pine Creek were getting better over time. Monitoring years MY2 noted various scouring of Little Pine Creek. The third monitoring (MY3) period was conducted by North Carolina State University, the fourth (MY4--Draft) by EcoLogic Associates according to information provided by EEP. The monitoring report from Monitoring Year 4 (MY4--Draft) indicated an increase in bank slumping both in number of occurrences and total extent, deterioration of in-stream bed morphology according to the longitudinal changes and an increased number of fines in the pebble counts; the Little Pine Creek riparian buffer vegetation had poor survivorship of planted trees and shrubs. Due to the vast amount of problems reported from at least three consecutive years of monitoring the EEP decided to augment the design and construction of Little Pine Creek and select sections of Brush Creek. This report represents monitoring year 4 (MY4). The MY4 report follows a second "as-built" process and report (noted as As-Built 2). Therefore, cross-sectional and longitudinal data was compared only to that of the 2006 As-built plan and profile. In addition an as-built planting plan and previous year's monitoring data were not provided. Vegetative planting, remedial maintenance activities were conducted during the winter of 2007 by the WRC. MACTEC compared vegetative success based on comparison of only one other monitoring effort conducted in the same year, MY4 2007.

The objective of vegetation monitoring is to provide an accurate and rapid assessment of the survival and growth of woody plant restoration and regeneration as an integral component of the Brush Creek/Little Pine Creek (BCLPC) stream restoration project. Planted trees, shrubs, and vegetative cover along the riparian areas of BCLPC appear to be meeting established success criteria based on compiled vegetation monitoring data. The *Little Pine Creek/Brush Creek Monitoring Methodology Report* outlined vegetation success criteria as survival of a minimum of 320 stems/acre for trees after MY5. Survival of planted woody species compiled from MY4 vegetation data is approximately 542 stems/acre

Although success criteria of 320 stems per acre was met, evidence of severe drought or mammal browse was prominent in all vegetation plots sampled. Previous monitoring reports from MY2 and MY3 indicate that the survivorship of planted trees and shrubs was poor throughout the entire buffer. Additional observation of vegetation plots for invasive plant species and mitigation measures for mammal browse is recommended.

The overall success of this project is tenuous at this point in time. MACTEC found a significant number of areas with stream bank slumping, erosion, mass-wasting and structural stress along Little Pine Creek. However, these sorts of problem areas have the potential to reach equilibrium without further construction activity. MACTEC recommends that future monitoring contractors pay close attention to the problem areas identified in the report. MACTEC found that the structural enhancements performed on Brush Creek are holding together very well. Future monitoring along Brush Creek should be kept to a minimum.

## V. Project Background

### 1. *Project Objectives*

The restoration of Little Pine Creek and enhancement of Brush Creek located downstream of the Big Oak Road Bridge in Alleghany County, North Carolina, was conducted to correct identified system deficiencies to 950-linear feet of Little Pine Creek and 2,640-linear feet of Brush Creek. Deficiencies were addressed using a Priority 1 restoration approach for Little Pine Creek and Enhancement for Brush Creek. Additional objectives of the project were to establish a riparian zone along the stream, improve the aquatic habitat within the channel and the riparian area, and incorporation of this project into a watershed-wide management plan.

### 2. *Project Structure*

A Priority 1 stream restoration design was implemented for 950-lf of Little Pine Creek and 2,640-lf of Brush Creek and riparian buffer. The project involved channel dimension adjustments, pattern alterations, in-stream structures (rock vanes, root wads, rock and log vanes, and woody debris) to provide grade control and channel stability, and riparian buffer restoration which included the replanting of woody vegetation, construction of floodplain wetland depressions, and fencing for exclusion of farm animals.

**Exhibit Table 1. Project Restoration Components  
Brush/ Little Pine Creeks—Project #54**

<b>Project Segment or Reach ID</b>	<b>Type</b>	<b>Approach</b>	<b>Restored Length (Lf)</b>	<b>Stationing</b>	<b>Comment</b>
Brush Creek - Reach 1	R	P2	340		Channel relocation; Rock Sills; Point Bar construction; Re-vegetated
Brush Creek - Reach 2	E	E2	2,300		repair and expand riparian buffer
Little Pine Creek	R	P2	950	0+00 – 10+00	Relocation of channel; new pattern, profile, dimension, and structures

### 3. *Location and Setting*

The project consisted of 4.3 square mile portion of the Little Pine Creek and 26.3 square mile portion of the Brush Creek watershed (located within USGS Hydrologic Unit Code 05050001, NCDWQ Sub-basin NEW03 10-9-10 New River Basin) located northeast of the city limits of Sparta, North Carolina in Alleghany County (Figure 1). To access the site from I-77, travel north on North Carolina (NC) Highway

21. Follow NC-21 turn right (north) on Shuffletown Road (SR1464). Follow Shuffletown Road for five miles. Turn left on Glade Valley Road. Follow Glade Valley Road for one mile and turn right on Big Oak Road. The project is located downstream of the Big Oak Road bridge.

