AS-BUILT REPORT
for the
BRUSH and LITTLE PINE CREEKS
STREAM RESTORATION REPAIRS

Alleghany County, North Carolina

FINAL

EEP Project Number: 00054
Contract Number: D06082; Task Order: 06NW01-3

Period Covered: 1 August 2006 – 30 April 2008

Submitted: May 2008; Resubmitted 17 June 2009

Prepared by the North Carolina Wildlife Resources Commission
in Partnership with the
North Carolina Ecosystem Enhancement Program
1652 Mail Service Center
Raleigh, NC 27699-1652

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I. Executive Summary

This as-built report describes the stream channel repair work and site conditions following construction during September-October 2006 on 375 linear feet (lf) of Brush Creek (BC) and 1,013 lf of stream channel on Little Pine Creek (LPC), located in the New River drainage, Alleghany County, North Carolina (Figure 1). Pre- and post-construction data comparisons are presented where possible.

In 2001, approximately 600 lf of previously channelized LPC was replaced with 950 lf of new meandering channel connected to its floodplain, while 340 lf of streambank were stabilized on a 2,300 lf reach of BC. Through subsequent monitoring of the project site, streambanks and structures became unstable and were identified as being in need of repair (NCSU 2004). Survivorship of planted trees and shrubs also was low and fescue *Festuca spp.* from the surrounding pasture became established within the conservation easement area (NCSU 2004). The North Carolina Ecosystem Enhancement Program (EEP) requested that the original project design firm, HDR of the Carolinas, Inc. (HDR), prepare a stream restoration repair plan for LPC and BC. The plan was completed in August 2005 (HDR 2005a, 2005b). The EEP tasked the North Carolina Wildlife Resources Commission (NCWRC) to implement and oversee the repair work.

The repair project objectives included, but were not limited to, streambank re-grading to relieve pressure on the banks during high flows; installation of in-stream structures to stabilize the banks and bank toe; to provide grade control by repositioning riffle areas to stop the channel from incising; and planting of vegetation along disturbed streambanks for long-term bank stability and habitat improvement (HDR 2005a, 2005b).

Most of the repair work was performed on 1,013 lf of LPC. Some modifications to the 2005 repair plan were necessary because the stream channel had changed since the repair plan was drafted. Portions of the upper section of LPC were well vegetated with woody shrubs. Unstable streambanks interspersed between the stable vegetative streambanks were reshaped with steeper banks and a higher bankfull bench elevation than called for by the repair plans. This was necessary to maintain the stream channel's dimension throughout this section. Below station 4+25.0 the bankfull bench was built at the target elevation; however, the top of bank width was wider than called for by the repair plan. This was needed to accommodate the increased bank height near the confluence with BC.

Monitoring cross-sections were established on LPC and BC at new locations, therefore, direct comparisons with previous monitoring data were not possible. Little Pine Creek has a mean entrenchment ratio of 3.4, mean width/depth ratio of 17.2, mean bankfull width of 27.6 ft, and mean bankfull cross-sectional area of 45.2 ft^2. The repair work converted LPC from an E4 to C4 stream channel type.

Brush Creek's cross-section characteristics post-construction included an entrenchment ratio of 2.9, width/depth ratio of 22.8, mean bankfull width of 63.5 ft, and mean bankfull cross-sectional area of 177.5 ft^2. Previously established cross-sections on BC were not monitored for this report. Longitudinal profile data were not collected on BC for this report.

The new cross-section locations did not allow for direct comparisons of previously collected cross-section pebble count data on LPC and BC. However, general comparisons of riffle cross-section data are possible between monitoring years. In general, the range of the 2006 riffle D_{50} substrate (27.3 mm – 39.1 mm) on LPC increased from the range found in the 2004 survey (0.1 mm – 3.0 mm). The BC 2006 pebble count data revealed that the substrate was larger (D_{50} = 55.4 mm) than the range of substrates (D_{50} = 2.4 mm – 6.2 mm), at all of the riffles in 2004. The repair work appears to have increased the stream's competency to move sediment. A reach pebble count was not taken in previous monitoring years; therefore, a comparison of those data was not possible.

Disturbed areas were seeded with annual and perennial native seed mixtures and mulched with straw or net-free matting. Containerized native trees and shrubs were planted along the stream banks at a density of 495/acre. A total of 930 live stakes (3,376 stakes/acre) were also planted along the stream bank.

One vegetative problem area was observed at the time of the as-built survey. Beavers *Castor canadensis* had consumed some of the trees planted along BC. Approximately 54% of the trees and shrubs were destroyed in the BC vegetation monitoring plot. The U. S. Department of Agriculture eradicated three beavers from the project area. This area should be replanted with shrubs able to withstand browsing, and large trees.

Invasion of the conservation easement area by Fescue will be an ongoing problem at this site because it is prevalent in an adjacent pasture. It will compete with the native herbaceous and woody vegetation; spot herbicide treatments around the base of the trees and shrubs should help reduce this competition.

II. Project Background

This as-built report describes the project's background and summarizes stream channel repair work completed during September-October 2006 on 375 linear feet (lf) of BC and 1,013 lf of LPC in the New River drainage, Alleghany County, North Carolina (Figure 1), and compares it with the pre-construction conditions.

A. Project Objectives

The original 2000 project objectives described in the conceptual plan (HDR 2000) were as follows:

1. To replace 600 feet of altered LPC stream channel with a new, 950-foot meandering channel that is reconnected to the floodplain and designed to maintain stable dimension, pattern, and profile, while effectively transporting anticipated streamflow and sediment load.
2. To restore a vegetated riparian corridor 30-50 ft wide along each side of the new channel to improve water quality and increase available aquatic and terrestrial habitat.

3. To restore channel dimensions and stabilize 340 ft of streambank along BC that is currently experiencing severe bank collapse, thereby improving downstream water quality by reducing sedimentation and resulting in improved aquatic habitat.
4. To restore and enhance a 2,300 ft degraded riparian corridor along BC, using bioengineering techniques, such as reshaping unstable streambanks, adding in stream structures for aquatic habitat, and planting riparian buffer vegetation.
5. To improve overall terrestrial habitat connectivity through the revegetation of riparian corridors along both streams, and improve overall aquatic habitat by increasing habitat complexity.

The objectives for the 2006 repair work were to reshape eroding banks, create a bankfull bench, install in-stream structures, and replant the riparian area with native trees, shrubs, and herbaceous vegetation on 375 lf of BC and on the entire project length of LPC. Upon completion of this work fencing was to be reinstalled to exclude cattle from the riparian area (HDR 2005a).

B. Project Structure, Restoration Type, and Approach

In 1969, LPC was channelized from the Big Oak Road bridge (SR 1454, Figure 1) to its confluence with BC, which caused significant bank failure on BC. This bank failure was linked to a variety of factors, including the steep angle of the LPC confluence, deflection of BC streamflow by point bar formation downstream of the confluence, the unconsolidated alluvial composition of the collapsing BC streambank, and limited riparian vegetation (HDR 2005a).

The original restoration of LPC and BC occurred from April to July 2001; the riparian area was replanted in January 2002. Approximately 600 lf of the straightened LPC channel was replaced with 950 lf of new meandering channel that was reconnected to the floodplain and designed to maintain stable dimension, pattern, and profile. The relocated channel was built as an E4 stream type (HDR 2003; Rosgen 1996). Vegetation was planted to establish a dense root mass along the stream banks and in the riparian zone. In addition, 340 lf of eroding stream banks on BC were stabilized and 2,300 lf of BC was replanted with native woody vegetation. Brush Creek and LPC were fenced to exclude cattle from the riparian area (HDR 2005a).

During three years of monitoring, several areas of the original project were found to be in need of repair. The EEP employed HDR Engineering, Incorporated of the Carolinas (HDR) to develop a stream restoration repair plan for BC and LPC, and retained the NCWRC to oversee the construction. The repair plan for LPC included reshaping stream banks; installation of in-stream structures to improve bank stability and provide channel grade control; installation of coir fiber logs for bank toe protection; and re-vegetating the banks with live stakes, containerized plants, and seeding the riparian area with a native seed mix to reestablish a herbaceous ground cover (Exhibit Table I). Little Pine Creek was changed from an E4 stream type to a C4 stream type (Rosgen 1996) because of these channel modifications. The repair plan for BC included reshaping stream banks, installing in-stream structures, and re-vegetating the stream banks (Exhibit Table I). Work on BC was limited to two small sections (stations 0+00.0 to 02+25.0 and 07+00.0 to 08+50.0).

Exhibit Table I.—Project Repair Components.
Brush-Little Pine Creeks/Project Number (00054)

Project Segment or Reach ID	Pre-existing feet/Acres	Type[a]	Approach[b]	As-built Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Little Pine Cr	950 lf	EI	P2	1,013 lf	NA	NA	0+00-10+13	Installed rock vanes, root wads, digger logs, and log vanes, redistributed riffles, sloped banks, created bankfull benches, and revegetated riparian area.
Brush Cr I	375 lf	EII	P3	375 lf	NA	NA	0+00-2+25, 7+00-8+50	Installed three rock vanes and created a bankfull bench on the right bank (0+00-2+25). Installed a series of root wads on the left bank (1+50-2+25). Installed four rock vanes on the left bank (7+00-8+50). Revegetated disturbed riparian areas.

Mitigation Unit Summations

Stream (lf)	Wetlands (Acre)	Non-riparian Wetlands (Acre)	Total Wetlands (Acre)	Buffer (Acre)	Comment
1,388	0.0	0.0	0.0		

R = Restoration EII = Enhancement II P1 = Priority 1 P3 = Priority 3
EI = Enhancment I S = Stabilization P2 = Priority 2 SS = Stream Bank Stabilization

[a]Source: USACE 2003.

[b]Source: Rosgen 2006.

C. Location and Setting

The Brush-Little Pine creeks project site (Figure 1) is located in Alleghany County, North Carolina in the Blue Ridge Province of the Appalachian Mountains. It is 6.5 miles east of Sparta, 7.25 miles north, northwest of Roaring Gap, and 1.75 miles southwest of Ennice.

Land uses within the watershed consist mostly of forest land converted to various agricultural activities (cattle operations and row crops), Christmas tree farming, and forestry. A significant portion of the watershed remains in second growth forest. Some agricultural land has been converted for use as single family home sites.

D. Project History and Background

The project's background and history are summarized in the following tables:

- Exhibit Table II - project activity with the associated planned and actual year completed.
- Exhibit Table III - contact information for the project's designer, construction contractors, and groups conducting the site monitoring.
- Exhibit Table IV – General geographical, morphological, and water quality characteristics of the project.

Figure 1.—Project Location Map.

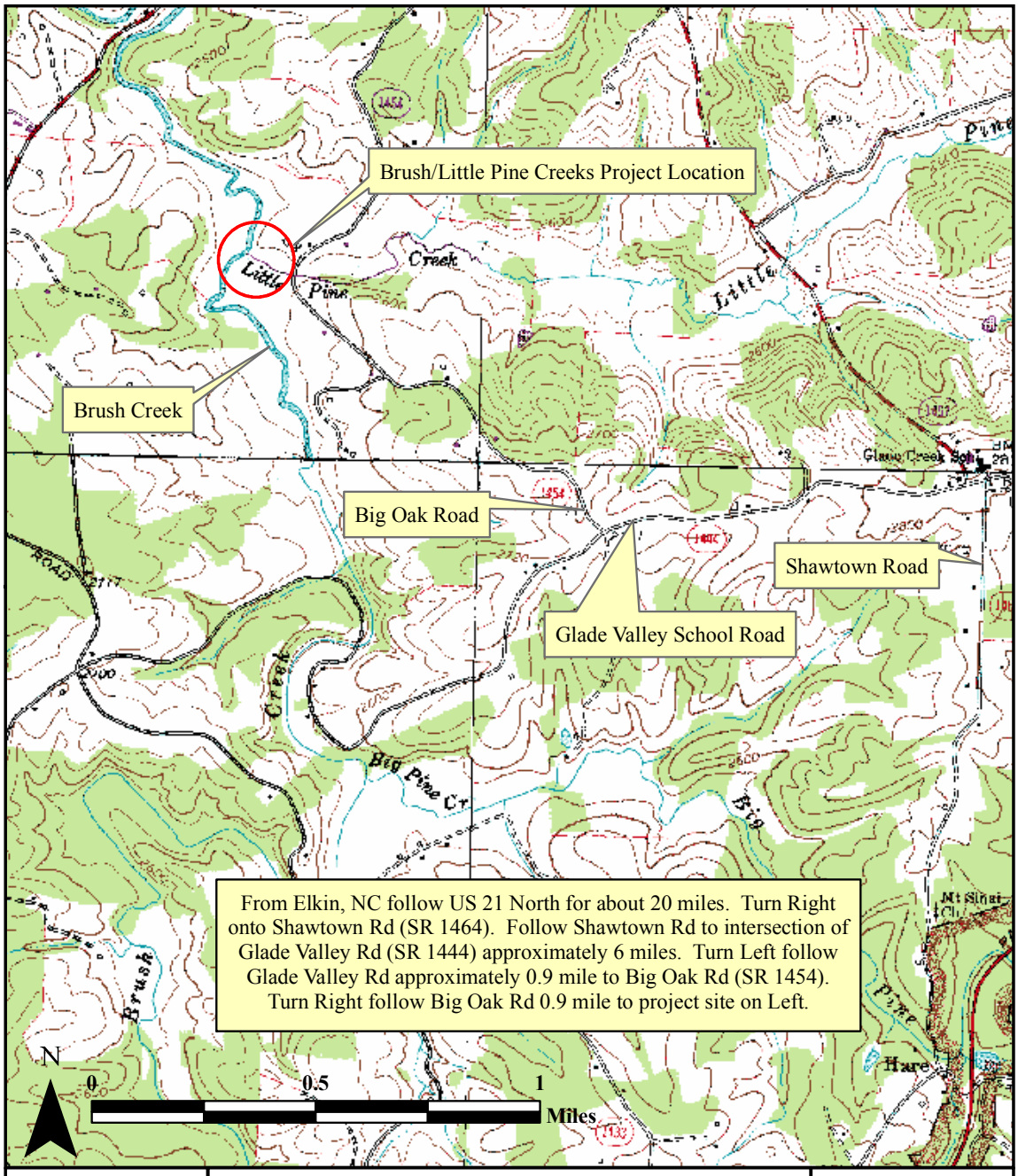


Figure 1. Project Location Map
Brush and Little Pine Creeks Stream Restoration Maintenance
EEP Project Number 054, As-built (2006)
Alleghany County, North Carolina
April 2008

Source:
United States Department of the Interior, Geological Survey
Cumberland Knob, Glade Valley, Roaring Gap, and Sparta East Quadrangles, 7.5 Minute Series (Topographic).

