Stream Restoration Plan

McIntyre Creek in Hornets Nest Park
Mecklenburg County, North Carolina

N.C. Wetlands Restoration Program
NCDENR

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EXECUTIVE SUMMARY

The North Carolina Wetlands Restoration Program (WRP) intends to restore 5,358 linear feet of a degraded section of McIntyre Creek. The subject reach is located within Hornet's Nest Park in Mecklenburg County, North Carolina.

The goals and objectives of the McIntyre Creek Stream Restoration Project are:

- Restore a stable channel morphology that is capable of moving the flows and sediment provided by its watershed;
- Improve water quality and reduce land and riparian vegetation loss resulting from lateral erosion and bed degradation;
- Improve aquatic habitat with bed variability and the use of in-stream structures;
- Stabilize tributaries draining into McIntyre Creek
- Provide educational opportunities (to be directed through Mecklenburg County); and,
- Improve natural aesthetics in a park setting.

The restoration design of McIntyre Creek is based on a Priority Level 1 approach. The design proposes constructing a new meandering channel on the McIntyre Creek floodplain (currently a terrace within the flood prone area of the existing channel). The re-establishment of a riffle-pool sequence and appropriate pool spacing with respect to the channel pattern will be addressed in the profiling of the design channel. In-stream structures have also been incorporated to reduce the burden of energy dissipation on the channel geometry. Cross-Vanes, J-Hook Vanes (J-Vanes), and J-Vane/Log Combination Structures will be used to stabilize the restored channel.

The confluences of the two tributaries within the project reach will be stabilized with grade control structures and step sequences where necessary to match the proposed grade of the restored main channel. A vegetated buffer and bank stabilization measures will also be incorporated in these short connections.

Excavated materials from the design channel will be used to backfill the majority of the existing channel, however a linear depression (oxbow) will remain in the existing channel belt width (from Stations 19+00 to 27+00). This feature will be connected to the restored channel by a low gradient drainage feature above the design bankfull stage. It will improve flood storage and aquatic habitat in the floodplain and it will provide a mechanism to stabilize numerous small tributaries (intermittent and ephemeral) that have been influenced by base level lowering in the McIntyre Creek watershed.

Monitoring shall consist of the collection and analysis of stream stability and riparian/stream bank vegetation survivability data to assist in the evaluation of the project in meeting established restoration objectives. Specifically, the success of channel modification, erosion control and re-vegetation parameters will be assessed using measurements of stream dimension, pattern, and profile, site photographs, and vegetation sampling.

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1.0 INTRODUCTION

1.1 Project Description

The North Carolina Wetlands Restoration Program (WRP) intends to restore a degraded section of McIntyre Creek located within Hornet's Nest Park in Mecklenburg County, North Carolina (Figure 1). This Plan presents detailed information regarding the existing site and watershed conditions, the morphological design criteria developed from a selected reference reach, and the project design parameters based upon natural channel restoration methodologies.

1.2 Project Goals and Objectives

The goals and objectives of the McIntyre Creek Stream Restoration Project are:

- Restore a stable channel morphology that is capable of moving the flows and sediment provided by its watershed;
- Improve water quality and reduce land and riparian vegetation loss resulting from lateral erosion and bed degradation;
- Improve aquatic habitat with bed variability and the use of in-stream structures;
- Stabilize tributaries draining into McIntyre Creek
- Provide educational opportunities (to be directed through Mecklenburg County); and,
- Improve natural aesthetics in a park setting.

1.3 Project Progression

The McIntyre Creek Stream Restoration Project is based on a seven-phase approach from inception through post-construction monitoring (assessment/characterization, reference reach, conceptual design, restoration plan/final design, construction documents/bid package, construction management, and 1st-year monitoring). Phases I-III have been completed and this plan constitutes a major portion of Phase IV.

A summary of Phases I-III is as follows:

- Phase I included the assessment and characterization of the project reach and watershed. This included: the acquisition and analysis of available site and watershed data (using GIS), the detailed geomorphic investigation (Rosgen Level III) and a sediment transport analysis of McIntyre Creek, the review of existing hydrology/hydraulics modeling, a constraints evaluation, and the monitoring of stream/watershed hydrology using gauges and data-loggers;

- Phase II included the identification and assessment of appropriate reference reaches to use as analogs for the restoration of McIntyre Creek. The reference reach approach involves deriving dimensionless ratios based on interrelated stream characteristics of stable streams of similar "type" and disposition as the disturbed stream. These ratios