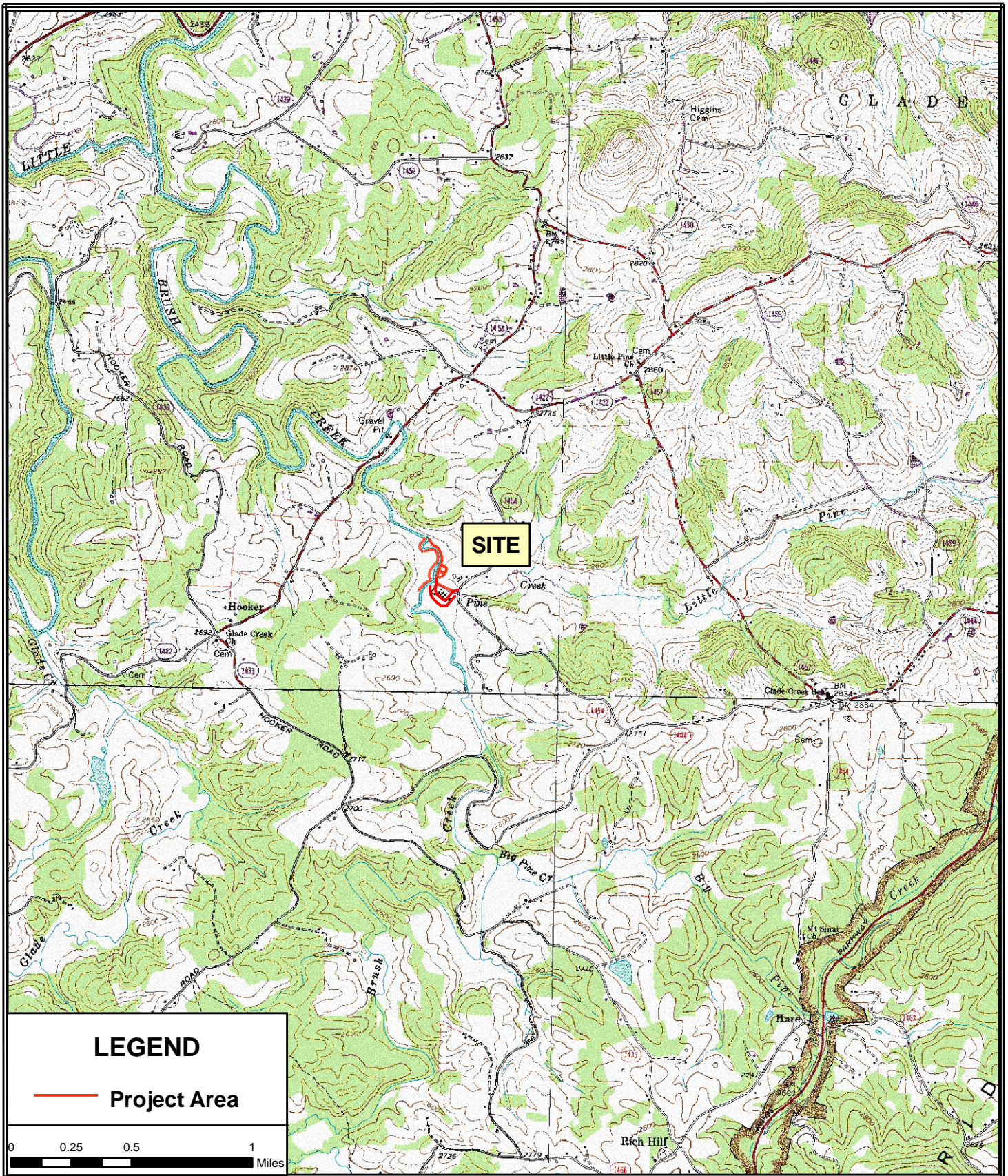
#### *4. History and Background*

Project planning was initiated for the Brush Creek and Little Pine Creek Stream Enhancement/Restoration in 2000 for the implementation of a stream restoration project in Alleghany County, North Carolina (Figure 1). Following coordination with local leaders, the Wetlands Restoration Program and citizen groups, the project was initiated and focused on the restoration of 950 linear feet of Little Pine Creek and 2,640 linear feet of Brush Creek. Detailed environmental assessments and engineering studies were conducted to help generate design plans and documents to facilitate stream and riparian buffer restoration.

Implementation of the project was completed by September 2001. The restoration of Brush Creek and Little Pine Creek was intended to correct system deficiencies including severe bank erosion, channel widening, stream channelization, the loss of riparian vegetation, and watershed development.