Exhibit Table II.–Project Activity and Reporting History.
Brush-Little Pine Creeks/Project Number (054)

Activity or Report	Data Collection Complete	Actual Completion or Delivery
Restoration Plan	NA	Oct 2000
Final Design	NA	NA
Construction	NA	Jul 2001
Temporary seed mix applied to entire project area	NA	Jul 2001
Permanent seed mix applied to entire project area	NA	Jul 2001
Bare root and live stakes plantings for the entire project area	NA	Jan 2002
Mitigation/as-built (Year 0 Monitoring - baseline)	2001	Jun 2002
Year 1 monitoring	May 2002	Jan 2003
Year 2 monitoring	Sep 2003	Mar 2003
Year 3 monitoring	June 2004	Feb 2004
Stream restoration maintenance plan - Brush and Little Pine Creeks	NA	Aug 2005
Stream restoration maintenance construction - Brush and Little Pine Creeks	NA	Nov 2006
Temporary and permanent seed mix applied to entire project area	NA	Nov 2006
Containerized plantings for the entire area	NA	Dec 2006
Live stakes planted	NA	Dec 2006
As-built report	Feb 2007	Apr 2008
Year 4 Monitoring		
Year 5 Monitoring		

Bolded items represent those events or deliverables that are variable. Non-bolded items represent events that are standard components over the course of a typical project.

Exhibit Table III.—Project Contact Table.
Brush-Little Pine Creeks/Project Number (054)

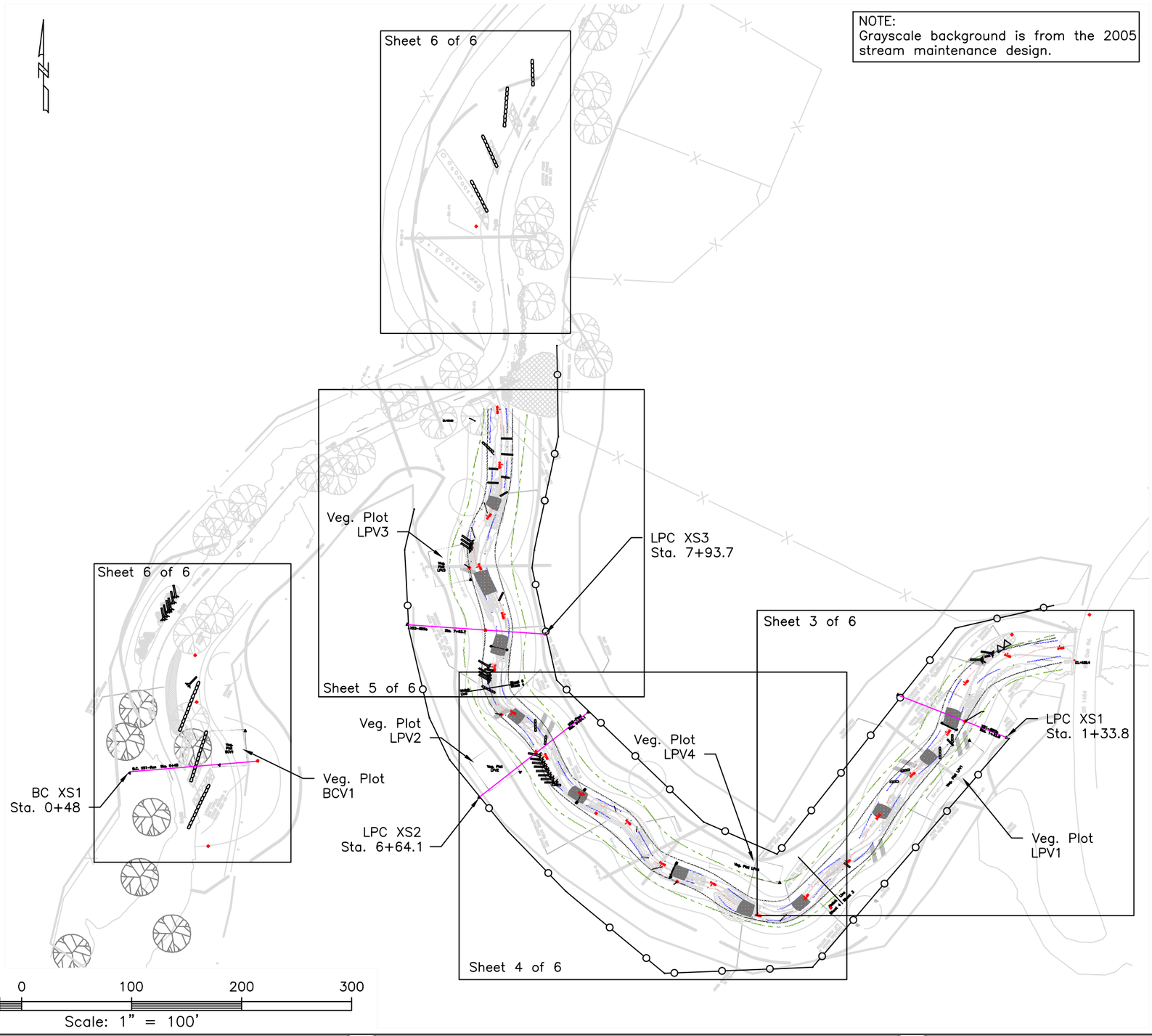
Designer HDR Engineering, Inc. of the Carolinas	Mr. Christopher R. Matthews 128 S. Tryon St., Suite 1400 Charlotte, NC 28202 (704) 338-6778
Construction Contractor North Carolina Wildlife Resources Commission Watershed Enhancement Group Field Office	Mr. Mark Fowlkes P.O. Box 387 Elkin, NC 28621 (336) 527-1547
Sub-Construction Contractor Yadkin Valley Construction, Inc. Grading and Fencing	Mr. Terry Benton 2961 Old 60 Hwy. Ronda, NC 28670 (336) 984-2219
Planting Contractor Habitat Assessment and Restoration Program, Inc.	Mr. James F. Matthews, Ph.D. 9305-D Monroe Rd. Charlotte, NC 28270 (704) 841-2841
Seeding Contractor North Carolina Wildlife Resources Commission Watershed Enhancement Group Field Office	Mr. Mark Fowlkes P.O. Box 387 Elkin, NC 28621 (336) 527-1547
Seed Mix Sources	New England Wetland Plants, Inc. (413) 548-8000
Nursery Stock Suppliers	HARP, Inc (704) 841-2841 Foggy Mountain Nursery (336) 385-2222
Monitoring Performers **Year 1** HDR Engineering, Inc. of the Carolinas	Mr. Christopher R. Matthews 128 S. Tryon St., Suite 1400 Charlotte, NC 28202 (704) 338-6778
Year 2 - Year 3 Biological & Agricultural Engineering Water Resources Research Institute North Carolina State University	Mr. Dan Clinton Campus Box 7625 Raleigh, NC 27695 (919) 515-6771

Exhibit Table IV.—Project Background Table.
Brush-Little Pine Creeks/Project Number (054)

Project County	Alleghany County
Drainage Area (square miles)	Brush Creek: 26.3 Little Pine Creek: 4.3
Drainage Impervious Cover Estimate (%)	Brush Creek: <10 Little Pine Creek: <10
Stream Order Reference: USGS 1:24,000 Topographic maps	Brush Creek: fourth order perennial stream Little Pine Creek: third order perennial stream
Physiographic Region Reference: http://www.geology.enr.state.nc.us/proj_earth/proj_earth.html	Blue Ridge Province
Ecoregion Reference: USACE 2003	New River Plateau
Rosgen Stream Classification of As-built	2002, E4; 2006, C4
Dominant Soil Types Reference: http://websoilsurvey.nrcs.usda.gov/app/	Alluvial Land, Chester Loam, Codorus Complex, Comus Fine Sandy Loam, and Tate Loam
Reference Site ID	Data not available
USGS HUC for Project and Reference	05050001
NCDWQ Sub-basin for Project and Reference	05-07-03
NCDWQ Classification for Project and Reference Reference: http://h2o.enr.state.nc.us/csu/	Brush Creek: C TR Little Pine Creek: 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	NA
Percentage of Project Easement Fenced	100%

E. As-built Plan View

Figure 2 - Brush-Little Pine Creeks As-built and Problem Area Plan View



Legend

- Thalweg
- Edge of Water
- Bankfull
- Terrace Crest
- Existing Fence Line
- PS-# Photo Station Location
- Rebar Pin Set
- Root Wad
- Existing Root Wad Found
- Rock Vane
- Rock Sill
- Log Vane
- Digger Log
- Augmented Riffle

Ecosystem Enhancement Program

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION
WATERSHED ENHANCEMENT GROUP

P.O. BOX 387
ELKIN, NORTH CAROLINA 28621

336.527.1547 OFFICE
336.527.1548 FAX

Brush Creek/Little Pine Creek Maintenance

Alleghany County, NC — As-Built Survey - Jan. 22, 207

Overall Plan View

DRAWN BY: J. Ferguson	DATE: March, 2007
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REVISION: J. Ferguson	DATE: June, 2009
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Figure 2 (Cont.) - Brush-Little Pine Creeks As-built and Problem Area Plan View

NOTE:
Grayscale background is from the 2005 stream maintenance design.

N

Vegetation Problem Area
(Brush Creek)
Woody plants were
eaten by beaver.

Veg. Plot
LPV3

LPC XS3
Sta. 7+93.7

Veg. Plot
LPV2

LPC XS1
Sta. 1+33.8

BC XS1
Sta. 0+48

Veg. Plot
BCV1

LPC XS2
Sta. 6+64.1

Veg. Plot
LPV1

Legend

- Thalweg
- Edge of Water
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- Terrace Crest
- Existing Fence Line
- Rebar Pin Set
- Root Wad
- Existing Root Wad Found
- Rock Vane
- Rock Sill
- Log Vane
- Digger Log
- Augmented Riffle
- Vegetation Problem Area

Ecosystem Enhancement Program

100 0 100 200 300

Scale: 1" = 100'

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Brush Creek/Little Pine Creek Maintenance

Alleghany County, NC — As-Built Survey - Jan. 22, 207

Vegetation Problem Area Plan View

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REVISION: J. Ferguson	DATE: June, 2009
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SHEET 2 OF 6

Figure 2 (Cont.) - Brush-Little Pine Creeks As-built and Problem Area Plan View

Monitoring Pin Coordinates:

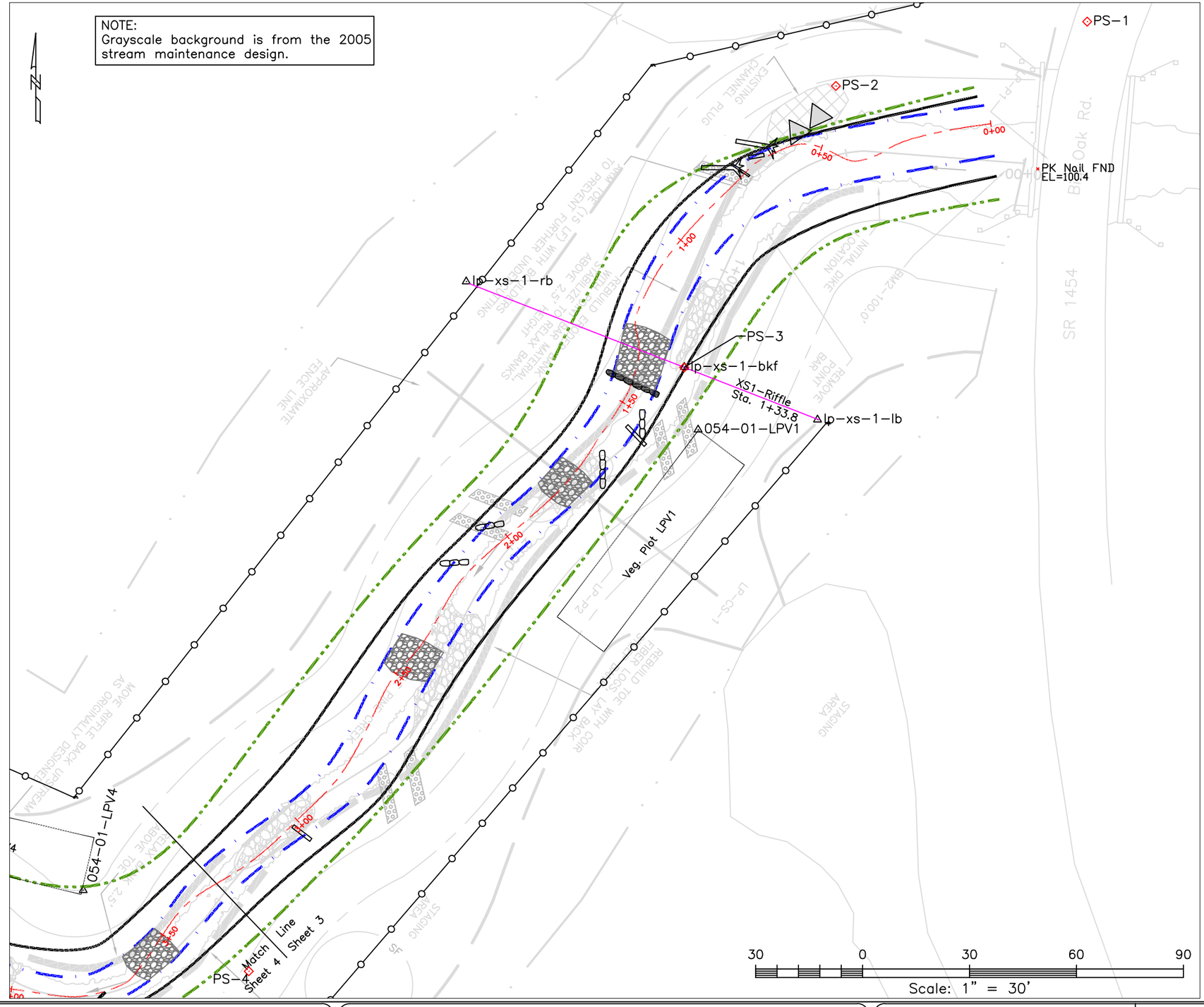
Little Pine Creek

Location	Latitude(N)	Longitude(W)
Veg. Plots:		
054-01-LPV1	36.50591020°	81.00769455°
054-01-LPV2	36.50580894°	81.00908181°
054-01-LPV3	36.50628667°	81.00924745°
054-01-LPV4	36.50554587°	81.00827233°
Cross Sectons:		
lp-xs-1-lb	36.50591981°	81.00758077°
lp-xs-1-bkf	36.50595858°	81.00771178°
lp-xs-1-rb	36.50602071°	81.00791864°
lp-xs-2-lp	36.50574429°	81.00920903°
lp-xs-2-bkf	36.50586082°	81.00903444°
lp-xs-2-rb	36.50596233°	81.00887254°
lp-xs-3-lb	36.50617149°	81.00944020°
lp-xs-3-bkf	36.50616173°	81.00919816°
lp-xs-3-rb	36.50615447°	81.00901317°
Longitudinal Profile:		
begin survey	36.50614744°	81.00742900°
end survey	36.50671371°	81.00917776°
Photo Stations:		
PS-1	36.50623056°	81.00733122°
PS-2	36.50617709°	81.00756979°
PS-3	36.50595799°	81.00770895°
PS-4	36.50548606°	81.00811273°
PS-5	36.50554358°	81.00858985°
PS-6	36.50570996°	81.00884450°
PS-7	36.50586088°	81.00903451°
PS-8	36.50595143°	81.00914380°
PS-9	36.50616173°	81.00919818°
PS-10	36.50631667°	81.00925134°

Brush Creek

Location	Latitude(N)	Longitude(W)
Veg. Plots:		
054-01-BCV1	36.50589788°	81.00993449°
Cross Sectons:		
bc-xs-4-lb	36.50578678°	81.01028959°
bc-xs-4-bkf	36.50580545°	81.01000965°
bc-xs-4-rb	36.50582344°	81.00989429°
Photo Stations:		
PS-11	36.50560838°	81.01004210°
PS-12	36.50582348°	81.00989432°
PS-13	36.50596754°	81.01008668°
PS-14	36.50608395°	81.01009412°
PS-15	36.50716885°	81.00925196°

NOTE:
Grayscale background is from the 2005 stream maintenance design.



