Hillsdale Park (South Buffalo Creek) Stream Restoration
Greensboro, North Carolina
Annual Monitoring Report
Monitoring Year 2007

NCDENR EEP
1619 Mail Service Center
Raleigh, NC 27699-1619

Monitoring Year: 2007
Measurement Year 4
As-Built Date: 2004
NCEEP Project Number 177

March 2008

Submitted by:

WK Dickson and Co., Inc.
720 Corporate Center Drive
Raleigh, NC 27607
(919) 782-0495

HILLSDALE PARK (SOUTH BUFFALO CREEK) STREAM RESTORATION
2007 MONITIORING REPORT

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I. EXECUTIVE SUMMARY/PROJECT ABSTRACT

The Hillsdale Park Stream Restoration Site includes 5,302 linear feet of South Buffalo Creek and 529 linear feet of a tributary within the City of Greensboro, Guilford County, North Carolina. The site was constructed between February and March 2004. The following report provides the Year 4, 2007 Monitoring information.

Overall, the project is doing well with a few minor areas of erosion and several sections where coir fiber matting has pulled away from the bank. The unstable problem areas should be monitored and remediation options developed if they worsen. Seven exotic and/or invasive species were observed within the plots during the vegetation sampling in 2007. The majority of the site has the presence of one or more invasive or exotic species with the ability to negatively impact the site. Most of the site is heavily covered in porcelain berry and has become a serious problem. Porcelain berry is very aggressive woody perennial vine, growing over and damaging the existing vegetation, including small shrubs and trees. Porcelain berry occurs on nearly all excavated floodplain benches and is aggressively invading the surrounding buffers. It is recommended that action be taken to control and eradicate the porcelain berry at this site.

The vegetation monitoring for Hillsdale Park was based on the Carolina Vegetation Survey (CVS) Ecosystem Enhancement Program's (EEP) protocol for recording vegetation. This report summarizes the vegetation results as well as describes the protocol for vegetation monitoring.

II. PROJECT BACKGROUND

A. Project Objectives

The objectives of the restoration of South Buffalo Creek in Hillsdale Park are:

- Restore unstable stream channels to natural stable forms by modifying dimension, pattern, and/or profile based on reference reach parameters.
- Improve floodplain functionality by matching bankfull stage with floodplain elevation.
- Establish native floodplain vegetation through a forested riparian buffer.
- Improve the natural aesthetics of the stream corridor.
- Obtain mitigation credits for unavoidable impacts to streams within the same Hydrologic Unit Code (HUC).

B. Project Restoration Components

South Buffalo Creek and its unnamed tributary (HR3) are located in Hillsdale Park, a community park in the City of Greensboro. The existing stream channels had low sinuosity and varying levels of incision due to historic channelization. The alternative of creating a stable meandering stream with bankfull stage corresponding to the existing floodplain elevation was evaluated. However, topographic and development restrictions did not allow for a new channel pattern to be established. The existing incised channels were enhanced by excavating new floodplain benches at the design bankfull stage and installing structures to improve bed features and control channel grade.

The restoration project was divided into three reaches (i.e., HR1, HR2, tributary HR3), each having a different mitigation type and approach. The design for Reach 1 (HR1) was based on a Rosgen Priority 3 restoration approach along with establishment of a 25-foot vegetated buffer on

both banks. A new floodplain was created at a lower elevation by excavating a stable bankfull bench of varying width. The resulting bank height ratio was 1.0. Reach 1 was further subdivided into two reaches, HR1a and HR1b. The break between the subreaches began at the Vanstory Street culvert. Reach HR1a from station 10+00 to 23+75 was converted from an incised E4/B4c to a B4c channel as part of the restoration work. The existing channel functioned like a Gc type stream due to the high banks.

Reach 2 (HR2) flows from West Meadow View Road to the I-40 culvert. The reach was stabilized by using rock cross vanes, J-hooks, and root wads for bank stability. Woody transplants and sod mats were also used for stabilize the streambanks along the channel. Reach HR2 from station 52+00 to 62+12 was converted from a B4c/E4/F4 to a B4c. A 25-foot vegetated buffer was added to the left bank of Reach 2.

Reach 3 (HR3) was an unnamed tributary to South Buffalo Creek, flowing into the creek at the end of Reach 2 just prior to the I-40 culvert. There were no changes in dimension, pattern, or profile for this reach. However, three rock cross vanes were used to stabilize the channel upstream of its confluence with Reach HR2.

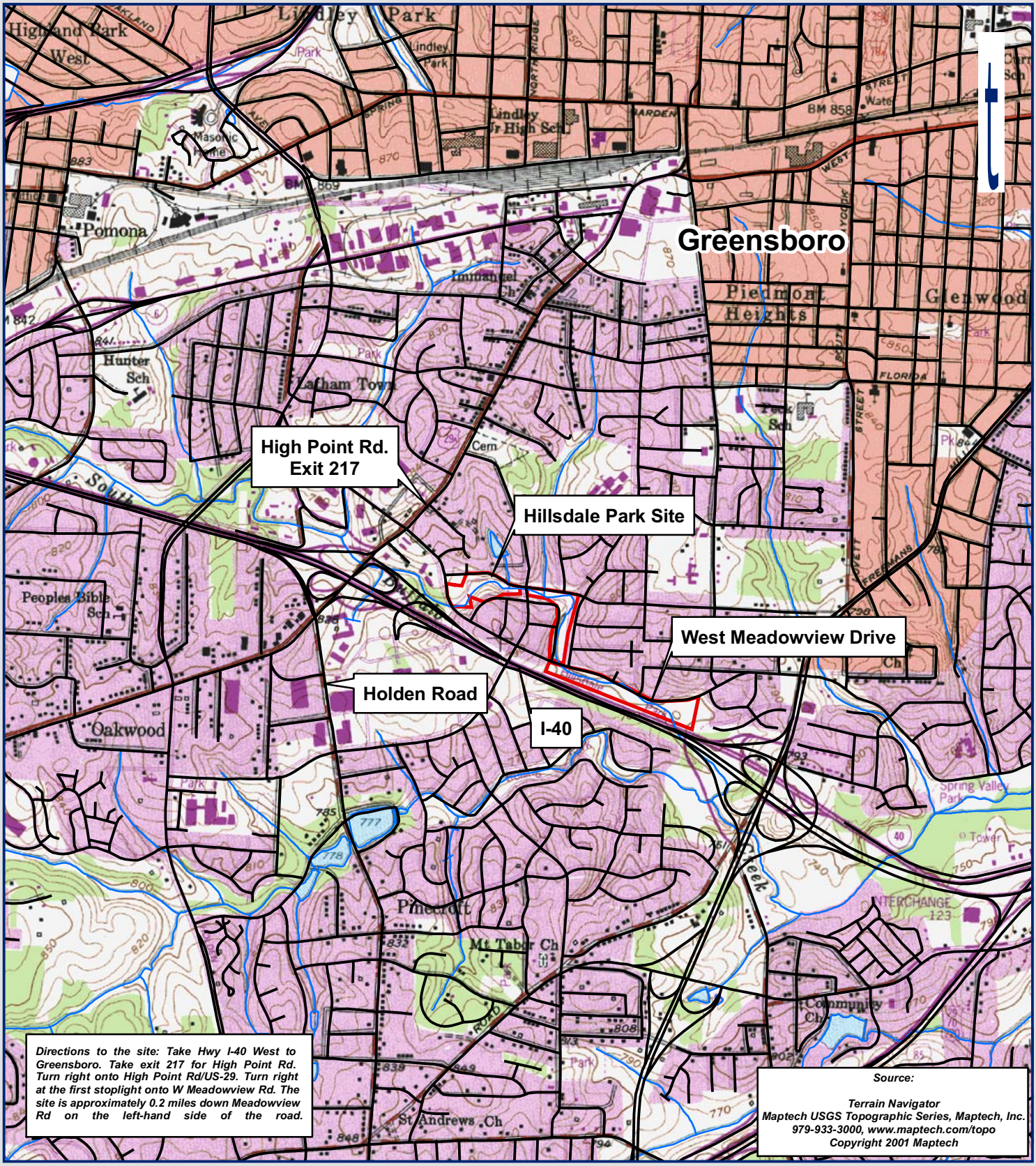
Additional details regarding the restoration components of the project are provided in Table I.