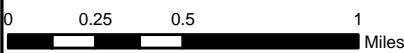
The original construction of Little Pine Creek took place in 2001. An as-built survey was conducted followed by four years of monitoring (2002 through 2005). Monitoring reports MY1, MY2, MY3, and the draft of MY4 reported significant morphological areas of concern for both Little Pine Creek and Brush Creek. These areas seemed to be getting worse overtime and in addition, the vegetation success was not adequate for mitigation credit. The decision was made to augment the project in 2006 with a new design and some re-construction. Re-construction of Little Pine Creek and portions of Brush Creek took place in 2006. An as-built survey (denoted in this report as As-Built 2) was conducted in November of 2006. This report therefore reflects the first monitoring year of data collected at four new cross-sections, monitoring year (MY4) for Brush and Little Pine Creeks.





**LEGEND**

— Project Area



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**VICINITY MAP  
 BRUSH CREEK/LITTLE PINE CREEK  
 ALLEGHANY COUNTY, NORTH CAROLINA**

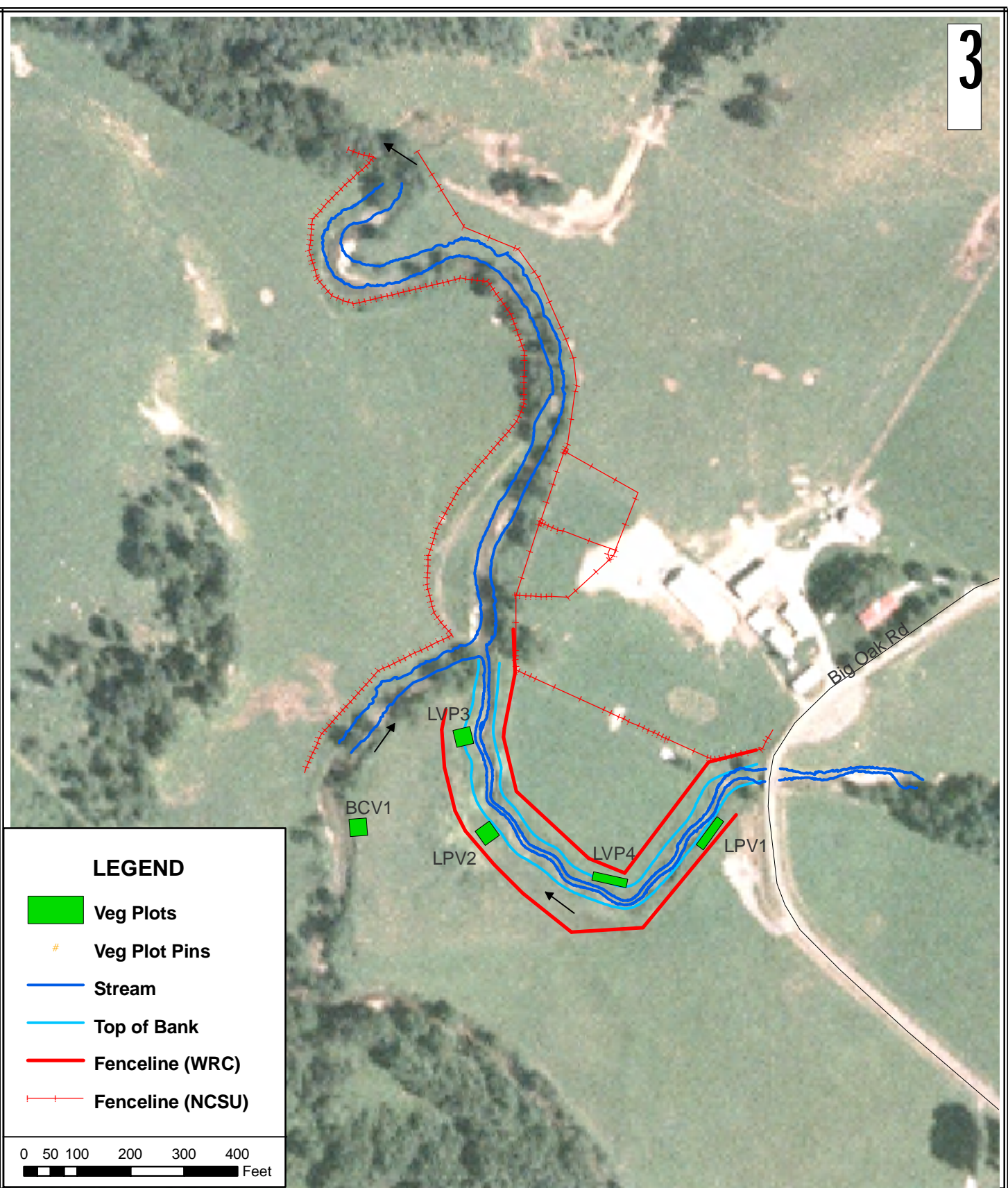
DRAWN:	AKD	DATE:	NOVEMBER 2007
REVIEW:	RLS	SCALE:	1" = 250'
APPROVAL:	RGH	JOB No:	6470-06-1410/03

