ELLERBE CREEK STREAM RESTORATION SITE

MONITORING REPORT - YEAR 1

OCTOBER 2005

Designed and Monitored By:

Stantec Consulting, Inc.
801 Jones Franklin Road, Suite 300
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Submitted To:

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

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1.0 EXECUTIVE SUMMARY/PROJECT ABSTRACT

The North Carolina Ecosystem Enhancement Program (EEP) restored 6,279 linear feet of Ellerbe Creek located on Hillandale Golf Course in Durham, North Carolina. Construction of the project began on January 15, 2004 and the stream restoration was completed on December 17, 2004. Approximately 4 bankfull events occurred during construction.

Ellerbe Creek in its preconstruction condition had a very low sinuosity and was entrenched throughout its length on the course. The surrounding landuse contributed to the majority of the instability of the stream. The stream had been channelized historically with only a grass buffer existing along the stream bank. The golf course had intensively managed the existing vegetation adjacent to the stream.

The watershed lies within US Geological Survey (USGS) Hydrologic Unit Code 03020201. The watershed area was delineated from the USGS Northwest Durham Quadrangle for North Carolina. The drainage area for the entire site covers approximately 2,150 acres (Figure 3). There are several tributaries that enter Ellerbe Creek upstream of the restoration site.

The portion of Ellerbe Creek that runs through the Hillandale Golf Course is a typical urban stream. It has been channelized and is strongly influenced by stormwater flows. The channel is incised four to six feet below the top of bank. Eroding and slumping banks were noted along the majority of the stream. Portions of the channel, particularly downstream of Hillandale Road, have been heavily rip rapped. The channel substrate varies from sand and silt, to displaced riprap, to a soft shale 'bedrock' in some areas.

There are numerous site constraints that limited the restored stream's design sinuosity and belt width. These constraints are expected of a large urban stream project located on a golf course. The stream crosses and parallels several golf holes and fairways with irrigation lines that are buried near the stream, however, the irrigation lines were not a constraint to the design. The planting plan is complicated by golf fairways crossing the stream, limiting the height of the vegetation that can be planted in these areas.

A large number of utility crossings also affected the design. Approximately eight water lines and five sewer lines, some as large as 34 inches in diameter, cross the stream with easements ranging from 15 to 25 feet on each side of the pipe for a total easement width of 30 to 50 feet. The stream also receives runoff from roughly 14 different stormwater outfalls, some as large as 48 inches. The design was completed taking into account each one of these crossings and outfalls to ensure channel stability after construction. During construction, the City of Durham instructed NCEEP that no construction was to occur within the easement area of the sewer and water lines. Therefore, the design was adjusted in the field during construction to accommodate the City's request. Banks in the immediate area of the water and sewer were stabilized to the greatest extent possible without disturbance to the water and sewer easement area. Measures were taken to stabilize the stormwater outfalls to the stream. Several areas of concentrated flow located through the adjacent fairways were identified as well. Floodplain interceptors were installed at these locations to catch flow from these areas and provide a stable passage to the stream.

Construction of the stream was also constrained by the numerous golf cart bridge crossings that existed throughout the project. The stream was built to all flow under the bridge crossings in a manner than was the most stable for the stream. However, in multiple cases these bridges compromised the amount of floodplain that could be excavated. Slopes along the bridge foundations were stabilized with class B rock and plantings were feasible.

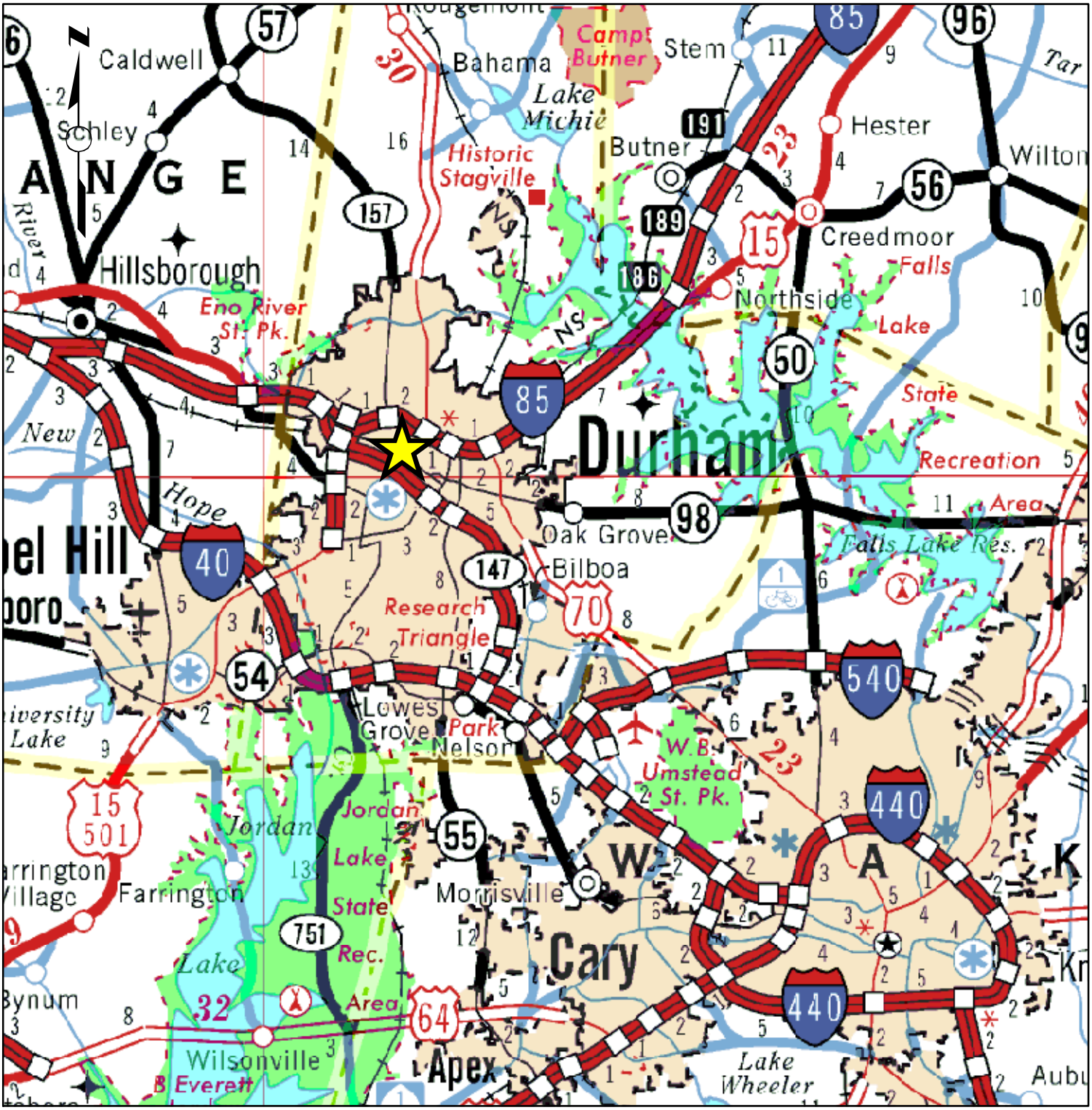
The stream restoration was based upon the principles of natural channel design. Every effort was made to consider future landuse changes within the watershed while completing the design. The pattern, dimension, and profile were restored throughout the project. Bankfull benches were cut to provide as

much floodplain as possible for the stream while working around the many constraints throughout the project. Rock structures and root wads were installed to provide further stability to the stream. Vegetation was installed along the channel slopes and floodplain to provide stability and shade for the stream in future years.

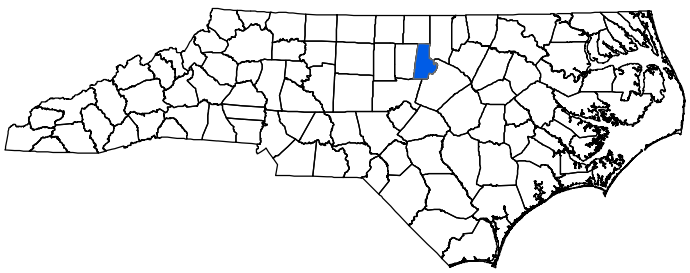
2.0 PROJECT BACKGROUND

2.1 Location and Setting

The Ellerbe Creek site is located on the Hillandale Golf course, which is located on the western edge of the City of Durham in Durham County. The reach of Ellerbe Creek to be restored is bound to the west by I85/NC 15/501 Bypass, to the north by Indian Trail, to the south by Sprunt Avenue, and to the east by Albany Street (Figures 1 and 2). Ellerbe Creek is a tributary to the Neuse River. The watershed area is detailed in Figure 3.



Not to Scale



North Carolina Ecosystem Enhancement Program

Ellerbe Creek
Hillandale Golf Course
Durham County, North Carolina

Figure 1. Project Vicinity

0 500 1,000 2,000 3,000 Feet

North Carolina Ecosystem Enhancement Program

Legend

- Ellerbe Creek
- Project Area

Ellerbe Creek
Hillandale Golf Course
Durham County, North Carolina

Figure 2. Project Location

0 0.5 1 2 3 4 5 Miles

Legend

Ellerbe Creek

Watershed Area

North Carolina Ecosystem Enhancement Program

Ellerbe Creek
Hillandale Golf Course
Durham County, North Carolina

Figure 3. Watershed Area

2.2 Structure and Objectives

The restoration of Ellerbe Creek was divided into four reaches, three on Ellerbe Creek, and one on an unnamed tributary (Figure 4).

Approximately 80% of the land within the watershed consists of impervious areas with commercial lots, industrial lots, parking lots, and roads. The remaining land use consists of forested land and maintained residential areas. The Hillandale Golf Course and Croasdaile Country Club are the two major open areas within the watershed. Current land use within the project area is not expected to change in the future because it is mostly developed at this time.

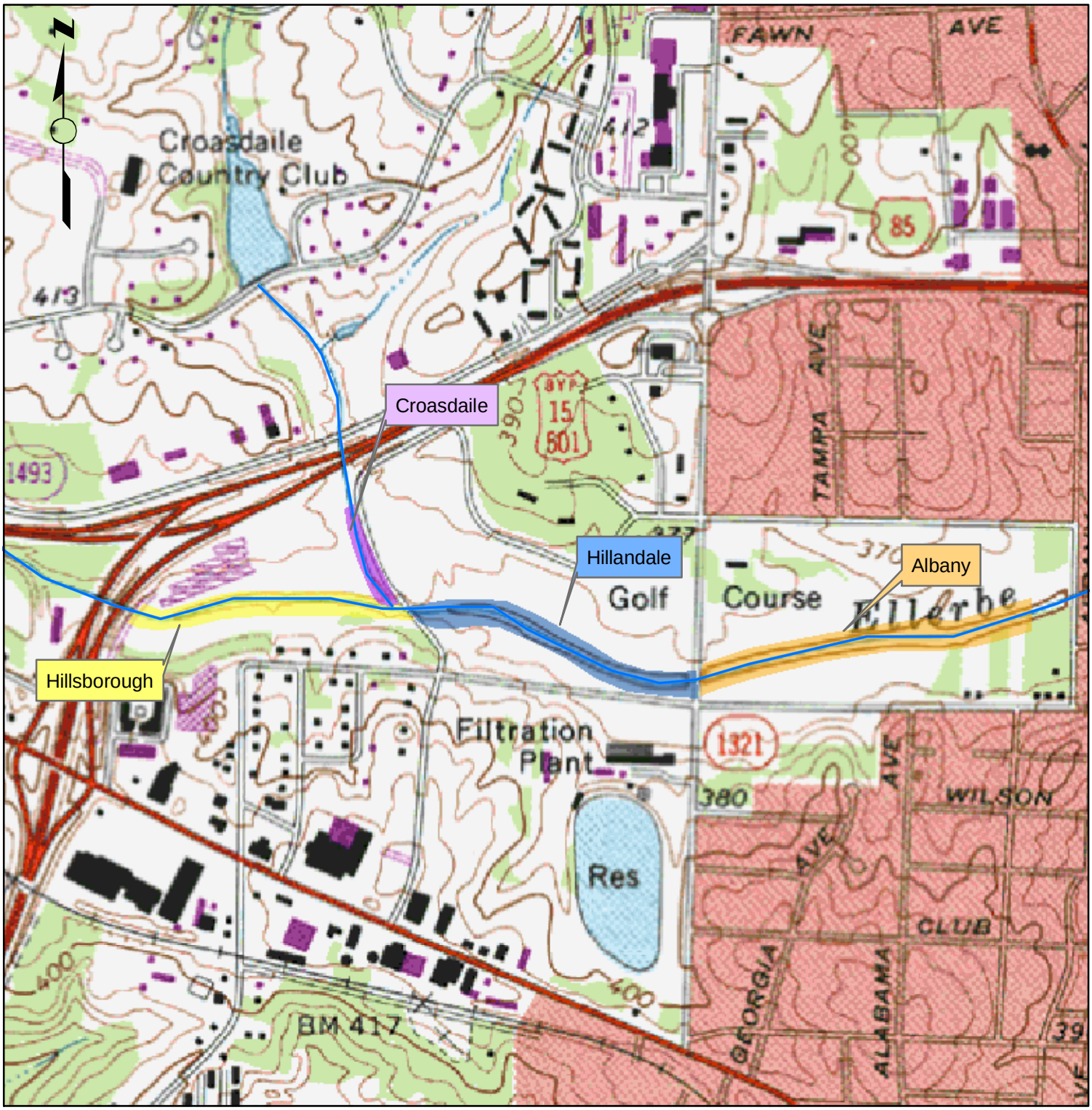
For a complete description of the existing conditions prior to construction, see the Ellerbe Creek Stream Restoration Plan prepared by Stantec in March 2003.

Stantec utilized natural channel design while considering watershed and site conditions of the stream to provide the highest level of stability. Information was collected on existing conditions, reference conditions, and proposed conditions for the stream, buffer, and wetland restoration areas. The design was intended to transform the G4/F4 stream to a C channel at its completion. Pattern, dimension, and profile were redesigned to provide the highest level of restoration considering site constraints. The design was developed based upon reference data for the stream type, watershed, and location. The restoration parameters were developed using reference data and hydraulic geometry relationships. The stream design afforded the best available floodplain considering the onsite constraints. City sewer and water easements, golf course fairways, and golf cart bridges limited the ability to provide floodplain in areas of the project. Bankfull benches were established to provide floodplain access for high flow conditions.

As a guide for taking existing conditions survey, *The Stream Channel Reference Sites: An Illustrated Guide to Field Technique, US Forest Service General Technical Report RM-245* (Harrelson *et al*, 1994) and *Applied River Morphology* (Rosgen, 1996) were used as references to classify the stream and reference reaches. The existing conditions of the surrounding area were first observed and recorded in order to understand what was occurring within the system and why. The field data collected were used to determine width-to-depth ratio, entrenchment ratio, slope, sinuosity, sediment transport analysis, and dominant type of channel material for the existing conditions and reference reaches. This enabled the development of a plan, which focuses on the restoration of the entire system. The plan included the restored channel morphology design, structure design and placement, streambank stabilization measures, and erosion and sediment control plan. Stantec conducted construction management and oversight for the duration of the restoration. SEI Environmental, Inc. carried out the construction of the stream. Dewberry and Davis, under contract to SEI, provided the As-Built survey for the project.

Exhibit Table I. Construction Dates

Reach	Start of Construction	Completion of Construction
Hillsborough	January 15, 2004	May 19, 2004
Hillandale	March 2, 2004	May 21, 2004
Croasdaile	June 2, 2004	June 11, 2004
Albany	October 11, 2004	December 17, 2004



North Carolina Ecosystem Enhancement Program

Ellerbe Creek
Hillandale Golf Course
Durham County, North Carolina

Figure 4. Stream Reaches

2.3 Project History and Background

Exhibit Table II. Project Structure Table Project Number and Name: 010551001 (Ellerbe Creek Stream Restoration)	
Segment/Reach ID	**Linear Feet or Acreage**
Hillsborough	1,663 LF
Hillandale	1,939 LF
Croasdaile	703 LF
Albany	1,974 LF
Total	**6,279** LF

Exhibit Table III. Project Objectives Table Project Number and Name: 010551001 (Ellerbe Creek Stream Restoration)			
Segment/Reach ID	**Objectives**	**Linear Feet or Acreage**	**Comment**
Hillsborough	Restoration	1663 LF	Changed dimension, pattern, and profile (Priority 2 Restoration)
Croasdaile	Restoration	199 LF	Changed dimension, pattern, and profile (Priority 2 Restoration)
Croasdaile	Enhancement	504 LF	Changed dimension and profile (Priority 2 Restoration)
Hillandale	Restoration	1321 LF	Changed dimension, pattern, and profile (Priority 2 Restoration)
Hillandale	Enhancement	618 LF	Changed dimension and profile (Priority 2 Restoration)
Albany	Restoration	1207 LF	Changed dimension, pattern, and profile (Priority 2 Restoration)
Albany	Enhancement	391 LF	Changed dimension and profile (Priority 2 Restoration)
Albany	Preservation	376 LF	Protected existing stream
Buffer	Restoration	17.41 AC	Restored buffer area
Stormwater Wetland	Creation	0.15 AC	Created wetlands
Pocket Wetlands	Creation	0.23 AC	Created wetlands

Exhibit Table IV. Project Activity and Reporting History Project Number 010551001 (Ellerbe Creek Stream Restoration)		
Activity or Report	**Calendar Year of Completion or Planned Completion**	**Actual Completion Date**
Restoration Plan	2003	March 2003
Mitigation Plan	2005	May 2005
Construction	2004	March 2005
Temporary and Permanent S&EC mix applied to entire project area	2004	December 2004
Bare Root Plantings	2004	January 2004
As-Built report	2004	May 2005
Initial – Year 1 monitoring	2005	October 2005
Year 2 Monitoring		
Year 3 Monitoring		
Year 4 Monitoring		
Year 5 Monitoring		
Year 5+ Monitoring		

Exhibit Table V. Project Contact Table Project Number 010551001 (Ellerbe Creek Stream Restoration)	
Designer	**Firm Information / Address**
Brad Fairley	Stantec Consulting, Inc. 801 Jones Franklin Road, Suite 300 Raleigh, North Carolina 27606
Construction Contractor	**Firm Information / Address**
Jackie Utley	SEI Environmental, Inc. 130 Penmarc Drive, Suite 108 Raleigh, North Carolina 27603-2470
Planting Contractor	**Firm Information / Address**
Jim Matthews	Harp, Inc PO Box 655 Newell, North Carolina 28126
Seeding Contractor	**Company Information / Address**
Jackie Utley	SEI Environmental, Inc. 130 Penmarc Drive, Suite 108 Raleigh, North Carolina 27603-2470
Sharon Day	Mellow Marsh Farms 1312 Woody Store Road Siler City, North Carolina 27344
Monitoring Performers	**Firm Information / Address**
Stream Monitoring	Stantec Consulting, Inc. 801 Jones Franklin Road, Suite 300 Raleigh, North Carolina 27606 (919) 851-6866
Vegetation and Wetland Monitoring	Stantec Consulting, Inc. 801 Jones Franklin Road, Suite 300 Raleigh, North Carolina 27606 (919) 851-6866

Exhibit Table VI. Project Background Table Project Number 010551001 (Ellerbe Creek Stream Restoration)	
Project County	Durham
Drainage Area	Hillsborough Reach – 1,140 Acre
	Hillandale Reach – 1,810 Acre
	Albany Reach – 2,150 Acre
	Croasdaile Reach - 535 Acre
Drainage impervious cover estimate (%)	80 % impervious
	20 % forest and residential
Stream Order	Third Order
Physiographic Region	Piedmont
Ecoregion	Triassic Basins
Rosgen Classification of As-built	C4
Cowardin Classification	
Dominant soil types	Cartecay, Chewacla, and Congaree.
Reference site ID	SCO#010551001A
USGS HUC for Project and Reference	Ellerbe: 03020201; Cabin Branch: : 03020201; Trib to Marks Creek:
NCDWQ Sub-basin for Project and Reference	Ellerbe: 03-04-01; Cabin Branch: 03-04-01; Trib to Marks Creek: 03-04-02
NCDWQ classification for Project and Reference	Ellerbe: Impaired Cabin Branch: Not Rated; Trib to Marks Creek: Excellent
Any portion of any project segment 303d listed?	Yes
Any portion of any project segment upstream of a 303d listed segment?	Yes
Reasons for 303d listing or stressor	No identified causes for impairment
% of project easement fenced	None

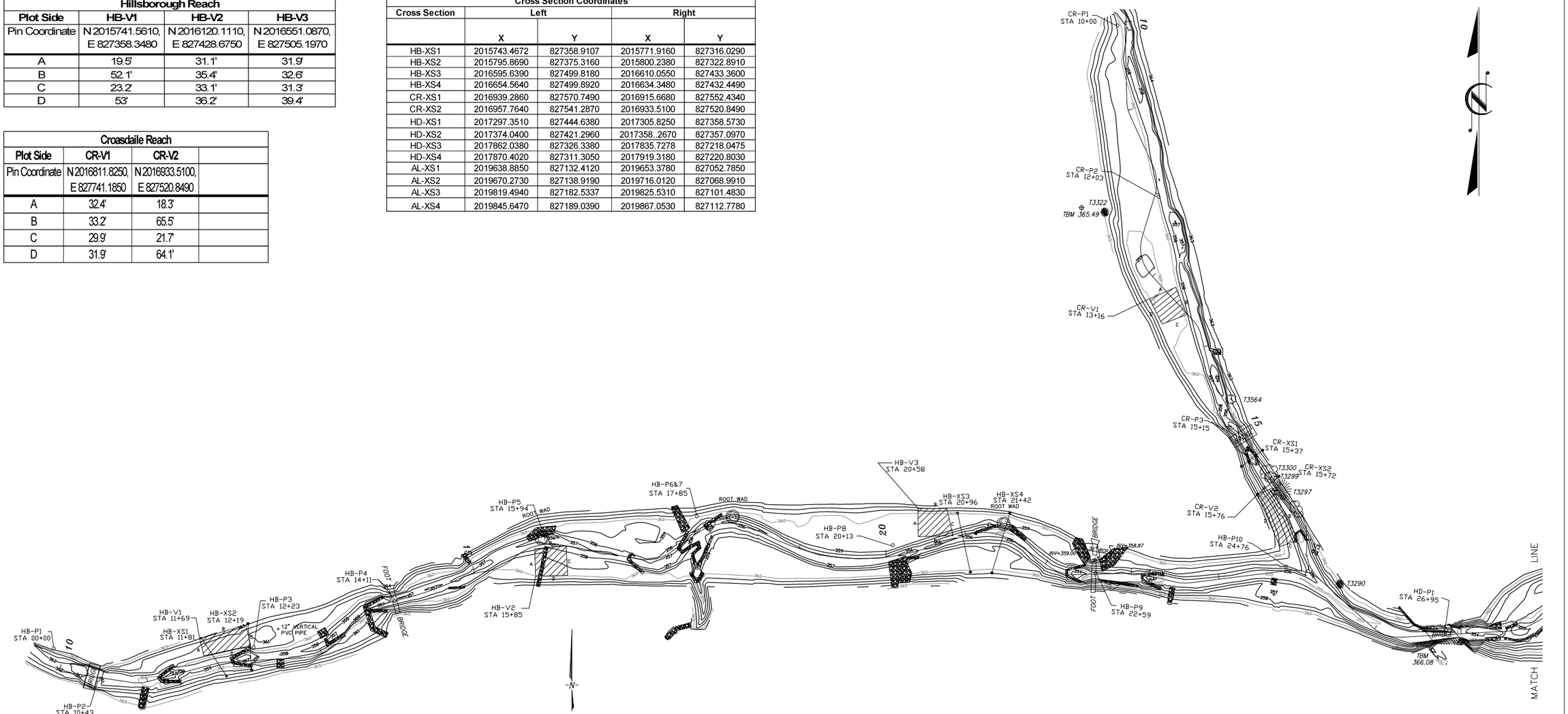
2.4 Monitoring Plan View

The monitoring plan view is located in Figure 5.