Table I. Project Restoration Components
Hillsdale Park Stream Restoration/Project No. 177

Project Segment or Reach ID	Mitigation Type	Approach	Existing Feet/Acres	Stationing	Comment
Reach HR1	Enhancement	Priority 3	3,037 lf	10+00 to 40+45	Bankfull benches and rock cross vanes
Reach HR2	Enhancement	Priority 3	2,265 lf	40+45 to 62+12	Root wads and stabilization
Tributary HR3	Stabilization	Bank Stabilization	138 lf	10+00 to 11+66	Stabilization using rock cross vanes

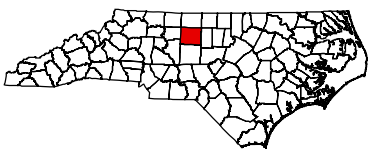
C. Location and Setting

The Hillsdale Park Stream Restoration Site includes 5,302 linear feet of South Buffalo Creek and 529 linear feet of a tributary referred to as Tributary HR3. These streams are tributaries to the Haw River (USGS 8-digit hydrologic unit 03030002, 14-digit hydrologic unit 03030002020050). The site is located in the City of Greensboro near the intersection of Interstate 40 and High Point Road (US Highway 29A) in Guilford County, North Carolina (See Figure 1).



Ecosystem Enhancement Program

Figure 1.
Hillsdale Park Stream Restoration Site
Vicinity Map
Guilford County, NC



0 1,000 2,000 4,000 Feet

D. Project History and Background

The construction of South Buffalo Creek was completed in early 2004 with the As-Built survey occurring in February 2005. Year 1 monitoring took place in April 2005, Year 2 monitoring occurred in October 2005, Year 3 monitoring occurred in October 2006, and Year 4 monitoring was completed in November 2007. Additional details regarding the timeline of the project are provided in Table II below.

Table II. Project Activity and Reporting History
Hillsdale Park Stream Restoration/Project No. 177

Activity or Report	Data Collection Complete	Actual Completion or Delivery
Restoration Plan	NA	February 2005
Final Design-90%	NA	NA
Construction	NA	March 15, 2004
Temporary S&E mix*	NA	NA
Permanent seed mix applied to reach/segments 1&2	NA	NA
Woody plantings for reach/segments 1&2	NA	March 15, 2004
Mitigation Plan /As-Built (Year 0 Monitoring-baseline)	NA	February 2005
Year 1 Monitoring	April 2005	April 2005
Year 2 Monitoring	October 2005	November 2005
Year 3 Monitoring	October 2006	December 2006
Year 4 Monitoring	October 2007	November 2007
Year 5 Monitoring		

NA-Historical project documents necessary to provide these data were unavailable at the time of this report submission

*Seed and mulch is added as each section of construction is completed.

The project was designed by Buck Engineering. Construction was performed by LJ, Incorporated. Monitoring activities for Year 4 were performed by WK Dickson and Co., Inc. Additional information regarding contractors is shown in Table III.

Table III. Project Contact Table Hillsdale Park Stream Restoration/Project No. 177	
Designer POC	Buck Engineering Mr. Mike Rooney 8000 Regency Parkway, Suite 200 Cary, NC 27511 (919) 463-5490
Construction Contractor POC	LJ, Incorporated Mr. Arden Reiser PO Box 3188 Mooresville, North Carolina 28117 (704) 799-2670
Planting Contractor POC	NA
Seeding Contractor POC	NA
Seed Mix Sources	NA
Nursery Stock Suppliers	NA
Monitoring POC	WK Dickson and Co., Inc. Mr. Daniel Ingram 3101 John Humphries Wynd Raleigh, NC 27612 (919) 782-0495

NA-Historical project documents necessary to provide these data were unavailable at the time of this report submission

The project is located within Guilford County, within the ecoregion of the Southern Outer Piedmont in the Piedmont physiographic province of North Carolina. The site is located within a highly urbanized area. Additional information regarding this stream is included in Table IV.

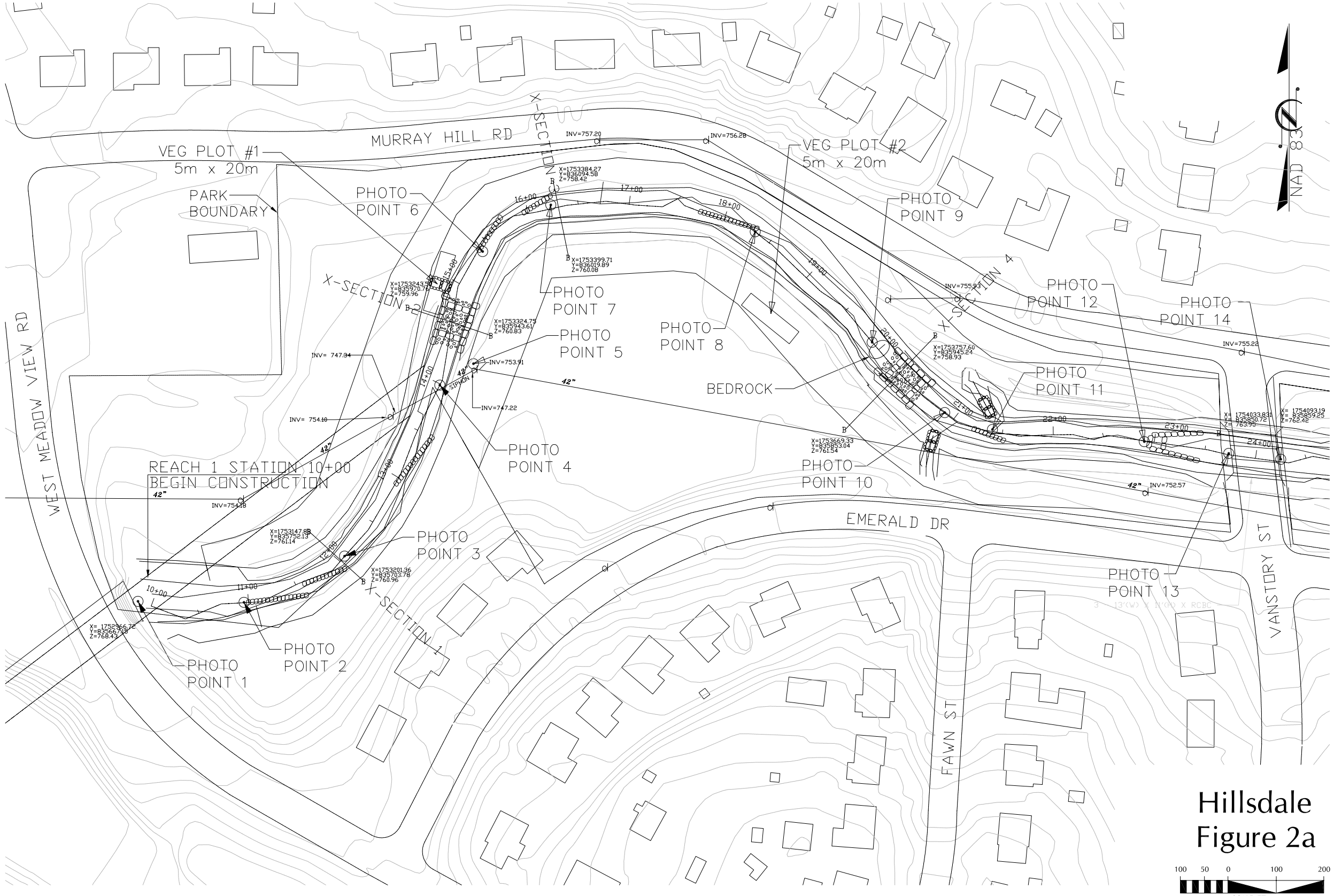
Table IV. Project Background Table Hillsdale Park Stream Restoration/Project No. 177	
Project County	Guilford
Drainage Area	
South Buffalo Creek	10.0 sq. mi.
Tributary	0.29 sq. mi.
Drainage impervious cover estimate (%)	>20%
Stream Order	
South Buffalo Creek	3rd order
Tributary	1st order
Physiographic Region	Piedmont
Ecoregion	Southern Outer Piedmont
Rosgen Classification of As-Built	B4c
Cowardian Classification	N/A
Dominant Soil Types	Congaree loam, Enon-Urban land complex, Mecklenburg-Urban land complex
Reference Site ID	E5, Ut Lake Jeanette (Guilford), McClintock 1 & 2 (Mecklenburg); B4c, DuHart (Gaston), Silas (Forsyth), Morgan (Orange)
USGS HUC for Project	03030002 (Cape Fear)
USGS HUC for Reference	Ut Lake Jeanette 03030002, McClintock 03050103, DuHart 03050102, Silas 03040101, Morgan 03030002
NCDWQ Sub-basin for Project	030602
NCDWQ Sub-basin for Reference	Ut Lake Jeanette 030602, McClintock 030834, DuHart 030836, Silas 030704, Morgan 030606
NCDWQ Classification for Project	C, NSW
NCDWQ Classification for Reference	Ut Lake Jeanette-WSIII, NSW; McClintock-C, DuHart-WS-V, Silas-C, Morgan-WS-II, HQW, NSW, CA
Any Portion of any project segment 303d listed?	Yes-all of South Buffalo Creek and its tributaries
Any portion of any project segment upstream of a 303d listed segment?	Yes, South Buffalo Creek to confluence with Buffalo Creek
Reasons for 303d listing or stressor	Impaired biological stressor, stressor not identified, Urban runoff-storm sewers
% of project easement fenced	None