FIGURE

**1**

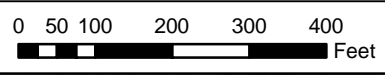
SOURCES: NCEP, NCSU, NCWRC, USGS (CUMBERLAND KNOB, GLADE VALLEY, ROARING GAP, & SPARTA E TOPOGRAPHIC QUADRANGLES)





**LEGEND**

- Veg Plots
- Veg Plot Pins
- Stream
- Top of Bank
- Fenceline (WRC)
- Fenceline (NCSU)



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**VEGETATION PLOTS  
 BRUSH CREEK/LITTLE PINE CREEK  
 ALLEGHANY COUNTY, NORTH CAROLINA**

DRAWN:	AKD	DATE:	NOVEMBER 2007
REVIEW:	RLS	SCALE:	1" = 250'
APPROVAL:	RGH	JOB No:	6470-06-1410/03

FIGURE  
**2**

SOURCES: NCEP, NCSU, NCWRC, USDA (NAIP 2006 AERIAL MOSAIC)



<b>Table II. Project Activity and Reporting History</b>		
<b>Project Number and Name: 054 (Brush Creek and Little Pine)</b>		
<b>Activity or Report</b>	<b>Calendar Year of Completion or Planned Completion</b>	<b>Actual Completion Date</b>
Restoration Plan	*	*
Mitigation Plan	*	*
Temporary S&E mix applied to entire project area	*	*
As-Built report	October-01	October-01
As-Built 2 report	January-07	January-07
Permanent seed mix applied to reach	*	*
Structural maintenance (Bank repair and revegetation)	*	January-07
Year 1 monitoring	January-02	June-02
Year 2 Monitoring	November-03	January-04
Year 3 Monitoring	November-04	December-04
Year 4 Monitoring	November-05	Not completed
As-Built 2	December-06	January-07
Year 4 Monitoring	November-07	December-07

<b>Table III. Project Contact Table</b>	
<b>Project Number and Name: 00009 (Brush Creek/Little Pine )</b>	
<b>Designer</b>	HDR Engineering, Inc. of the Carolinas. 128 South Tryon St, Suite 1400 Charlotte, North Carolina 28202
Primary project design POC	unknown
<b>Construction Contractor</b>	A&D Environmental & Industrial Services
Construction contractor POC	unknown
<b>Planting Contractor</b>	Shamrock Environmental
Planting contractor POC	Mr. Bill Wright (336) 375-1989
<b>Seeding Contractor</b>	*
Planting contractor point of contact	
Seed Mix Sources	*
Nursery Stock Suppliers	*
<b>Monitoring Performers</b>	MACTEC Engineering and Consulting, Inc. 3301 Atlantic Avenue Raleigh, North Carolina 27604 (919) 876-0416
Stream Monitoring POC	Robert Sain (828) 252-8130
Vegetation Monitoring POC	Amin Davis (919) 876-0416

\* Historical project documents reviewed did not provide these data.

<b>Table IV. Project Background Table</b>	
<b>Project Number and Name: 279 (Brown Branch )</b>	
Project County	Alleghany, North Carolina
Drainage Area	26.3 sq. mi. (Brush Creek)
Drainage impervious cover estimate (%)	4.3 sq.mi. (Little Pine Creek) Estimated at <5%
Stream Order	3rd order (Brush Creek)
	2 <sup>nd</sup> order (Little Pine Creek)
Physiographic Region	Mountains
Ecoregion	Southern Crystalline Ridges and Mountains (66d)
Rosgen Classification of As-built	B3 (Brush Creek)
	E4 (Little Pine Creek)
Cowardin Classification	Not applicable
Dominant soil types	Cardorus complex, Tate loam, Chester loam, Alluvial
Reference site ID	Long Creek in VA
USGS HUC for Project and Reference	05050001
NCDWQ Sub-basin for Project and Reference	NEW03 10-9-10
NCDWQ classification for Project and Reference	C; Tr
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	100% (Brush Creek) 100% (Little Pine Creek)

## **VI. Project Condition and Monitoring Results**

The site was initially evaluated in 2002 with subsequent monitoring efforts in 2003, 2004 and 2005. A re-design and construction took place in 2006. The As built (2) survey took place in 2006. This survey effort left several markers on-site that were relatively easy to find and tie into. MACTEC was able re-established datum locations without much difficulty and recorded previously established survey locations when available.

### **A. Vegetation Assessment**

Although post-construction vegetation monitoring has been ongoing for several years, vegetative survival could only be compared between two vegetation sampling events conducted during MY4. An as-built planting plan and previous year's monitoring data were not provided. Remedial maintenance activities conducted during the winter of 2007 by the WRC included installing vegetative plantings, establishing five new vegetation plots, and performing vegetation sampling per the CVS-EEP Protocol for Recording Vegetation Version 4.1 (Lee et al. 2007). Four vegetation plots were established along Little Pine Creek and one vegetation plot was established along Brush Creek. MACTEC re-sampled these same vegetation plots in



October 2007, and the results of vegetative success and survival are based primarily on these recent plantings and a comparison between these two MY4 sampling events.