Legend

- Thalweg
- Edge of Water
- Bankfull
- Terrace Crest
- Existing Fence Line
- PS-# Photo Station Location
- Rebar Pin Set
- Root Wad
- Existing Root Wad Found
- Rock Vane
- Rock Sill
- Log Vane
- Digger Log
- Augmented Riffle

Ecosystem Enhancement Program

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Little Pine Creek Maintenance

Alleghany County, NC — As-Built Survey - Jan. 22, 207

Sta. 0+00 - Sta. 3+25

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REVISION: J. Ferguson	DATE: June, 2009
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SHEET 3 OF 6

Figure 2 (Cont.) - Brush-Little Pine Creeks As-built and Problem Area Plan View

Monitoring Pin Coordinates:

Little Pine Creek

Location	Latitude(N)	Longitude(W)
Veg. Plots:		
054-01-LPV1	36.50591020°	81.00769455°
054-01-LPV2	36.50580894°	81.00908181°
054-01-LPV3	36.50628667°	81.00924745°
054-01-LPV4	36.50554587°	81.00827233°
Cross Sectons:		
lp-xs-1-lb	36.50591981°	81.00758077°
lp-xs-1-bkf	36.50595858°	81.00771178°
lp-xs-1-rb	36.50602071°	81.00791864°
lp-xs-2-lp	36.50574429°	81.00920903°
lp-xs-2-bkf	36.50586082°	81.00903444°
lp-xs-2-rb	36.50596233°	81.00887254°
lp-xs-3-lb	36.50617149°	81.00944020°
lp-xs-3-bkf	36.50616173°	81.00919816°
lp-xs-3-rb	36.50615447°	81.00901317°
Longitudinal Profile:		
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PS-5	36.50554358°	81.00858985°
PS-6	36.50570996°	81.00884450°
PS-7	36.50586088°	81.00903451°
PS-8	36.50595143°	81.00914380°
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Brush Creek

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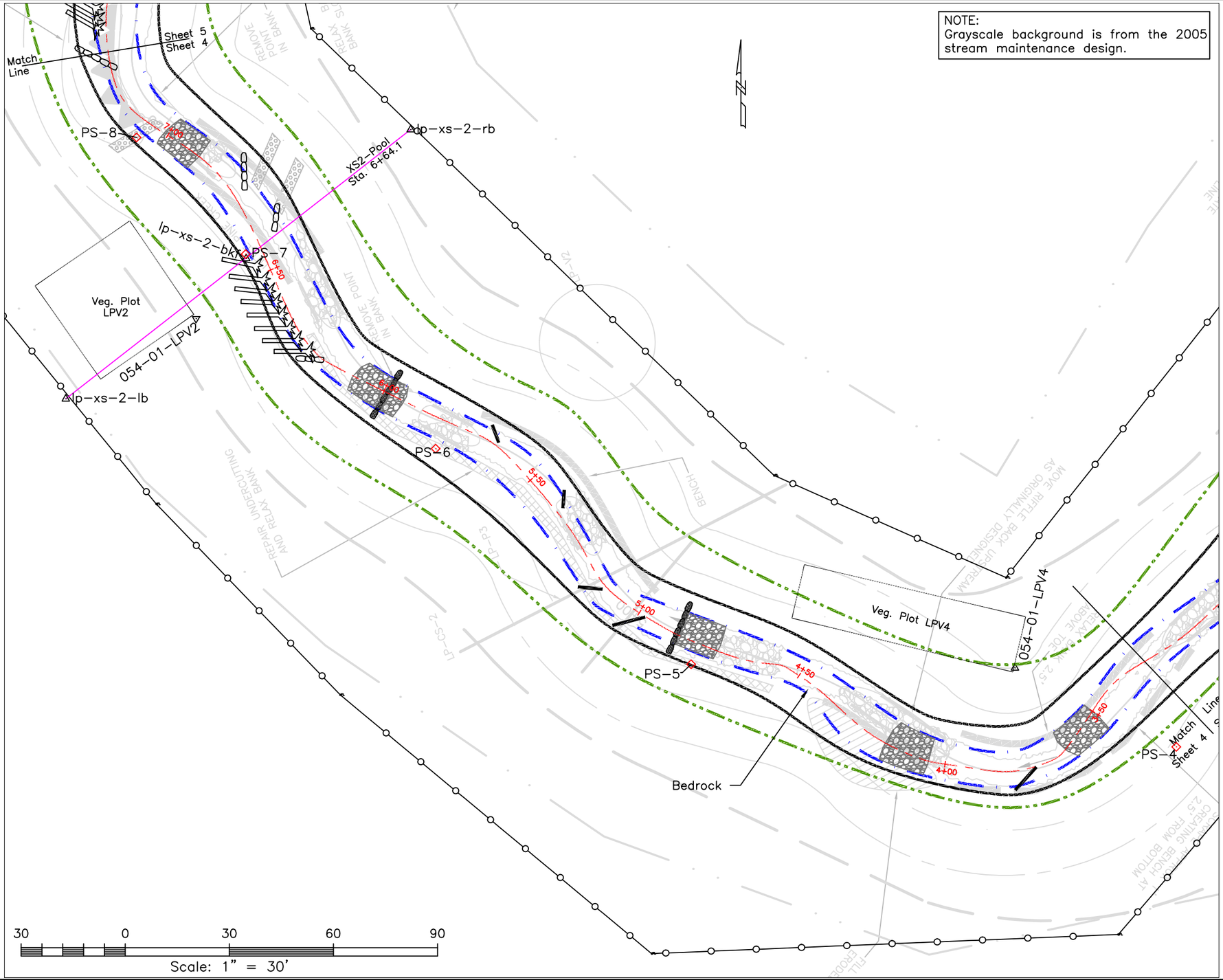

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- Digger Log
- Augmented Riffle

Ecosystem Enhancement Program

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Little Pine Creek Maintenance

Alleghany County, NC — As-Built Survey - Jan. 22, 207

Sta. 3+25 - Sta. 7+20

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REVISION: J. Ferguson	DATE: June, 2009
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SHEET 4 OF 6

Figure 2 (Cont.) - Brush-Little Pine Creeks As-built and Problem Area Plan View

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Little Pine Creek

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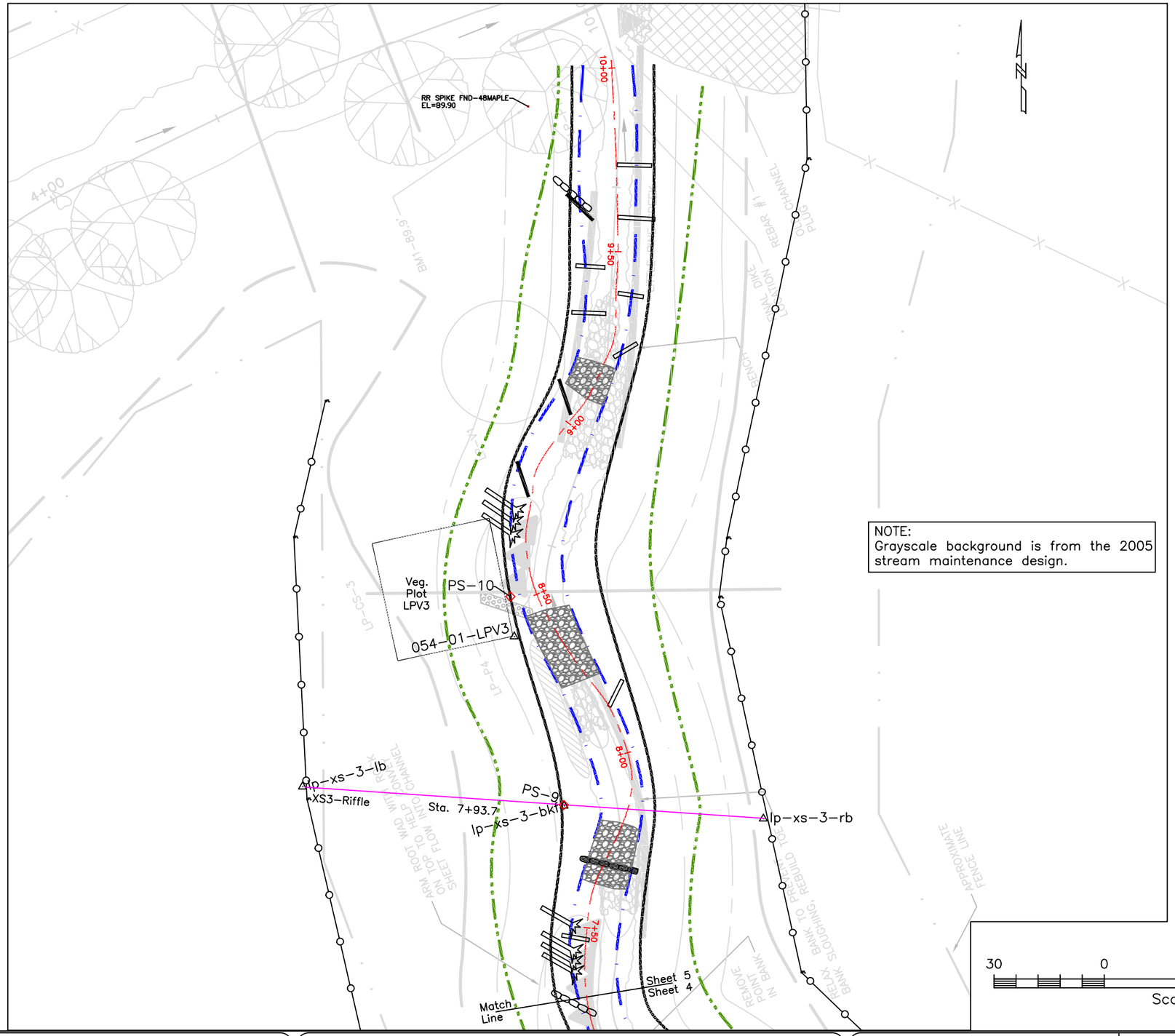
PS-4	36.50548606°	81.00811273°
PS-5	36.50554358°	81.00858985°
PS-6	36.50570996°	81.00884450°
PS-7	36.50586088°	81.00903451°
PS-8	36.50595143°	81.00914380°
PS-9	36.50616173°	81.00919818°
PS-10	36.50631667°	81.00925134°

Brush Creek

Location	Latitude(N)	Longitude(W)
Veg. Plots:		
054-01-BCV1	36.50589788°	81.00993449°
Cross Sectons:		
bc-xs-4-lb	36.50578678°	81.01028959°
bc-xs-4-bkf	36.50580545°	81.01000965°
bc-xs-4-rb	36.50582344°	81.00989429°
Photo Stations:		
PS-11	36.50560838°	81.01004210°
PS-12	36.50582348°	81.00989432°
PS-13	36.50596754°	81.01008668°
PS-14	36.50608395°	81.01009412°
PS-15	36.50716885°	81.00925196°



Ecosystem Enhancement Program

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION
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Little Pine Creek Maintenance