E. Monitoring Plan View

A series of monitoring devices have been installed on-site. A total of twelve (12) individual cross-sections were located. Cross-sections were plotted from left to right facing downstream. Each cross-section is also a designated photographic point that is photographed annually. There are forty-five (45) permanent photo points located at various points along the length of the channel. Seven (7) vegetation-monitoring plots were randomly located within the riparian buffer of the Hillsdale Park Stream Restoration project. The locations of all monitoring devices are shown on Figures 2a through 2d (Monitoring Plan View).

LEGEND

- STREAM TOP OF BANK
- STREAM CENTERLINE
- VEG PLOT
- SINGLE-ARM DEFLECTOR
- OUTLET BASIN
- DROP CROSS-VANE
- CONSTRUCTED RIFFLE
- DOUBLE-WING DEFLECTOR
- PHOTO POINT
- J-HOOK
- BOULDER CLUSTER
- BEDROCK



Hillsdale
Figure 2a

PROJECT MANAGER	DRAWING SCALE
DPI	1"=100'
DRAWN BY	SURVEY DATE
TRS	
APPROVED BY	MAP DATE
PROJECT NUMBER	
5045700RA	

WK DICKSON
Engineers • Planners • Surveyors
Landscape Architects

3101 JOHN HUMPHRIES WYND
RALEIGH, NC 27612
(919) 782-0495

Office Locations:
North Carolina
South Carolina
Georgia
Florida

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NORTH CAROLINA
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TITLE:

YEAR 4 MONITORING PLAN VIEW
HILLSDALE PARK
GREENSBORO
NORTH CAROLINA

LEGEND

- STREAM TOP OF BANK
- STREAM CENTERLINE
- VEG PLOT
- SINGLE–ARM DEFLECTOR
- OUTLET BASIN
- DROP CROSS–VANE
- CONSTRUCTED RIFFLE
- DOUBLE–WING DEFLECTOR
- PHOTO POINT
- J–HOOK
- BOULDER CLUSTER
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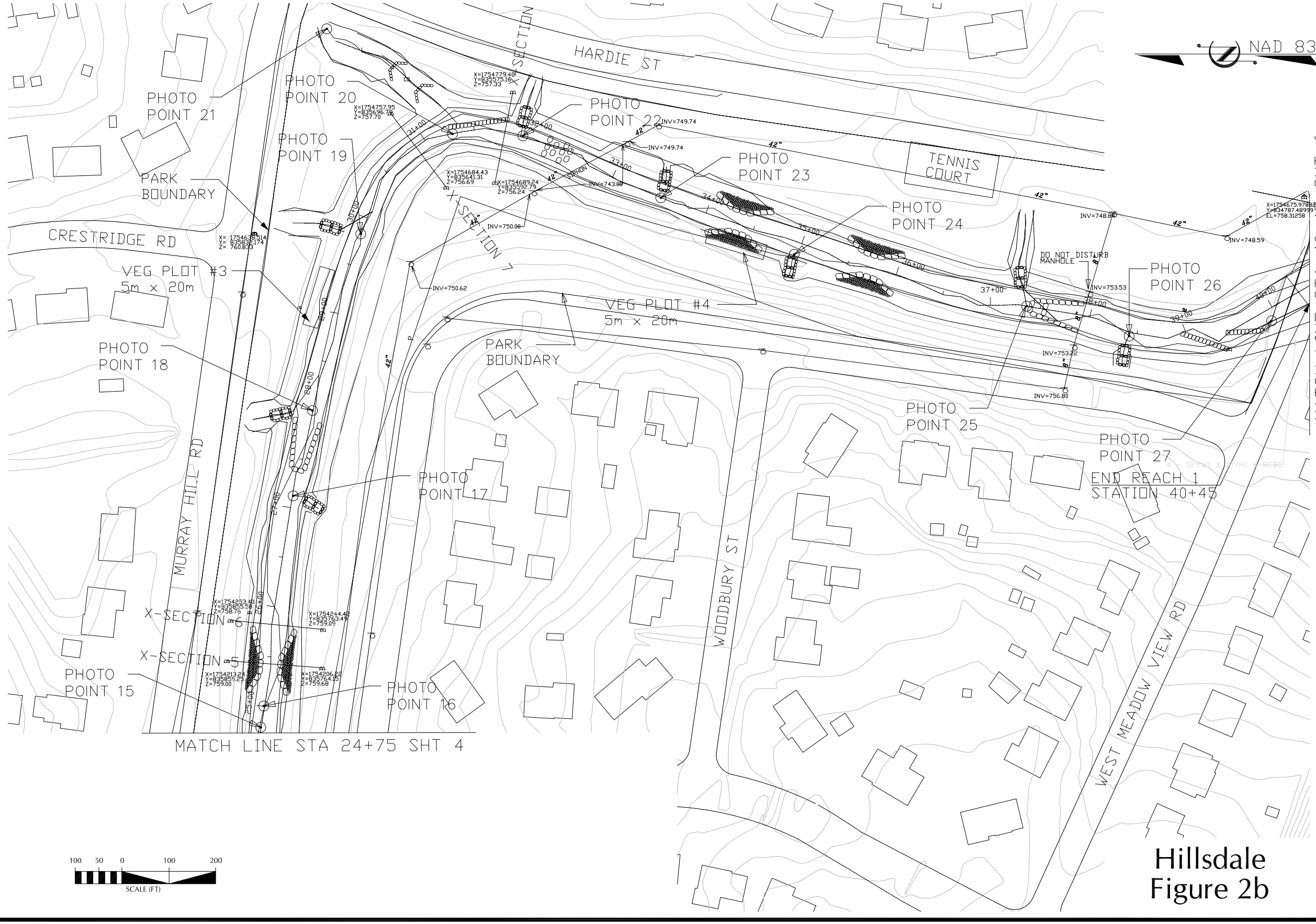