The *Little Pine Creek/Brush Creek Monitoring Methodology Report* outlined vegetation success criteria as survival of a minimum of 320 stems/ acre for trees after MY5. Survival of planted woody species compiled from October 2007 vegetation data is significantly less than survival estimated from winter 2007 vegetation data (542 stems/acre versus 907 stems/acre). Although success criteria of 320 stems per acre was met, evidence of severe drought or mammal browse was prominent in all vegetation plots sampled. Previous monitoring reports from MY2 and MY3 indicate that the survivorship of planted trees and shrubs has been poor in the past, prior to stream restoration augmentation performed in 2006.

*Hamamelis virginiana*, *Asimina triloba*, and *Prunus serotina* were the most abundant species observed in the woody stem count with a total of 10, 9, and 8 stems respectively within the 5 plots. Vegetation vigor was rated as fair to poor as nearly 60 percent (71 of 119) of woody stems planted earlier in 2007 were given vigor codes of weak, unlikely to survive, dead, or missing. *Fraxinus pennsylvanica* and *Hamamelis* were vigorous overall, while *Carpinus caroliniana* and *Juglans nigra* did not receive vigor codes greater than weak, with as many stems recorded as dead as were living. Nearly 60 percent (69 of 121) of all planted species showed some sign of damage with drought consisting of 67 percent of all damage categories. Vegetation plots LPV1 exhibited the most abundant damage with 86 percent (19 of 22) of planted species showing evidence of damage, while only 31 percent (10 of 32) of planted species in plot BCV1 showed evidence of damage.

1. Vegetative Problem Areas

Problem areas, as defined in EEP's *Content, Format, and Data Requirements for EEP Monitoring Reports*, are areas either lacking vegetation or containing exotic vegetation, and are categorized as Bare Bank, Bare Bench, Bare Floodplain, or Invasive Population. Invasive species were not observed frequently at the site, although previous monitoring reports mention *Fescue* invading the riparian buffer along Little Pine Creek. Another area of concern are mammal burrows observed in or adjacent to vegetation plots BCV1 and LPV1.

Recommendations include additional observations for invasive plant species such as *Fescue* mentioned in previous monitoring reports, mitigation measures for mammal browse, and replanting of more ecologically-tolerant woody vegetation.

2. Vegetative Problem Area Plan View

No problem areas as defined by EEP were observed during the vegetation monitoring for 2007. Therefore, no vegetative problem area plan view was prepared.

B. Stream Assessment

Two stream channels are present for this project; Brush Creek and a tributary, Little Pine Creek. Restoration of Brush Creek consisted primarily of stream enhancement activities; therefore no longitudinal profile data were taken. Restoration of Little Pine Creek consisted of stream restoration activities which altered the channels profile; longitudinal profile data were collected. Overall, the project streams are functioning well and holding grade. There were no problem areas found on Brush Creek proper but for Little Pine Creek, this stream did show some areas of concern. Table VIII shows a summary of monitoring measurement results. Little Pine Creek classifies as a C4. Channel dimension and pattern are similar to the second as-built (2006) conditions with the exception of some limited areas of bank erosion. Some structures are stressed in the stream channel. However, in most cases these do not appear to be causing major problems in the stream. Placed structures throughout most of the reach are holding grade and functioning appropriately.

1. *Procedural Items*

a. Morphometric Criteria

MACTEC staff evaluated the Brush Creek and Little Pine Creek site during May, September, October, and November 2007 to assess the condition and success of the project. Overall, the site appears to be maintaining a stable dimension, pattern, and profile, and planted woody stem density has met and exceeded future success criteria.

MACTEC staff collected MY4 quantitative geomorphological data (four cross sections and approximately 1,200 linear feet of stream) during October and November 2007, respectively. Photographs were taken at cross sections and vegetation monitoring plots. Permanent or fixed photo locations were identified from survey coordinates and photos were taken for the MY4 report.

Bank slumping and mass-wasting were the two most common areas of concern. These areas were only found along Little Pine Creek. The Brush Creek stream enhancement did not display any areas of concern. Areas of concern include several stressed structures in Little Pine Creek (see Appendix B and D) where water has channeled behind vanes and one area where the some head cut migration may be taking place near riffle #1. Also during general observations it was noted that the overall condition of the Little Pine Creek directly above where the project area begins was in poor shape. Cows were seen actively trampling the stream banks and the stream appeared to be over-widened and devoid of riparian vegetation. In addition, the bridge directly over the beginning of the Little Pine Creek project appears to be narrowing the flood prone area and an over-widened area persist just downstream of the bridge.

b. Hydrologic Criteria

No crest gauges are installed at this site to document bankfull events. Bankfull depth estimates were based on the rural piedmont regional curve for a stream with a drainage area of 4.3 square miles. According to the curve, a stream with a drainage area of 4.3 square miles would reach bankfull discharge at a height of 1.74 feet. No USGS peak flow data were available for streams in Allegheny County in 2007. A high flow event was apparent during MACTEC’s site visit, just five days after the event in October as noted in Table V. High flow water lines and debris racks were found throughout Little Pine Creek in November, 2007—the suspected depth was observed to reach at least 0.25 feet above bankfull or 2.0 feet. Drift lines, downed herbaceous and woody vegetation were also observed in the immediate floodplain providing further evidence that a bankfull event had taken place.