Hillsborough Reach			
Plot Side	**HB-V1**	**HB-V2**	**HB-V3**
Pin Coordinate	N 2015741.5610, E 827358.3480	N 2016120.1110, E 827428.6750	N 2016551.0870, E 827505.1970
A	19.5'	31.1'	31.9'
B	52.1'	35.4'	32.6'
C	23.2'	33.1'	31.3'
D	53'	36.2'	39.4'

Croasdaile Reach			
Plot Side	**CR-V1**	**CR-V2**	
Pin Coordinate	N 2016811.8250, E 827741.1850	N 2016933.5100, E 827520.8490	
A	32.4'	18.3'	
B	33.2'	65.5'	
C	29.9'	21.7'	
D	31.9'	64.1'	

Cross Section Coordinates				
Cross Section	**Left**		**Right**	
	X	**Y**	**X**	**Y**
HB-XS1	2015743.4672	827358.9107	2015771.9160	827316.0290
HB-XS2	2015795.8690	827375.3160	2015800.2380	827322.8910
HB-XS3	2016595.6390	827499.8180	2016610.0550	827433.3600
HB-XS4	2016654.5640	827499.8920	2016634.3480	827432.4490
CR-XS1	2016939.2860	827570.7490	2016915.6680	827552.4340
CR-XS2	2016957.7640	827541.2870	2016933.5100	827520.8490
HD-XS1	2017297.3510	827444.6380	2017305.8250	827358.5730
HD-XS2	2017374.0400	827421.2960	2017358..2670	827357.0970
HD-XS3	2017862.0380	827326.3380	2017835.7278	827218.0475
HD-XS4	2017870.4020	827311.3050	2017919.3180	827220.8030
AL-XS1	2019638.8850	827132.4120	2019653.3780	827052.7850
AL-XS2	2019670.2730	827138.9190	2019716.0120	827068.9910
AL-XS3	2019819.4940	827182.5337	2019825.5310	827101.4830
AL-XS4	2019845.6470	827189.0390	2019867.0530	827112.7780



LEGEND

- CONTROL IRON FOUND
- 36" RCP — REINFORCED CONCRETE PIPE
- ⊕ TBM — BENCHMARK
- TREE LINE
- RIP RAP
- ROCK STRUCTURE
- ROOT WAD
- CROSS SECTIONS
- PHOTOPOINT LOCATIONS
- VEGETATIVE PLOTS

60 0 30 60 120

1 INCH = 60FEET

PLAN VIEW BASED UPON AS-BUILT DRAWINGS PROVIDED BY DEWBERRY AND DAVIS, INC TITLED SEI ENVIRONMENTAL, INC TOPOGRAPHIC AS-BUILT SURVEY, ELLERBE CREEK, HILLANDALE GOLF COURSE AND SEALED BY LAWRENCE F. LEE, III ON MARCH 25, 2005.

DATA PRESENTED BY STANTEC CONSULTING, INC. INDICATES THE LOCATION OF PHOTO POINTS, CROSS SECTIONS, AND VEGETATION MONITORING PLOTS ONLY, AS OF MAY 25, 2005.

50 0 100
SCALE

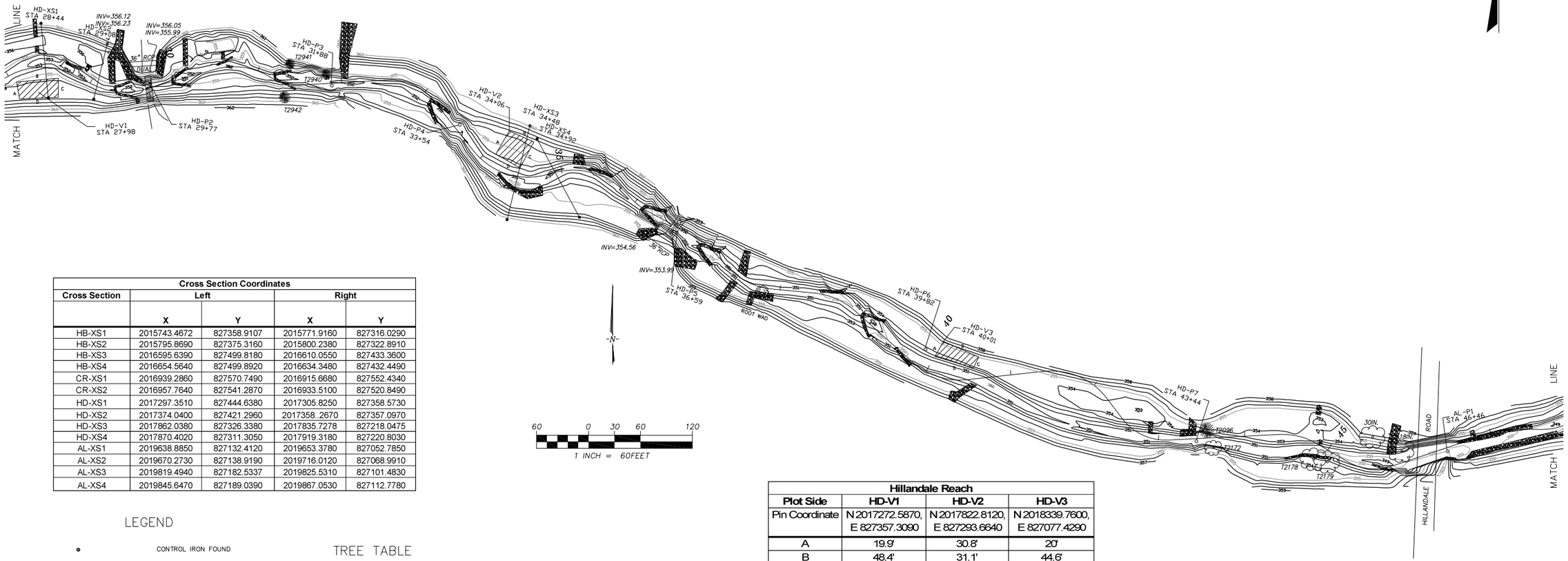
Ellerbe Creek

MONITORING

Plan View

Durham County, North Carolina

FIGURE 5A



Cross Section Coordinates				
Cross Section	Left		Right	
	X	Y	X	Y
HB-XS1	2015743.4672	827358.9107	2015771.9160	827316.0290
HB-XS2	2015795.8690	827375.3160	2015800.2380	827322.8910
HB-XS3	2016595.6390	827499.8180	2016610.0550	827433.3600
HB-XS4	2016654.5640	827499.8920	2016634.3480	827432.4490
CR-XS1	2016939.2860	827570.7490	2016915.6680	827552.4340
CR-XS2	2016957.7640	827541.2870	2016933.5100	827520.8490
HD-XS1	2017297.3510	827444.6380	2017305.8250	827358.5730
HD-XS2	2017374.0400	827421.2960	2017358..2670	827357.0970
HD-XS3	2017862.0380	827326.3380	2017835.7278	827218.0475
HD-XS4	2017870.4020	827311.3050	2017919.3180	827220.8030
AL-XS1	2019638.8850	827132.4120	2019653.3780	827052.7850
AL-XS2	2019670.2730	827138.9190	2019716.0120	827068.9910
AL-XS3	2019819.4940	827182.5337	2019825.5310	827101.4830
AL-XS4	2019845.6470	827189.0390	2019867.0530	827112.7780

Hillandale Reach			
Plot Side	HD-V1	HD-V2	HD-V3
Pin Coordinate	N 2017272.5870, E 827357.3090	N 2017822.8120, E 827293.6640	N 2018339.7600, E 827077.4290
A	19.9'	30.8'	20'
B	48.4'	31.1'	44.6'
C	22.2'	34.2'	14.2'
D	44.7'	32'	46.1'

LEGEND

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TREE TABLE

T2096 18" CEDAR
T2172 20" MAPLE
T2178 30" OAK
T2179 30" OAK
T2940 12" CEDAR
T2941 12" TWIN CEDAR
T2942 14" CEDAR
T3290 10" CEDAR
T3297 24" PINE
T3299 14" GUM
T3300 20" GUM
T3322 10" TRIPLET CEDAR
T3564 12" PEAR
T4909 34" PINE
T4913 22" PINE
T4914 25" PINE
T4916 18" CEDAR

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PLAN VIEW BASED UPON AS-BUILT DRAWINGS PROVIDED BY DEWBERRY AND DAVIS, INC TITLED SEI ENVIRONMENTAL, INC TOPOGRAPHIC AS-BUILT SURVEY, ELLERBE CREEK, HILLANDALE GOLF COURSE AND SEALED BY LAWRENCE F. LEE, III ON MARCH 25, 2005.

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50 0 100
SCALE

Ellerbe Creek

MONITORING

Plan View

Durham County, North Carolina

FIGURE 5B

Cross Section Coordinates				
Cross Section	Left		Right	
	X	Y	X	Y
HB-XS1	2015743.4672	827358.9107	2015771.9160	827316.0290
HB-XS2	2015795.8690	827375.3160	2015800.2380	827322.8910
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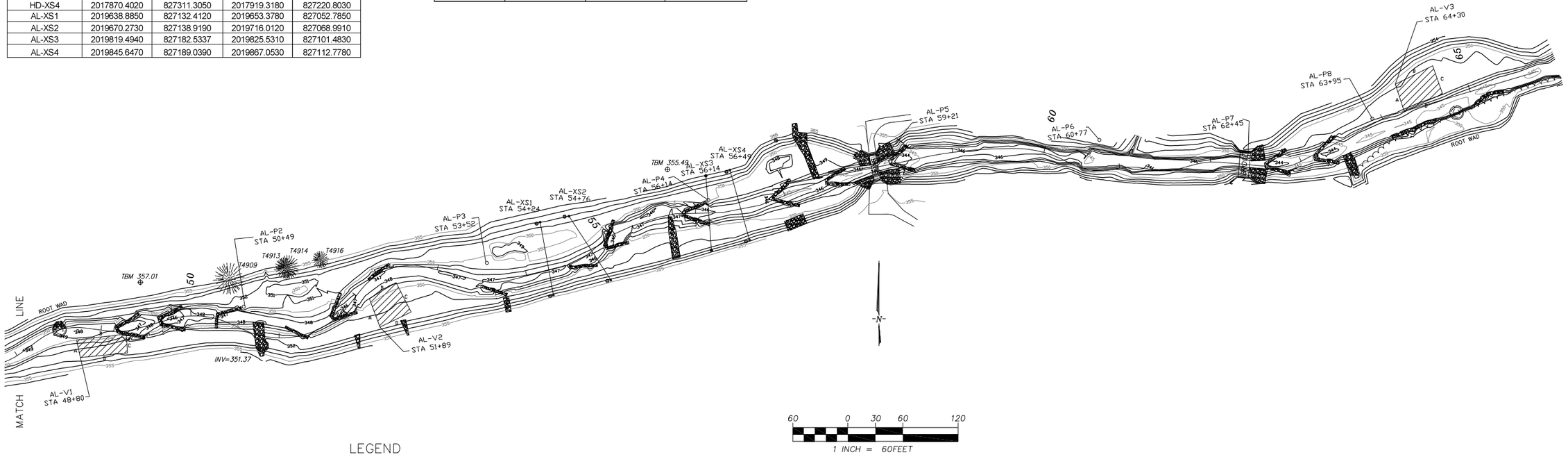
AL-XS2	2019670.2730	827138.9190	2019716.0120	827068.9910
AL-XS3	2019819.4940	827182.5337	2019825.5310	827101.4830
AL-XS4	2019845.6470	827189.0390	2019867.0530	827112.7780

Albany Reach			
Plot Side	AL-V1	AL-V2	AL-V3
Pin Coordinate	N 2019138.1520, E 826984.8090	N 2019452.9280, E 827048.9830	N 2020579.9630, E 827253.2620
A	19.8'	33.1'	30.4'
B	54.7'	33.9'	45.8'
C	20.6'	36.1'	34.3'
D	51.5'	37.7'	45.8'



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50 0 100
SCALE

Ellerbe Creek

MONITORING

Plan View

Durham County, North Carolina

FIGURE 5C

3.0 PROJECT CONDITION AND MONITORING RESULTS

3.1 Vegetation Assessment

3.1.1 Soil Data

Exhibit Table VII. Preliminary Soil Data Project Number 010551001 (Ellerbe Creek Stream Restoration)					
Series	**Max Depth (in.)**	**% Clay on Surface**	**K***	**T***	**OM %***
Altavista silt loam	41	12 to 27	0.24	5	1.75
Cartecay	80	12 to 27	0.32	5	2.50
Chewacla	60	12 to 27	0.28	5	2.50
Wahee	65	8 to 27	0.37	2	2.50
White Store	60	11.3	0.28	3	1.25

*K= soil erodibility; T = soil loss tolerance; OM = organic matter

3.1.2 Vegetative Problem Areas

Exhibit Table VIII. Vegetative Problem Areas Project Number 010551001 (Ellerbe Creek Stream Restoration)			
Feature/Issue	**Station # / Range**	**Probable Cause**	**Photo #**
Rill Erosion	34+00 to 34+25	Steep terrace slope.	VP-1
Invasive Plant Species	29+88	Mimosa	VP-2

3.1.3 Stem Counts

Survival of planted vegetation was be evaluated using survival plots and counts. Three vegetation-monitoring plots were established for three of the stream reaches and two plots established on the Croasdaile Reach. A standard quadrat area of 100 square meters was established. Rebar was driven into the ground to identify the location of the most upstream corner closest to the toe of slope (ie. Vegetation plots on the left bank have a corner pin located at the left toe of slope). Due to the site constraints, the length and width of the plots vary to some degree.

All quadrats were permanently established in the field and records of sampling locations was be maintained. All tree species that are expected to form the forest canopy will be inventoried within the quadrat. Shrub species that are expected to exist in the midstory, including streamside livestaking, was be counted.

Evaluation of planted vegetation survival will continue for at least five years. When stakes do not survive, a determination will be made as to the need for replacement; in general, if the mortality rate is greater than 30%, stakes will be replaced.
Success of planted vegetation will be determined based upon the survival of 320 stems per acre at the end of 3 years of monitoring. A tolerance of 10% mortality rate will be acceptable for each of years 4 and 5.

The final vegetated success criteria will be survival of 260 trees per acre through year 5. (Stream Monitoring Guidelines, April 2003)

3.1.4 Vegetation Plots

Planting of the Hillsboro, Croasdaile, and Hillandale Reaches occurred in late February and March of 2004. The planting of the Albany Section occurred in December 2004. The 2005 growing season was been extremely dry with corresponding very low flows in the stream channel. The first full growing season for the project has therefore been somewhat stressful for the newest plantings. For aesthetics, the golf course has been allowed to cut only the tallest weedy species from the planted areas. The following sections provide a brief description of each plot as found on October 11, 2005.

Hillsborough Plot 1

This plot has been mowed between the plantings. In May 2005 the plot had very little herbaceous cover with some weedy growth. In October 2005 the plot was fairly thick with henbit (*Lamium amplexicaule*), broom sedge (*Andropogon virginicus*), spurge (*Euphorbia* spp.), plantain (*Plantago* spp.), lespedeza (*Lespedeza* spp.), aster (*Aster* spp., daisy fleabane (*Erigeron annuus*), dog fennel (*Eupatorium capillifolium*), and fescue grass (*Festuca* spp.). Survivability of most planted species was good. The live stakes in the area were doing well.

Hillsborough Plot 2

In May 2005 this plot was becoming thick with vegetation dominated by Juncus (*Juncus* spp.), jewelweed (*Impatiens capensis*), goldenrod (*Solidago* spp.), and sedges (*Cyperus* spp.). In October the Juncus had expanded its coverage and black willow (*Salix niger*) was also coming in. The plot was dense with other species such as smartweed (*Polygonum pensylvanicum*), lespedeza, common evening primrose (*Oenothera biennis*), foxtail grass (*Setaria* spp.), sedges, and bindweed (*Convolvulus arvensis*). Survivability of most species was good except for the highbush blueberry (*Vaccinium corymbosum*), which had dropped from six stems to one.

Hillsborough Plot 3

In May this plot was very sparsely vegetated with only scattered grasses. The plot remains somewhat sparsely vegetated with lespedeza, henbit, signal grass (*Urochloa* spp.), St. John's-wort (*Hypericum* spp.), and clover (*Trifolium* spp.). This area of the floodplain appears to remain fairly dry which, with the dry weather and low stream flows, has put additional stress on the vegetation. Again, survivability of most species was good except for the highbush blueberry.

Croasdaile Plot 1

This plot lies just below a stormwater treatment facility for I-85 construction and adjacent to a wetland pocket, so the floodplain is somewhat wetter than other areas. In May 2005 the plot sparsely vegetated with the plantings and some scattered Juncus. In October, although not densely vegetated, the plot contained good mixture of species including Juncus, seedbox (*Ludwigia* spp.), sedges, carex (*Carex* spp.), prickly sida (*Sida spinosa*), lespedeza, daisy fleabane, henbit, and Queen Anne's lace (*Daucus carota*). There was good survivability of planted species.

Croasdaile Plot 2

This plot lies along the terrace/bank slope near the confluence with Ellerbe Creek. Some herbaceous cover was noted in May. In October 2005, a number of volunteer tree seedlings including red maple (*Acer rubrum*), sweetgum (*Liquidambar styraciflua*), persimmon (*Diospyros virginiana*), and tag alder (*Alnus serrulata*) were found in the plot along with lespedeza, plantain, signal grass, sedges, primrose, aster, and Queen Anne's lace. There was good survivability of all planted species.

Hillandale Plot 1

This plot lies just below the Croasdaile Road bridge and experiences considerable flooding when the stream flow is high. Heavy debris lines were noted on the floodplain from past flood events. In May this plot was very sparsely vegetated by both planted species and volunteers. The October stem count showed the plot with a dense ground cover of Juncus, partridge pea (*Cassia fasciculate*), clover, daisy fleabane, cocklebur (*Xanthium pensylvanicum*), common ragweed (*Ambrosia artemisiifolia*), tag alder, clover, plantain, bermuda grass (*Cynodon dactylon*), fescue, and black willow. There was good survivability of all planted species.

Hillandale Plot 2

In May, dog fennel and a few grasses were beginning to cover the ground between plantings. In October the plot had a dense ground cover of various grasses including bermuda grass, fescue, foxtail grass, broomsedge, ragweed, dog fennel, primrose, Queen Anne's lace, and henbit. There was good survivability of all planted species.

Hillandale Plot 3

In May this plot was somewhat sparsely vegetated with herbaceous species. The October stem count found the plot with dense vegetation along the stream bank and less so up on the floodplain. Volunteer species included daisy fleabane, henbit, lespedeza, goldenrod, broomsedge, foxtail grass, Queen Anne's lace, and a few mimosa (*Albizia julibrissin*) seedlings. Plantings of highbush blueberry, elderberry, and leucothoe could not be found; most of the rest of the plantings appear to be surviving.