Hillsdale Figure 2b

PROJECT MANAGER	DPI
DRAWN BY	TRS
APPROVED BY	
DRAWING SCALE	1"=100'
SURVEY DATE	
MAP DATE	
PROJECT NUMBER	5045700RA

WK DICKSON
Engineers • Planners • Surveyors
Landscape Architects

3101 JOHN HUMPHRIES WYND
RALEIGH, NC 27612
(919) 782–0495

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LEGEND

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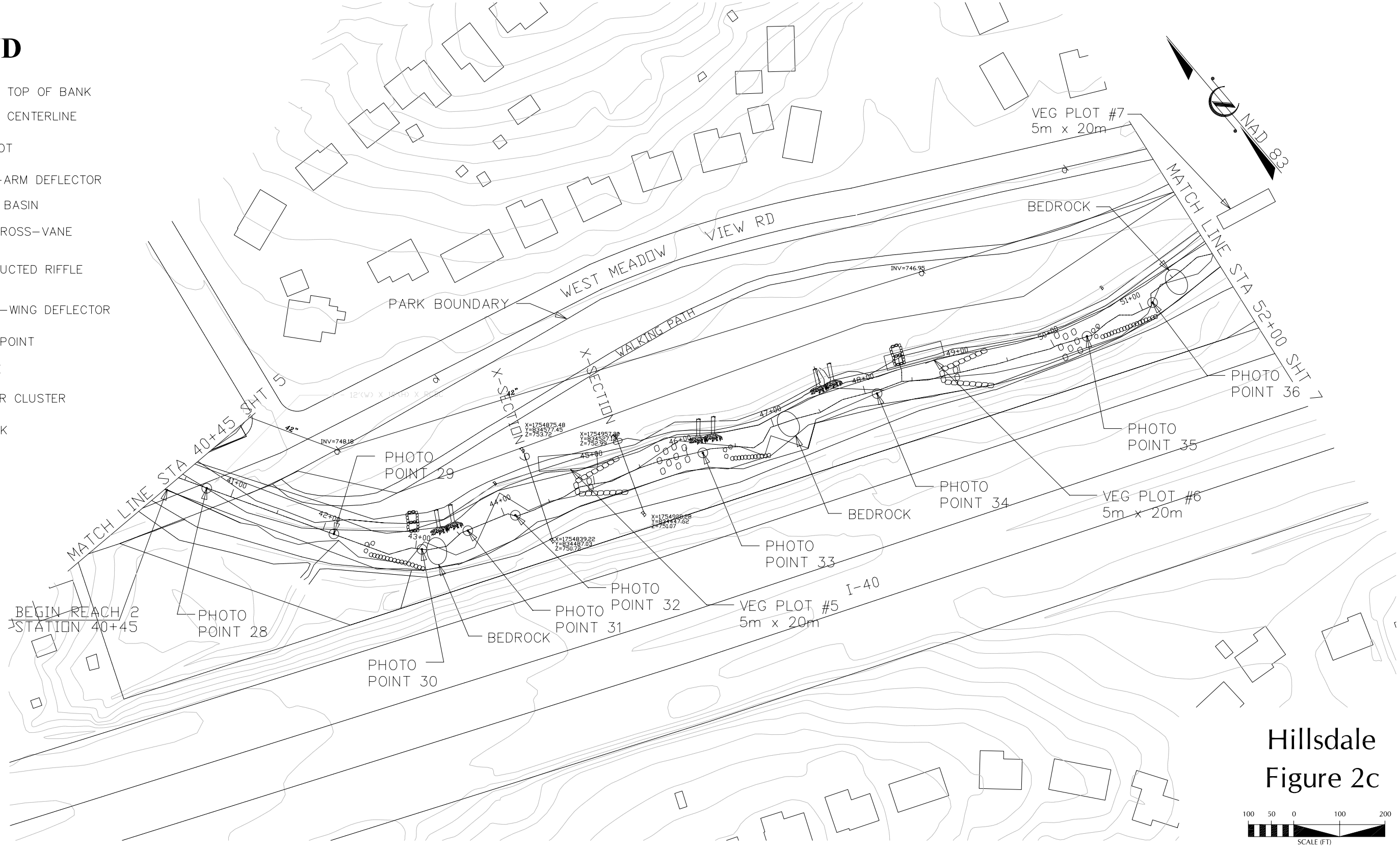

Hillsdale
Figure 2c

100 50 0 100 200
SCALE (FT)

PROJECT MANAGER	DRAWING SCALE
DPI	1"=100'
DRAWN BY	SURVEY DATE
TRS	
APPROVED BY	MAP DATE
PROJECT NUMBER	
5045700RA	

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Landscape Architects

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RALEIGH, NC 27612
(919) 782-0495

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NORTH CAROLINA

LEGEND

- STREAM TOP OF BANK
- STREAM CENTERLINE
- VEG PLOT
- SINGLE–ARM DEFLECTOR
- OUTLET BASIN
- DROP CROSS–VANE
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- DOUBLE–WING DEFLECTOR
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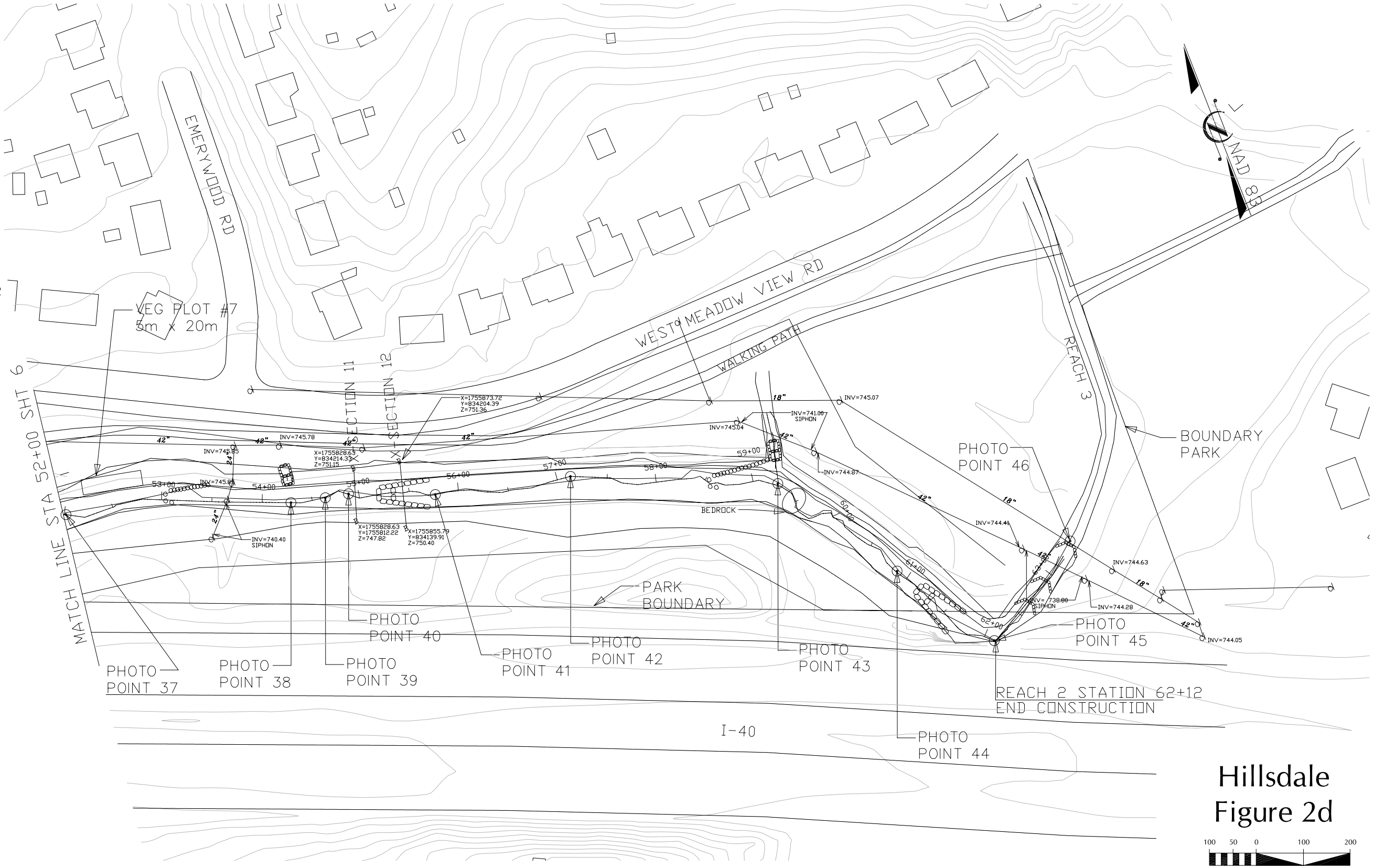