Date of Data Collection	Date of Occurrence (mm/dd/yyyy)	Method	Photo # (if available)
12/8/2006	12/8/2006	On-site observation and high water indicators observed.	Not Available
11/1/2007	10/23/2007	On-site observation and high water indicators observed.	See MY4 X-section photos

### c. Bank Stability Assessments

Bank stability or BEHI and NBS assessments were not completed during MY4. This assessment is typically required by the EEP to be performed prior to and during the MY5 assessment of a project

#### *2. Problems Areas Plan View (stream)*

Exhibit B.1 in Appendix B provides categorical feature issues by station and type, the suspected cause, and representative photo number.

#### *3. Problem Areas Summary Table*

Exhibit Problem Areas Summary Table is provided in Appendix B.

#### *4. Numbered Issues Photo Station*

Numbered Issues photos may be found in Appendix B, section 2.

#### *5. Fixed Photo Station Photos*

Fixed Photo Station photos may be found in Appendix B, section 3.

#### *6. Stability Assessment*

The longitudinal profile of Little Pine Creek remained in close approximation to the As Built (2) survey data collected in December 2006 (see Appendix B). In general the channel bed seems to be maintaining bed form and its intended function. The first riffle (station 1+34, riffle cross-section #1) showed a water surface slope of 2% and was dropping at a steep angle into a short run and then a lateral pool. This slope represented a max riffle slope that was slightly steeper than that of the 2006 As-built. Riffle length increased and there was evidence of gravel that had migrated and filled in the channel bed in between short riffle sections. Starting at station 4+00 and extending to around 4+85, two riffles actually became more like one long riffle. Channel pattern appears to be self maintaining since construction in 2006 (see Appendix D).

Four cross-sections were surveyed during the MY4 assessment—one cross-section on Brush Creek and three cross-sections on Little Pine Creek. The Brush Creek Run Cross-Section indicates a smaller bankfull area than that taken during 2006. This difference is likely due to a difference of opinion in bankfull identification between field observers. The Brush Creek pebble count indicated a wider spread of particles with a slightly smaller D50 and D85 (see Appendix B, sections 5 and 7). Little Pine Creek channel cross-sectional areas were almost identical; however pebble count data did vary from that of the 2006 as-built.

Riffle D50 and D85 materials appear to be slightly smaller while pool materials seemed to have coarsened. A bankfull event occurred five days before the pebble data were collected. The combination of this bankfull event and the actual data collected in the field would suggest bed material movement. The riffle material is changing as would be expected in a natural system (see Appendix B, sections 5 and 7).

Significant bank slumping and a moderate amount of mass-wasting was observed for approximately 25% of Little Pine Creek's bank length. Dense vegetation was established along the channel banks and actually masked some of the bank slumping and point erosion areas that were observed. This observation may be further confirmed with the bankfull indicators observed, represented in the



longitudinal profile (see Appendix B). Bankfull indicators were found at a consistently lower elevation than that of the As-Built survey. This indicates a channel in flux with bank material and soil that may have slumped in and settled over the past year. All though Little Pine Creek has experienced point area of mass-wasting and bank slumping there was little evidence to suggest potential meander migration. The banks have re-vegetated and appear to have stabilized any point areas of erosion. However because the channel appears to be in flux, Little Pine Creek should be monitored closely for at least one more year to make sure conditions continue to improve.

This project consisted of a series of several log vanes on Little Pine Creek and seven large rock vanes located on Brush Creek. Log vanes observed on Brush Creek appeared fully functional at low water levels but minor scour was observed at the tie-in point near bankfull. The seven rock vanes on Brush Creek appeared intact and fully functional at low and high water levels.

This project consisted of a series of four sets of rootwads on Little Pine Creek and one set of approximately six large rootwads located on Brush Creek. The rootwads observed on Little Pine Creek were holding and functioning exceptionally well. The rootwads observed on Brush Creek were holding and functioning as intended.