Alleghany County, NC — As-Built Survey - Jan. 22, 207

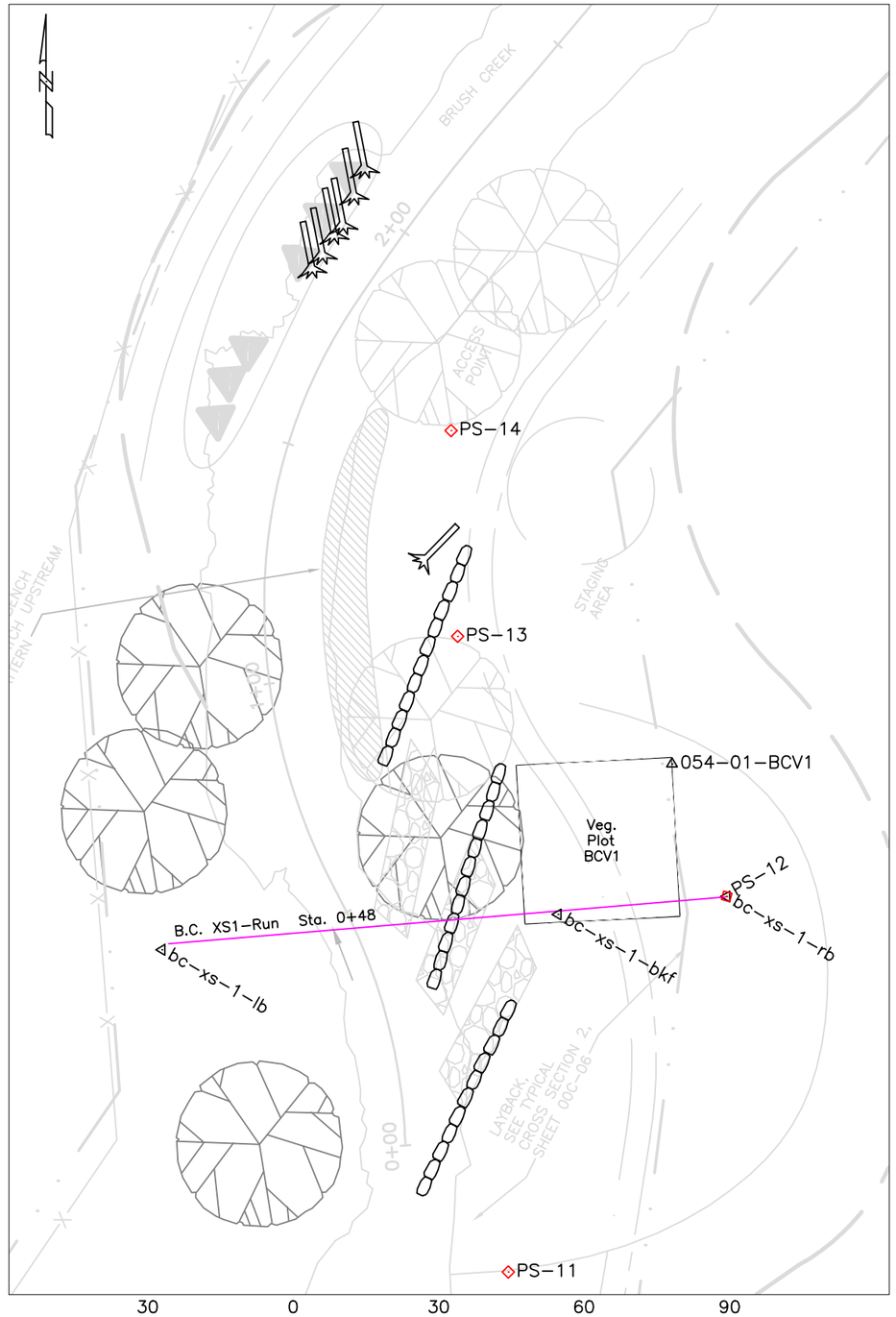
Sta. 7+20 - Sta. 10+00

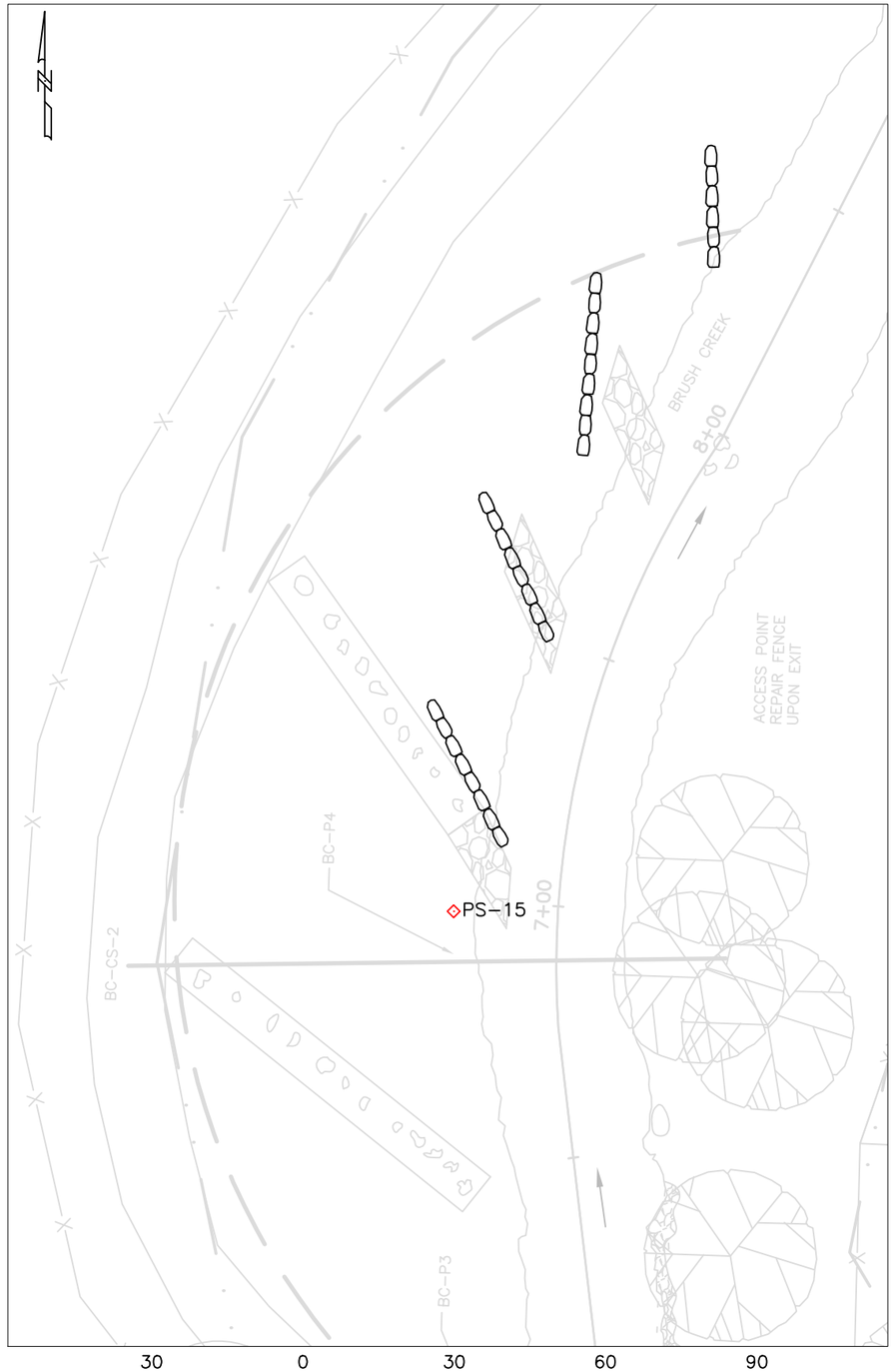
DRAWN BY: J. Ferguson	DATE: March, 2007
APPROVED:	DATE:
REVISION: J. Ferguson	DATE: June, 2009
CAD FILE ID: BLPASBLT.DWG	

SHEET 5 OF 6

Figure 2 (Cont.) - Brush-Little Pine Creeks As-built and Problem Area Plan View

NOTE:
Grayscale background is from the 2005 stream maintenance design.





Legend

- PS–# Photo Station Location
- Rebar Pin Set
- Root Wad
- Rock Vane

Monitoring Pin Coordinates:

Little Pine Creek

Location	Latitude(N)	Longitude(W)
Veg. Plots:		
054-01-LPV1	36.50591020°	81.00769455°
054-01-LPV2	36.50580894°	81.00908181°
054-01-LPV3	36.50628667°	81.00924745°
054-01-LPV4	36.50554587°	81.00827233°
Cross Sectons:		
lp-xs-1-lb	36.50591981°	81.00758077°
lp-xs-1-bkf	36.50595858°	81.00771178°
lp-xs-1-rb	36.50602071°	81.00791864°
lp-xs-2-lp	36.50574429°	81.00920903°
lp-xs-2-bkf	36.50586082°	81.00903444°
lp-xs-2-rb	36.50596233°	81.00887254°
lp-xs-3-lb	36.50617149°	81.00944020°
lp-xs-3-bkf	36.50616173°	81.00919816°
lp-xs-3-rb	36.50615447°	81.00901317°
Longitudinal Profile:		
begin survey	36.50614744°	81.00742900°
end survey	36.50671371°	81.00917776°
Photo Stations:		
PS-1	36.50623056°	81.00733122°
PS-2	36.50617709°	81.00756979°
PS-3	36.50595799°	81.00770895°
PS-4	36.50548606°	81.00811273°
PS-5	36.50554358°	81.00858985°
PS-6	36.50570996°	81.00884450°
PS-7	36.50586088°	81.00903451°
PS-8	36.50595143°	81.00914380°
PS-9	36.50616173°	81.00919818°
PS-10	36.50631667°	81.00925134°

Brush Creek

Location	Latitude(N)	Longitude(W)
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bc-xs-4-bkf	36.50580545°	81.01000965°
bc-xs-4-rb	36.50582344°	81.00989429°
Photo Stations:		
PS-11	36.50560838°	81.01004210°
PS-12	36.50582348°	81.00989432°
PS-13	36.50596754°	81.01008668°
PS-14	36.50608395°	81.01009412°
PS-15	36.50716885°	81.00925196°

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Brush Creek Maintenance

Alleghany County, NC — As-Built Survey - Jan. 22, 207

Sta. 0+00 - 2+50 & Sta. 6+00 - 9+00

DRAWN BY: J. Ferguson	DATE: March, 2007
APPROVED:	DATE:
REVISION: J. Ferguson	DATE: June, 2009
CAD FILE ID: BLPASBLT.DWG	

SHEET 6 OF 6

III. Methods

On LPC, two representative riffle and one representative pool cross-sections were measured, the longitudinal profile surveyed, and cross-section and reach-wide pebble count data collected. On BC both cross-section survey data and pebble count data were obtained from a riffle. All data were taken using standard stream survey techniques (Harrelson et al. 1994). A Nikon DTM 821 total station was used to survey the stream's pattern, profile, and dimension. Mountain and piedmont regional hydraulic geometry curve data were used to evaluate bankfull elevation conditions in the field (Harman et al. 1999). Cross-section data were used to classify the stream based on existing morphological features of the stream channel and valley type (Rosgen 1994, 1996). Site and reference conditions were analyzed and the project design developed using RIVERMorph stream assessment and restoration software, Version 4.0.1 (RSARS 2006) and AutoCAD (2004) Version 2004.0.0. Vegetation surveys were conducted using the EEP and the Carolina Vegetation Survey level 1 protocol (Lee et al. 2006) to determine plant survival. Regulatory guidance, procedures, and success criteria as described in U.S. Army Corps of Engineers stream mitigation document (USACE 2003) and the original conceptual plans (HDR 2000) were also used. Detailed methods and deviations in standard methods are detailed in individual sections below.

Geographic location information was collected using a Trimble Geo XT handheld mapping grade Global Positioning System receiver. Coordinates were collected at the beginning, end, and bankfull pin locations for all cross-sections, the beginning and end of the longitudinal profile, the origin of each vegetation-monitoring plot, and at photographic stations. Sufficient fixes were obtained to allow positions to be determined with sub-meter precision.

IV. Project Conditions and As-built Results

A. Vegetation

The repair work disturbed approximately 3 acres of riparian land along BC and LPC. Disturbed areas were seeded with a mixture of annual wheat *Triticum sp*. and winter rye *Secale cereale* (40 lb/acre) to establish a temporary ground cover; a native herbaceous seed mix (10 lb/acre) was planted to establish a permanent ground cover (Appendix A, Exhibit Table A.VIII.). Salvaged sod mats were used on disturbed stream banks to provide an immediate ground cover and to minimize erosion. A total of 1,485 (495/acre) containerized native trees and shrubs were planted in the riparian areas along BC and LPC (Appendix A, Exhibit Table A.IX.). Individual species were planted in designated zones depending on their tolerance for ground moisture (HDR 2005a). A total of 930 live stakes (310 stakes/acre) were also planted along the stream banks on approximately 4 foot centers (Appendix A, Exhibit Table A.X.). Live stakes were planted at higher densities near structures and in areas of greater bank stress. A total of 23 plant species were planted.

Vegetation was surveyed on January 11 and January 22, 2007 in four representative plots along LPC and one plot on the reshaped bank of BC (Figure 2). At the direction of EEP staff, the pre-existing vegetation plots on BC were not surveyed. The location and number of new plots were placed pursuant to EEP staff guidance. All plots were either 10.0 m x 10.0 m (32.8 ft

x 32.8 ft) or 20.0 m x 5.0 m (65.6 ft x 16.4 ft). Plot corners were marked with 0.5 inch iron rebar. All woody stems in the plots were marked with orange flagging. Some plants were difficult to identify because they either lacked leaves, had damaged stems, or both. Photographs of the vegetation plots were taken from the point of origin at the time of the vegetation survey. Subsequently, when it was discovered the original photographs were missing; they were retaken on April 18, 2007.

Vegetation data, including stem counts, plant vigor, and plant damage are presented in Appendix A. Stem counts for LPC plots 1 through 4 and BC plot 1 revealed 22 live stems (891 stems/acre), 17 live stems (688 stems/acre), 26 live stems (1,053 stems/acre), 22 live stems (891 stems/acre), and 25 live stems (1,012 stems/acre) were present, with an average of 22 live stems per plot (907 stems/acre). A total of 20 species were identified in the plots, averaging approximately 9 species per plot.

Twenty-one percent of the total stems in the monitoring plots were identified as damaged. A majority of damage was caused by beavers (48%) and human trampling (23%). Beavers removed the tops of stems leaving stumps. Stumps were counted as live stems, but given a vigor rating of 1 – "unlikely to survive the next year". Human trampling occurred mostly to live stakes. Damaged stems were identified in all plots; however, BC plot 1 accounted for the majority of damage to total stems. Beavers impacted 54% of the plants in BC plot 1.

To reduce further impacts from beaver, the U. S. Department of Agriculture was contracted and eradicated three beavers from the project area. The remaining woody vegetation appears to be in good condition and planted at high enough densities to tolerate some additional mortality without jeopardizing the site's ability to meet future success criteria (320 stems/acre in monitoring year 3; USACE 2003).

1. Vegetative Problem Area

One problem area was identified during the as-built survey (Figure 2, Sheet 2). Beavers ate a significant portion of the planted trees and shrubs along the enhanced portion of Brush Creek's right bank from station 0+0.0 to station 1+50.0 (Appendix A, Exhibit Table A.VI. and photograph in Appendix A, Section 2) leaving mostly stumps.

It is recommended the problem area on BC be replanted with larger diameter containerized woody plant species such as silky dogwood *Cornus amomum* and silky willow *Salix sericea* that are adapted to being browsed. In addition, the monitoring and beaver eradication program should continue until tree and shrub species become fully established.

Fescue occurs throughout the project site and on adjacent pastures. It will compete with native herbaceous and woody vegetation (NCSU 2003, 2004) until woody vegetation grows large enough to shade out the fescue. At that time, the native herbaceous plants should be able to become established. Because of the extensive seed source from the adjacent pasture, it is not feasible to eradicate it entirely. However, herbicide treatments around trees for the first two or three years should reduce competition with the fescue.

2. Problem area plan view

Problem areas are identified in Figure 2.

B. Stream

1. Procedural Items

a. Morphometric Criteria

The post-construction survey data were collected on January 4, 22, and 23 and February 22, 2007. On LPC cross-section dimensions were measured at stations 1+33.8 (riffle), 6+64.1 (pool), and 7+93.7 (riffle), longitudinal profile data were collected, and four pebble counts made (three cross-sections and one reach-wide (Figure 2). A representative riffle cross-section was surveyed and a pebble count sample taken along the enhanced portion of BC at station 0+48.0. Previously established cross-sections were not measured and longitudinal profile elevation data were not collected on BC at the direction of EEP staff. Half-inch rebar was used to mark the beginning and end of each transect, as well as to identify the approximate bankfull elevation.

Existing benchmarks were utilized for the survey. These included a nail in the middle of the Big Oak Road (SR 1454) bridge crossing of LPC and a benchmark pin in a cherry tree near the confluence of LPC and BC (Figure 2). However, the existing benchmark pin, BM2 (HDR 2005a), used for the original longitudinal profile could not be found. The benchmark on the bridge was arbitrarily given an elevation of 100 ft. The post-construction longitudinal profile elevations and stationing did not match the 2004 survey data. To make the data match, the 2004 elevation data (NCSU 2004) were adjusted down by 6.5 ft and 45 ft was added to the longitudinal stationing. This resulted in the 2004 longitudinal profile starting at station 0+70.0 instead of station 0+25.0. Direct comparisons of pre- and post-construction longitudinal profile data are limited. Comparisons of pre- and post-construction cross-section and pebble count data were also limited, since post-construction cross-section data were taken at different locations.

A bank stability assessment, stream stability assessment, and stream problem area survey were not performed as directed by EEP staff.

b. Hydrologic Criteria

One bankfull event occurred between the end of construction and the installation of a crest gauge. A debris wrack line above the bankfull elevation was identified on January 24, 2007 (Exhibit Table V. and Appendix B, Section 7). To monitor additional bankfull events, a crest gauge was installed on the left bank next to the first cross-section bankfull pin (lp-xs-1-bkf) on LPC.