Albany Plot 1

This plot lies just below the Hillandale Road Bridge. The plot in May was sparsely vegetated with herbaceous species and most of the live stakes of elderberry were dead. In October the stream bank was densely covered with grasses and smartweed and only a couple of live stakes were found. Volunteer species included foxtail grass, lespedeza, signal grass, sedges, ragweed, clover, and crabgrass (*Digitaria* spp.).

Albany Plot 2

In May 2005 this plot contained only the planted seedlings. By October a sparse groundcover of henbit, lespedeza, foxtail grass, and sedges had volunteered. A large number of the Virginia willow live stakes were missing along with highbush blueberry. The rest of the planted species had good survivability.

Albany Plot 3

This plot is located in the new floodplain at the downstream end of the project and was planted with a large number of trees. Volunteer vegetation was sparse in May. The October stem count found more dense volunteer vegetation along the stream bank and a developing ground cover of sedges, ragweed, daisy fleabane, henbit, fescue, crabgrass, signal grass, dog fennel, and a few alder seedlings.

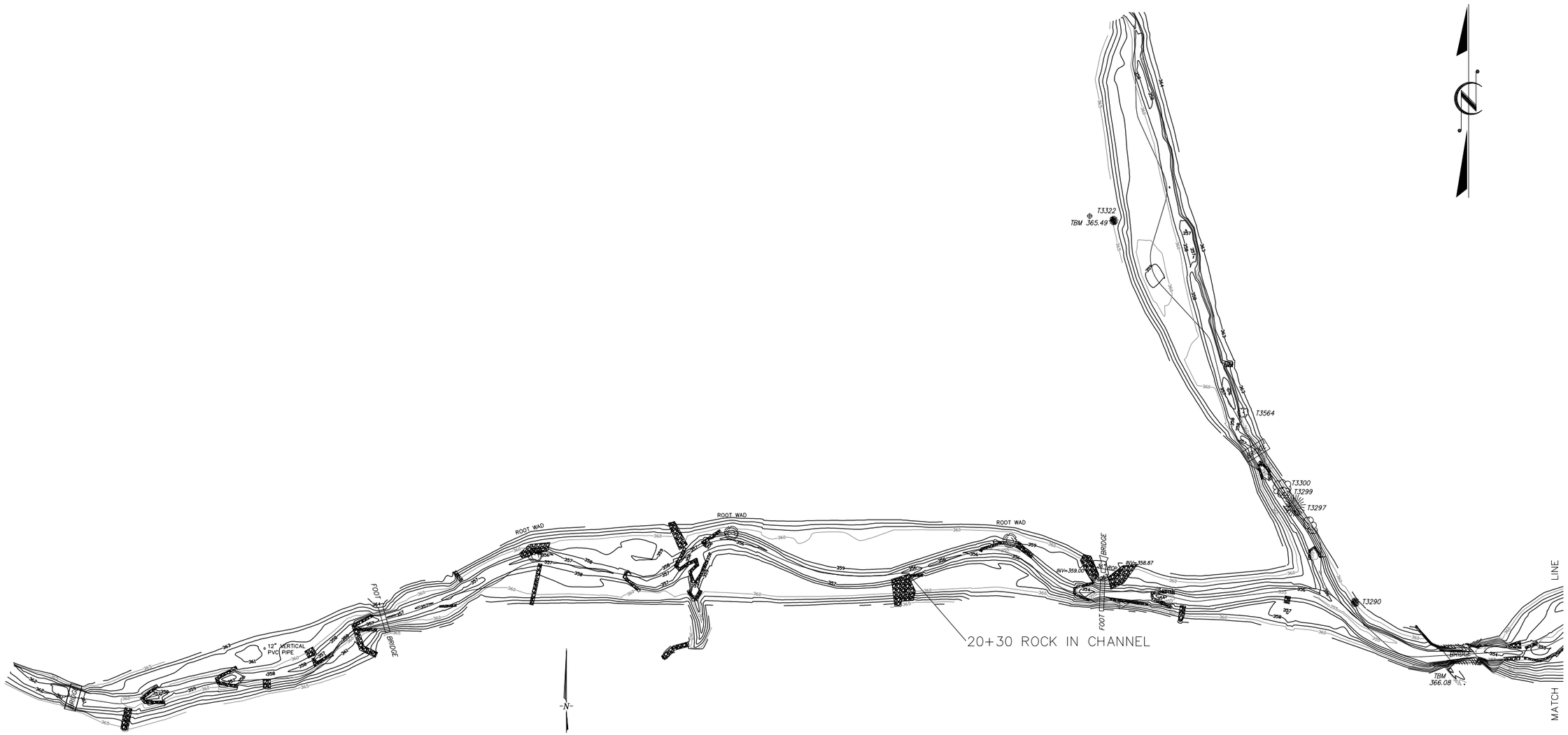
Exhibit Table IX: Stem Counts for Each Species Arranged by Plot.
Project Number 010551001 (Ellerbe Creek Stream Restoration)

Species	Hillsboro Plots			Croasdaile Plots		Hillandale Plots			Albany Plots			Initial Totals	Year 1 Totals	Survival %
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**			
Shrubs														
Alnus serrulata							1			1		8	2	25
Aronia arbutifolia		2	3	2		3	11	3	1	1		33	26	79
Callicarpa americana				2	4				2	3		15	11	73
Clethra alnifolia		1				1			3			8	5	62
Cornus amomum	19	10	12	12	9	3		6	7	8	5	93	91	98
Ilex verticillata	3											3	3	100
Itea virginca								2	1	29		57	32	56
Myrica cerifera			1	1								2	2	100
Salix sericea	1	13										23	14	61
Sambucus Canadensis		1			18		5		2		2	51	28	55
Symphoricarpos orbiculata					4							4	4	100
Vaccinium corymbosum		1	1		8							26	10	38
Viburnum nudum						5						7	5	71
Trees														
Betula nigra	15		5				3				15	42	38	90
Cornus florida			1									1	1	100
Fraxinus pennsylvanica	5							5			15	35	25	71
Juniperus virginiana			2				3					5	5	100
Quercus coccinea	2			1	1						2	7	6	86
Quercus phellos	2		2				3	3			10	24	20	87
Totals	**74**	**28**	**27**	**18**	**71**	**12**	**26**	**19**	**16**	**42**	**49**	**444**	**328**	**74**

3.2. Stream Assessment

3.2.1 Problem Areas Plan View

The problem areas plan view can be found in Figure 6.



LEGEND

⊙	CONTROL IRON FOUND
36" RCP	REINFORCED CONCRETE PIPE
⊕ TBM	BENCHMARK
	TREE LINE
	RIP RAP
	ROCK STRUCTURE
	ROOT WAD
	CROSS SECTIONS
	PHOTOPOINT LOCATIONS
	VEGETATIVE PLOTS

60 0 30 60 120

1 INCH = 60FEET

50 0 100

SCALE

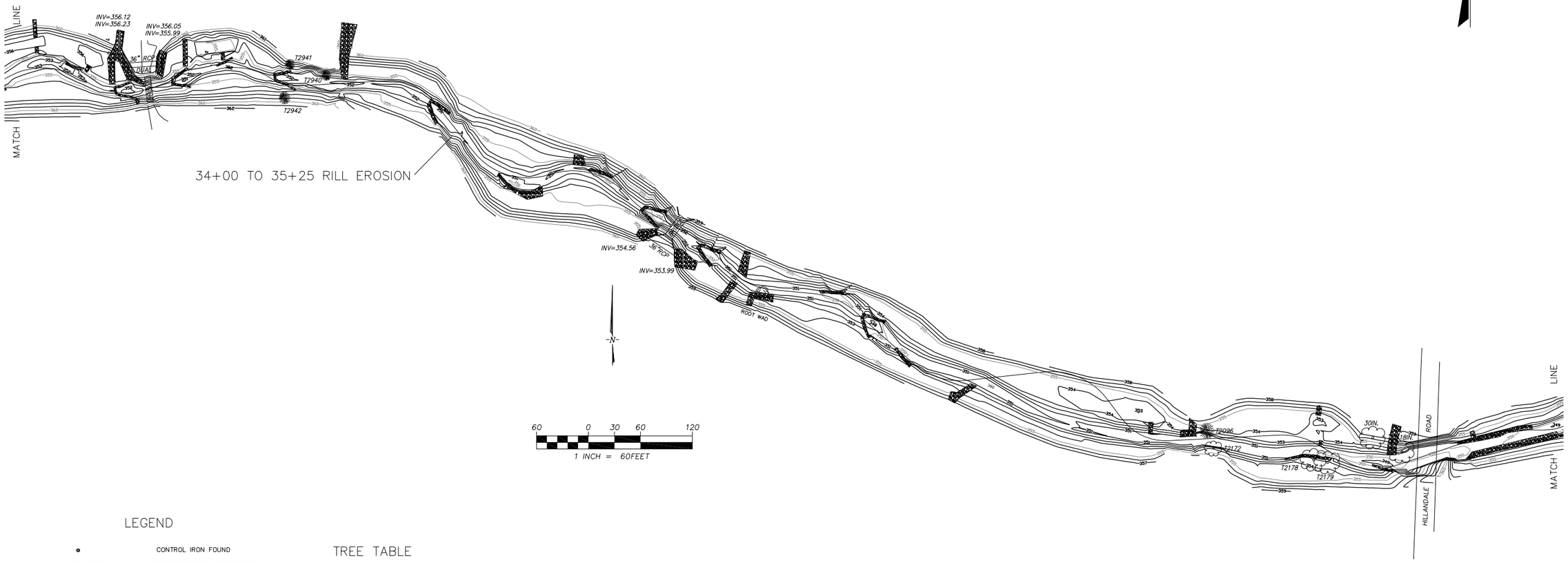
Ellerbe Creek

STREAM PROBLEM AREAS

Plan View

Durham County, North Carolina

FIGURE 6A



LEGEND

●	CONTROL IRON FOUND
36" RCP	REINFORCED CONCRETE PIPE
⊕ TBM	BENCHMARK
	TREE LINE
	RIP RAP
	ROCK STRUCTURE
	ROOT WAD
	CROSS SECTIONS
	PHOTOPOINT LOCATIONS
	VEGETATIVE PLOTS

TREE TABLE

T2096	18" CEDAR
T2172	20" MAPLE
T2178	30" OAK
T2179	30" OAK
T2940	12" CEDAR
T2941	12" TWIN CEDAR
T2942	14" CEDAR
T3290	10" CEDAR
T3297	24" PINE
T3299	14" GUM
T3300	20" GUM
T3322	10" TRIPLET CEDAR
T3564	12" PEAR
T4909	34" PINE
T4913	22" PINE
T4914	25" PINE
T4916	18" CEDAR

50 0 100
SCALE

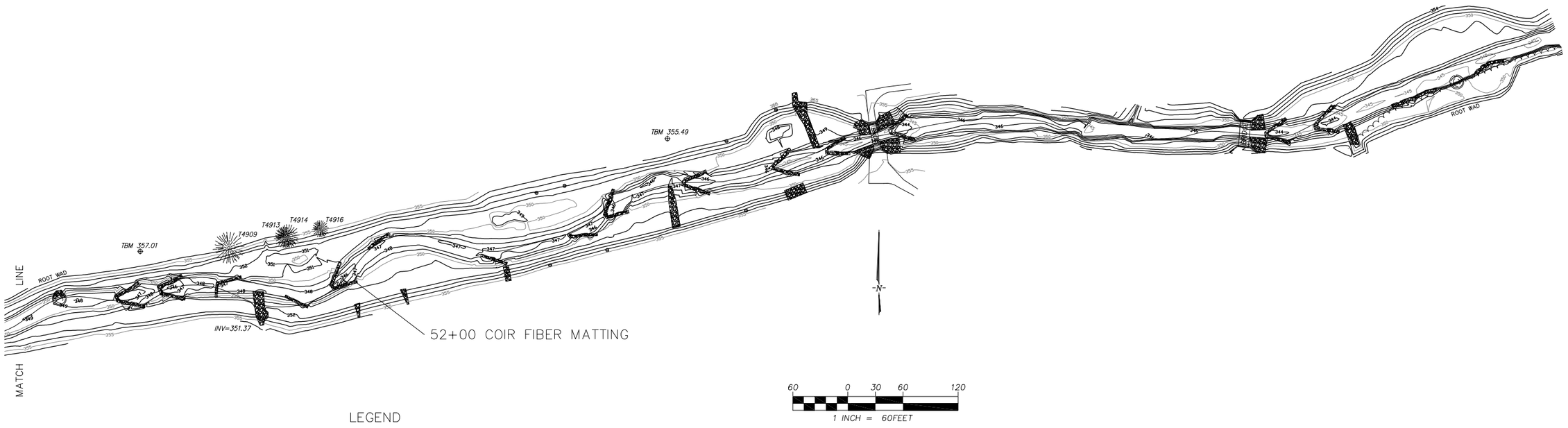
Ellerbe Creek

STREAM PROBLEM AREAS

Plan View

Durham County, North Carolina

FIGURE 6B



60 0 30 60 120

1 INCH = 60FEET

LEGEND

- CONTROL IRON FOUND
- 36" RCP — REINFORCED CONCRETE PIPE
- TBM — BENCHMARK
- TREE LINE
- RIP RAP
- ROCK STRUCTURE
- ROOT WAD
- CROSS SECTIONS
- PHOTOPOINT LOCATIONS
- VEGETATIVE PLOTS

50 0 100

SCALE

Ellerbe Creek

STREAM PROBLEM AREAS

Plan View

Durham County, North Carolina

FIGURE 6C

3.2.2 Stream Problem Areas

Exhibit Table X. Stream Problem Areas Project Number 010551001 (Ellerbe Creek Stream Restoration)			
Feature Issue	**Station numbers**	**Suspected Cause**	**Photo number**
Rock washed into stream from junction box.	20+30	Undersized rock at junction box outlet.	SP1
Coir fiber matting detached from bank.	52+00	Matting in need of additional tacking.	SP2
Leak in storm water wetland weir	Upper wetland	Unknown	SP3

3.2.3 Numbered Issue Photo Section

Appendix A presents Vegetation Problem Photos and Vegetation Plot Photos.

3.2.4 Fixed Station Photos

Photographs were taken at fixed positions throughout the project post construction and during the first year of monitoring. Post construction photos were taken in March 2005. The first year monitoring report for the project is scheduled for completion in November 2005. Therefore, considering time constraints photos were not taken within the same 2-month time period of the growing season.

Appendix B presents the Fixed Photo Stations, Permanent Stream Cross Sectional Data, Pebble Counts, 2005 Monitoring Profile, and Stream Problem Photos.

3.2.5 Stability Assessment

Exhibit Table XIa. Categorical Stream Feature Visual Stability Assessment Project Number 010551001 (Ellerbe Creek Stream Restoration) Segment/Reach: Hillsborough						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%	90%				
B. Pools	100%	80%				
C. Thalweg	100%	95%				
D. Meanders	100%	98%				
E. Bed General	100%	85%				
F. Channel General	100%	95%				
G. Banks	75%	98%				
H. Vanes / J Hooks etc.	100%	95%				
I. Wads and Boulders	100%	95%				

Exhibit Table XIb. Categorical Stream Feature Visual Stability Assessment Project Number 010551001 (Ellerbe Creek Stream Restoration) Segment/Reach: Croasdaile						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%	95%				
B. Pools	100%	95%				
C. Thalweg	100%	95%				
D. Meanders	100%	95%				
E. Bed General	100%	95%				
F. Channel General	100%	95%				
G. Banks	75%	95%				
H. Vanes / J Hooks etc.	100%	95%				
I. Wads and Boulders	100%	95%				

Exhibit Table XIc. Categorical Stream Feature Visual Stability Assessment Project Number 010551001 (Ellerbe Creek Stream Restoration) Segment/Reach: Hillandale						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%	90%				
B. Pools	100%	85%				
C. Thalweg	100%	95%				
D. Meanders	100%	95%				
E. Bed General	100%	75%				
F. Channel General	100%	80%				
G. Banks	75%	95%				
H. Vanes / J Hooks etc.	100%	95%				
I. Wads and Boulders	100%	95%				

Exhibit Table XId. Categorical Stream Feature Visual Stability Assessment Project Number 010551001 (Ellerbe Creek Stream Restoration) Segment/Reach: Albany						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%	60%				
B. Pools	100%	60%				
C. Thalweg	100%	80%				
D. Meanders	100%	95%				
E. Bed General	100%	50%				
F. Channel General	100%	90%				
G. Banks	75%	85%				
H. Vanes / J Hooks etc.	100%	95%				
I. Wads and Boulders	100%	95%				

3.2.6 Quantitative Morphology

Exhibit Table XIIa. Baseline Morphology and Hydraulic Summary
Project Number 010551001 (Ellerbe Creek Stream Restoration)
Segment/Reach: Ellerbe Creek (Hillsborough, Hillandale, and Albany Reaches)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream (s)			Design			As-built		
Dimension	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
BF Width (ft)							19.9	20.7		10.1	14.3		22	26		16.3	24.8	
Floodprone Width (ft)							25	40		47	59		48	57		50	100	
BF Cross Sectional Area (ft^2)							37.9	48.3		7.2	21.4		28.9	42.3		25.8	82.4	
BF Mean Depth (ft)							1.5	2.4		0.7	1.5		1.8	2.2		1.3	3.3	
BF Max Depth (ft)							37.	4.0		1.3	2.2		2.7	3.2		2.2	4.8	
Width/Depth Ratio							8	13		10	14		28.9	42.3		12.7	19.2	
Entrenchment Ratio							1.2	2.0		3.3	5.8		2.2	2.2		2.4	3.9	
Wetted Perimeter(ft)							28.28	24.77		11.61	17.25		21.89	24.59		19.9	38.4	
Hydraulic radius (ft)							1.34	1.95		0.62	1.24		1.32	1.72		1.3	2.6	
Pattern																		
Channel Beltwidth (ft)							25	33		38	80		90	105		11.6	55.38	36.7
Radius of Curvature (ft)							NA	19	15	37.73	160		45	95		34.78	114	67
Meander Wavelength (ft)							NA	129	65	32	105		85	295		103	304	185
Meander Width ratio							1.3	1.6		3.74	7.89		4.0	4.1		0.47	2.41	1.48
Profile																		
Riffle length (ft)													2	103				
Riffle slope (ft/ft)							0.906	1.091	0.0109				0.0013	0.002				
Pool length (ft)													**2**	**27**				
Pool spacing (ft)							19	29	24	5	49		24	160				
Substrate																		
d50 (mm)									8.3					5		0.01	4.4	
d84 (mm)																5	49	
Additional Reach Parameters																		
Valley Length (ft)																	5200	
Channel Length (ft)																	5576	
Sinuosity								1.03			1.2			1.11			1.05	
Water Surface Slope (ft/ft)								0.994									0.97	
BF slope (ft/ft)																		
Rosgen Classification								G4			C4b, C5			C4			C4	
Number of Bankfull Events																	6	
Extent of BF floodplain (acres)																		
*BEHI																		
*Habitat Index																		
*Macrobenthos																		

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

Exhibit Table XIIb. Baseline Morphology and Hydraulic Summary
Project Number 010551001 (Ellerbe Creek Stream Restoration)
Segment/Reach: Ellerbe Creek (Croasdaile Reach)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
BF Width (ft)							19.9	20.7		10.1	14.3				17.5	9.1	11.5	
Floodprone Width (ft)							25	40		47	59				50			21.2
BF Cross Sectional Area (ft^2)							37.9	48.3		7.2	21.4				16.9	14.5	19.7	
BF Mean Depth (ft)							1.5	2.4		0.7	1.5				1.5	1.3	2.2	
BF Max Depth (ft)							37.	4.0		1.3	2.2				2.1	1.9	2.8	
Width/Depth Ratio							8	13		10	14				12			9.0
Entrenchment Ratio							1.2	2.0		3.3	5.8				2.9			1.9
Wetted Perimeter(ft)										11.61	17.25							
Hydraulic radius (ft)							1.34	1.95		0.62	1.24				1.01	1.1	1.6	
Pattern																		
Channel Beltwidth (ft)							25	33		38	80				82.63			
Radius of Curvature (ft)							NA	19	15	37.73	160		36	44				
Meander Wavelength (ft)							NA	129	65	32	105		156	233				
Meander Width ratio							1.3	1.6		3.74	7.89				4.7			
Profile																		
Riffle length (ft)																		
Riffle slope (ft/ft)							0.906	1.091	0.0109						0.002			
Pool length (ft)																		
Pool spacing (ft)							19	29	24				29.2	78				
Substrate																		
d50 (mm)									8.3									
d84 (mm)																		
Additional Reach Parameters																		
Valley Length (ft)																	687	
Channel Length (ft)																	703	
Sinuosity								1.03			1.20 - 1.23			1.05			1.02	
Water Surface Slope (ft/ft)								0.994										
BF slope (ft/ft)																		
Rosgen Classification								G4			C4b, C5			C4			B4	
Number of Bankfull Events																		
Extent of BF floodplain (acres)																		
*BEHI																		
*Habitat Index																		
*Macrobenthos																		

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

Exhibit Table XIIIa. Morphology and Hydraulic Monitoring Summary
Project Number 010551001 (Ellerbe Creek Stream Restoration)
Segment/Reach: Hillsborough Reach