<b>Table VII. Categorical Stream Feature Visual Stability Assessment</b>				
<b>Brush-Little Pine Creeks (054)</b>				
<b>Segment/Reach: Little Pine (1000feet)</b>				
<b>Features</b>	<b>As Built2</b>	<b>MY-04</b>		
A. Riffles	100%	95%		
B. Pools	100%	100%		
C. Thalweg	100%	100%		
D. Meanders	100%	93%		
E. Bed General	100%	95%		
F. Bank Condition	100%	80%		
G. Vanes / J Hooks etc.	100%	92%		
F. Wads and Boulders	100%	100%		

7. *Quantitative Measures Tables (Morph and Hydro)*

Baseline morphology and Summary morphology data are located in tables VII and VIII, respectively. Data gaps in the following tables are due to a lack of data from previous monitoring events. Attempts were made to locate and populate data tables with previously recorded data.

C. Wetland Assessment

Please note that Table X (Wetland Criteria Attainment) is not included because this restoration project does not have a wetlands component.

**Table VIII. Baseline Morphology and Hydraulic Summary  
Brush-Little Pine Creeks (054)  
Segment/Reach Little Pine Creek (1000 ft)**

Parameter	Regional Curve Interval			Pre-Existing Condition			Project Reference Reach			Design			As-built 2002			As-built 2006		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
<b>Dimension</b>																		
BF Width (ft)						19			18			20	31.5	33.7	32.6	24.7	24.91	24.8
Floodprone Width (ft)						22.7			334			82	>100	>100	>100	105.1	126.1	115.6
BF Cross-Sectional Area (ft <sup>2</sup> )			56.27			27.7			34.6			41.1	86.7	88.7	87.7	45.07	45.29	45.2
BF Mean Depth (ft)						1.2			2.5			2.3	2.6	2.8	2.7	1.49	1.82	1.7
BF Max Depth (ft)						2			4.1			4	4.8	5	4.9	2.69	2.76	2.7
Width/Depth Ratio						16.34			7.17			8.81	11.3	13	12.15	13.69	20.72	17.2
Entrenchment Ratio						1.2			18.6			4.1	3.2	3.0	3.1	2.66	4.22	3.4
Bank Height Ratio													*	*	*	1.32	2.12	1.7
Wetted Perimeter (ft)													*	*	*	26.18	31.24	28.7
Hydraulic Radius (ft)													*	*	*	1.44	1.73	1.6
<b>Pattern</b>																		
Channel Beltwidth (ft)						41.7			39			50	24	50	33	24.9	45.3	35.38
Radius of Curvature (ft)									23			25	39	62	50.5	40.3	60.5	47.66
Meander Wavelength (ft)						125			1.105			110	90	125	110	89.2	124	108.4
Meander Width Ratio						6.6			5.6			5.5	0.76	1.48	1.01	0.9	1.64	1.28
<b>Profile</b>																		
Riffle Length (ft)													6	47	18	10.36	46.34	20.53
Riffle Slope (ft/ft)													0.003	0.0634	0.0309	0.0029	0.0188	0.0122
Pool Length (ft)													34	112	45	10.25	89.95	31.95
Pool Spacing (ft)						150.5			66.8			62.5	51	150	73	60.32	176.81	112.97
<b>Substrate</b>																		
D <sub>50</sub> (mm)						11			40			50.00	*	*	*	27.30	39.10	33.20
D <sub>84</sub> (mm)						60			110			100	*	*	*	40	66.7	53.35
<b>Additional Reach Parameters</b>																		
Valley Length (ft)															571			571
Channel Length (ft)															1013			1013
Sinuosity						1			1.7			1.6			1.77			1.77
Water Surface Slope (ft/ft)															0.0057			0.0067
BF Slope (ft/ft)						0.007			0.009			0.006			0.0058			0.0057
Rosgen Classification						F4			E4			E4			C4			C4

**Table VIII. Morphology and Hydraulic Monitoring Summary  
Brush-Little Pine Creeks (054)  
Segment/Reach Little Pine Creek (1000 ft)**

<b>Little Pine</b>												
<b>Parameter</b>	AB 1 2002			AB2 2006			MY-04 2007			MY-05 2008		
<b>Pattern</b>	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Channel Beltwidth (ft)	24.0	50.0	33.0	33.0	45.3	35.4	33.0	45.3	35.4			
Radius of Curvature (ft)	39.0	62.0	50.5	40.3	60.5	47.7	40.3	60.5	47.7			
Meander Wavelength (ft)	90.0	125.0	110.0	89.2	111.4	108.4	89.2	111.4	108.4			
Meander Width Ratio	0.8	1.5	1.0	1.3	1.7	1.3	1.3	1.7	1.3			
<b>Profile</b>												
Riffle Length (ft)	6.0	47.0	18.0	10.4	46.3	20.5	10.8	88.3	23.1			
Riffle Slope (ft/ft)	0.0030	0.0634	0.0309	0.0029	0.0188	0.0122	0.0035	0.0201	0.0111			
Pool Length (ft)	34.0	112.0	45.0	10.3	90.0	32.0	15.0	110.0	40.0			
Pool Spacing (ft)	51.0	150.0	73.0	60.3	176.8	113.0	55.0	250.0	126.0			
<b>Additional Reach Parameters</b>												
Valley Length (ft)				*	*	571.0	*	*	600.0			
Channel Length (ft)				*	*	1013.0	*	*	1013.0			
Sinuosity			1.7	*	*	1.8	*	*	1.7			
Water Surface Slope (ft/ft)			0.0125	*	*	0.0057	*	*	0.0048			
BF Slope (ft/ft)				*	*	0.0058	*	*	0.0057			
Rosgen Classification			E4	*	*	C4	*	*	C4			
Habitat Index*				*	*	*	*	*	*			
Macrobenthos*				*	*	*	*	*	*			

\* Inclusion will be project specific and determined by As-built monitoring /plan success criteria.