Exhibit Table V.—Verification of Bankfull Events.
Brush-Little Pine Creeks/Project Number (054)

Date of Data Collection	Date of Occurrence	Method	Photograph Number (if available)
01/24/07	January 2007	Visual inspection of wrack line	LP_Bankfull_1-24-2007

c. Bank Stability Assessment

Bank erosion hazard index (BEHI) and near bank stress (NBS) assessments are not conducted as a routine part of the as-built survey. Exhibit Table VI is a place holder and will be populated with data at the appropriate time.

Exhibit Table VI.—BEHI and Sediment Export Estimates.
Brush-Little Pine Creeks/Project Number (054)

Time Point	Segment/ Reach	Linear Footage or Acreage	Extreme		Very High		High		Moderate		Low		Very Low		Sediment Export
			ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	Ton/year

2. Plan Modifications

The repair plan was based on 2004 monitoring survey data. Both BC's and LPC's morphology changed between the 2004 monitoring survey and when construction took place in September 2006. Structures were placed in the general vicinity shown in the design plans with variations dependent on the current channel characteristics. The repair plan was modified during construction with approval from the designer and EEP personnel in order to provide greater stream stability and project success. Major modifications are listed below.

Little Pine Creek.-Between station 0+50.0 and station 0+75.0 on LPC the repair plan called for adding a root wad and mini-rock vane along the right bank. Two root wads were added to the right bank with logs in between the root wads. These logs fill in gaps between the root wads, help stabilize the bank, act as digger logs to help maintain pool depth, and provide fish habitat. The additional root wads made the proposed mini-rock vane at station 0+72.0 unnecessary.

Two mini-rock vanes were installed on the left bank between station 1+50.0 and station 1+70.0 on LPC as the plans called for; however, a bankfull bench was not created between the rock vanes because the existing bank was stable. At station 1+75.0 the stream bed was reshaped to create a riffle by elevating the head of the existing riffle elevation to increase its slope. This riffle was not augmented with larger rock. At least one bankfull event occurred after construction was completed and prior to the as-built survey. During this time, the riffle decreased in slope to the degree that it had evolved into a shallow pool. The riffle at station 2+43.0 was also reworked and steepened at the request of the designer; this enhancement was not on the original repair plan.

The two proposed mini-rock vanes along the left bank of LPC between station 2+60.0 and station 2+80.0 were not installed. This section of bank was stable and vegetated with silky dogwood. Bank stress was further reduced by creating a bankfull bench along the right bank. An existing digger log at station 3+05.0 was left in place to provide habitat complexity in the stream.

A log vane was installed along the left bank of LPC at station 3+79.0 to help direct water away from the bank and around the meander bend; this enhancement was not on the original repair plan. The toe of the left bank was protected with a coir log, while a bankfull bench was created along the right bank. With the other enhancements at this location, the proposed bankfull bench along the left bank between stations 3+70.0 and 4+20.0 was not necessary.

At the direction of EEP and HDR staff, a bankfull bench was built on both sides of LPC station 4+25.0 to its confluence with BC. The bench was built at a lower elevation than called for in the repair plan to accommodate the increased bank height in this area.

The riffle at station 4+55.0 was augmented with larger diameter rock at the request of the designer and EEP. Four additional log vanes were installed; one each at stations 5+05.0 and 5+20.0 along the left bank and one each at stations 5+40.0 and 5+71.0 along the right bank. The log vanes direct water away from the bank and increase habitat complexity. A rock vane and 8 root wads were installed along the left bank between stations 6+20.0 and 6+64.0 to help direct water away from and stabilize the bank. These enhancements were not in the repair plan.

A mini-rock vane, 4 root wads, and a digger/footer log were installed along the left stream bank between station 7+00.0 and station 7+50.0. The repair plan called for a mini-rock vane and 6 root wads.

A digger log was installed on the right bank at station 8+14.0 to provide additional aquatic habitat; it was not in the repair plan.

A mini-rock vane with three root wads was proposed for the left bank at station 8+50.0. The low bankfull bench built on the adjacent right bank, along with the three installed root wads and coir logs created a stable environment and making the mini-rock vane unnecessary.

Two additional log vanes were installed at stations 8+75.0 and 9+05.0 on LPC to help redirect water away from the banks and enhance aquatic habitat. Although not in the repair plan, the riffle at station 9+19.0 was augmented with larger rock at the request of the HDR engineer. The area between station 8+68.0 and the confluence with BC has little current (backwater) where fine sediment was being deposited. Five digger logs were installed in this area in an attempt to provide increased water velocity, improved habitat, and to help move sediment out of this area. A log/rock vane was installed on the left bank at station 9+70.0 to help stabilize the bank.

Brush Creek.-The repair plan called for extending the left bank into the existing stream channel and installing three root wads between station 1+50.0 and station 1+75.0. The bank at station 1+75.0 had previously been stabilized with large rock. This area was currently stable and provided backwater habitat for fish. Six root wads were installed on the left bank between

station 1+80.0 and station 2+10.0; only three were called for in the repair plan. An additional rock vane was installed on the left bank at station 8+40.0.

3. Problem Area Plan View

No stream problem areas were observed. A problem area plan view is not included in the as-built report.

4. Stream Problem Area Table

No stream problem areas were observed. Appendix B, Exhibit Table B.I. Problem Areas Table is used as a place holder for future monitoring reports.

5. Numbered Issue Photographs

No stream channel problem areas were observed during the as-built survey; therefore, problem photographs are not included in the as-built report.

6. Fixed Station Photographs

Fixed station photographs document pre- and post-construction conditions and are located in Appendix B, Section 3.

7. Stability Assessment Table

At the direction of EEP, a visual stability assessment was not performed at the time of the as-built survey. Stability assessments had not been performed in previous monitoring years. The stream was stable at the time of the as-built survey.

8. Quantitative Measures Summary

Exhibit Table VII summarizes the baseline quantitative morphological data collected from the cross-section surveys, longitudinal profile surveys, and pebble counts for LPC. Similar data were not summarized for BC because data from only one cross-section and one pebble count were collected (Exhibit Table VIII). These data will be compared with future monitoring data. The cross-section, longitudinal profile, and pebble count data are presented in Appendix B, Sections 4 and 5. These measurements will be used to illustrate the degree of departure of the stream channel and substrate characteristics, if any, between the as-built channel condition and that found during future monitoring surveys.

The repair typical drawings provided approximate width and depth parameters supporting the overall goal of constructing a channel with C type characteristics as opposed to the E type as described in the original design plan. The intent of constructing a C type channel was to reduce the pressures on the steeper banks that typified the original E channel. By increasing the width/depth ratio in this somewhat flashy mountain valley, the channel will have time to narrow on it's own by depositing sediment on the bankfull benches and the subsequent advancement of

vegetation. The original design plan called for bankfull widths of approximately 23 ft to 28 ft, bankfull mean depths of 1.5 ft to 2.0 ft, and cross-sectional areas of 42 ft^2 to 46 ft^2 (G. Melia, EEP, personal communication).

The results of the repair work on the LPC channel appear to have closely matched the design ranges identified in the typical drawings of the repair plan. The LPC 2006 as-built riffle bankfull width roughly met the design ranges with a mean bankfull width of 27.6 ft (range - 24.9 ft to 30.3 ft; Exhibit Table VII). Riffle bankfull cross-sectional area ranged between 45.1 ft^2 and 45.3 ft^2 and mean depth ranged between 1.5 ft and 1.8 ft. The stream channel with the larger bankfull width allowed for a greater width/depth ratio while still maintaining a stable C channel type.

The repair plan typical drawings also specified creating a bankfull bench 2.5 ft above the stream bottom (HDR 2005a, 2005b). Cross-sections 1, 2, and 3 had bankfull benches 3.5 ft, 3.2 ft, and 2.4 ft above the stream bottom. The cross-section 1 bankfull bench is higher than the design specification; however, the stream banks have a 3:1 slope and are stable. The upper section of LPC from station 0+0.0 to approximately station 4+25.0 had a higher bankfull bench than the lower section of LPC (station 4+25.0 down to the confluence with BC). As stated earlier, the bankfull bench was lowered downstream of station 4+25.0 at the direction of EEP and HDR staff. Cross-section 2 is a pool with larger mean and maximum bankfull depths than the riffle cross-sections. Its bankfull bench elevation was built at the targeted height.

The repair plan's cross-section design criteria for BC called for bank sloping to start approximately 3 ft above the existing stream channel bottom. Cross-section 1 on BC met this criterion. An inner-berm was created at approximately 2.1 ft above the existing stream channel bottom and a bench created 3.2 ft above the bottom.

The LPC stream pattern was similar to that found in previous years. Repair work focused on reshaping the banks to establish a bankfull bench and not changing LPC's pattern. Little Pine Creek's mean riffle length, mean riffle slope, mean pool length, and mean pool-to-pool spacing decreased from the 2004 monitoring survey. Pattern and profile data were not collected on BC.

Comparisons of pre- and post-construction cross-section pebble counts on LPC and BC were also limited, since post-construction cross-sections were taken at different locations and reach pebble counts were not taken in previous years (Appendix B, Section 6). On LPC, the substrate material size had generally decreased in both riffles and pools between the original as-built survey in 2001 and the monitoring survey in 2004. The 2004 riffle D_{50} particle sizes ranged from 0.1 mm to 3.0 mm, whereas in the 2006 as-built survey they were found to range from 27.3 mm to 39.1 mm (Exhibit Table VIII.). The 2006 as-built riffle D_{84} particle sizes were within approximately the same range (66.7 mm to 82.3 mm) as the 2004 survey data. The 2006 LPC pool D_{50} particle size of 0.2 mm was similar to the 0.1 mm found in 2004, but the D_{84} particle size increased from 8.7 mm in 2004 to 40.0 mm in 2006. The BC 2006 pebble count data, collected at a riffle, revealed that the substrate was larger (D_{50} = 55.4 mm and D_{84} = 95.8 mm) than the range of substrates (D_{50} = 2.4 mm to 6.2 mm and D_{84} = 28.6 mm to 33.1 mm), at all of the riffles in 2004 (NCSU 2004).

C. Farm Management Plan

In 2001, BC and LPC were fenced to exclude cattle from the riparian area (HDR 2005a). The original fencing on LPC was placed an unknown distance inside the conservation easement boundary. To facilitate completing the stream repairs, fencing on the left bank of LPC was removed before construction was started. Prior to reinstalling the fence, EEP consulted with the landowner to obtain agreement on its location. Although the exact location of the easement boundary was unknown, the fence was reinstalled farther from the creek to ensure a larger portion of the conservation easement and riparian area was protected from disturbance.

Exhibit Table VII.—Baseline Morphology and Hydraulic Summary
Brush-Little Pine Creeks/Project Number (054)
Segment/Reach: Little Pine Creek (1,013 ft)

Parameter	Regional Curve Interval			Pre-Existing Condition			Project Reference Reach			Design (2000)			As-built (2001)				MY-01 (2002)				MY-02 (2003)				MY-03 (2004)				As-built (2006)			
Dimension	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	N	Min	Max	Mean	N	Min	Max	Mean	N	Min	Max	Mean	N	Min	Max	Mean	N
Bankfull Width (ft)						19.0			18.0			20.0			20.0	2	31.2	33.7	32.5	2	31.5	32.6	32.1	2	31.5	32.2	31.9	2	24.9	30.3	27.6	2
Floodprone Width (ft)						22.7			334.0			82.0			200.0														80.4	105.1	92.8	2
Bankfull Cross-Sectional Area (ft^2)			56.3			27.7			34.6			41.1			42.8	2	90.6	92.4	91.5	2	87.8	101.7	94.8	2	94.5	97.1	95.8	2	45.1	45.3	45.2	2
Bankfull Mean Depth (ft)						1.2			2.5			2.3			2.1	2	2.7	2.9	2.8	2	2.7	3.2	3.0	2	2.9	3.1	3.0	2	1.5	1.8	1.7	2
Bankfull Max Depth (ft)						2.0			4.1			4.0			5.5	2	4.9	5.2	5.1	2	5.0	5.5	5.3	2	4.9	6.0	5.5	2	2.7	2.8	2.7	2
Width/Depth Ratio						16.3			7.2			8.8			9.5	2	10.8	12.5	11.7	2	9.8	12.1	11.0	2	10.2	11.1	10.7	2	13.7	20.7	17.2	2
Entrenchment Ratio						1.2			18.6			4.3			10.0														2.7	4.2	3.4	2
Bank Height Ratio															0.9				0.9										1.3	1.0	1.2	2
Bankfull Wetted Perimeter (ft)																													26.2	31.2	28.7	2
Hydraulic Radius (ft)																													1.4	1.7	1.6	2
Pattern																																
Channel Beltwidth (ft)						41.7			39.0			50.0			20.0				20.0		37.0	62.0	46.0	11	23.0	65.0	34.0	9	24.9	45.3	35.4	5
Radius of Curvature (ft)									23.0			25.0			50.5				50.5		18.0	65.0	42.0	13	26.0	147.0	56.0	14	40.3	60.5	47.7	5
Meander Wavelength (ft)						125.0			1.1			110.0									86.0	139.0	113.0	9	91.0	164.0	113.0	12	89.2	124.0	108.4	5
Meander Width Ratio						6.6			5.6			5.5			1.3				1.2										0.9	1.6	1.3	5
Profile																																
Riffle Length (ft)																					18.0	96.0	37.0	6	14.0	50.0	25.0	6	11.14	27.3	17.43	8
Riffle Slope (ft/ft)													0.003	0.063	0.031	14	0.001	0.079	0.036	12	0.006	0.027	0.018	6	0.014	0.034	0.022	6	0.006	0.033	0.016	8
Pool Length (ft)																					44.0	121.0	78.0	6	45.0	90.0	54.0	7	8.3	84.7	51.0	10
Pool Spacing (ft)						150.5			66.8			62.5	0.0		90.5	13	34.2	127.5	90.5	11	116.0	192.0	162.0	5	71.0	183.0	121.0	6	51.9	125.5	91.3	10
Substrate																																
D_{50} (mm)						11.0			40.0			50.0																			27.3	
D_{84} (mm)						60.0			110.0			100.0																			76.7	
Additional Reach Parameters																																
Valley Length (ft)																															571.0	
Channel Length (ft)																															1,013.0	
Sinuosity						1.0			1.7			1.6			1.7				1.7												1.8	
Water Surface Slope (ft/ft)																			0.014												0.007	
Bankfull Slope (ft/ft)						0.007			0.009			0.006																			0.006	
Rosgen Classification						F4			E4			E4			E4				E4												C4	

Exhibit Table VIII.–Morphology and Hydraulic As-Built Summary
Brush-Little Pine Creeks/Project Number (054)
Segment/Reach: Little Pine Creek (1,013 ft)

Parameter	Cross Section 1[a] Riffle							Cross Section 2[a] Pool[b]							Cross Section 3[a] Riffle[b]						
Dimension	AB1[c,d]	MY1	MY2	MY3	AB2[d]	MY4	MY5	AB1[c]	MY1	MY2	MY3	AB2	MY4	MY5	AB1[c]	MY1	MY2	MY3	AB2	MY4	MY5
Bankfull Width (ft)	31.5	31.2	31.5	31.5	24.9			33.7	33.7	32.6	32.2	24.7			35.4	37	40.4	36.8	30.3		
Floodprone Width (ft)					105.1							126.1							80.4		
Bankfull Cross-sectional Area (ft^2)	86.7	90.55	101.7	97.1	45.3			88.7	92.4	87.8	94.5	54.4			86.6	96.6	100.4	86.4	45.1		
Bankfull Mean Depth (ft)	2.8	2.9	3.2	3.1	1.8			2.6	2.7	2.7	2.9	2.2			2.4	2.6	2.5	2.3	1.5		
Bankfull Max Depth (ft)	5.0	5.2	5.0	4.9	2.8			4.8	4.9	5.5	6.0	3.9			4.5	5.3	6.4	4.9	2.7		
Width/Depth Ratio	11.3	10.8	9.8	10.2	13.7			13.0	12.5	12.1	11.1	11.2			14.8	14.2	16.2	16.0	20.3		
Entrenchment Ratio					4.2							5.1							2.7		
Bank Height Ratio		0.85			1.3							1.7							2.1		
Bankfull Wetted Perimenter (ft)					26.2							28.0							31.2		
Hydraulic Radius (ft)					1.7							1.9							1.4		
Substrate																					
D_{50} (mm)	29.1	25.0	10.2	3.0	39.1			38.9	34.1	0.5	0.9	0.2			<2	3.3	0.4	0.1	27.3		
D_{84} (mm)	77.5	79.0	50.9	41.2	82.3			82.3	88.9	15.5	79.7	40.0			5.8	11.3	6.4	8.7	66.7		

[a]Locations of the cross-sections changed after the 2006 repairs to Little Pine Creek.