Parameter	Cross Section HB-1 Riffle						Cross Section HB-2 Pool						Cross Section 3 Riffle						Cross Section 4 Pool					
Dimension	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
BF Width (ft)	21.8						16.1						38						24.4					
Floodprone Width (ft)	100						100						100						100					
BF Cross Sectional Area (ft^2)	33.1						54						38.2						56.3					
BF Mean Depth (ft)	1.5						3.4						1.0						2.3					
BF Max Depth (ft)	2.6						4.6						2.8						4.4					
Width/Depth Ratio	14.3						4.8						37.7						10.6					
Entrenchment Ratio	4.6						6.2						2.6						4.1					
Wetted Perimeter(ft)	22.8						21.5						38.7						27.3					
Hydraulic radius (ft)	1.5						2.5						1.0						2.1					
Substrate																								
d50 (mm)	12						9.6						.062						0.83					
d84 (mm)	30						41						1200						13					

Parameter	MY-01 (2005)			MY-02 (2006)			MY-03 (2007)			MY-04 (2008)			MY-05 (2009)			MY+ (2010)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width ratio																		
Profile																		
Riffle length (ft)																		
Riffle slope (ft/ft)																		
Pool length (ft)																		
Pool spacing (ft)																		
Additional Reach Parameters	**Hillsborough Reach**																	
Valley Length (ft)	1586																	
Channel Length (ft)	1663																	
Sinuosity	1.05																	
Water Surface Slope (ft/ft)	0.97																	
BF slope (ft/ft)																		
Rosgen Classification	C4																	
Number of Bankfull Events	6																	
Extent of BF floodplain (area)																		
BEHI*																		
Habitat Index*																		
Macrobenthos*																		

Exhibit Table XIIIb. Morphology and Hydraulic Monitoring Summary
Project Number 010551001 (Ellerbe Creek Stream Restoration)
Segment/Reach: Hillandale Reach

Parameter	Cross Section 1 Pool						Cross Section 2 Riffle						Cross Section 3 Pool						Cross Section 4 Pool					
Dimension	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
BF Width (ft)	30						41.9						45.2						39.2					
Floodprone Width (ft)	100						100						100						105					
BF Cross Sectional Area (ft^2)	37.3						38.8						101.5						69.2					
BF Mean Depth (ft)	1.2						0.9						2.2						1.8					
BF Max Depth (ft)	3.0						2.9						4.5						4.0					
Width/Depth Ratio	24.2						45.1						20.1						22.3					
Entrenchment Ratio	3.3						2.4						2.2						2.7					
Wetted Perimeter(ft)	31.2						43.3						46.6						40.4					
Hydraulic radius (ft)	1.2						0.9						2.2						1.7					
Substrate																								
d50 (mm)	0.59						0.062						7						0.062					
d84 (mm)	8						0.062						18						0.062					

Parameter	MY-01 (2005)			MY-02 (2006)			MY-03 (2007)			MY-04 (2008)			MY-05 (2009)			MY+ (2010)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width ratio																		
Profile																		
Riffle length (ft)																		
Riffle slope (ft/ft)																		
Pool length (ft)																		
Pool spacing (ft)																		
Additional Reach Parameters	**Hillandale Reach**																	
Valley Length (ft)	1804																	
Channel Length (ft)	1939																	
Sinuosity	1.07																	
Water Surface Slope (ft/ft)																		
BF slope (ft/ft)																		
Rosgen Classification	C4																	
Number of Bankfull Events																		
Extent of BF floodplain (area)																		
BEHI*																		
Habitat Index*																		
Macrobenthos*																		

Exhibit Table XIIIc. Morphology and Hydraulic Monitoring Summary
Project Number 010551001 (Ellerbe Creek Stream Restoration)
Segment/Reach: Albany Reach

Parameter	Cross Section 1 Riffle						Cross Section 2 Riffle						Cross Section 3 Riffle						Cross Section 4 Pool					
Dimension	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
BF Width (ft)	31.7						28						21.3						28.9					
Floodprone Width (ft)	100						100						100						71.9					
BF Cross Sectional Area (ft^2)	69.1						70.1						71.4						55.7					
BF Mean Depth (ft)	2.2						2.5						3.3						1.9					
BF Max Depth (ft)	3.9						4.6						4.4						3.3					
Width/Depth Ratio	14.5						11.2						6.4						15					
Entrenchment Ratio	3.2						3.6						4.7						2.5					
Wetted Perimeter(ft)	33.5						30.7						25.3						30					
Hydraulic radius (ft)	2.1						2.3						2.8						1.9					
Substrate																			3.5					
d50 (mm)	0.062						0.86						9.2						12					
d84 (mm)	3.8						10						22											

Parameter	MY-01 (2005)			MY-02 (2006)			MY-03 (2007)			MY-04 (2008)			MY-05 (2009)			MY+ (2010)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width ratio																		
Profile																		
Riffle length (ft)																		
Riffle slope (ft/ft)																		
Pool length (ft)																		
Pool spacing (ft)																		
Additional Reach Parameters	**Albany Reach**																	
Valley Length (ft)	1888																	
Channel Length (ft)	1974																	
Sinuosity	1.04																	
Water Surface Slope (ft/ft)																		
BF slope (ft/ft)																		
Rosgen Classification	C4																	
Number of Bankfull Events																		
Extent of BF floodplain (area)																		
BEHI*																		
Habitat Index*																		
Macrobenthos*																		

Exhibit Table XIIId. Morphology and Hydraulic Monitoring Summary
Project Number 010551001 (Ellerbe Creek Stream Restoration)
Segment/Reach: Croasdaile Reach

Parameter	Cross Section 1 Riffle						Cross Section 2 Riffle						Cross Section 3 Riffle						Cross Section 4 Pool					
Dimension	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
BF Width (ft)	9.4						13.4																	
Floodprone Width (ft)	9.8						23.3																	
BF Cross Sectional Area (ft^2)	20.4						17.9																	
BF Mean Depth (ft)	2.2						1.3																	
BF Max Depth (ft)	2.5						2.1																	
Width/Depth Ratio	4.4						10																	
Entrenchment Ratio	1.0						1.7																	
Wetted Perimeter(ft)	11.1						14.8																	
Hydraulic radius (ft)	1.8						1.2																	
Substrate																								
d50 (mm)	12						12																	
d84 (mm)	24						20																	

Parameter	MY-01 (2005)			MY-02 (2006)			MY-03 (2007)			MY-04 (2008)			MY-05 (2009)			MY+ (2010)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width ratio																		
Profile																		
Riffle length (ft)																		
Riffle slope (ft/ft)																		
Pool length (ft)																		
Pool spacing (ft)																		
Additional Reach Parameters	**Croasdaile Reach**																	
Valley Length (ft)	687																	
Channel Length (ft)	703																	
Sinuosity	1.02																	
Water Surface Slope (ft/ft)																		
BF slope (ft/ft)																		
Rosgen Classification	B4																	
Number of Bankfull Events																		
Extent of BF floodplain (area)																		
BEHI*																		
Habitat Index*																		
Macrobenthos*																		

4.0 METHODOLOGY SECTION

4.1 Monitoring Survey Data Collection

Dimension and profile data was obtained using Real Time Kinetic (RTK) and total station survey. Benchmark points from the as-built survey were used to tie the monitoring survey data into the as-built alignment. This method was used for two reasons. The vegetative cover at Ellerbe Creek is currently small enough that little interference of the RTK system was noticed. RTK is a survey grade Global Positioning System (GPS) unit that provided the ability to survey the stream accurately with a relative benchmark to compare stream data obtained in Year 1 Monitoring to the As-Built conditions.

4.2 Culvert Outlet Impacts to Ellerbee Creek

During monitoring, instream vegetation and various fish species were identified in the upper reaches of the stream (Hillsborough, Croasdaile, and the majority of the Hillandale Reach). A culvert that discharges from the water treatment plant enters Ellerbe Creek at STA 43+00. From that point downstream, monitoring staff did not identify any aquatic vegetation or any fish. It became apparent that discharge from the culvert was significantly impacting the ecological health of the stream. Stantec contacted NCEEP, which in turn contacted the City of Durham. City of Durham officials investigated the situation and identified high levels of chloramines that were being discharged from the wastewater treatment plant. The City has taken actions to remedy the problems associated with the stream discharge. On a subsequent site visit, it appears that the remedial steps taken by the City are making a positive impact on the downstream portions of Ellerbe Creek. Some algae species were identified in the down stream portions, however, there were no fish or other aquatic vegetation identified.

4.3 Channel Aggradations

During construction, there were several limiting factors that either altered design pattern or design profile. After construction had begun, the City of Durham specified that no excavation could occur within the sewer and water pipe easements that crossed and paralleled the stream. The elevation of the bottom of several sewer and/or water pipes was at or near the streambed elevation of the design channel. It is believed that the several pipes are slowing stream velocity enough to deposit sediment upstream of the areas that pipes are crossing. This is suspected at a pipe crossing at STA 15+25 and to a greater extent at STA 61+00.

A second limiting factor at the site was the amount of bedrock that was discovered during construction. Bedrock elevations within the proposed alignment were higher at some locations than the proposed design stream alignment. Stream construction attempted to remedy the unforeseen problems by setting elevations of channel and vane drop structures to provide adequate slope.

The Year 1 Monitoring identified areas of the channel that aggradation has occurred from STA 56+00 to the end of project of Albany Reaches of the channel. It is believed that the main reason for aggradation of the stream are several beaver dams that have formed downstream of the project. This is slowing stream velocity significantly causing sediments to settle instead of transporting through the stream as designed.

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APPENDIX A

Vegetation Problem Area Photos

Vegetation Monitoring Plot Photos

Vegetation Problem Photos

VP-1: Invasive Species - Mimosa Tree
(STA 29+88)

VP-2: Rill Erosion (STA34+00 to 34+25)

APPENDIX A

Vegetation Problem Area Photos

Vegetation Monitoring Plot Photos

Vegetation Plot Photos

HB-V1

HB-V2

HB-V3

HD-V1

HD-V2

HD-V3

AL-V1

AL-V2

AL-V3

Vegetation Plot Photos

CRB-V1

CR-V2

APPENDIX B

Fixed Photo Stations

Stream Permanent Cross Section

Stream Pebble Count Data

2005 Monitoring Longitudinal Profile Raw Data

2005 Monitoring Profile

Stream Problem Photos

Photo Stations

HB-P01 STA 00+00

HB-P02 STA 10+43 (BRIDGE)

HB-V1 STA 11+69

HB-XS1 STA 11+81

HB-XS2 STA 12+19

HB-P03 STA 12+23

HB-P04 STA 14+11 (BRIDGE)

HB-P05 STA 15+94

HB-V2 STA 15+65

Photo Stations

HB-P06 STA 17+85

HB-P07 STA 17+85

HB-P08 STA 20+13

HB-V3 STA 20+58

HB-XS3 STA 20+96

HB-XS4 STA 21+42

HB-P09 STA 22+59

HB-P10 STA 24+76

HD-P01 STA 26+95

Photo Stations

HD-V1 STA 27+98

HD-XS1 STA 28+44

HD-XS2 STA 29+08

HD-P02 STA 29+77 (BRIDGE)

HD-P03 STA 31+88 (PIPE)

HD-P04 STA 33+54

HD-V2 STA 34+06

HD-XS3 STA 34+48

HD-XS4 STA 34+92

Photo Stations

HD-PO5 STA 36+59

HD-P06 STA 39+82

HD-V3 STA 40+01

HD-P07 STA 43+44

AL-P01 STA 46+46 (BRIDGE)

AL-V1 STA 48+40

AL-P02 STA 50+49

AL-V2 STA 51+89

AL-P03 STA 53+52

Photo Stations

AL-XS1 STA 54+24

AL-XS2 STA 54+76

AL-XS3 STA 56+14

AL-P04 STA 56+19

AL-XS4 STA 56+49

AL-P05 STA 59+21 (BRIDGE)

AL-P06 STA 60+77

AL-P07 STA 62+45 (BRIDGE)

AL-P08 STA 63+95

Photo Stations

AL-V31STA 64+30

CR-P01 STA 10+00

CR-P02 STA 12+03

CR-V1 STA 13+16

CR-P03 STA 15+15

CR-XS1 STA 15+37

CR-XS2 STA 15+72

CR-V2 STA 15+72

APPENDIX B

Fixed Photo Stations

Stream Permanent Cross Section

Stream Pebble Count Data

2005 Monitoring Longitudinal Profile Raw Data

2005 Monitoring Profile

Stream Problem Photos

Stream Permanent Cross Section

HB-XS1

Cross Section HB-1

Bankfull Dimensions	
33.1	x-section area (ft.sq.)
21.8	width (ft)
1.5	mean depth (ft)
2.6	max depth (ft)
22.8	wetted parimeter (ft)
1.5	hyd radi (ft)
14.3	width-depth ratio

Flood Dimensions	
100.0	W flood prone area (ft)
4.6	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
983	threshold grain size (mm):

Bankfull Flow	
---	velocity (ft/s)
---	discharge rate (cfs)
---	Froude number

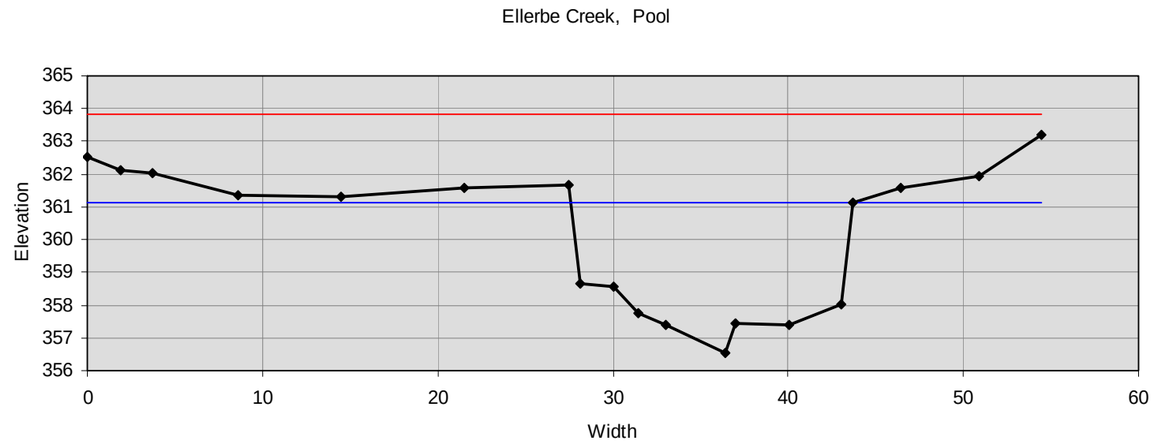
Flow Resistance	
---	Manning's roughness
---	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
22	channel slope (%)
19.99	shear stress (lb/sq.ft.)
3.21	shear velocity (ft/s)
---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

HB-XS2

Cross Section HB-2



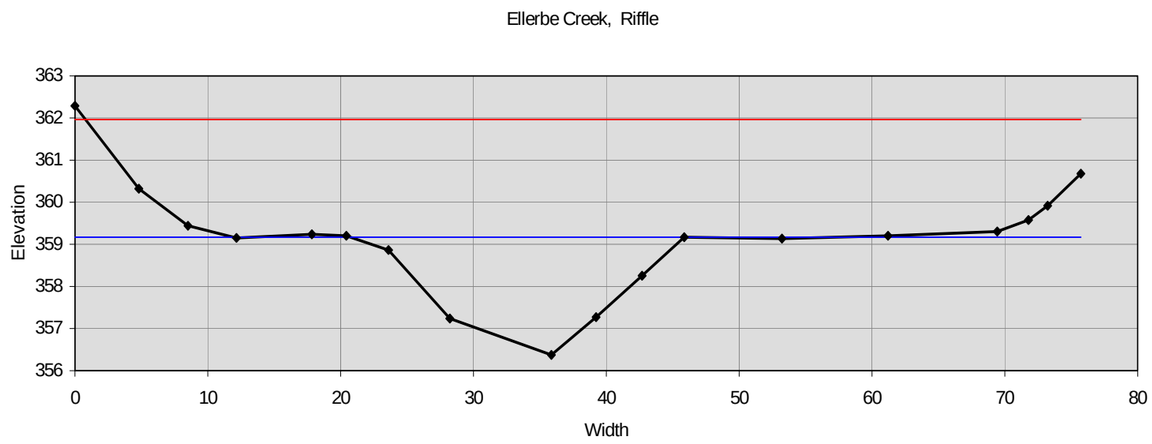
Bankfull Dimensions		Flood Dimensions		Materials	
54.0	x-section area (ft.sq.)	100.0	W flood prone area (ft)	0.83	D50 Riffle (mm)
16.1	width (ft)	6.2	entrenchment ratio	13	D84 Riffle (mm)
3.4	mean depth (ft)	---	low bank height (ft)	1699	threshold grain size (mm):
4.6	max depth (ft)	---	low bank height ratio		
21.5	wetted parimeter (ft)				
2.5	hyd radi (ft)				
4.8	width-depth ratio				

Bankfull Flow		Flow Resistance		Forces & Power	
57.1	velocity (ft/s)	0.023	Manning's roughness	22	channel slope (%)
3085.7	discharge rate (cfs)	0.04	D'Arcy-Weisbach fric.	34.57	shear stress (lb/sq.ft.)
6.34	Froude number	13.5	resistance factor u/u*	4.22	shear velocity (ft/s)
		78.8	relative roughness	2636	unit strm power (lb/ft/s)

Stream Permanent Cross Section

HB-XS3

Cross Section HB-3



Bankfull Dimensions	
38.2	x-section area (ft.sq.)
38.0	width (ft)
1.0	mean depth (ft)
2.8	max depth (ft)
38.7	wetted parimeter (ft)
1.0	hyd radi (ft)
37.7	width-depth ratio

Flood Dimensions	
100.0	W flood prone area (ft)
2.6	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
666	threshold grain size (mm):

Bankfull Flow	
---	velocity (ft/s)
---	discharge rate (cfs)
---	Froude number

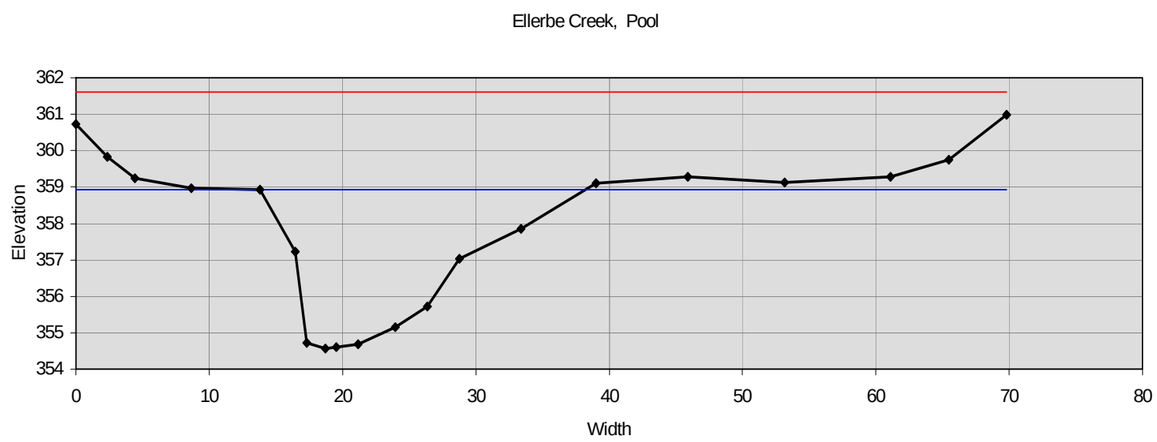
Flow Resistance	
---	Manning's roughness
---	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
22	channel slope (%)
13.55	shear stress (lb/sq.ft.)
2.64	shear velocity (ft/s)
---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

HB-XS4

Cross Section HB-4



Bankfull Dimensions	
56.3	x-section area (ft.sq.)
24.4	width (ft)
2.3	mean depth (ft)
4.4	max depth (ft)
27.3	wetted parimeter (ft)
2.1	hyd radi (ft)
10.6	width-depth ratio

Flood Dimensions	
100.0	W flood prone area (ft)
4.1	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
1389	threshold grain size (mm):

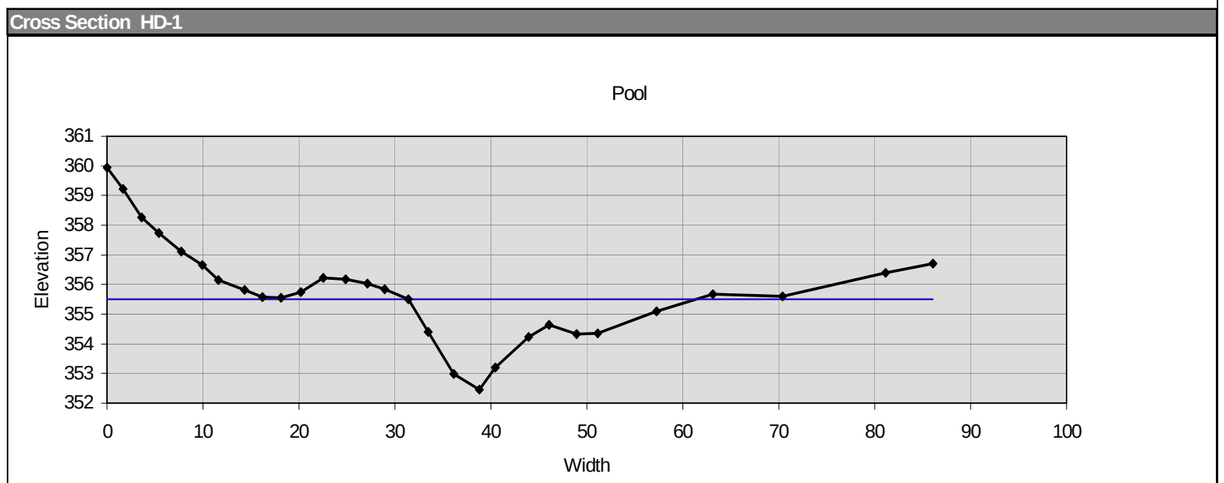
Bankfull Flow	
---	velocity (ft/s)
---	discharge rate (cfs)
---	Froude number