**Table IX. Morphology and Hydraulic Monitoring Summary  
 Little Pine Creeks Brush-Little Pine(054)  
 Segment/Reach: Little Pine Creek (1,000 ft)**

Parameter	Cross Section 1 <sup>a</sup>							Cross Section 2 <sup>a</sup>							Cross Section 3 <sup>a</sup>						
	Riffle							Pool <sup>b</sup>							Riffle <sup>b</sup>						
Dimension	AB1	MY1	MY2	MY3	AB2	MY4	MY5	AB1	MY1	MY2	MY3	AB2	MY4	MY5	AB1	MY1	MY2	MY3	AB2	MY4	MY5
BF Width (ft)	31.5	31.2	31.5	31.5	24.9	25.4		33.7	33.7	32.6	32.2	24.7	26.4		35.4	37	40.4	36.8	30.3	34	
Floodprone Width (ft)					105.1	>100						126.1	>100						110	>100	
BF Cross-sectional Area (ft <sup>2</sup> )	86.7	90.55	101.7	97.1	45.3	44.39		88.7	92.4	87.8	94.5	54.4	51.85		86.6	96.6	100.4	86.4	45.1	45.97	
BF Mean Depth (ft)	2.8	2.9	3.2	3.1	1.8	1.7		2.6	2.7	2.7	2.9	2.2	2		2.4	2.6	2.5	2.3	1.8	1.4	
BF Max Depth (ft)	5.0	5.2	5.0	4.9	2.8	2.8		4.8	4.9	5.5	6.0	3.9	3.8		4.5	5.3	6.4	4.9	2.8	2.8	
Width/Depth Ratio	11.3	10.8	9.8	10.2	13.7	14.5		13.0	12.5	12.1	11.1	11.2	13.4		14.8	14.2	16.2	16.0	20.3	25.1	
Entrenchment Ratio					4.2	3.9						5.1	5.1						2.7	2.7	
Bank Height Ratio		0.85			1.3	1.3						1.7	1.1						2.1	2.1	
Wetted Perimeter (ft)					26.2	26.0						28.0	28.0						31.2	31.2	
Hydraulic Radius (ft)					1.7	1.7						1.9	1.9						1.4	1.5	
<b>Substrate</b>																					
D <sub>50</sub> (mm)	29.1	25.0			39.1	30.3		38.9	34.1			0.2	1.4		<2	3.3			27.3	15.8	
D <sub>84</sub> (mm)	77.5	79.0			82.3	64.4		82.3	88.9			40.0	54.3		5.8	11.3			66.7	50.0	

<sup>a</sup>Locations of the cross-sections changed after the 2006 repairs to Little Pine Creek.

<sup>b</sup>Cross Section 2 is a pool at AB2 and Cross Section 3 is a Riffle at AB2.

<b>Table IX. Morphology and Hydraulic Monitoring Summary</b>							
<b>Brush Creek (054) Brush-Little Pine</b>							
<b>Segment/Reach: Brush Creek I (500 ft)</b>							
<b>Parameter</b>	<b>Cross Section 1 of 1</b>						
	<b>Run</b>						
<b>Dimension</b>	AB2	MY4	MY5				
BF Width (ft)	63.5	65.0					
Floodprone Width (ft)	181.8	>100					
BF Cross-sectional Area (ft <sup>2</sup> )	177.5	146.0					
BF Mean Depth (ft)	2.8	2.2					
BF Max Depth (ft)	5.5	3.3					
Width/Depth Ratio	22.8	28.9					
Entrenchment Ratio	2.9	2.9					
Bank Height Ratio	1.6	1.4					
Wetted Perimeter (ft)	66.1	66.1					
Hydraulic Radius (ft)	2.7	2.2					
<b>Substrate</b>							
D <sub>50</sub> (mm)	55.4	22.7					
D <sub>84</sub> (mm)	95.8	75.0					

Table X: Wetland Criteria Attainment (not applicable for this project).

## **Methodology Section**

Monitoring methods used are based on NC Department of Environment and Natural Resources, NC Ecosystem Enhancement Program, and US Army Corps of Engineers' guidelines as referenced below.

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**Click on the Desired Link Below**

**Appendix A**

**Appendix B**

**Appendix C**

**Appendix D**