[b]Cross Section 2 was located at a riffle prior to AB2 and Cross Section 3 was located at a pool prior to AB2.

[c]AB1 cross-section data originated from the 2004 monitoring report.

[d]As-built = AB

Exhibit Table VIII.–Morphology and Hydraulic As-Built Summary Continued.
Brush-Little Pine Creeks/Project Number (054)
Segment/Reach: Brush Creek (375 ft)

Parameter	**Cross Section 1 Riffle**						
Dimension	AB2[a]	MY4	MY5				
Bankfull Width (ft)	63.5						
Floodprone Width (ft)	181.8						
Bankfull Cross-sectional Area (ft^2)	177.5						
Bankfull Mean Depth (ft)	2.8						
Bankfull Max Depth (ft)	5.5						
Width/Depth Ratio	22.8						
Entrenchment Ratio	2.9						
Bank Height Ratio	1.6						
Bankfull Wetted Perimenter (ft)	66.1						
Hydraulic Radius (ft)	2.7						
Substrate							
D_{50} (mm)	55.4						
D_{84} (mm)	95.8						

[a]As-built = AB

V. Acknowledgements and References

J. Mickey, J. Wasseen, II and M. Fowlkes of the NCWRC oversaw project construction; M. Fowlkes, J. Wasseen, II, and J. Ferguson collected and analyzed the field data; M. Fowlkes and J. Wasseen, II prepared this report. J. Borawa improved the report with this thorough review and thoughtful suggestions. G. Melia of EEP and D. Carowell and C. Mathews of HDR assisted with construction oversight.

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VI. Appendix A.—Vegetation Data

1. Vegetation Data Tables

Exhibit Table A.I.—Vegetation Metadata.
Brush-Little Pine Creeks/Project Number (054)

Report Prepared by	Jim Wasseen II
Date Prepared	3/30/2007 11:18
Database Name	CVS_EEP_DataEntry_v204.mdb
Database Location	C:\Documents and Settings\Staci Hining\My Documents\Stream Mitigation\EEP\B&LP Creeks repairs
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	This worksheet, which is a summary of the project and the project data.
Plots	List of plots surveyed.
Vigor	Frequency distribution of vigor classes.
Vigor by Spp.	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 Spp.	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Stem Count by Plot and Spp.	Count of living stems of each species for each plot; dead and missing stems are excluded.
PROJECT SUMMARY----------	
Project Code	54
Project Name	Brush Creek
Description	Stream repair on Brush and Little Pine Creeks in Alleghany County NC.
Length (ft)	1,013
Stream-to-Edge Width (ft)	
Area (sq m)	8,498
Required Plots (calculated)	4
Sampled Plots	5

Exhibit Table A.II.–Vegetation Vigor by Species.
Brush-Little Pine Creeks/Project Number (054)

	Vigor Class[a]					
Species	**4**	**3**	**2**	**1**	**0**	**Missing**
Alnus serrulata	1					
Asimina triloba	11	1				
Betula nigra	9					
Cornus amomum	1					
Diospyros virginiana	2					
Fraxinus pennsylvanica	5					
Juglans nigra	2	1	1			
Pinus strobus	2					
Quercus alba	1	2	1			
Rhododendron calendulaceum	3					
Rhododendron viscosum	1					
Salix nigra	3					
Sambucus canadensis	9		4			
Tsuga canadensis	1					
Carpinus caroliniana	8					
Hamamelis virginiana	10					
Liriodendron tulipifera	1					
Physocarpus opulifolius	6					
Prunus serotina	12					
Acer rubrum	1		1			
Unknown				12		2
TOTAL: 21	**89**	**4**	**7**	**12**		**2**

[a]4 = Excellent, 3 = Good, 2 = Weak, 1 = Unlikely to survive
0 = Dead, Missing = Plant missing

Exhibit Table A.III.–Vegetation Damage by Species.
Brush-Little Pine Creeks/Project Number (054)

Species	All Damage Categories	No Damage	Beaver	Deer	Human Trampled	Unknown
Acer rubrum	2	1		1		
Alnus serrulata	1	1				
Asimina triloba	12	12				
Betula nigra	9	9				
Carpinus caroliniana	8	7				1
Cornus amomum	1	1				
Diospyros virginiana	2	2				
Fraxinus pennsylvanica	5	5				
Hamamelis virginiana	10	10				
Juglans nigra	4	3			1	
Liriodendron tulipifera	1	1				
Physocarpus opulifolius	6	6				
Pinus strobus	2	2				
Prunus serotina	12	12				
Quercus alba	4				2	2
Rhododendron calendulaceum	3	3				
Rhododendron viscosum	1	1				
Salix nigra	3	3				
Sambucus canadensis	13	9			4	
Tsuga canadensis	1	1				
Unknown	14	1	13			
TOTAL: 21	**114**	**90**	**13**	**1**	**7**	**3**

Exhibit Table A.IV.–Vegetation Damage by Plot.
Brush-Little Pine Creeks/Project Number (054)

Plot	All Damage Categories	No Damage	Beaver	Deer	Human Trampled	Unknown
054-01-BCV1	26	12	13		1	
054-01-LPV1	22	21			1	
054-01-LPV2	17	14		1	1	1
054-01-LPV3	27	22			3	2
054-01-LPV4	22	21			1	
TOTAL: 5	**114**	**90**	**13**	**1**	**7**	**3**

Exhibit Table A.V.–Stem Count by Plot and Species.
Brush-Little Pine Creeks/Project Number (054)

Species	Total Number of Stems	Number of plots	Avg Number of stems	Plot 054-01-BCV1	Plot 054-01-LPV1	Plot 054-01-LPV2	Plot 054-01-LPV3	Plot 054-01-LPV4
Acer rubrum	2	2	1		1	1		
Alnus serrulata	1	1	1				1	
Asimina triloba	12	4	3		5	1	1	5
Betula nigra	9	3	3		2	2		5
Carpinus caroliniana	8	4	2	1	1	1	5	
Cornus amomum	1	1	1					1
Diospyros virginiana	2	1	2		2			
Fraxinus pennsylvanica	5	2	2.5	2		3		
Hamamelis virginiana	10	3	3.3		5	1		4
Juglans nigra	4	3	1.3	1			2	1
Liriodendron tulipifera	1	1	1		1			
Physocarpus opulifolius	6	2	3	3			3	
Pinus strobus	2	1	2					2
Prunus serotina	12	4	3		1	6	4	1
Quercus alba	4	3	1.3		1	2	1	
Rhododendron calendulaceum	3	2	1.5		2		1	
Rhododendron viscosum	1	1	1		1			
Salix nigra	3	1	3	3				
Sambucus canadensis	13	3	4.3	3			7	3
Tsuga canadensis	1	1	1				1	
Unknown	12	1	12	12				
TOTAL: 21	**112**	**21**		**25**	**22**	**17**	**26**	**22**

Exhibit Table A.VI.–Vegetation Problem Area.
Brush-Little Pine Creeks/Project Number (054)

Feature/Issue	Station Number/Range	Probable Cause	Photo #
Bare Bench	Brush Creek 0+0 to 1+50	Beaver activity	VPA1

Exhibit Table A.VII.—Permanent Photograph Stations.
Brush-Little Pine Creeks/Project Number (054)

Stream	Location[a]	Bearing (° from North)
Little Pine Creek	054-01-LPV1	38
	054-01-LPV2	310
	054-01-LPV3	304
	054-01-LPV4	304
Brush Creek	054-01-BCV1	280

[a]GPS coordinates are included on the plan view (Figure 2).

Exhibit Table A.VIII.—Herbaceous Seed Mixture.
Brush-Little Pine Creeks/Project Number (054)

Scientific Name	Common Name	Percent
Bidens aristosa	Tickseed sunflower	10
Chamaecrista fasciculata	Partridge pea	10
Elymus virginicus	Virgina wild rye	15
Juncus effusus	Soft rush	5
Lolium multiflorum	Annual rye	25
Panicum clandestinum	Deer tongue	15
Polygonum pensylvanicum	Pennsylvania smartweed	10
Tripsacum dactyloides	Eastern gamma grass	5
Verbena hastata	Blue vervain	5

Exhibit Table A.IX.–Woody Vegetation Planted.
Brush-Little Pine Creeks/Project Number (054)

Scientific Name	Common Name	Zone[a] 1	2	3	4
Shrub and Small Trees		**Number Planted**			
Alnus serrulata	Tag alder	99	49		
Asimina triloba	Common pawpaw			26	50
Carpinus caroliniana	Ironwood	31	12	26	
Hamamelis virginiana	Witch-hazel		51	26	50
Lindera benzoin	Spicebush				
Physocarpus opulifolius	Ninebark		51	5	
Pinus strobes	White pine				25
Rhododendron calendulaceum	Flame azalea		53	21	
Rhododendron viscosum	Swamp azalea		14	26	
Sambucus Canadensis	Elderberry	170			
Large Trees					
Acer rubrum	Red maple			32	
Betula nigra	River birch			88	70
Diospyros virginiana	Persimmon			54	1
Fraxinus pennsylvanica	Green ashe			88	70
Juglans nigra	Black walnut				57
Liriodendron tulipifera	Tulip poplar				31
Platanus occidentalis	Sycamore				1
Prunus serotina	Black cherry			88	70
Quercus alba	White oak				40
Tsuga canadensis	Eastern hemlock				10
	Total	300	230	480	475

[a]Zone 1 – Includes the area from the water's edge to the bankfull elevation,

Zone 2 – Includes the inner half of any bankfull bench (half closest to the stream),

Zone 3 – Includes the outer half of any bankfull bench (half furthest from the stream) plus five (5) feet out from the top of bank,

Zone 4 – Includes the area from the edge of zone 3 to the edge of the riparian planting zone (outer limits of the conservation easement area).

Exhibit Table A.X.–Live Stakes Planted.
Brush-Little Pine Creeks/Project Number (054)

Scientific Name	Common Name	Number Planted
Cornus amomum	Silky dogwood	250
Physocarpus opulifolius	Ninebark	230
Salix sericea	Silky willow	225
Salix nigra	Black willow	50
Sambucus canadensis	Elderberry	175
	Total	930

2. Vegetation Problem Area Photographs

VPA1: Example of beaver damage;
November 2006

3. Vegetation As-built Plot Photographs

Little Pine Creek vegetation plot 0054-01-LPV1, bearing 38, April 2007.

Little Pine Creek vegetation plot 0054-01-LPV2, bearing 310, April 2007.

Little Pine Creek vegetation plot 0054-01-LPV3, bearing 304, April 2007.

Little Pine Creek vegetation plot 0054-01-LPV4, bearing 304, April 2007.

Brush Creek vegetation plot 0054-01-BCV1, bearing 280, April 2007.

VII. Appendix B.—Stream Data

1. Stream Problem Areas Table

There were no stream problem areas.

Exhibit Table B.I.—Stream Problem Areas
Brush-Little Pine Creeks/Project Number (054)

Feature/Issue	Station #/Range	Suspected Cause	Photo #

2. Representative Stream Problem Area Photographs

There were no problem stream areas; therefore, no photographs were needed.

3. Stream Photographic Stations

Exhibit Table B.II.—Permanent Photograph Stations
Brush-Little Pine Creeks/Project Number (054)

Stream	Location[a]	Bearing (° from North)
Little Pine Creek	PS-1	240
	PS-2	270
	PS-3	245
	PS-3	20
	PS-3	300
	PS-4	276
	PS-5	312
	PS-6	314
	PS-7	68
	PS-7	138
	PS-7	351
	PS-8	322
	PS-9	10
	PS-9	110
	PS-9	174
	PS-10	4
Brush Creek	PS-11	4
	PS-12	211
	PS-12	275
	PS-12	349
	PS-13	180
	PS-14	340
	PS-15	20

[a]GPS locations are listed on the plan view (Figure 2).

PS-1, bearing 240°: Pre-construction view of station 0+00 to station 3+00; September 2006.

PS-1, bearing 240°: Post-construction view of station 0+00 to station 3+00; April 2007.

PS-2, bearing 270°: Pre-construction view of station 0+50 to station 1+00; April 2006.

PS-2, bearing 270°: Post-construction view of station 0+50 to station 1+00; October 2006.

PS-3, bearing 245°: Post-construction view of station 1+33 to station 2+50; April 2007.

PS-3, bearing 20°: Post-construction view of station 1+33 to station 0+50; April 2007.

PS-3, bearing 300°: Cross-section 1 at station 1+33, April 2007.

PS-4, bearing 276°: Pre-construction view of station 3+50 to station 5+00; April 2006.

PS-4, bearing 276°: Post-construction view of station 3+50 to station 5+00; October 2006.

PS-5, bearing 312°: Pre-construction view of station 4+75 to station 6+00; April 2006.

PS-5, bearing 312°: Post-construction view of station 3+50 to station 6+00; October 2006.

PS-6, bearing 314°: Pre-construction view of station 5+75 to station 7+00; April 2006.

PS-6, bearing 314°: Post-construction view of station 5+75 to station 7+00; October 2006.

PS-7, bearing 351°: Post-construction view of station 6+64 to station 8+00; April 2007.

PS-7, bearing 138°: Post-construction view of station 6+64 to station 5+50; April 2007.

PS-7, bearing 68°: Cross-section 2 at station 6+64; April 2007.

PS-8, bearing 322°: Pre-construction view of station 7+10 to station 8+00; April 2006.

PS-8, bearing 322°: Post-construction view of station 7+10 to station 8+00; October 2006.