Flow Resistance	
---	Manning's roughness
---	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
22	channel slope (%)
28.27	shear stress (lb/sq.ft.)
3.82	shear velocity (ft/s)
---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

HD-XS1



Bankfull Dimensions	
37.3	x-section area (ft.sq.)
30.0	width (ft)
1.2	mean depth (ft)
3.0	max depth (ft)
31.2	wetted parimeter (ft)
1.2	hyd radi (ft)
24.2	width-depth ratio

Flood Dimensions	
100.0	W flood prone area (ft)
3.3	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
---	threshold grain size (mm):

Bankfull Flow	
---	velocity (ft/s)
---	discharge rate (cfs)
---	Froude number

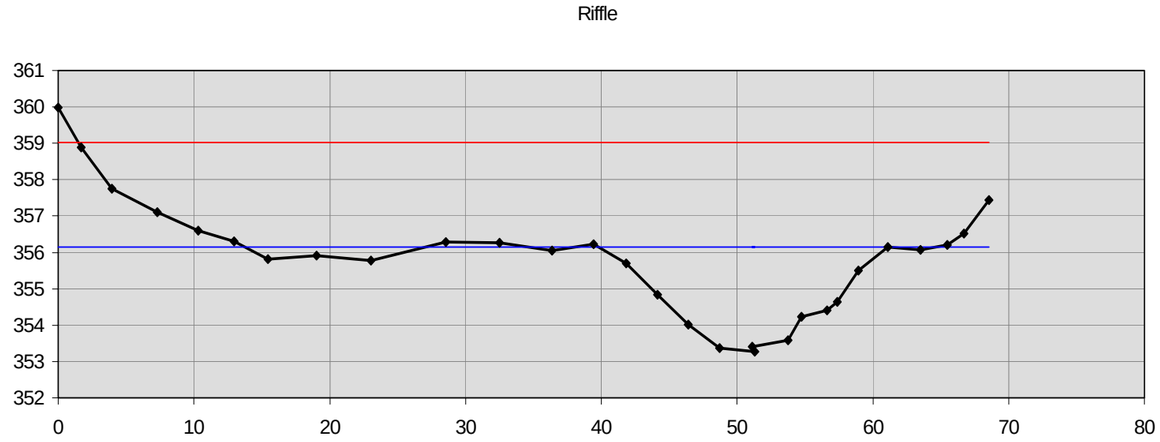
Flow Resistance	
---	Manning's roughness
---	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
---	channel slope (%)
---	shear stress (lb/sq.ft.)
---	shear velocity (ft/s)
---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

HD-XS2

Cross Section HD-2



Bankfull Dimensions	
38.8	x-section area (ft.sq.)
41.9	width (ft)
0.9	mean depth (ft)
2.9	max depth (ft)
43.3	wetted parimeter (ft)
0.9	hyd radi (ft)
45.1	width-depth ratio

Flood Dimensions	
100.0	W flood prone area (ft)
2.4	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
---	threshold grain size (mm):

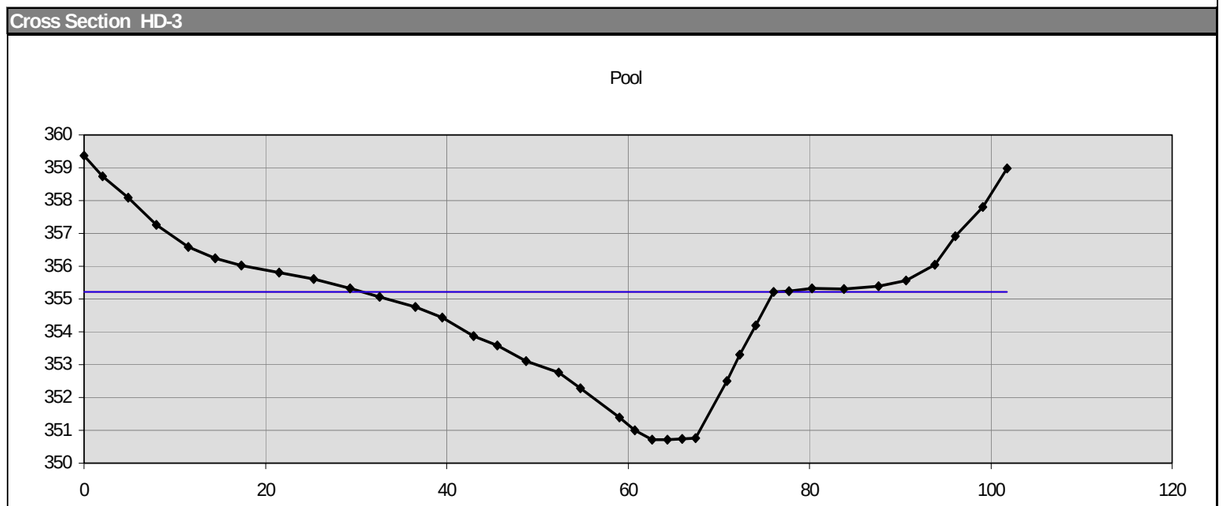
Bankfull Flow	
---	velocity (ft/s)
---	discharge rate (cfs)
---	Froude number

Flow Resistance	
---	Manning's roughness
---	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
---	channel slope (%)
---	shear stress (lb/sq.ft.)
---	shear velocity (ft/s)
---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

HD-XS3



Bankfull Dimensions	
101.5	x-section area (ft.sq.)
45.2	width (ft)
2.2	mean depth (ft)
4.5	max depth (ft)
46.6	wetted parimeter (ft)
2.2	hyd radi (ft)
20.1	width-depth ratio

Flood Dimensions	
100.0	W flood prone area (ft)
2.2	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
---	threshold grain size (mm):

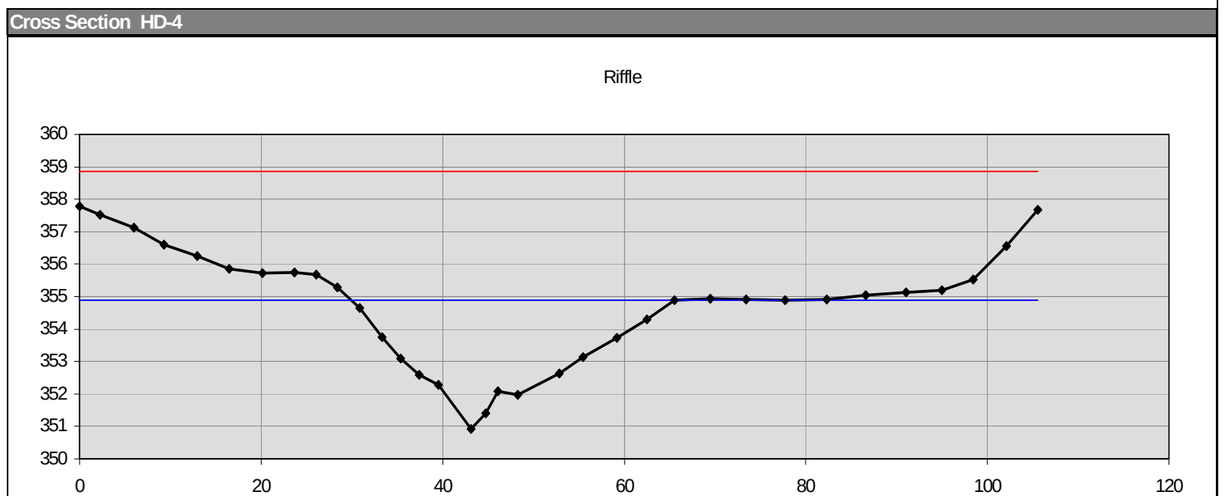
Bankfull Flow	
---	velocity (ft/s)
---	discharge rate (cfs)
---	Froude number

Flow Resistance	
---	Manning's roughness
---	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
---	channel slope (%)
---	shear stress (lb/sq.ft.)
---	shear velocity (ft/s)
---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

HD-XS4

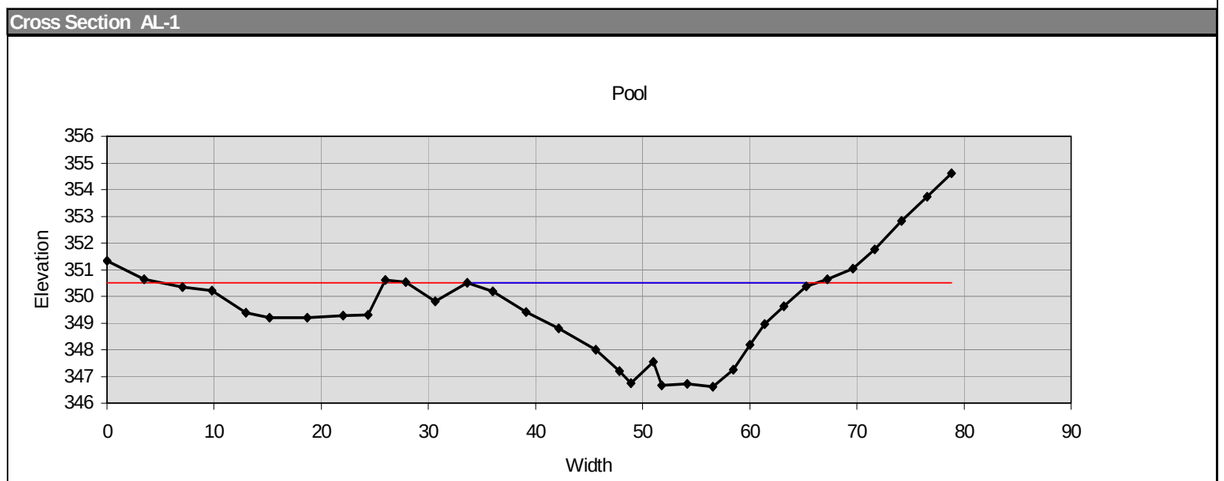


Bankfull Dimensions		Flood Dimensions		Materials	
69.2	x-section area (ft.sq.)	105.0	W flood prone area (ft)	---	D50 (mm)
39.3	width (ft)	2.7	entrenchment ratio	---	D84 (mm)
1.8	mean depth (ft)	---	low bank height (ft)	---	threshold grain size (mm):
4.0	max depth (ft)	---	low bank height ratio		
40.4	wetted parimeter (ft)				
1.7	hyd radi (ft)				
22.3	width-depth ratio				

Bankfull Flow		Flow Resistance		Forces & Power	
---	velocity (ft/s)	---	Manning's roughness	---	channel slope (%)
---	discharge rate (cfs)	---	D'Arcy-Weisbach fric.	---	shear stress (lb/sq.ft.)
---	Froude number	---	resistance factor u/u*	---	shear velocity (ft/s)
		---	relative roughness	---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

AL-XS1



Bankfull Dimensions	
69.1	x-section area (ft.sq.)
31.7	width (ft)
2.2	mean depth (ft)
3.9	max depth (ft)
33.5	wetted parimeter (ft)
2.1	hyd radi (ft)
14.5	width-depth ratio

Flood Dimensions	
100.0	W flood prone area (ft)
3.2	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
---	threshold grain size (mm):

Bankfull Flow	
---	velocity (ft/s)
---	discharge rate (cfs)
---	Froude number

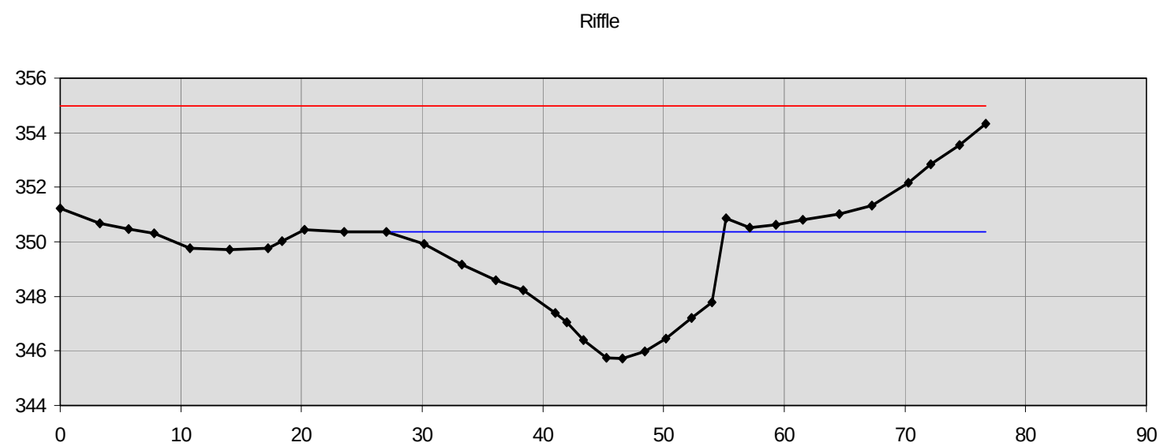
Flow Resistance	
---	Manning's roughness
---	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
---	channel slope (%)
---	shear stress (lb/sq.ft.)
---	shear velocity (ft/s)
---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

AL-XS2

Cross Section AL-2

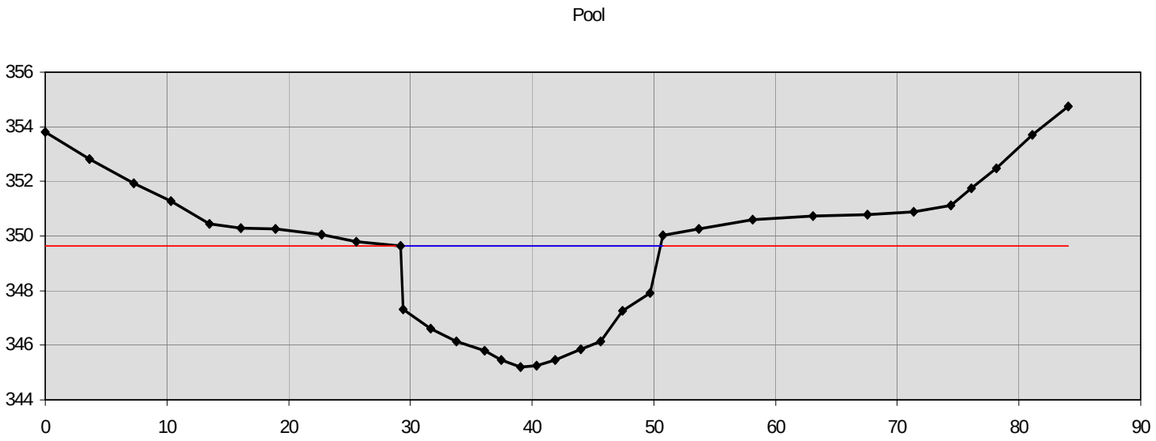


Bankfull Dimensions		Flood Dimensions		Materials	
70.1	x-section area (ft.sq.)	100.0	W flood prone area (ft)	---	D50 (mm)
28.0	width (ft)	3.6	entrenchment ratio	---	D84 (mm)
2.5	mean depth (ft)	---	low bank height (ft)	---	threshold grain size (mm):
4.6	max depth (ft)	---	low bank height ratio		
30.7	wetted parimeter (ft)				
2.3	hyd radi (ft)				
11.2	width-depth ratio				

Bankfull Flow		Flow Resistance		Forces & Power	
---	velocity (ft/s)	---	Manning's roughness	---	channel slope (%)
---	discharge rate (cfs)	---	D'Arcy-Weisbach fric.	---	shear stress (lb/sq.ft.)
---	Froude number	---	resistance factor u/u*	---	shear velocity (ft/s)
		---	relative roughness	---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

AL-XS3



Bankfull Dimensions	
71.4	x-section area (ft.sq.)
21.3	width (ft)
3.3	mean depth (ft)
4.4	max depth (ft)
25.3	wetted parimeter (ft)
2.8	hyd radi (ft)
6.4	width-depth ratio

Flood Dimensions	
100.0	W flood prone area (ft)
4.7	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
---	threshold grain size (mm):

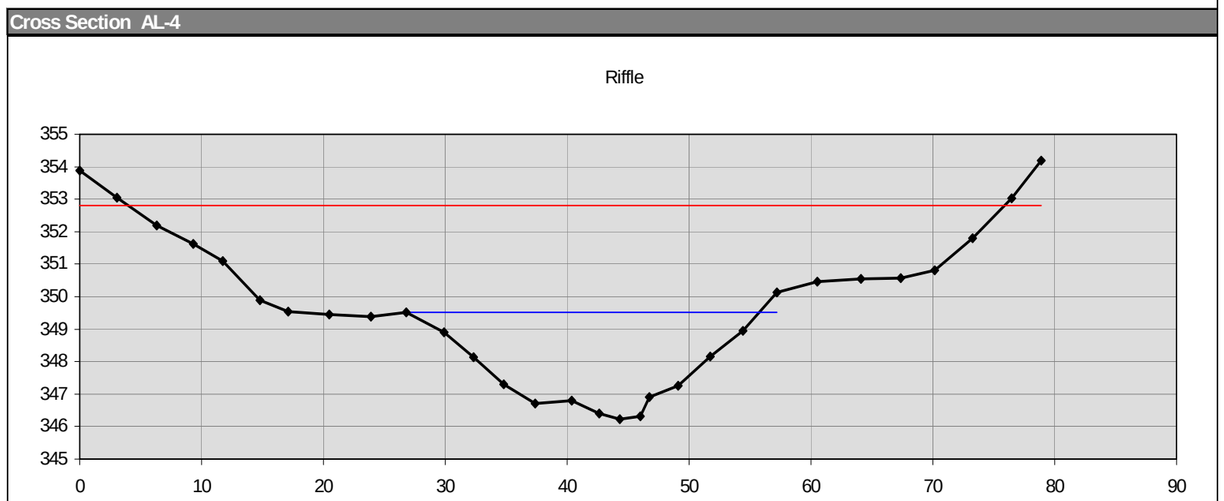
Bankfull Flow	
---	velocity (ft/s)
---	discharge rate (cfs)
---	Froude number

Flow Resistance	
---	Manning's roughness
---	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
---	channel slope (%)
---	shear stress (lb/sq.ft.)
---	shear velocity (ft/s)
---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

AL-XS4



Bankfull Dimensions	
55.7	x-section area (ft.sq.)
28.9	width (ft)
1.9	mean depth (ft)
3.3	max depth (ft)
30.0	wetted parimeter (ft)
1.9	hyd radi (ft)
15.0	width-depth ratio

Flood Dimensions	
71.9	W flood prone area (ft)
2.5	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Materials	
---	D50 (mm)
---	D84 (mm)
---	threshold grain size (mm):

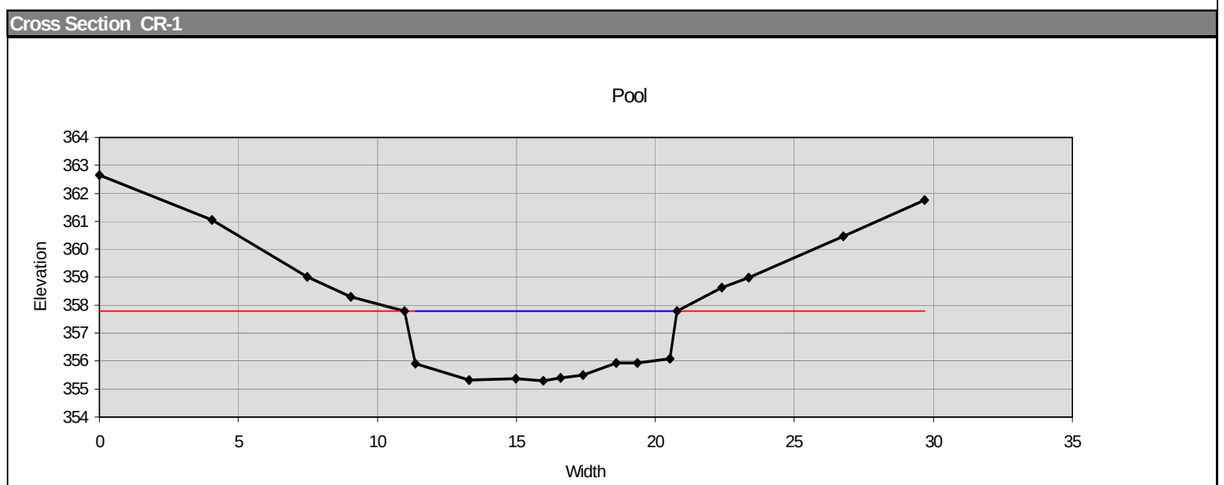
Bankfull Flow	
---	velocity (ft/s)
---	discharge rate (cfs)
---	Froude number

Flow Resistance	
---	Manning's roughness
---	D'Arcy-Weisbach fric.
---	resistance factor u/u*
---	relative roughness

Forces & Power	
---	channel slope (%)
---	shear stress (lb/sq.ft.)
---	shear velocity (ft/s)
---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