Hillsdale
Figure 2d

100 50 0 100 200
SCALE (FT)

PROJECT MANAGER	DRAWING SCALE
DPI	1"=100'
DRAWN BY	SURVEY DATE
TRS	
APPROVED BY	MAP DATE
PROJECT NUMBER	
5045700RA	

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RALEIGH, NC 27612
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TITLE:

YEAR 4 MONITORING PLAN VIEW
HILLSDALE PARK
GREENSBORO
NORTH CAROLINA

III. PROJECT CONDITION AND MONITORING RESULTS

Monitoring results are discussed below. An initial visual survey was conducted on March 27, 2007 with a more detailed monitoring survey (evaluation of vegetation plots) conducted in August and September 2007.

A. Vegetation Assessment

Planted zones related to the stream restoration consist of the riparian buffer zone and the stream banks. The riparian buffer zone initiates at the top of the bank and continues out perpendicular to the immediate channel following the general pattern of the meandering channel. The planted stream bank initiates at the normal base flow elevation and extends to the top of bank or interface with the floodplain.

The "CVS-EEP Protocol for Recording Vegetation" was utilized during Year 4 vegetation monitoring. Seven 5 m x 20 m (100 m^2) plots are located throughout the riparian corridor. Level 1 and Level 2 plots were used for the Hillsdale vegetation monitoring.

1. Soil Data

Soils present in the riparian areas adjacent to South Buffalo Creek are characteristic of those found in alluvial landforms in the Southern Outer Piedmont. However, extensive grading and dredging has likely modified much of the naturally occurring soils on site.

Congaree soils (*Oxyaquic Udifluvents*) are the prevalent map unit along the channel. Formed in recent alluvial sediments, they are deep, well to moderately well drained soils with moderate permeability.

Other soil series found along the stream corridor are Enon-Urban land complex and Mecklenburg-Urban land complex soils. Enon soils (*Ultic Hapludalfs*) are very deep, well drained, slowly permeable soils found on ridgetops and side slopes in the Piedmont. Mecklenburg soils (*Ultic Hapludalfs*) are very deep, well drained soils with slow permeability.

2. Vegetative Problem Areas

Seven exotic and/or invasive species were observed within the plots during the vegetation sampling in 2007. These include ailanthus (*Ailanthus altissima*), Chinese privet (*Ligustrum sinense*), bittersweet (*Celastrus* sp.), Japanese honeysuckle (*Lonicera japonica*), mimosa (*Albizia julibrissin*), multiflora rose (*Rosa multiflora*), and porcelain berry (*Ampelopsis brevipedunculata*).

The majority of the site has the presence of one or more invasive or exotic species with the ability to impact the site. Most of the site is heavily covered in porcelain berry. This woody perennial vine is very aggressive and has a tendency to grow over vegetation, including small shrubs and trees. In some areas porcelain berry is extremely dense and is damaging trees; in all other areas it has the potential to become a serious problem. Furthermore, porcelain berry occurs on nearly all excavated floodplain benches and is aggressively invading the surrounding buffers. It is recommended that action be taken to control and eradicate the porcelain berry at this site.

Additionally, the vegetation within about 25 feet of each side of the Vanstory Street bridge has been mowed. All vegetative problem areas are described in Table 6 in Appendix A. The vegetative plan view is provided in Appendix B, B-1 Current Conditions Plan View.

3. Stem Counts

Methodology
Vegetation monitoring at Hillsdale Park consisted of seven 5 m x 20 m plots. The method used to count woody stems followed the protocol described in the "CVS-EEP Protocol for Recording Vegetation". The tables provided in Appendix A were derived from the software used for entering the data collected during vegetation monitoring. Table 2 in Appendix A gives a description of the vigor of each species found in each plot. The vigor of a plant is determined by the extent of any damage incurred by the plant on its bark, leafy material, or tissue. Woody stems are also counted in each plot. The intent of recording natural woody stems is to assess the overall recovery and compositional trajectory of the plot. A tally is made for the number of stems for each size class for each species found. Table 5 in Appendix A lists species found in each plot and is tallied by the number found in each plot.

4. Vegetation Plot Photos

Photos of the vegetation plots are located in Section A-3 of Appendix A. For levels 1 and 2, one photograph is required for each plot. However, section A-2 includes two photos for each plot, generally taken from each of the two outside corners facing diagonally toward the opposite corner of the plot.

B. STREAM ASSESSMENT

WK Dickson and Co., Inc personnel performed an initial site visit at Hillsdale Park on August 6th to August 10th, 2007. During the field visit qualitative observations were recorded regarding the condition of the stream restoration project. Cross section and longitudinal surveys were also performed at the time of this visit. Twelve cross sections and approximately 3,000 linear feet of stream profile were surveyed. Photographs were taken at all permanent photo points. A bed material analysis was not performed since this is a sand/small gravel stream. No significant coarsening is expected over time. A pebble count was performed for Year 4. The photographs show that vegetation is generally growing well and is a good combination of woody and herbaceous growth. Banks are stable with no unusual bank erosion. At this time, no repairs are recommended. Problem areas should be monitored and if they worsen over time, then solutions should be discussed to assess the reason for the problem and potential repair options. Stream problem areas are described in Appendix B, Table B.1.

Hydrologic Assessment

One crest gage was installed in fall of 2007 at this site located at X: 1756282.738; Y: 833937.777 to document bankfull flow events. The following USGS stream gauge data had been used in past reports to verify bankfull events. Although this technique has been used to establish the occurrence of bankfull events for the history of this project, it is not scientifically valid. It is, at the current time, the only means available to infer the occurrence of bankfull discharge(s) at the site, as no high water marks were observed in the field. Potential occurrences were extrapolated based on USGS stream gauge discharge data for South Buffalo Creek at US 220 (approximately 2 miles southeast of project site) with a drainage area of 15.4 square miles. Bankfull events were

determined by comparing the stream discharge (cfs) against the drainage area on the urban piedmont regional curve. According to the urban piedmont curve, a bankfull event occurs on a stream with a 15.4 square mile drainage area when the discharge is between 1,538 and 1,718 cfs. Based on USGS data, at least five bankfull events occurred in 2007. The dates and maximum discharges of these bankfull events are listed in Table V.

Figure 3. USGS Stream Gauge Discharge Data for South Buffalo Creek at US 220.