PS-9, bearing 10°: Post-construction view of station 7+93 to station 10+00; April 2007.

PS-9, bearing 174°: Post-construction view of station 7+93 to station 6+50; April 2007.

PS-9, bearing 110°: Cross-section 3 at station 6+64; April 2007.

PS-10, bearing 4°: Pre-construction view of station 8+32 to station 10+00; April 2006.

PS-10, bearing 4°: Post-construction view of station 8+32 to station 10+00; October 2006

PS-11, bearing 4°: Pre-construction view of Brush Creek station 0+00 to station 1+50; April 2006.

PS-11, bearing 4°: Post-construction view of Brush Creek station 0+00 to station 1+50; October 2006

PS-12, bearing 349°: Post-construction view of Brush Creek station 0+48 to station 1+50; April 2007.

PS-12, bearing 211°: Post-construction view of Brush Creek station 0+48 to station 0+00; April 2007.

PS-12, bearing 275°: Cross-section 1 on Brush Creek; April 2007.

PS-13, bearing 180°: Pre-construction view of Brush Creek station 1+00 to station 0+00; June 2006.

PS-13, bearing 180°: Post-construction view of Brush Creek station 1+00 to station 0+00; September 2006.

PS-14, bearing 340°: Pre-construction view of Brush Creek station 1+25 to station 2+00; September 2006.

PS-14, bearing 340°: Post-construction view of Brush Creek station 1+25 to station 2+00; September 2006.

PS-15, bearing 20°: Pre-construction view of Brush Creek station 7+00 to station 8+50; October 2006.

PS-15, bearing 20°: Post-construction view of Brush Creek station 7+00 to station 8+50; October 2006.

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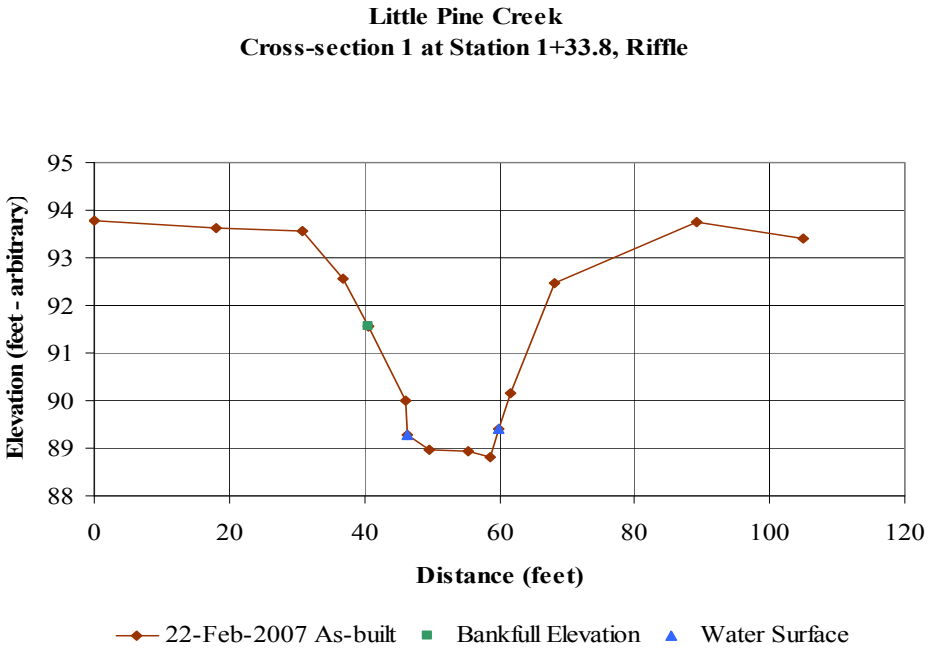
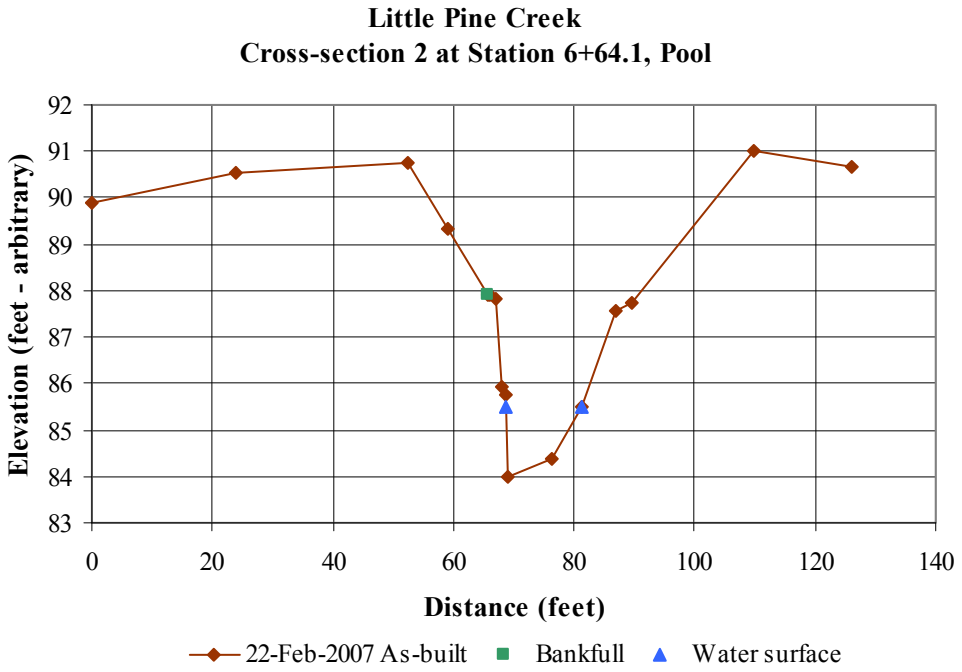
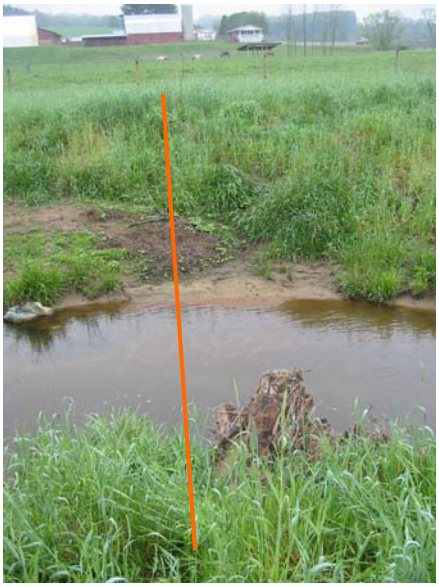
4. Annual Overlays of Cross-Section Plots



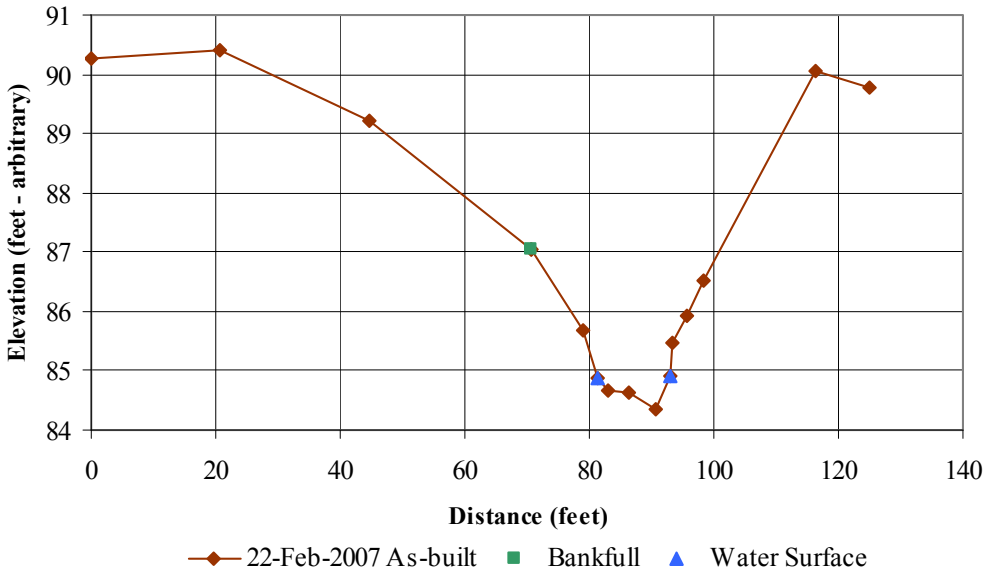
Summary Data			
Bankfull Cross-sectional Area (ft^2)	54.3	Bankfull Max Depth (ft)	2.8
Bankfull Width (ft)	24.9	Width/Depth Ratio	13.7
Bankfull Mean Depth (ft)	1.8	Entrenchment Ratio	4.2



Summary Data			
Bankfull Cross-sectional Area (ft^2)	54.4	Bankfull Max Depth (ft)	3.9
Bankfull Width (ft)	24.7	Width/Depth Ratio	NA
Bankfull Mean Depth (ft)	2.2	Entrenchment Ratio	NA

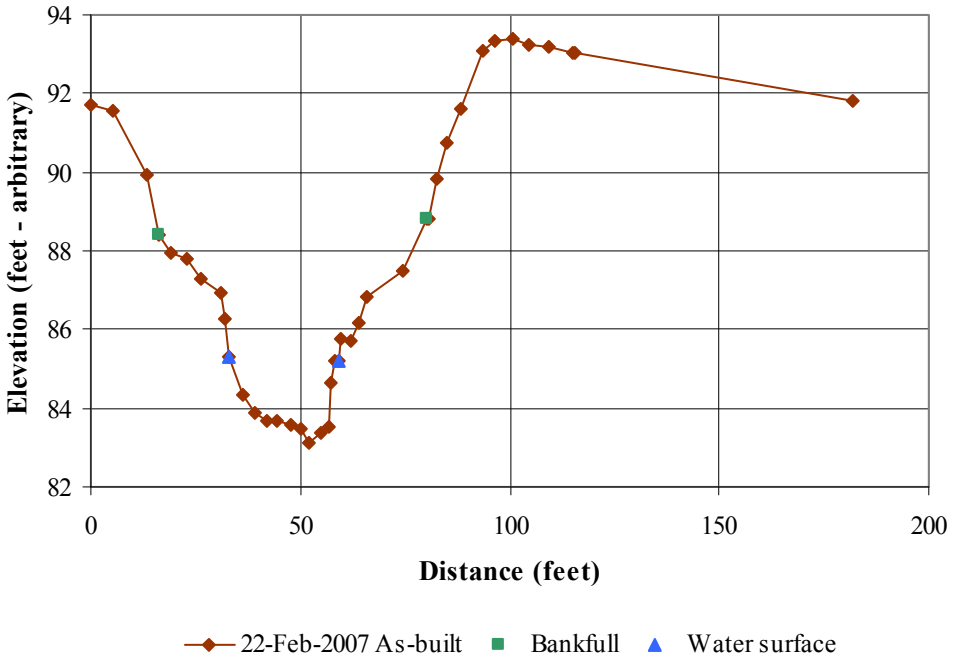


Little Pine Creek
Cross-section 3 at Station 7+93.7, Riffle



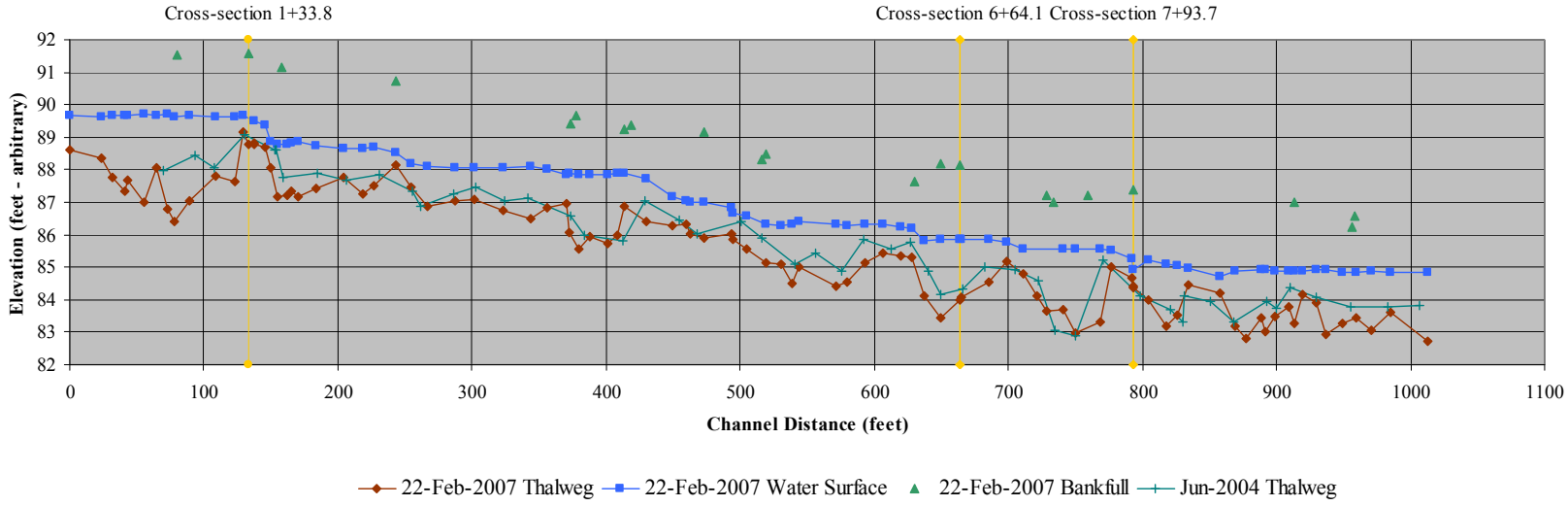
Summary Data			
Bankfull Cross-sectional Area (ft^2)	45.1	Bankfull Max Depth (ft)	2.7
Bankfull Width (ft)	30.3	Width/Depth Ratio	20.3
Bankfull Mean Depth (ft)	1.5	Entrenchment Ratio	2.7

Brush Creek
Cross-section 1 at Station 0+48, Run



Summary Data			
Bankfull Cross-sectional Area (ft^2)	177.5	Bankfull Max Depth (ft)	5.5
Bankfull Width (ft)	63.5	Width/Depth Ratio	22.8
Bankfull Mean Depth (ft)	2.8	Entrenchment Ratio	2.9