CR-XS1

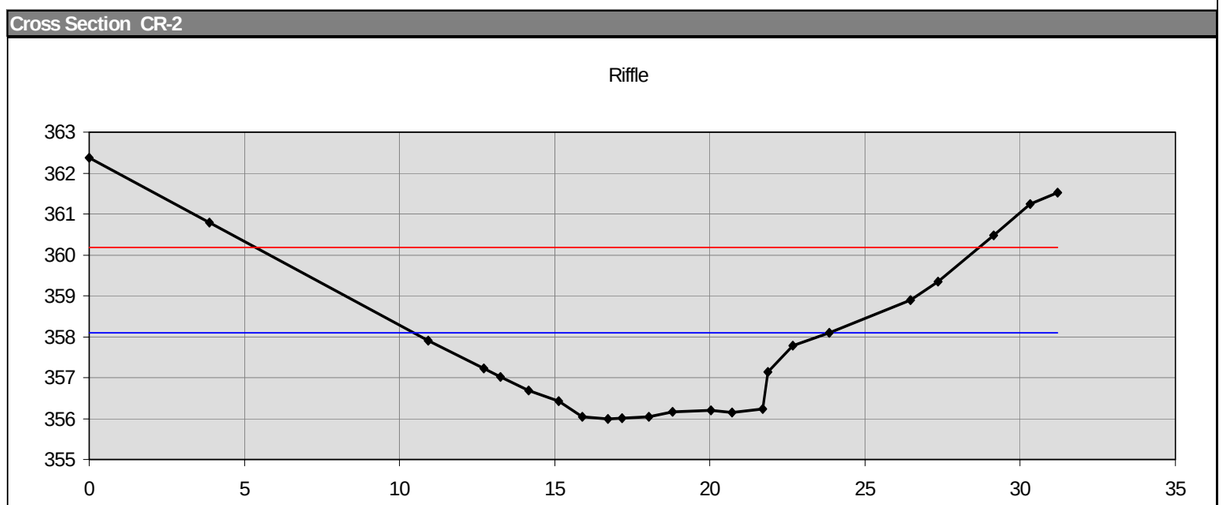


Bankfull Dimensions		Flood Dimensions		Materials	
20.4	x-section area (ft.sq.)	9.8	W flood prone area (ft)	---	D50 (mm)
9.4	width (ft)	1.0	entrenchment ratio	---	D84 (mm)
2.2	mean depth (ft)	---	low bank height (ft)	---	threshold grain size (mm):
2.5	max depth (ft)	---	low bank height ratio		
11.1	wetted parimeter (ft)				
1.8	hyd radi (ft)				
4.4	width-depth ratio				

Bankfull Flow		Flow Resistance		Forces & Power	
---	velocity (ft/s)	---	Manning's roughness	---	channel slope (%)
---	discharge rate (cfs)	---	D'Arcy-Weisbach fric.	---	shear stress (lb/sq.ft.)
---	Froude number	---	resistance factor u/u*	---	shear velocity (ft/s)
		---	relative roughness	---	unit strm power (lb/ft/s)

Stream Permanent Cross Section

CR-XS2



Bankfull Dimensions		Flood Dimensions		Materials	
17.9	x-section area (ft.sq.)	23.3	W flood prone area (ft)	---	D50 (mm)
13.4	width (ft)	1.7	entrenchment ratio	---	D84 (mm)
1.3	mean depth (ft)	---	low bank height (ft)	---	threshold grain size (mm):
2.1	max depth (ft)	---	low bank height ratio		
14.8	wetted parimeter (ft)				
1.2	hyd radi (ft)				
10.0	width-depth ratio				

Bankfull Flow		Flow Resistance		Forces & Power	
---	velocity (ft/s)	---	Manning's roughness	---	channel slope (%)
---	discharge rate (cfs)	---	D'Arcy-Weisbach fric.	---	shear stress (lb/sq.ft.)
---	Froude number	---	resistance factor u/u*	---	shear velocity (ft/s)
		---	relative roughness	---	unit strm power (lb/ft/s)

APPENDIX B

Fixed Photo Stations

Stream Permanent Cross Section

Stream Pebble Count Data

2005 Monitoring Longitudinal Profile Raw Data

2005 Monitoring Profile

Stream Problem Photos

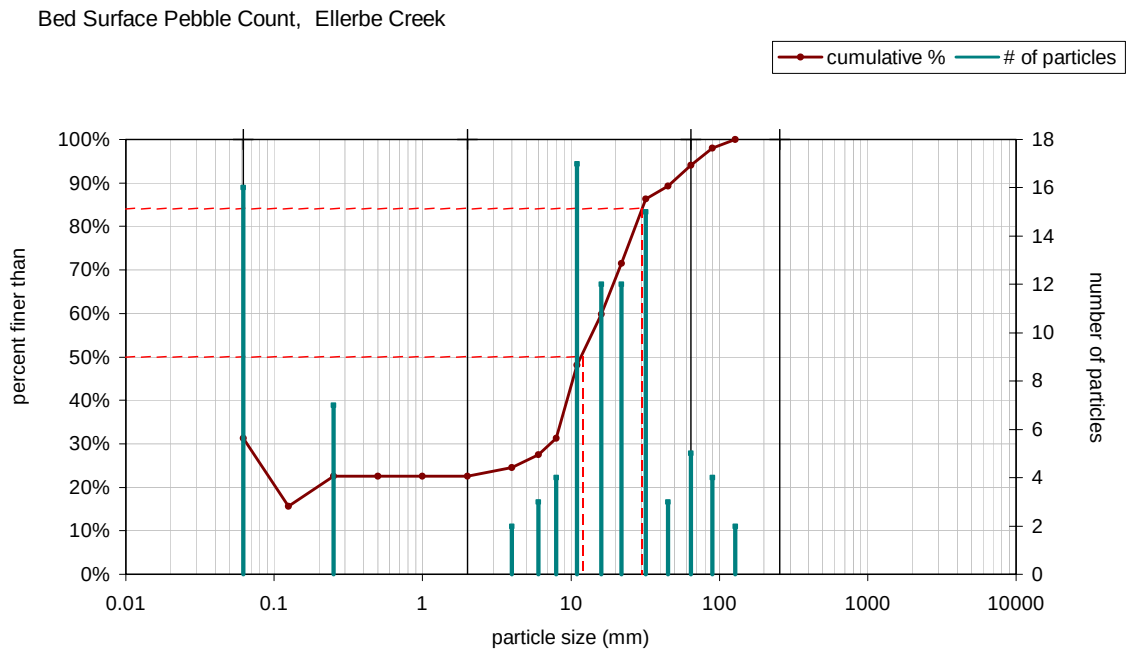
Stream Pebble Count Data

HB-XS1

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**16**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**7**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	
very coarse sand	1 - 2	
very fine gravel	2 - 4	**2**
fine gravel	4 - 6	**3**
fine gravel	6 - 8	**4**
medium gravel	8 - 11	**17**
medium gravel	11 - 16	**12**
coarse gravel	16 - 22	**12**
coarse gravel	22 - 32	**15**
very coarse gravel	32 - 45	**3**
very coarse gravel	45 - 64	**5**
small cobble	64 - 90	**4**
medium cobble	90 - 128	**2**
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		102
bedrock ----------		
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		102

Note: HB-XS1 (Wetted Perimeter)



Size (mm)	
D16	0.062
D35	8.6
D50	12
D65	18
D84	30
D95	69

Size Distribution	
mean	1.4
dispersion	98.0
skewness	-0.58

Type	
silt/clay	16%
sand	7%
gravel	72%
cobble	6%
boulder	0%

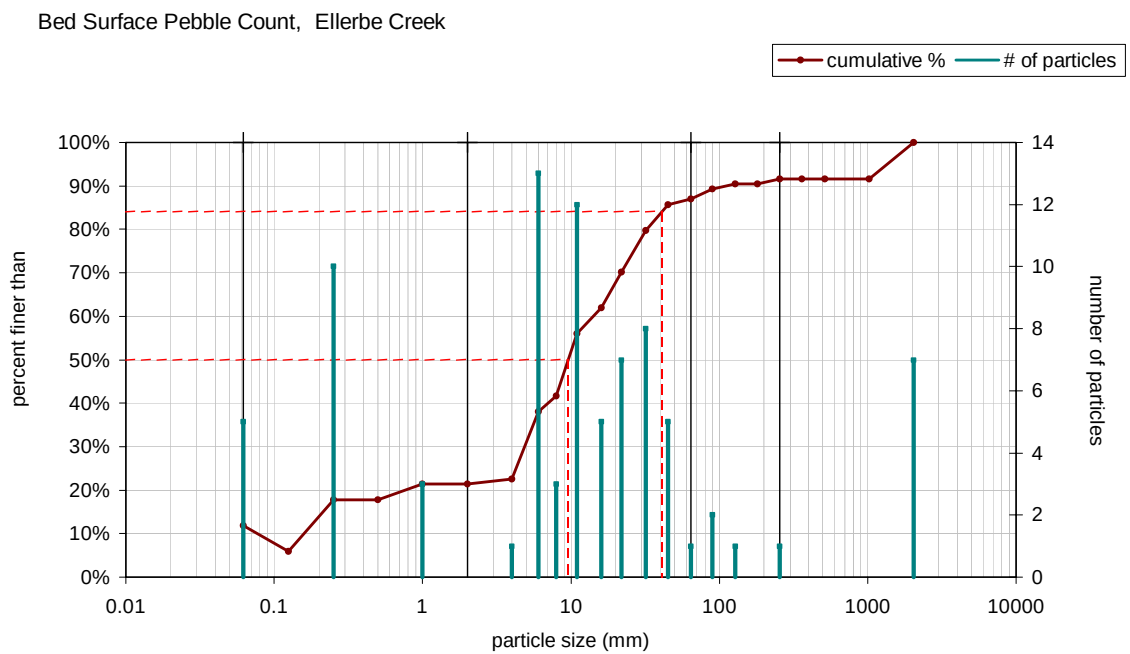
Stream Pebble Count Data

HB-XS2

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**5**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**10**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	**3**
very coarse sand	1 - 2	
very fine gravel	2 - 4	**1**
fine gravel	4 - 6	**13**
fine gravel	6 - 8	**3**
medium gravel	8 - 11	**12**
medium gravel	11 - 16	**5**
coarse gravel	16 - 22	**7**
coarse gravel	22 - 32	**8**
very coarse gravel	32 - 45	**5**
very coarse gravel	45 - 64	**1**
small cobble	64 - 90	**2**
medium cobble	90 - 128	**1**
large cobble	128 - 180	
very large cobble	180 - 256	**1**
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	**7**
very large boulder	2048 - 4096	
total particle count:		84
bedrock ----------		**20**
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		104

Note: HB-2 Pool **(Wetted Perimeter)**



Size (mm)	
D16	0.22
D35	5.5
D50	9.6
D65	18
D84	41
D95	1400

Size Distribution	
mean	3.0
dispersion	24.0
skewness	-0.33

Type			
silt/clay	5%	bedrock	19%
sand	13%		
gravel	53%		
cobble	4%		
boulder	7%		

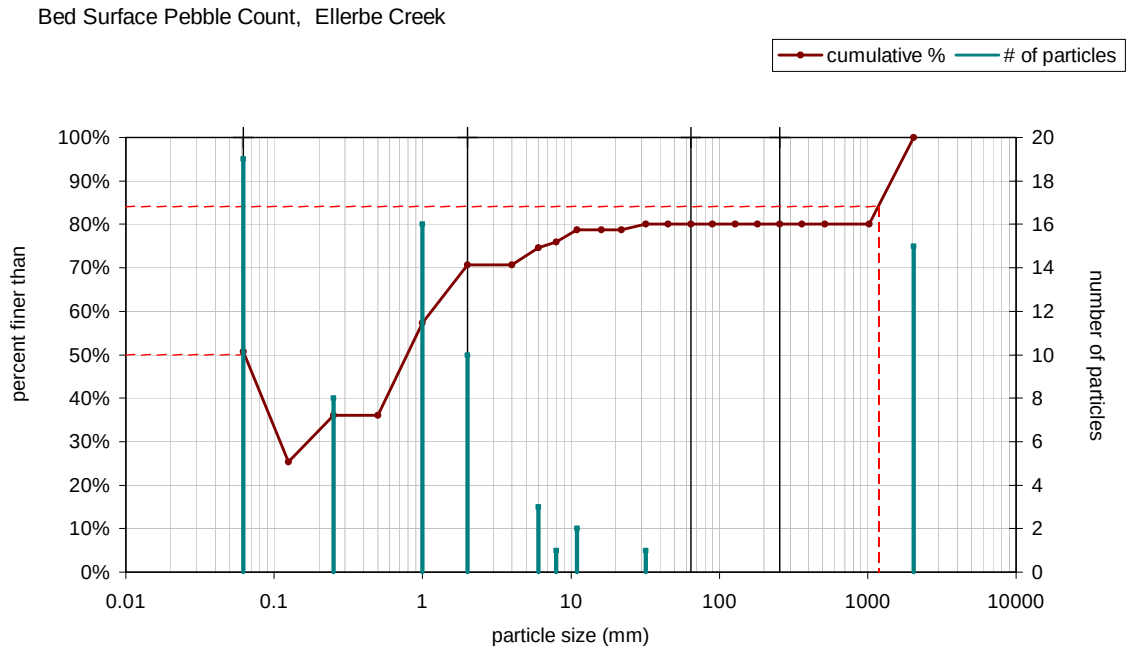
Stream Pebble Count Data

HB-XS3

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**19**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**8**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	**16**
very coarse sand	1 - 2	**10**
very fine gravel	2 - 4	
fine gravel	4 - 6	**3**
fine gravel	6 - 8	**1**
medium gravel	8 - 11	**2**
medium gravel	11 - 16	
coarse gravel	16 - 22	
coarse gravel	22 - 32	**1**
very coarse gravel	32 - 45	
very coarse gravel	45 - 64	
small cobble	64 - 90	
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	**15**
very large boulder	2048 - 4096	
total particle count:		75
bedrock ----------		**25**
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		100

Note: HB-XS3 (Wetted Perimeter)



Size (mm)	
D16	0.062
D35	0.062
D50	0.062
D65	1.5
D84	1200
D95	1700

Size Distribution	
mean	8.6
dispersion	9677.9
skewness	1.04

Type			
silt/clay	19%	bedrock	25%
sand	34%		
gravel	7%		
cobble	0%		
boulder	15%		

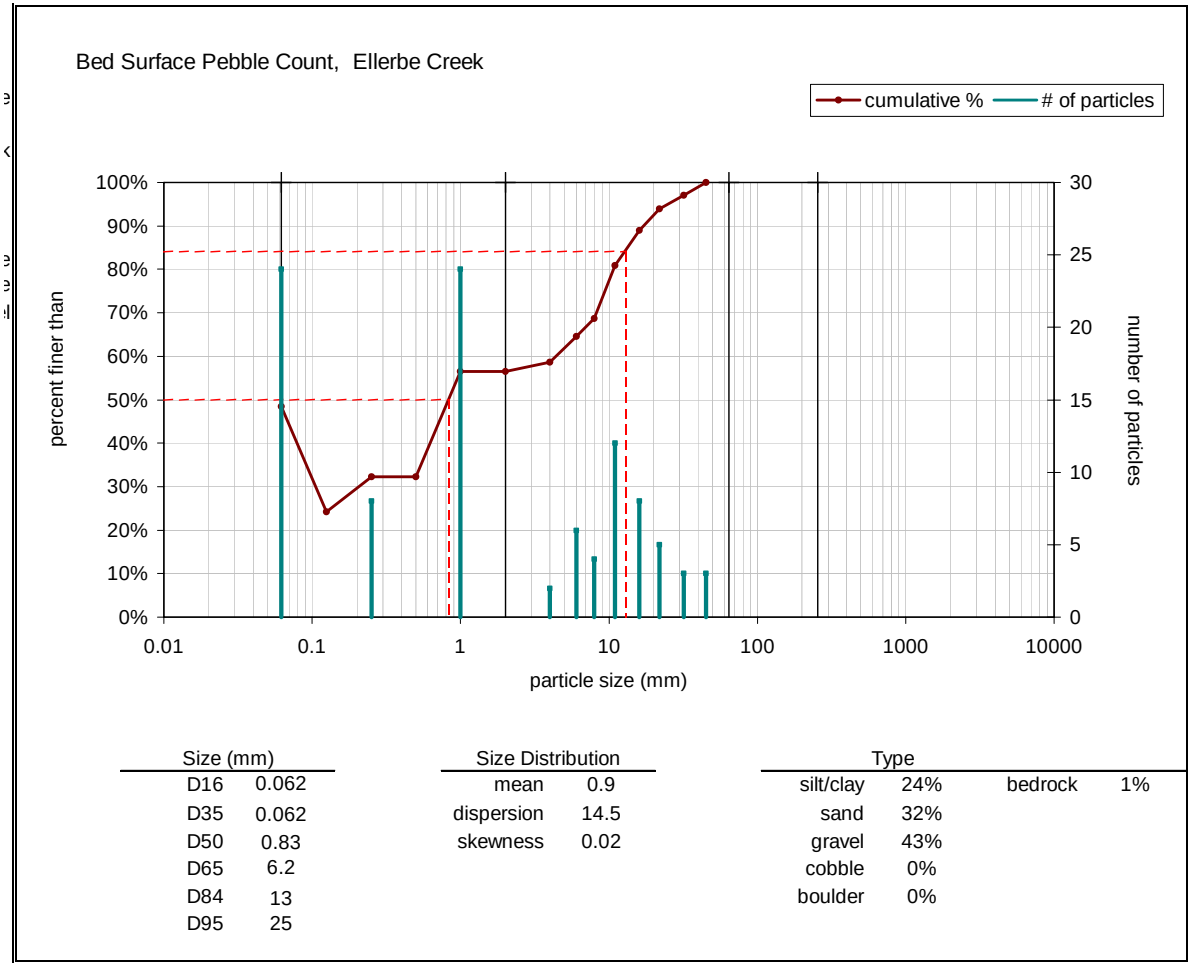
Stream Pebble Count Data

HB-XS4

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**24**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**8**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	**24**
very coarse sand	1 - 2	
very fine gravel	2 - 4	**2**
fine gravel	4 - 6	**6**
fine gravel	6 - 8	**4**
medium gravel	8 - 11	**12**
medium gravel	11 - 16	**8**
coarse gravel	16 - 22	**5**
coarse gravel	22 - 32	**3**
very coarse gravel	32 - 45	**3**
very coarse gravel	45 - 64	
small cobble	64 - 90	
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		99
bedrock ----------		**1**
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		100

Note: HB-XS4 (Wetted Perimeter)



Size (mm)	
D16	0.062
D35	0.062
D50	0.83
D65	6.2
D84	13
D95	25

Size Distribution	
mean	0.9
dispersion	14.5
skewness	0.02

Type			
silt/clay	24%	bedrock	1%
sand	32%		
gravel	43%		
cobble	0%		
boulder	0%		

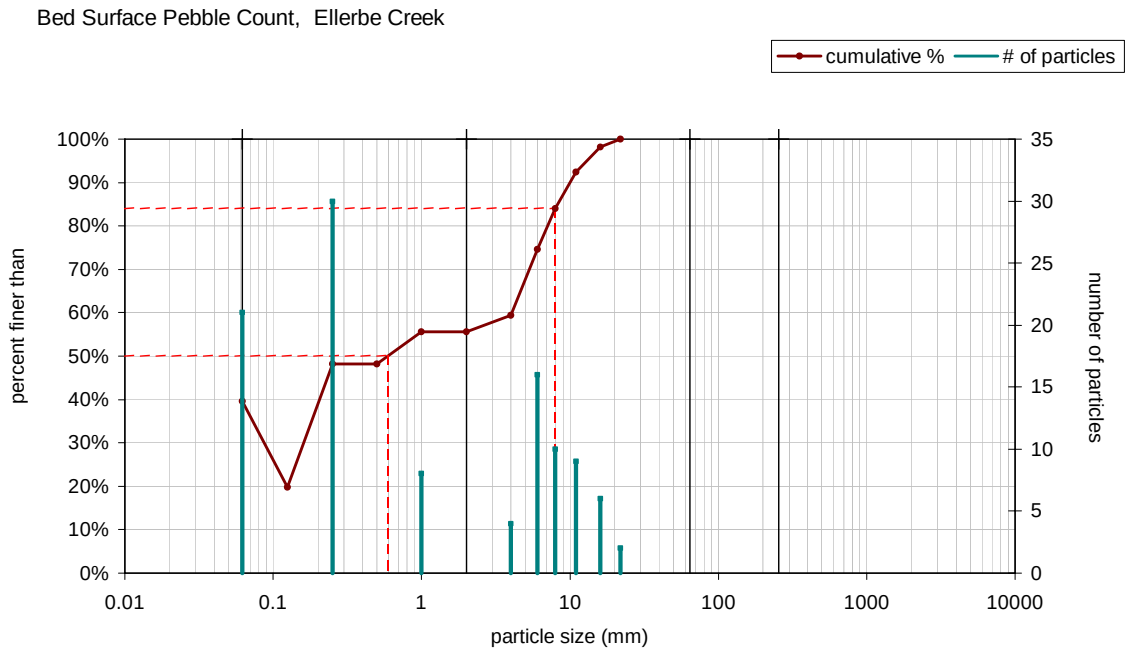
Stream Pebble Count Data

HD-XS1

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**21**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**30**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	**8**
very coarse sand	1 - 2	
very fine gravel	2 - 4	**4**
fine gravel	4 - 6	**16**
fine gravel	6 - 8	**10**
medium gravel	8 - 11	**9**
medium gravel	11 - 16	**6**
coarse gravel	16 - 22	**2**
coarse gravel	22 - 32	
very coarse gravel	32 - 45	
very coarse gravel	45 - 64	
small cobble	64 - 90	
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		106
bedrock ----------		
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		106

Note: HD-XS 1 (Wetted Perimeter)