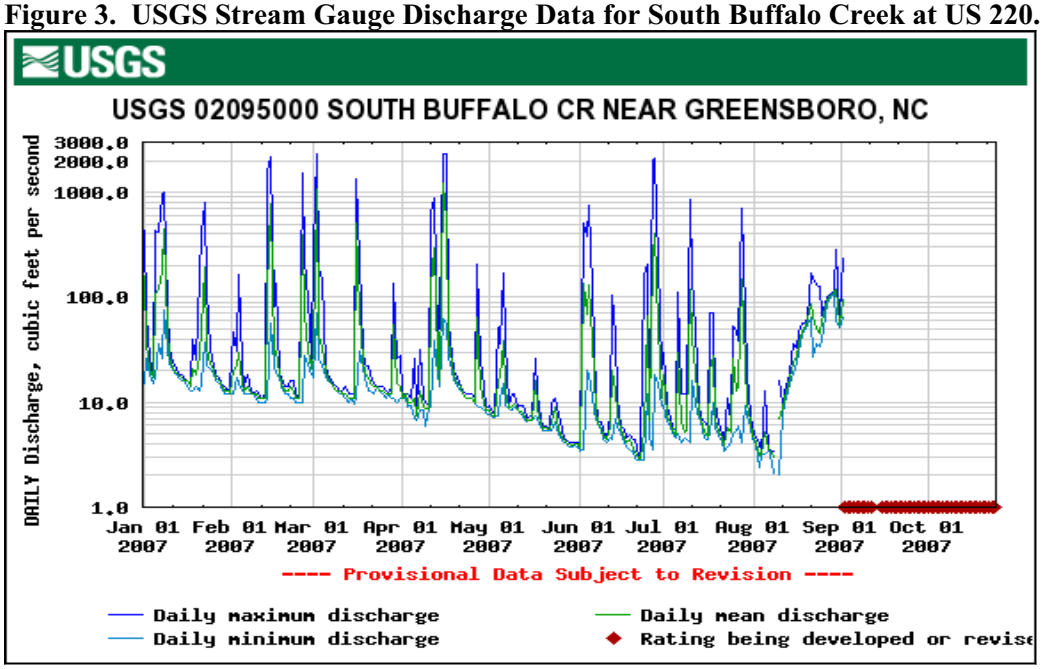

Table V lists bankfull events and high flows as they occurred in 2007.

Table V. Verification of Bankfull Events
Hillsdale Park Stream Restoration Site/Project No. 177

Date of Data Collection	Date of Occurrence	Maximum Discharge (cfs)	Method	Photo # (if available)
2007	February 14, 2007	2170	Proximal USGS gauge resource	NA
2007	February 25, 2007	1550	Proximal USGS gauge resource	NA
2007	March 2, 2007	2340	Proximal USGS gauge resource	NA
2007	April 16, 2007	2350	Proximal USGS gauge resource	NA
2007	June 28, 2007	2130	Proximal USGS gauge resource	NA

1. Problem Areas Plan View

An assessment of the stability of the channel was performed on August 6-8, 2007, by WK Dickson and Co., Inc. Several areas of concern were observed and documented including localized bank scour, aggradation, and failure of the engineered structures. These problem areas are shown in Appendix B, Section B-1.

2. Problem Areas Summary Table

The Problem Areas Table Summary is located in Appendix B as Table B.1.

3. Representative Stream Problem Areas Photos Section

Representative photos of each category of stream problem area were taken and are shown in Appendix B, Section B-3.

4. Fixed Photo Station Photos

Photos from established photo stations were collected on August 6, 2007 during the stream survey. These photos are included in Appendix B, Section B-4.

5. Stability Assessment

A visual qualitative assessment was performed to inspect channel facets, meanders, bed, banks, and installed structures. This visual assessment was confirmed and enhanced with a quantitative assessment of the physical stream survey. The goal of this assessment is to provide a percentage of the features listed in Table VI that are in a state of stability.

Table VI. Categorical Stream Feature Visual Stability Assessment
Hillsdale Park Stream Restoration/Project No. 177

Reach HR1/ (3,037 feet)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%	100%	100%	91%	91%	
B. Pools	100%	95%	100%	87%	87%	
C. Thalweg	100%	100%	50%	87.50%	88%	
D. Meanders	100%	100%	96.70%	77.50%	78%	
E. Bed General	100%	100%	96.70%	100%	100%	
F. Bank Condition	NA	NA	NA	98%	98%	
G. Vanes/J-Hooks etc.	100%	100%	100%	100%	100%	
H. Wads and Boulders	100%	100%	100%	100%	100%	
Reach HR2 (2,265 feet)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%	100%	100%	98%	98%	
B. Pools	100%	95%	95%	83%	83%	
C. Thalweg	100%	100%	NA	NA	90%	
D. Meanders	100%	100%	NA	NA	100%	
E. Bed General	100%	100%	100%	100%	100%	
F. Bank Condition	NA	NA	NA	98%	96%	
G. Vanes/J-Hooks etc.	100%	100%	100%	100%	93%	
H. Wads and Boulders	100%	100%	93.80%	100%	100%	

Note: Year 1 estimates are based upon review of text within the Buck Engineering Year 1 Monitoring Report.

6. Quantitative Morphology

The following tables (Table VII and Table VIII) summarize the quantitative data collected from the cross-sectional and longitudinal stream survey. These data were analyzed and summarized, and then compared with baseline data (i.e. as-built and previous year's data) available for this project. The SRI urban Piedmont curve was used to determine an average bankfull cross-sectional area, and bankfull was placed at the elevation that would yield this area (for 2007 cross-sections). When the elevations chosen for bankfull were plotted on the longitudinal profile, the points formed a reasonably uniform slope that was consistent with the low flow water surface slope. The baseline that has been chosen for 2007 is consistent with the regional curve and will provide accurate illustrations of departure if bankfull is located in the same manner for future years of monitoring. The results of analysis of the data show that there are some disparities between the 2007 data and the previous year's data. This can be explained by the fact that bankfull elevation fluctuates from year to year, but for ease of analysis the bankfull elevation has been kept at the same elevation as previous year's datum elevation. The Quantitative Morphology Tables illustrate the degree of departure, if any, of the current channel from the baseline data. Tables VII and VIII were compiled from the cross-section and profile raw data and plots located in Appendix B of this report.

Table VII. Baseline Morphology and Hydraulic Summary
Hillsdale Park Stream Restoration/Project No. 177

Reach HR1 (3,037 feet)																		
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)				46	59	52	36	44	*	25.6	46	33.5	36	44	*	28	40.2	37.95
BF Cross Sectional Area (ft2)				255	283	269	103	113	*	43.5	122	80	103	113	*	70.7	154.4	117.55
BF Mean Depth (ft)				4.5	6.0	5.2	2.6	2.9	*	1.7	2.6	2.4	2.6	2.9	*	2.5	3.9	3.2
BF Max Depth (ft)							3.7	4.0	*	*	*	*	3.7	4.0	*	3.4	5.9	5
Width/Depth Ratio							12.2	17.3	*	14.0	17.0	15.1	12.2	17.3	*	8.8	14.7	10.9
Entrenchment Ratio							1.5	2.4	*	*	*	*	2.3	2.3	*	1.8	3.3	2.5
Bank Height Ratio (BHR)							*	*	*	*	*	*	*	*	*	*	*	1.0
Wetted Perimeter (ft)							*	*	*	*	*	*	*	*	*	33	47.2	43.35
Hydraulic Radius (ft)							*	*	*	*	*	*	*	*	*	2.14	3.27	2.71
Pattern																		
Channel Beltwidth (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Radius of Curvature (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Meander Wavelength (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Meander Width Ratio							*	*	*	*	*	*	*	*	*	*	*	*
Profile																		
Riffle Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Riffle Slope (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Pool Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Pool -to-Pool Spacing (ft)							*	*	*	*	*	*	76	152	*	*	*	*
Substrate																		
d50 (mm)							*	*	*	3.0	64.0	19.1	*	*	*	*	*	*
d84 (mm)							*	*	*	77	180	bedrock	*	*	*	*	*	*
Additional Reach Parameters																		
Valley Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Channel Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Sinuosity							*	*	1.1	*	*	1.1	*	*	1.1	*	*	*
Water Surface Slope (ft/ft)							*	*	0.0016	*	*	*	*	*	0.0016	*	*	*
BF Slope (ft/ft)							*	*	*	*	*	*	*	*	*	*	*	*
Rosgen Classification							*	*	E4/B4c	*	*	B4c	*	*	E4/B4c	*	*	*
*Habitat Index							*	*	*	*	*	*	*	*	*	*	*	*
*Macrobenthos							*	*	*	*	*	*	*	*	*	*	*	*

*Historical documents necessary to provide this information were unavailable at the time of the report submission

Table VII Continued. Baseline Morphology and Hydraulic Summary
Hillsdale Park Stream Restoration/Project No. 177