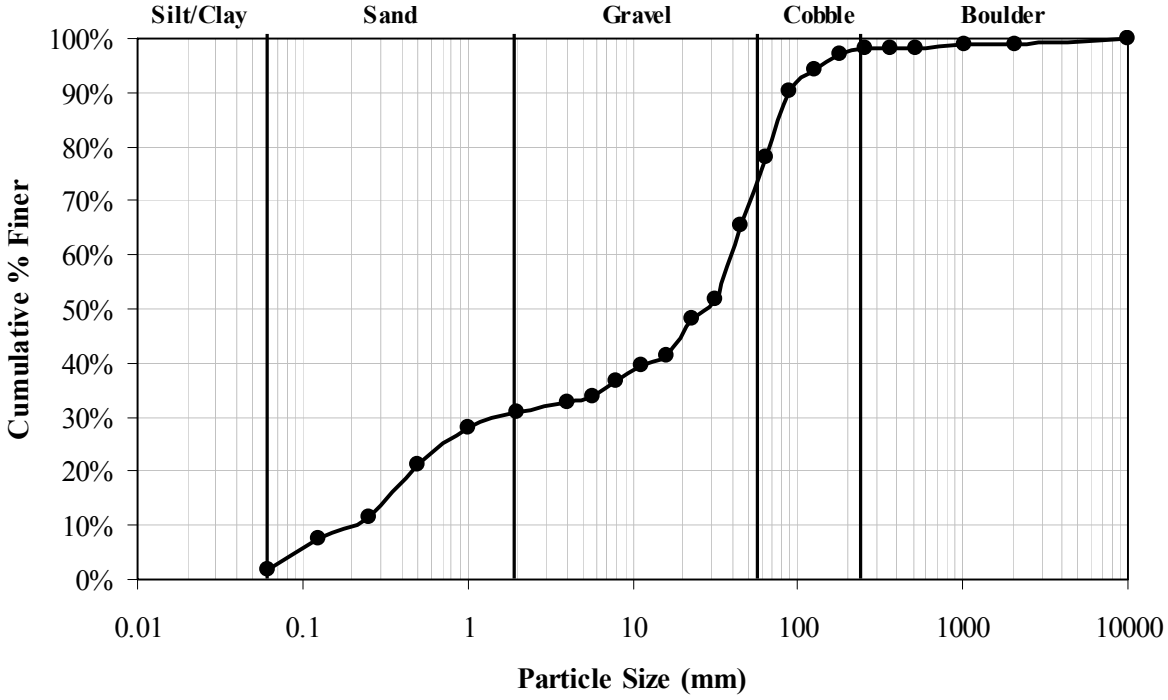
5. Annual Overlays of Longitudinal Profile Plots



6. Pebble Count Cumulative Frequency Distribution Plots

Little Pine Creek
Reach Pebble Count

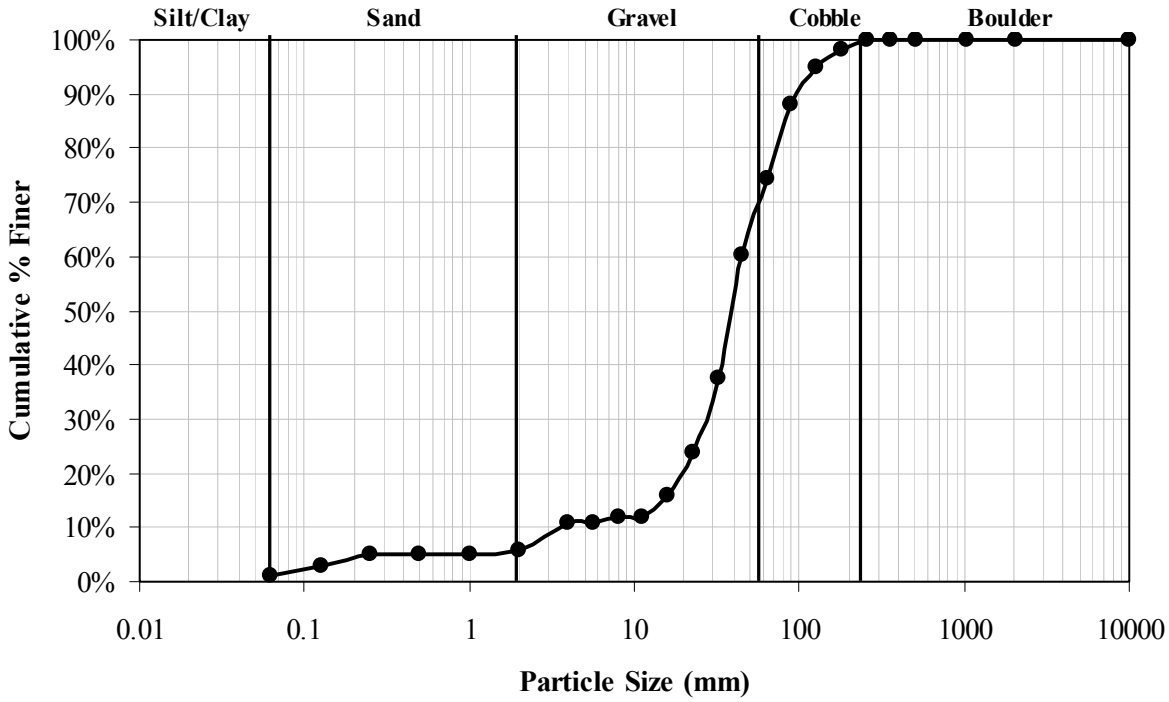
2006 Particle Size Distribution



D_{16} = 0.4 mm, D_{50} = 27.3 mm, D_{84} = 76.7 mm, D_{95} = 141.9 mm

Little Pine Creek
Cross-section 1 at Station 1+33.8, Riffle

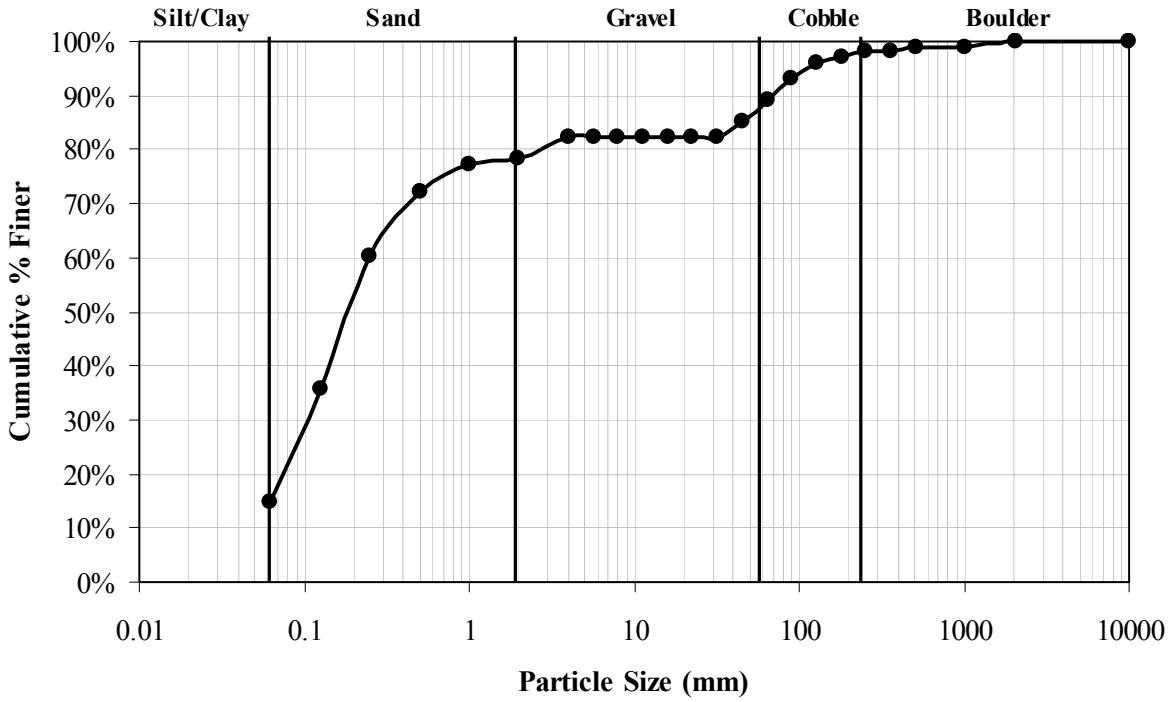
2006 Particle Size Distribution



D_{16} = 16.1 mm, D_{50} = 39.1 mm, D_{84} = 82.3 mm, D_{95} = 127.7 mm

Little Pine Creek
Cross-section 2 at Station 6+64.1, Pool

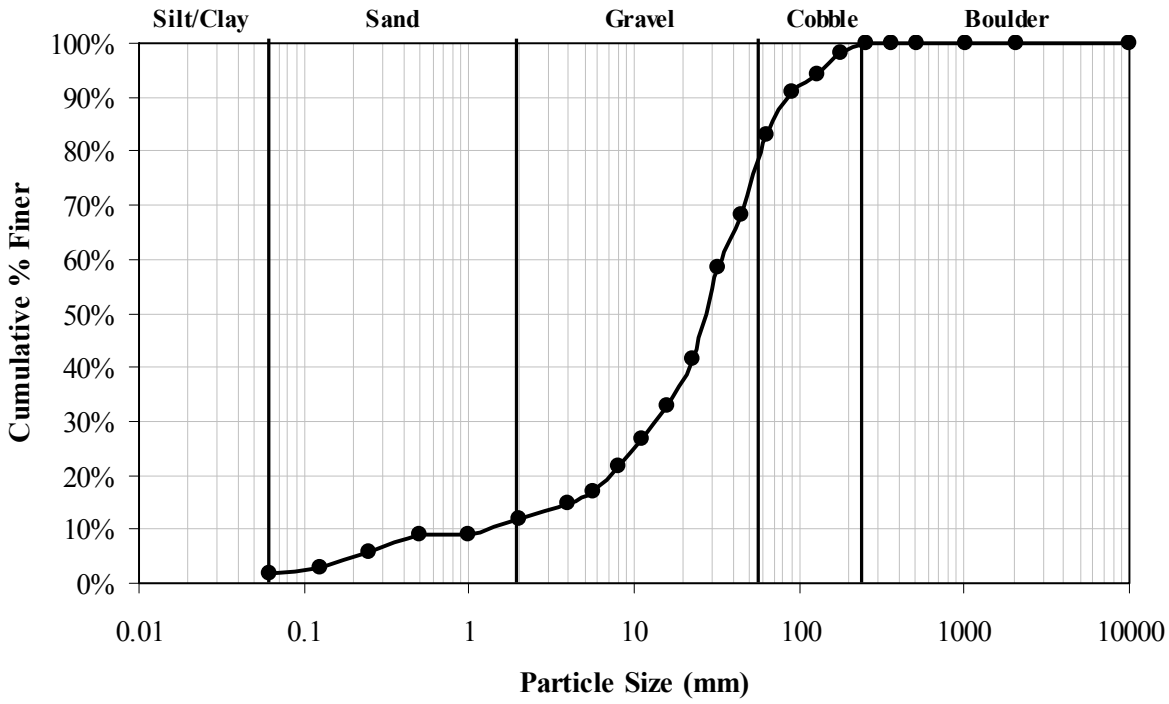
2006 Particle Size Distribution



D_{16} = 0.07 mm, D_{50} = 0.2 mm, D_{84} = 40.0 mm, D_{95} = 114.7 mm

Little Pine Creek
Cross-section 3 at Station 7+93.7, Riffle

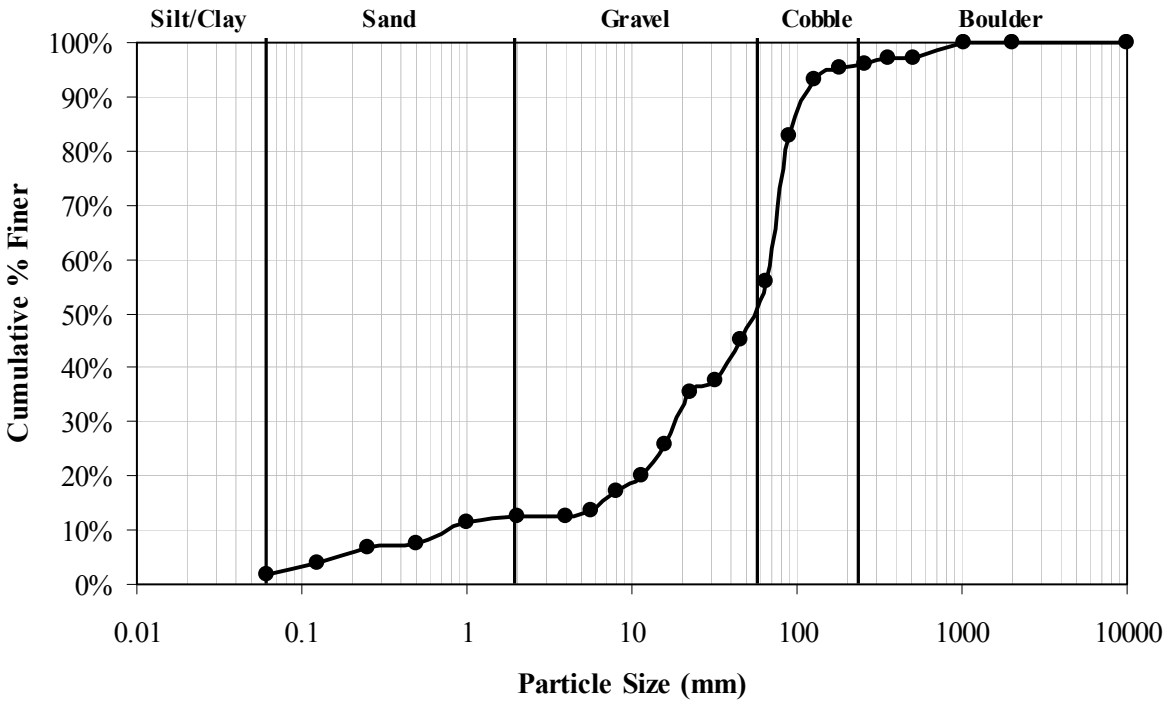
2006 Particle Size Distribution



D_{16} = 5.0 mm, D_{50} = 27.3 mm, D_{84} = 66.7 mm, D_{95} = 140.3 mm

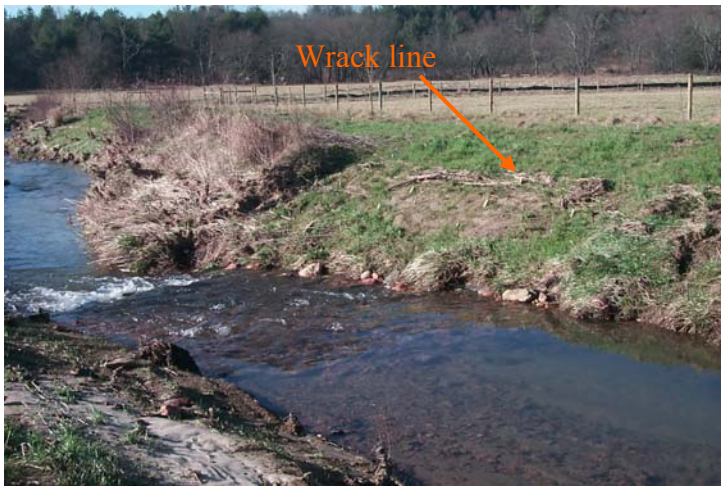
Brush Creek
Cross-section 1 at Station 0+48, Run

2006 Particle Size Distribution



D_{16} = 8.4 mm, D_{50} = 55.4 mm, D_{84} = 95.8 mm, D_{95} = 177.4 mm

7. Bankfull Event Verification Photographs



Wrack line following bankfull event identified on January 24, 2007.