Size (mm)	
D16	0.062
D35	0.062
D50	0.59
D65	4.6
D84	8
D95	13

Size Distribution	
mean	0.7
dispersion	11.5
skewness	0.05

Type	
silt/clay	20%
sand	36%
gravel	44%
cobble	0%
boulder	0%

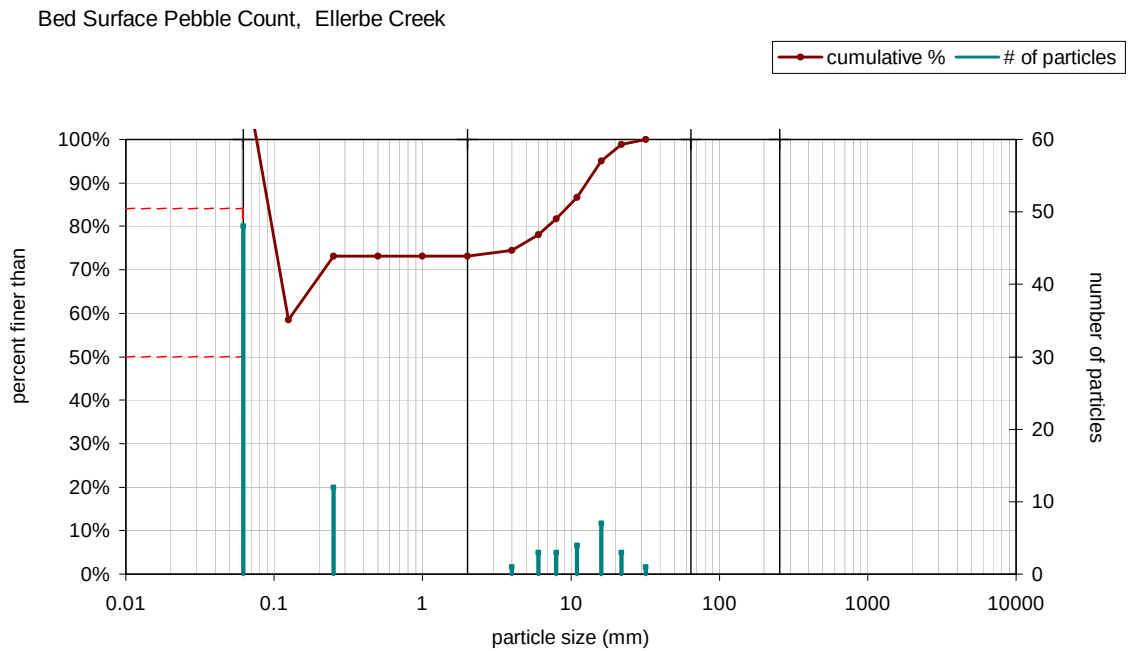
Stream Pebble Count Data

HD-XS2

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**48**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**12**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	
very coarse sand	1 - 2	
very fine gravel	2 - 4	**1**
fine gravel	4 - 6	**3**
fine gravel	6 - 8	**3**
medium gravel	8 - 11	**4**
medium gravel	11 - 16	**7**
coarse gravel	16 - 22	**3**
coarse gravel	22 - 32	**1**
very coarse gravel	32 - 45	
very coarse gravel	45 - 64	
small cobble	64 - 90	
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		82
bedrock ----------		**18**
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		100

Note: HD-XS2 (Wetted Perimeter)



Size (mm)	
D16	0.062
D35	0.062
D50	0.062
D65	0.062
D84	0.062
D95	0.062

Size Distribution	
mean	0.1
dispersion	1.0
skewness	---

Type			
silt/clay	48%	bedrock	18%
sand	12%		
gravel	22%		
cobble	0%		
boulder	0%		

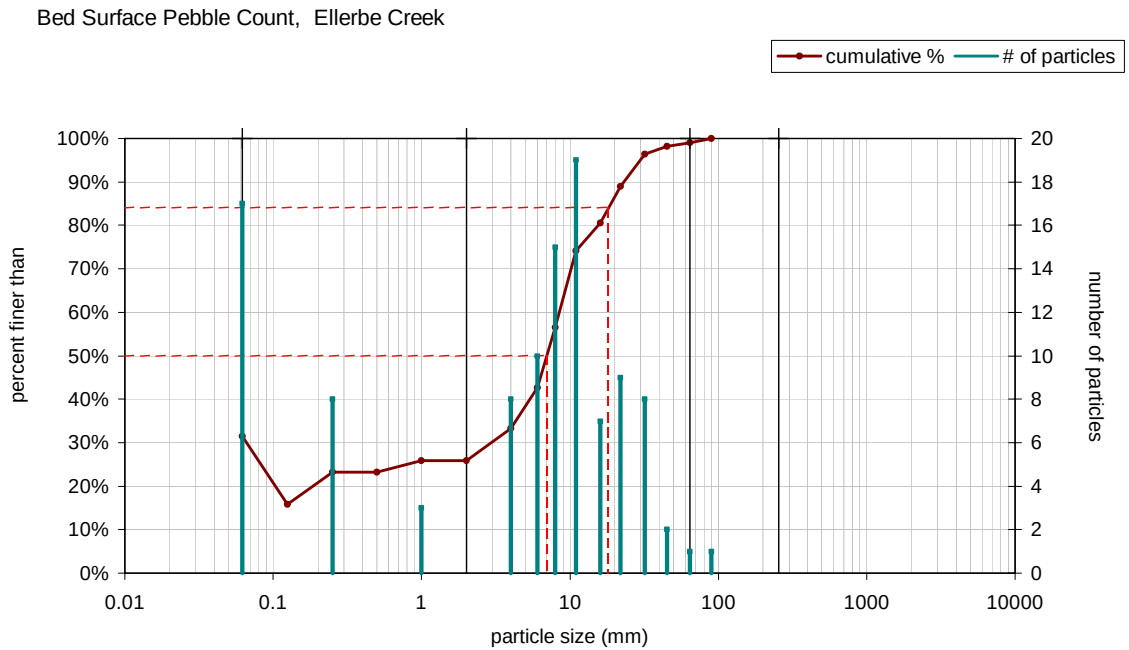
Stream Pebble Count Data

HD-XS3

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**17**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**8**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	**3**
very coarse sand	1 - 2	
very fine gravel	2 - 4	**8**
fine gravel	4 - 6	**10**
fine gravel	6 - 8	**15**
medium gravel	8 - 11	**19**
medium gravel	11 - 16	**7**
coarse gravel	16 - 22	**9**
coarse gravel	22 - 32	**8**
very coarse gravel	32 - 45	**2**
very coarse gravel	45 - 64	**1**
small cobble	64 - 90	**1**
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		108
bedrock ----------		**1**
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		109

Note: HD-XS3 (Wetted Perimeter)



Size (mm)	
D16	0.062
D35	4.3
D50	7
D65	9.3
D84	18
D95	30

Size Distribution	
mean	1.1
dispersion	57.7
skewness	-0.52

Type			
silt/clay	16%	bedrock	1%
sand	10%		
gravel	72%		
cobble	1%		
boulder	0%		

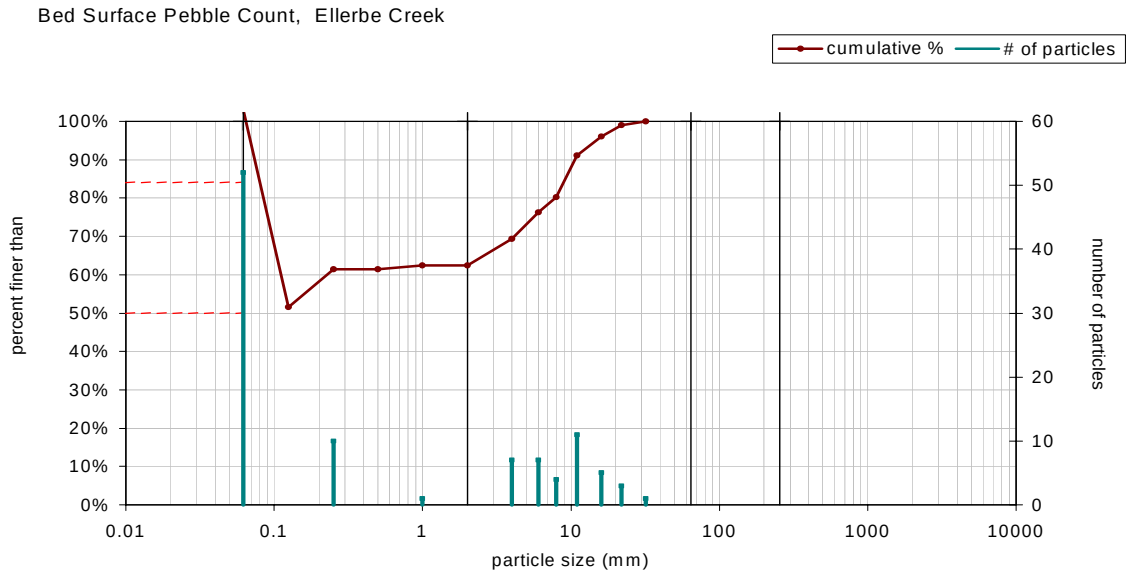
Stream Pebble Count Data

HD-XS4

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**52**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**10**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	**1**
very coarse sand	1 - 2	
very fine gravel	2 - 4	**7**
fine gravel	4 - 6	**7**
fine gravel	6 - 8	**4**
medium gravel	8 - 11	**11**
medium gravel	11 - 16	**5**
coarse gravel	16 - 22	**3**
coarse gravel	22 - 32	**1**
very coarse gravel	32 - 45	
very coarse gravel	45 - 64	
small cobble	64 - 90	
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		101
bedrock	----------	
clay hardpan	----------	
detritus/wood	----------	
artificial	----------	
total count:		101

Note: HD-XS4 (Wetted Perimeter)



Size (mm)	
D16	0.062
D35	0.062
D50	0.062
D65	0.062
D84	0.062
D95	0.062

Size Distribution	
mean	0.1
dispersion	1.0
skewness	---

Type	
silt/clay	51%
sand	11%
gravel	38%
cobble	0%
boulder	0%

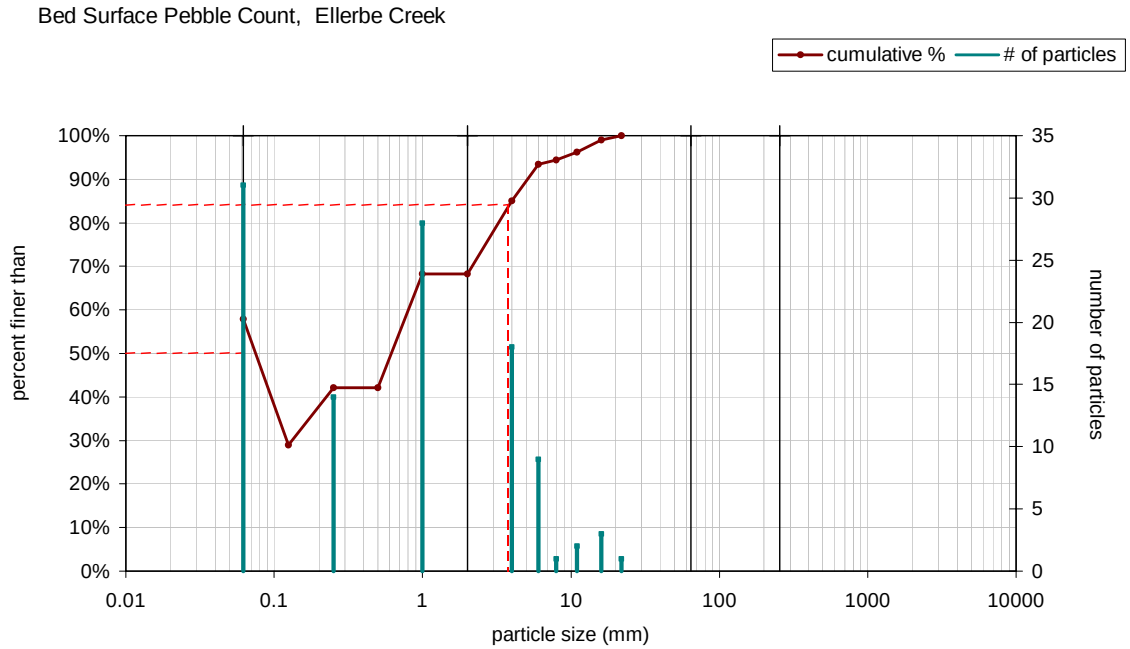
Stream Pebble Count Data

AL-XS1

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**31**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**14**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	**28**
very coarse sand	1 - 2	
very fine gravel	2 - 4	**18**
fine gravel	4 - 6	**9**
fine gravel	6 - 8	**1**
medium gravel	8 - 11	**2**
medium gravel	11 - 16	**3**
coarse gravel	16 - 22	**1**
coarse gravel	22 - 32	
very coarse gravel	32 - 45	
very coarse gravel	45 - 64	
small cobble	64 - 90	
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		107
bedrock ----------		
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		107

Note: AL-XS1 (Wetted Perimeter)



Size (mm)	
D16	0.062
D35	0.062
D50	0.062
D65	0.92
D84	3.8
D95	8.9

Size Distribution	
mean	0.5
dispersion	31.1
skewness	0.67

Type	
silt/clay	29%
sand	39%
gravel	32%
cobble	0%
boulder	0%

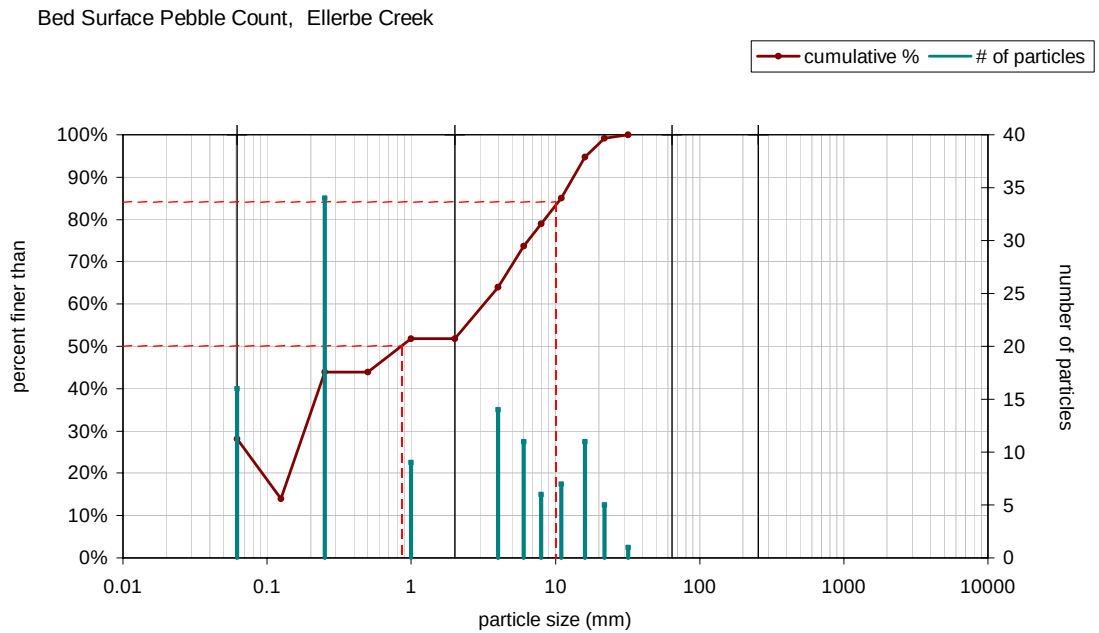
Stream Pebble Count Data

AL-XS2

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**16**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**34**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	**9**
very coarse sand	1 - 2	
very fine gravel	2 - 4	**14**
fine gravel	4 - 6	**11**
fine gravel	6 - 8	**6**
medium gravel	8 - 11	**7**
medium gravel	11 - 16	**11**
coarse gravel	16 - 22	**5**
coarse gravel	22 - 32	**1**
very coarse gravel	32 - 45	
very coarse gravel	45 - 64	
small cobble	64 - 90	
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		114
bedrock ----------		
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		114

Note: AL-XS2 (Wetted Perimeter)



Size (mm)	
D16	0.062
D35	0.2
D50	0.86
D65	4.2
D84	10
D95	16

Size Distribution	
mean	0.8
dispersion	12.7
skewness	-0.03

Type	
silt/clay	14%
sand	38%
gravel	48%
cobble	0%
boulder	0%

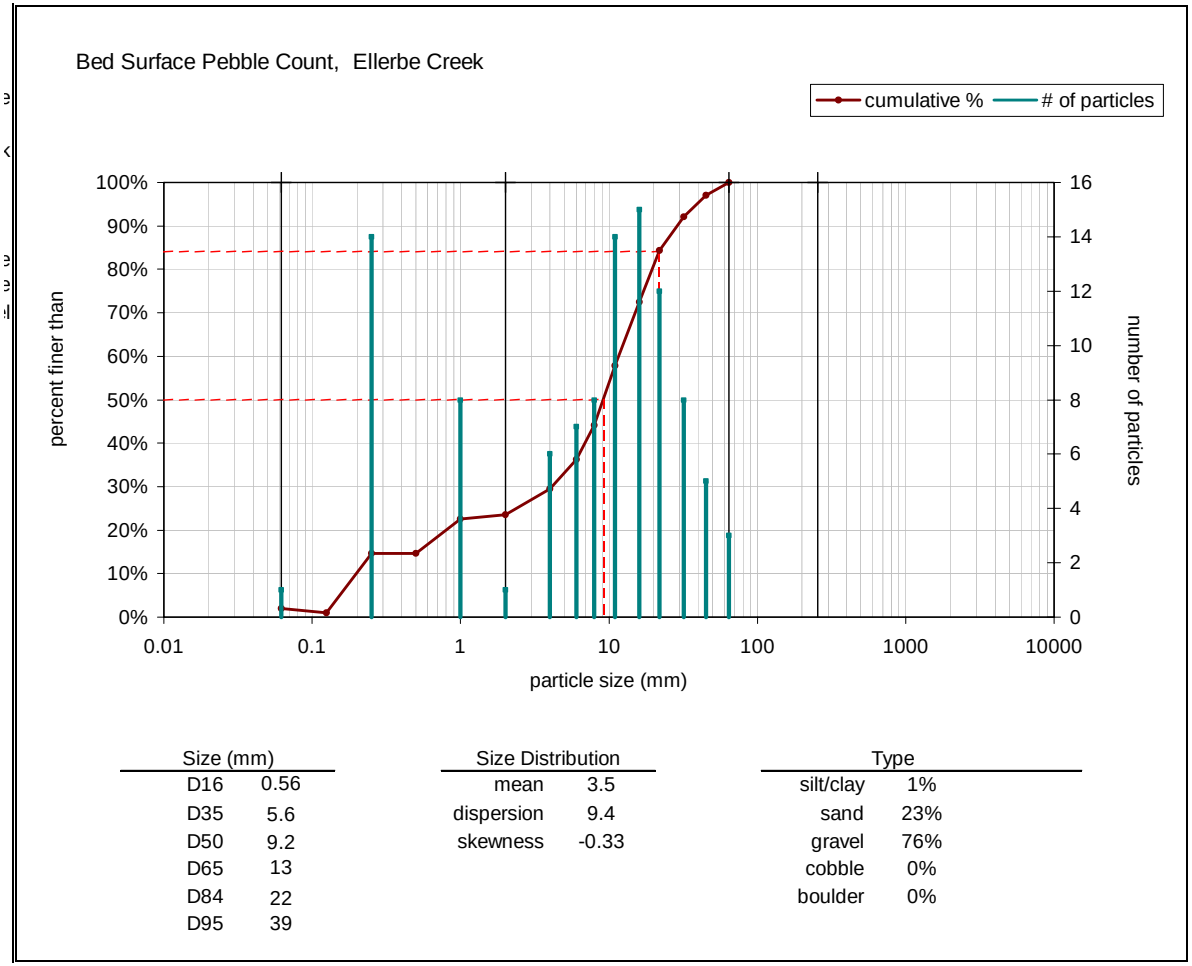
Stream Pebble Count Data

AL-XS3

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**1**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**14**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	**8**
very coarse sand	1 - 2	**1**
very fine gravel	2 - 4	**6**
fine gravel	4 - 6	**7**
fine gravel	6 - 8	**8**
medium gravel	8 - 11	**14**
medium gravel	11 - 16	**15**
coarse gravel	16 - 22	**12**
coarse gravel	22 - 32	**8**
very coarse gravel	32 - 45	**5**
very coarse gravel	45 - 64	**3**
small cobble	64 - 90	
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		102
bedrock ----------		
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		102

Note: HB-XS3 (Wetted Perimeter)