Reach HR2 (2,265 feet)																		
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)				46	59	52	66	66	*	25.6	46	33.5	*	*	66	19.7	52.4	41.1
BF Cross Sectional Area (ft2)				255	283	269	166	166	*	43.5	122	80	*	*	166	72.6	242.3	112.9
BF Mean Depth (ft)				4.5	6.0	5.2	*	*	2.5	1.7	2.6	2.4	*	*	2.5	2.3	5	3.4
BF Max Depth (ft)							*	*	3.6	*	*	*	*	*	3.6	2.9	7.4	4.75
Width/Depth Ratio							*	*	26.4	14.0	17.0	15.1	*	*	26.4	5.3	22.6	10.3
Entrenchment Ratio							*	*	1.1	*	*	*	*	*	2.3	1.5	4.3	2.15
Bank Height Ratio (BHR)							*	*	*	*	*	*	*	*	1.0	*	*	1.0
Wetted Perimeter (ft)							*	*	*	*	*	*	*	*	*	27.1	58.6	48.4
Hydraulic Radius (ft)							*	*	*	*	*	*	*	*	*	2.13	4.13	2.65
Pattern																		
Channel Beltwidth (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Radius of Curvature (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Meander Wavelength (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Meander Width Ratio							*	*	*	*	*	*	*	*	*	*	*	*
Profile																		
Riffle Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Riffle Slope (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Pool Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Pool –to-Pool Spacing (ft)							*	*	*	*	*	*	76	152	*	*	*	*
Substrate																		
d50 (mm)							*	*	*	3.0	64.0	19.1	*	*	*	*	*	*
d84 (mm)							*	*	*	77.0	bedrock	157.5	*	*	*	*	*	*
Additional Reach Parameters																		
Valley Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Channel Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Sinuosity							*	*	1.1	*	*	1.1	*	*	1.1	*	*	*
Water Surface Slope (ft/ft)							*	*	0.0035	*	*	*	*	*	0.0035	*	*	*
BF Slope (ft/ft)							*	*	*	*	*	*	*	*	*	*	*	*
Rosgen Classification							*	*	E4/B4c	*	*	B4c	*	*	E4/B4c	*	*	*
*Habitat Index							*	*	*	*	*	*	*	*	*	*	*	*
*Macrobenthos							*	*	*	*	*	*	*	*	*	*	*	*

*Historical documents necessary to provide this information were unavailable at the time of the report submission

Table VIII. Morphology and Hydraulic Monitoring Summary
Hillsdale Park Stream Mitigation Site/Project No. 177
Reach HR1 CS 1-6 (3,037 feet)

Parameter	Cross-Section 1 12+01 Pool					Cross-Section 2 14+61 Riffle					Cross-Section 3 16+31 Pool					Cross-Section 4 20+31 Riffle					Cross-Section 5 25+43 Riffle					Cross-Section 6 25+82 Pool				
Dimension	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4
BF Width (ft)	33.5	32.8	38.3	36.4	40.2	38	37.5	38.5	38	38.91	33.8	36.9	37.3	41.32	36.33	37.9	40.1	41.7	38.9	38.78	40.2	41.1	44.5	38.7	38.78	39.4	38.4	47.8	36.1	34.44
Floodprone Width (ft)	95	95	>85	**	**	68	68	74.4	84	70	110	110	**	**	**	75	75	89	99	94.8	73	73	*	82	88	110	110	**	**	**
BF Cross Sectional Area (ft2)	127	125.5	177.8	165.9	177.2	104.7	102.6	108.6	114.7	113.21	114.2	138.6	165.5	156.36	146.94	97.8	104.2	110.2	109.2	112.71	120.9	128	133	120	117.73	154.4	159.5	223.9	168.4	164.29
BF Mean Depth (ft)	3.8	3.8	4.6	4.6	4.4	2.8	2.7	2.8	3	2.91	3.4	3.8	4.4	3.78	4.04	2.6	2.6	2.6	2.8	2.91	3	3.1	3	3.1	3.04	3.9	4.2	4.7	4.7	4.77
BF Max Depth (ft)	5.8	5.7	7.1	6.9	6.6	3.8	4.1	3.9	4.6	4.29	5.5	6.4	7.2	7.44	6.65	3.4	3.7	3.7	3.8	3.82	4.5	4.7	5.5	5	4.89	5.5	6	7.8	6.2	6.37
Width/Depth Ratio	8.8	8.6	8.3	8	9.1	13.8	13.7	13.7	12.6	13.4	10	9.8	8.4	10.90	9	15.4	15.8	15.8	13.9	13.3	13.4	13.2	14.9	12.5	12.8	10.1	9.2	10.2	7.7	7.2
Entrenchment Ratio	2.8	2.9	>2.2	**	2.3	1.8	1.8	1.9	2.2	1.8	3.3	3	**	**	**	1.9	2.1	2.1	2.5	2.4	1.8	1.8	*	2.1	2.3	2.8	2.9	**	**	**
Wetted Perimeter (ft)	41.1	*	47.58	41.1	44.8	43.6	*	44.14	39.8	40.9	40.6	*	46.17		40.5	*	46.99	46.99	41	40.5	46.2	*	50.48	41.2	42.8	47.2	*	57.17	40.1	40
Hydraulic Radius (ft)	3.09	*	3.74	4	4	2.4	*	2.46	2.9	2.8	2.81	*	3.58		3.6	*	2.35	2.35	2.7	2.8	2.62	*	2.63	2.9	2.8	3.27	*	3.92	4.2	4.1
Substrate																														
d50 (mm)	*	*	*	*	8	*	*	*	*	18	*	*	*	*	0.91	*	*	*	*	52	*	*	*	*	19	*	*	*	*	0.65
d84 (mm)	*	*	*	*	130	*	*	*	*	98	*	*	*	*	80	*	*	*	*	180	*	*	*	*	64	*	*	*	*	93

Parameter	MY-01 (2005)					MY-02 (2005)					MY-03 (2006)					MY-04 (2007)					MY-05 (2008)					MY+ (2009)				
Pattern	Min	Max	Med			Min	Max	Med			Min	Max	Med			Min	Max	Med			Min	Max	Med			Min	Max	Med		
Channel Beltwidth (ft)	*	*	*			*	*	*			22	69	39			16	79	49												
Radius of Curvature (ft)	*	*	*			*	*	*			6	22	12			6	33	17												
Meander Wavelength (ft)	*	*	*			*	*	*			33	74	49			25	79	48												
Meander Width Ratio	*	*	*			*	*	*			0.59	1.85	1.05																	
Profile																														
Riffle Length (ft)	*	*	*			6	434	26			11	421	34			13	433	37												
Riffle Slope (ft/ft)	*	*	*			0	0.0197	0.0003			0	0.0220	0.0005			0	0.0240	0.0005												
Pool Length (ft)	*	*	*			10	140	28			12	155	37			14	160	40												
Pool -to-Pool Spacing (ft)	*	*	*			25	613	144			23	712	168			26	700	155												
Additional Reach Parameters																														
Valley Length (ft)	NA					2720					2720					2720														
Channel Length (ft)	NA					3045					3045					3045														
Sinuosity	NA					1.1195					1.12					1.12														
Water Surface Slope (ft/ft)	NA					0.00199					0.0017					0.0018														
BF Slope (ft/ft)	NA					0.00181					0.0018					0.0018														
Rosgen Classification	NA					B4c					B4c					B4c														
*Habitat Index	NA					NA					NA					NA														
*Macrobenthos	NA					NA					NA					NA														

*Historical documents necessary to provide this information were unavailable at the time of the report submission.
**Typically a flood prone width and entrenchment ratio are not calculated for a pool cross section.