Size (mm)	
D16	0.56
D35	5.6
D50	9.2
D65	13
D84	22
D95	39

Size Distribution	
mean	3.5
dispersion	9.4
skewness	-0.33

Type	
silt/clay	1%
sand	23%
gravel	76%
cobble	0%
boulder	0%

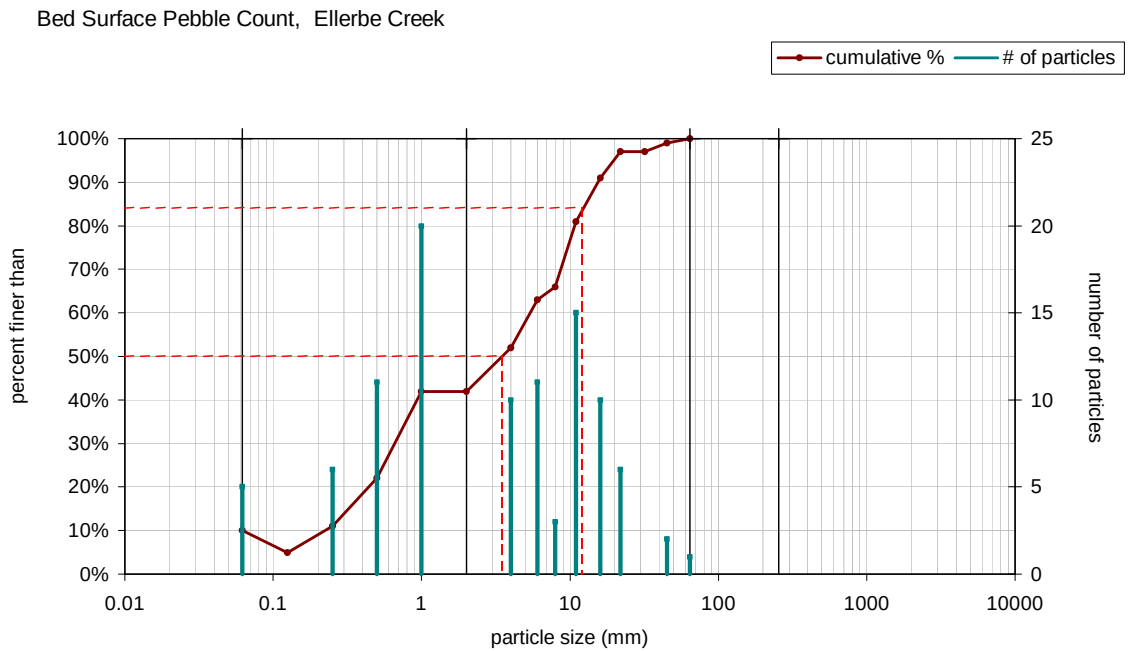
Stream Pebble Count Data

AL-XS4

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**5**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**6**
medium sand	0.25 - 0.5	**11**
coarse sand	0.5 - 1	**20**
very coarse sand	1 - 2	
very fine gravel	2 - 4	**10**
fine gravel	4 - 6	**11**
fine gravel	6 - 8	**3**
medium gravel	8 - 11	**15**
medium gravel	11 - 16	**10**
coarse gravel	16 - 22	**6**
coarse gravel	22 - 32	
very coarse gravel	32 - 45	**2**
very coarse gravel	45 - 64	**1**
small cobble	64 - 90	
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		100
bedrock ----------		**2**
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		102

Note: HB-XS4 (Wetted Perimeter)



Size (mm)	
D16	0.34
D35	0.78
D50	3.5
D65	7.3
D84	12
D95	20

Size Distribution	
mean	2.0
dispersion	6.9
skewness	-0.19

Type			
silt/clay	5%	bedrock	2%
sand	36%		
gravel	57%		
cobble	0%		
boulder	0%		

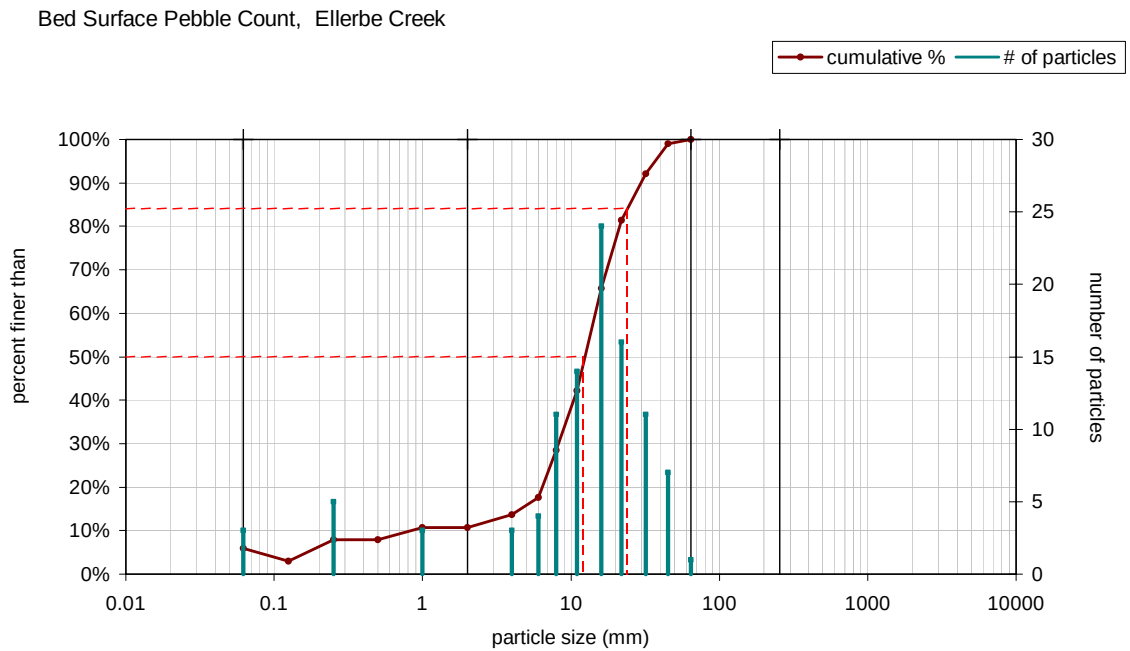
Stream Pebble Count Data

CR-XS1

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**3**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**5**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	**3**
very coarse sand	1 - 2	
very fine gravel	2 - 4	**3**
fine gravel	4 - 6	**4**
fine gravel	6 - 8	**11**
medium gravel	8 - 11	**14**
medium gravel	11 - 16	**24**
coarse gravel	16 - 22	**16**
coarse gravel	22 - 32	**11**
very coarse gravel	32 - 45	**7**
very coarse gravel	45 - 64	**1**
small cobble	64 - 90	
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		102
bedrock ----------		**5**
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		107

Note: CR-XS1 (Wetted Perimeter)



Size (mm)	
D16	5.1
D35	9.3
D50	12
D65	16
D84	24
D95	37

Size Distribution	
mean	11.1
dispersion	2.2
skewness	-0.04

Type			
silt/clay	3%	bedrock	5%
sand	7%		
gravel	85%		
cobble	0%		
boulder	0%		

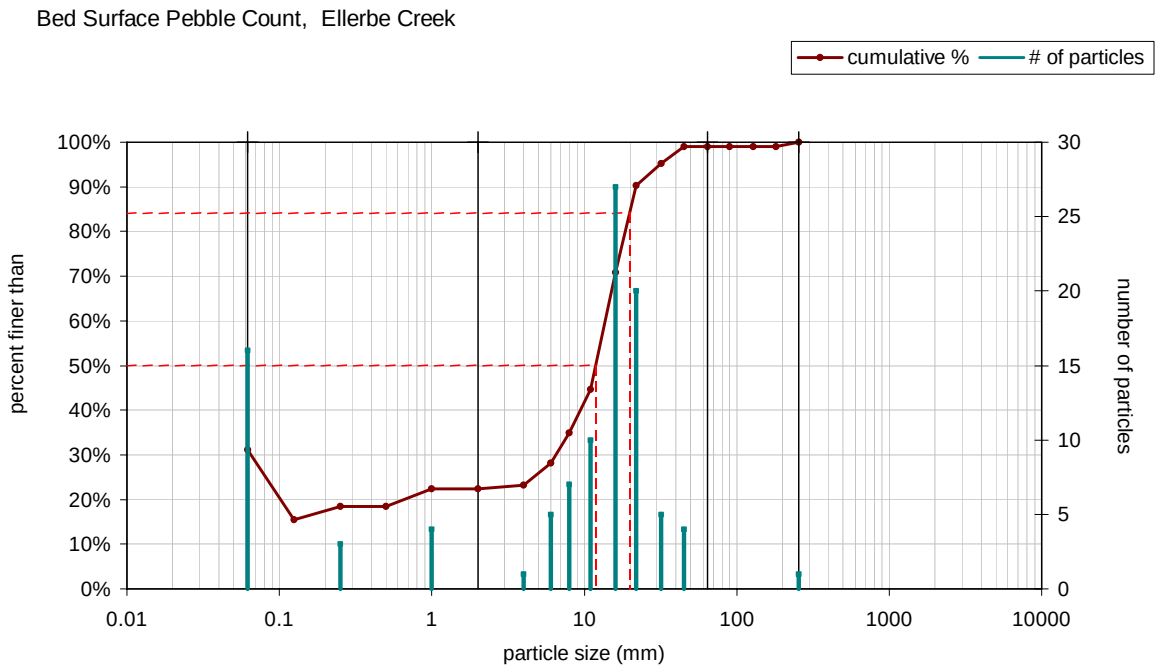
Stream Pebble Count Data

CR-XS2

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**16**
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	**3**
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	**4**
very coarse sand	1 - 2	
very fine gravel	2 - 4	**1**
fine gravel	4 - 6	**5**
fine gravel	6 - 8	**7**
medium gravel	8 - 11	**10**
medium gravel	11 - 16	**27**
coarse gravel	16 - 22	**20**
coarse gravel	22 - 32	**5**
very coarse gravel	32 - 45	**4**
very coarse gravel	45 - 64	
small cobble	64 - 90	
medium cobble	90 - 128	
large cobble	128 - 180	
very large cobble	180 - 256	**1**
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		103
bedrock ----------		**1**
clay hardpan ----------		
detritus/wood ----------		
artificial ----------		
total count:		104

Note: CR-XS2 (Wetted Perimeter)



Size (mm)	
D16	0.062
D35	8
D50	12
D65	15
D84	20
D95	32

Size Distribution	
mean	1.1
dispersion	97.6
skewness	-0.65

Type			
silt/clay	15%	bedrock	1%
sand	7%		
gravel	76%		
cobble	1%		
boulder	0%		

APPENDIX B

Fixed Photo Stations

Stream Permanent Cross Section

Stream Pebble Count Data

2005 Monitoring Longitudinal Profile Raw Data

2005 Monitoring Profile

Stream Problem Photos

2005 Monitoring Longitudinal Profile Raw Data

	STA	TWG	WS	LB	RB
BRIFF	1045.94	361.24	361.5	362.34	362.48
CPOOL	1058.63	359.8	361.46		
TRIFF	1062.23	361.2			
MRIFF	1083.24	361.26			
BRIFF	1129.84	359.94	360	360.86	361.05
CPOOL	1141.61	358.47	359.64		
HEAD	1149.98	359.6			
CPOOL	1169.15	357.04	359.21		
TRIFF	1200.89	359.2		361.32	361.24
TRIFF	1200.94	358.89			
XS	1219	358.74			
BRIFF	1223.61	358.56	358.96	361.11	361.06
CPOOL	1229.7	358.36			
HEADER	1235.22	358.74			
XS	1246.43	356.55			
CPOOL	1250.62	356.44	358.72		
TRIFF	1272.72	358.34	358.79	361.23	361.22
BRIFF	1289.88	358.29	358.8	361.01	360.71
CPOOL	1296.25	357.57	358.77		
TRIFF	1299.64	358.61	358.7		
BRIFF	1305.23	357.89		359.04	
CPOOL	1310.11	357.31	358.3		
HEADER	1347.98	358.36			
CPOOL	1357.35	356.75	358.17		
TRIFF	1391.01	357.93	358.16		
BRIFF	1403.43	357.27	357.87		
CPOOL	1417.34	356.01			
TRIFF	1449.25	356.92	357.92		
BRIFF	1457.51	357.07	357.88		
CPOOL	1468.41	356.5	357.88		
TRIFF	1498.14	357.1	357.81	359.11	358.71
CPOOL	1507.55	356.44	357.8		
CPOOL	1539.34	356.48	357.88		
TRIFF	1565.14	357.14	357.89	359.1	359.45
BRIFF	1599.4	357.09	357.96	359.16	359.27
BRIFF	1616.76	356.88			
CPOOL	1638.16	355.92	357.88	359.28	358.66
TRIFF	1667.2	357.28	357.88	358.76	358.68
BRIFF	1705.97	356.92	357.85	358.79	358.71
CPOOL	1720.28	357			
HEADER	1727.98	357.79			
CPOOL	1762.18	356.03	357.25		
HEADER	1786.17	357			
CPOOL	1791.45	355.39	356.84	357.84	357.98
HEADER	1826.65	356.2			
CPOOL	1835.47	356.17	356.74		
RIFF	1846.41	356.1			
CPOOL	1860.62	355.3	356.7		

	STA	TWG	WS	LB	RB
TRIFF	1905.43	356.12	356.67	359.51	359.61
BRIFF	1974.38	356.23	356.54	359.1	
CPOOL	1991.08	355.93	356.58		
TRIFF	2030.06	356.2	356.53	359.29	359.39
BRIFF	2049.25	355.84	356.25	359.16	
CPOOL	2059.86	355.49	356.28		
TRIFF	2076.46	356.03	356.24	359.08	359.49
XS	2132.65	356.37			
BRIFF	2147.39	356	356.24	358.52	358.6
XS	2179.93	354.6	356.16	358.47	358.61
TRIFF	2209.41	355.75			
BRIFF	2260.92	355.76	355.87	358.52	
CPOOL	2276.26	352.23	355.67		
TRIFF	2289.62	355.56	355.69		
BRIFF HEA	2348.51	355.36			
CPOOL	2357.68	353.25			
TRIFF	2380.66	354.99	355.48	358.16	357.4
BRIFF	2434.82	354.92	355.39	357.2	356.32
CPOOL	2472.42	353.84	355.55		
TRIFF	2559.82	355.13	355.56		
RIFF	2687.8	355.47	355.64		
RIFF DSBF	2736.7	355.29			
RIFF	2737.54	354.26			
BRIFF	2739.74	354			
CPOOL	2756.64	353.04	354.16		
TRIFF	2786.57	353.79	354.2	356.68	356.39
BRIFF	2788.77	353.95	354.19		
CPOOL	2800.26	352.22	354.2		
TRIFF	2831.03	353.86	354.22		
BRIFF	2853.91	353.65	353.85	355.62	355.64
CPOOL	2861.64	352.22	353.56		
CPOOL HL	2879.46	352.32			
XS	2879.59	352.46			
HEADER	2893.7	352.64			
CPOOL	2903.82	351.04	353.53		
XS	2933.11	353.28	353.49	355.49	356.18
TRIFF	2934.13	353.04			
HEADER	2964.7	353.29			
CPOOL	2984.34	351.15	353.22		
TRIFF	2997.55	352.91	353.28		
MRIFF	3013.82	352.66	352.91		
HEADER	3035.07	352.67			
CPOOL	3050.65	350.73	352.89		
TRIFF	3076.24	352.64	352.88	355.92	355.02
HEADER	3085.13	352.68			
CPOOL	3110.81	351.72	352.78		
HEADER	3154.81	352.74			
CPOOL	3161	351.17	352.78	355.99	355.24
TRIFF	3189.24	352.03	352.85		
BRIFF	3227.77	352.56	353.08		

	STA	TWG	WS	LB	RB
WS	3232.01	352.38	352.38		
CPOOL	3232.33	351.6			
TRIFF	3246.92	352.29	352.41	355.22	354.87
BRIFF	3295.68	352.13	352.33	355.18	353.84
CPOOL	3316.66	351.3	352.27		
HEADER	3347.39	352.01			
CPOOL	3365.81	350.54	351.97		
TRIFF	3417.43	351.97	352.21	355.1	356.23
BRIFF	3449.48	351.51	351.9	353.45	355.22
CPOOL	3478.04	350.14			
XS	3489.11	350.72			
TRIFF	3519.48	351.57	351.94	354.65	354.55
XS	3527.77	350.93			
HEADER	3568.27	351.36			
CPOOL	3581.08	350.15	351.87		
TRIFF	3610.57	351.35	351.88	354.04	354.82
HEADER	3645.49	351.43			
CPOOL	3672.24	349.69	351.74		
TRIFF	3696.51	351.75	351.91	354.95	
HEADER	3725.82	351.04			
CPOOL	3748.71	348.81	351.68		
TRIFF	3785.96	351.37	351.51	353.91	353.84
BRIFF	3793.53	351.32			
CPOOL	3817.2	349.92	351.39		
MGLIDE	3857.61	350.46			
HEADER	3883.06	350.24			
CPOOL	3900.88	349.84	351.31	352.44	353.86
HEADER	3937.67	351.17			
CPOOL	3957.28	348.12	351.22		
HEADER	3985.61	350.33			
CPOOL	4003.12	349.52	351.01	353.78	354.35
TRIFF	4051.34	350.47	351.16	354.04	354.18
CPOOL	4098.06	349.95	351.28	352.76	353.64
CPOOL	4126.6	350.14	351.29		
TRIFF	4190.98	351.05	351.18		
BRIFF	4289.33	350.5	350.8	353.99	353.95

APPENDIX B

Fixed Photo Stations

Stream Permanent Cross Section

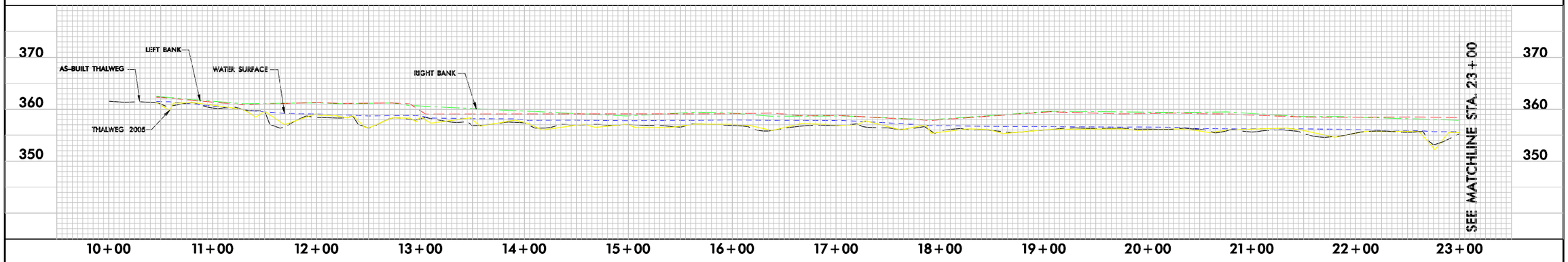
Stream Pebble Count Data

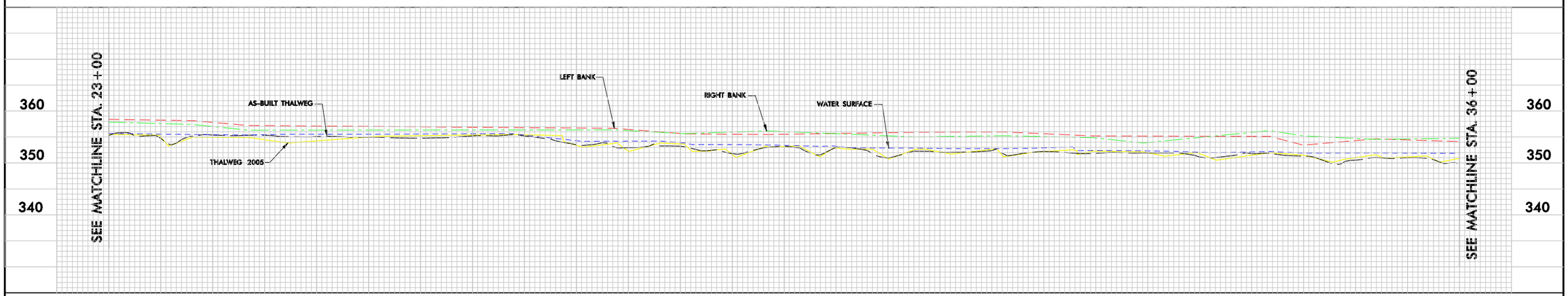
2005 Monitoring Longitudinal Profile Raw Data

2005 Monitoring Profile

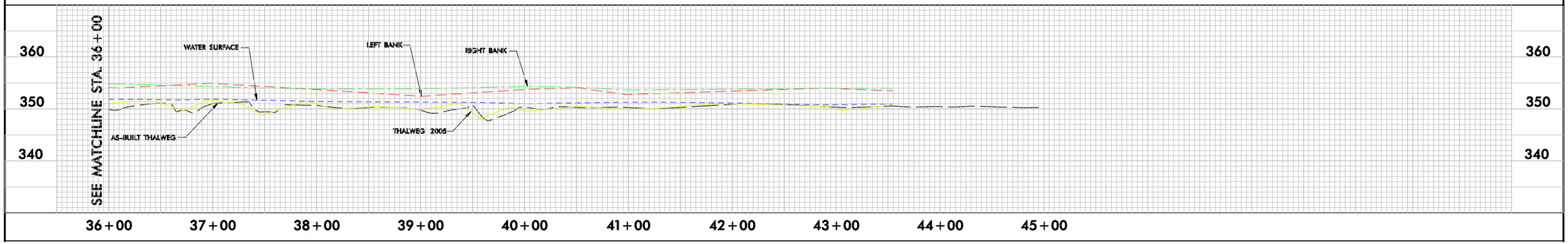
Stream Problem Photos

2005 MONITORING PROFILE





2005 MONITORING PROFILE



APPENDIX B

Fixed Photo Stations

Stream Permanent Cross Section

Stream Pebble Count Data

2005 Monitoring Longitudinal Profile Raw Data

2005 Monitoring Profile

Stream Problem Photos

Stream Problem Photos

SP1 – Rock in channel

SP2 – Coir fiber matting.

SP3 – Weir leak.