Table VIII Continued. Morphology and Hydraulic Monitoring Summary
Hillsdale Park Stream Mitigation Site/Project No. 177
Reach HR1 CS 7-8 (3,037 feet)

Parameter	Cross-Section 7 30+89 Riffle					Cross-Section 8 31+81 Pool																						
Dimension	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4
BF Width (ft)	28	28.1	33.4	29.4	28.02	38.9	35.7	42	33.8	38.45																				
Floodprone Width (ft)	62	62	70.5	64	60	130	130	**	**	90																				
BF Cross Sectional Area (ft2)	70.7	71.3	82	74.3	72.91	142.1	128	171.7	198.2	187.3																				
BF Mean Depth (ft)	2.5	2.5	2.5	2.5	2.6	3.7	3.6	4.1	5.9	4.87																				
BF Max Depth (ft)	3.8	3.8	4	3.9	3.8	5.9	5.6	6.6	9.6	7.12																				
Width/Depth Ratio	11.1	11.1	13.6	11.6	10.8	10.7	10	10.3	5.8	7.9																				
Entrenchment Ratio	2.2	2.2	2.1	2.2	2.1	3.3	3.6	**	**	2.3																				
Wetted Perimeter (ft)	33	*	38.31	32.2	29.9	46.3	*	50.18	41.7	45.3																				
Hydraulic Radius (ft)	2.14	*	2.14	2.3	2.4	3.07	*	3.42	4.8	4.1																				
Substrate																														
d50 (mm)	*	*	*	*	64	*	*	*	*	4.6																				
d84 (mm)	*	*	*	*	200	*	*	*	*	160																				

Parameter	MY-01 (2005)					MY-02 (2005)					MY-03 (2006)					MY-04 (2007)					MY-05 (2008)					MY+ (2009)				
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)																														
Pool Length (ft)																														
Pool -to-Pool Spacing (ft)																														
Additional Reach Parameters																														
Valley Length (ft)																														
Channel Length (ft)																														
Sinuosity																														
Water Surface Slope (ft/ft)																														
BF Slope (ft/ft)																														
Rosgen Classification																														
*Habitat Index																														
*Macrobenthos																														

*Historical documents necessary to provide this information were unavailable at the time of the report submission
**Typically a flood prone width and entrenchment ratio are not calculated for a pool cross section.

Table VIII Continued. Morphology and Hydraulic Monitoring Summary
Hillsdale Park Stream Mitigation Site/Project No. 177
Reach HR2 CS 9-12 (2,265 feet)

Parameter	Cross-Section 9 44+41 Riffle					Cross-Section 10 45+39 Pool					Cross-Section 11 54+96 Riffle					Cross-Section 12 55+43 Pool														
Dimension	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4	MY0	MY1	MY2	MY3	MY4
BF Width (ft)	52.4	53.6	49.1	53.7	55.5	48.6	47.8	53.3	47	59.84	33.6	36.9	34	31.1	33.82	19.7	20.3	21.1	20.5	20.91										
Floodprone Width (ft)	80	80	67.6	76	80	210	210	**	**	**	55	55	>53	52	50	53	53	**	**	54.4										
BF Cross Sectional Area (ft2)	121.5	122.1	93.8	131.7	137.24	242.3	240.6	256.2	277.6	272.81	104.3	107.2	103.3	92.2	104.28	72.6	87.1	89.1	84.3	87.35										
BF Mean Depth (ft)	2.3	2.3	1.9	2.5	2.47	5	5	4.8	5.9	4.56	3.1	2.9	3	3	3.08	3.7	4.3	4.2	4.1	4.18										
BF Max Depth (ft)	2.9	2.9	2.2	3.1	3.08	7.4	7	7.4	7.7	7.81	4.4	4.4	4.2	7.6	4.01	5.1	5.6	5.4	5.6	5.52										
Width/Depth Ratio	22.6	23.6	25.7	21.9	22.4	9.8	9.5	11.1	7.9	13.1	10.8	12.7	11.2	10.5	11	5.3	4.7	5	5	5										
Entrenchment Ratio	1.5	1.5	1.4	1.4	1.4	4.3	4.4	**	**	**	1.6	1.5	*	1.7	1.5	2.7	2.6	**	**	2.6										
Wetted Perimeter (ft)	57	*	52.92	55.7	57.4	58.6	*	62.91	53	65	39.8	*	40.07	42.9	37.1	27.1	*	29.55	26.1	26.1										
Hydraulic Radius (ft)	2.13	*	1.77	2.4	2.4	4.13	*	4.07	5.2	4.2	2.62	*	2.58	2.2	2.8	2.68	*	3.02	3.2	3.3										
Substrate																														
d50 (mm)	*	*	*	*	25	*	*	*	*	8	*	*	*	*	28	*	*	*	*	7.1										
d84 (mm)	*	*	*	*	72	*	*	*	*	100	*	*	*	*	260	*	*	*	*	240										

Parameter	MY-01 (2005)					MY-02 (2005)					MY-03 (2006)					MY-04 (2007)					MY-05 (2008)					MY+ (2009)				
Pattern	Min	Max	Med			Min	Max	Med			Min	Max	Med			Min	Max	Med			Min	Max	Med			Min	Max	Med		
Channel Beltwidth (ft)	*	*	*			*	*	*			24	66	46			32	64	45												
Radius of Curvature (ft)	*	*	*			*	*	*			9	21	12			12	26	15												
Meander Wavelength (ft)	*	*	*			*	*	*			34	81	60			31	88	62												
Meander Width Ratio	*	*	*			*	*	*			0.63	1.73	1.21			0.85	1.64	1.25												
Profile																														
Riffle Length (ft)	*	*	*			11	194	50			15	234	75			13	215	65												
Riffle Slope (ft)	*	*	*			0	0.014792	0.004292			0	0.0163	0.0074			0	0.0176	0.0068												
Pool Length (ft)	*	*	*			8	104	67			10	125	80			12	130	75												
Pool -to-Pool Spacing (ft)	*	*	*			108	443	180			105	438	205			107	448	210												
Additional Reach Parameters																														
Valley Length (ft)	NA					2115					2115					2115														
Channel Length (ft)	NA					2167					2167					2167														
Sinuosity	NA					1.025					1.025					1.025														
Water Surface Slope (ft/ft)	NA					0.00392					0.0037					0.0037														
BF Slope (ft/ft)	NA					0.00364					0.0022					0.0032														
Rosgen Classification	NA					B4c					B4c					B4c														
*Habitat Index	NA					NA					NA					NA														
*Macrobenthos	NA					NA					NA					NA														

*Historical documents necessary to provide this information was unavailable at the time of the report submission.
**Typically a flood prone width and entrenchment ratio are not calculated for a pool cross section.

C. WETLAND ASSESSMENT

There is no wetland restoration associated with this site. Table X is not applicable to this project.

IV. METHODOLOGY SECTION

The methodology used for vegetative monitoring is described in the "CVS-EEP Protocol for Recording Vegetation." The only exceptions to this protocol that were made was that it was determination that Green Ash was a volunteer species found in each plot. Also, per the procedure as discussed with Steve Roberts of NC EEP, only species that measured above 2m were to be considered a planted species. No additional deviations from the established procedures were performed in collecting data for this report.

RECOMMENDATIONS

It is recommended that crest gauges be installed at Hillsdale Park in order to measure bankfull flows if they occur onsite. It is also recommended that an invasive species control plan be developed and implemented.

References:

Lee, Michaeal T., Peet, Robert K., Roberts, Steven D., Wentworth, Thomas R. (2006). CVS-EEP Protocol for Recording Vegetation Version 4.0. Retrieved October 30, 2006, from: http://www.nceep.net/business/monitoring/veg/datasheets.htm

Radford, A.E., H.E. Ahles and F.R. Bell. 1968. *Manual of the Vascular Flora of the Carolinas.* The University of North Carolina Press, Chapel Hill, North Carolina.

Rosgen, D.L. (1996) *Applied River Morphology*. Wildland Hydrology Books, Pagosa Springs, Co.

USACOE (2003) *Stream Mitigation Guidelines*. USACOE, USEPA, NCWRC, NCDENR-DWQ

USACOE (1987) *Corps of Engineers Wetlands Delineation Manual*. Tech report Y-87-1. AD/A176.

Click on the Desired Link Below

Appendix A

Appendix B