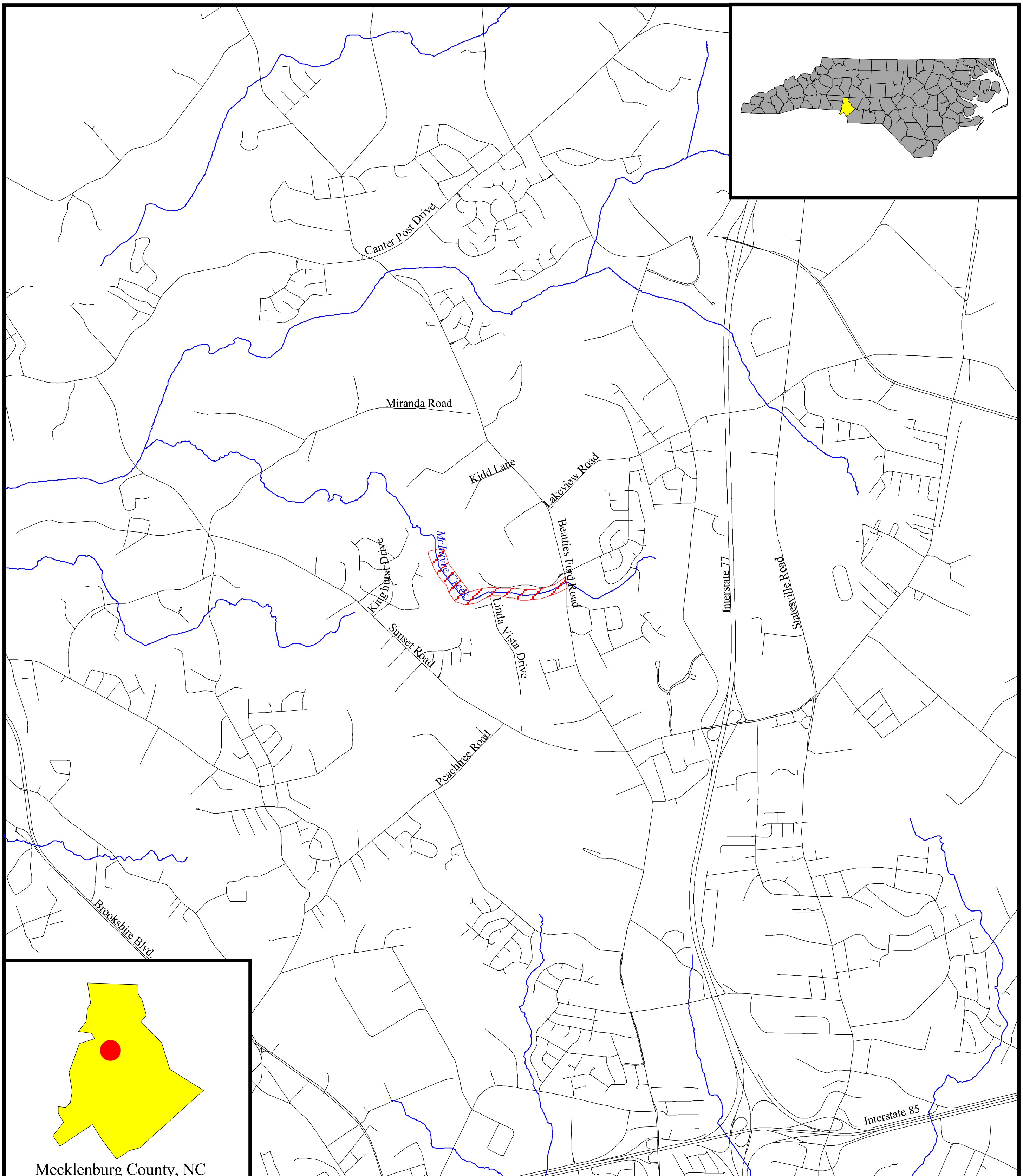

Figure 1: Vicinity Map

Approximate Project Reach
Streams
Roads

N

2000 0 2000 Feet

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serve as the foundation of the design process as they enable the development of morphological design criteria for the subject stream;

- Phase III consisted of the development of design criteria and a conceptual restoration design for presentation to the local stakeholders. The intent of this phase was to elicit comments and recommendations and identify potential problems associated with the general approach to conducting the restoration of McIntyre Creek.

2.0 EXISTING CONDITIONS

2.1 Watershed

2.1.1 General Description

McIntyre Creek is a third-order stream that drains in a westerly direction to Long Creek, which eventually joins the Catawba River to the southwest. The project watershed is located in the Piedmont physiographic province with elevations ranging from 840 feet above mean sea level (AMSL) to 700 feet AMSL over a longitudinal distance of 2.5 miles (1.1% mean slope from headwaters to downstream project limit). Refer to Figure 2.

The drainage area of the project reach at the upstream limits is 1.79 square miles. An additional 0.76 square miles (2.55 square miles total) drains to McIntyre Creek in the lower portion of the project reach (immediately below the gas pipeline crossing).

2.1.2 Surface Water Classification

The North Carolina Division of Water Quality (DWQ) assigns surface waters a classification in order to help protect, maintain, and preserve water quality. McIntyre Creek (NCDWQ Stream Index Number 11-120-3-(1)), in Hornet's Nest Park, is designated as a class C water body (NCDENR, 2002). Class C is a baseline water quality classification, intended to protect water resources for fishing, wildlife, fish and aquatic life propagation and survival, agriculture, and secondary recreation. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner. There are no restrictions on watershed development or types of discharges.

2.1.3 Geology and Soils

Local geology consists of intrusive rocks of the Charlotte Belt. These include metamorphosed quartz diorite, quartzite, metamorphosed mafic rock, and granitic rock.

Predominant soil types found within the project watershed include Cecil sandy clay loam (CeB, CeD), Enon sandy loam (EnB, EnD), and Monacan loam (MO). Refer to Figure 3.

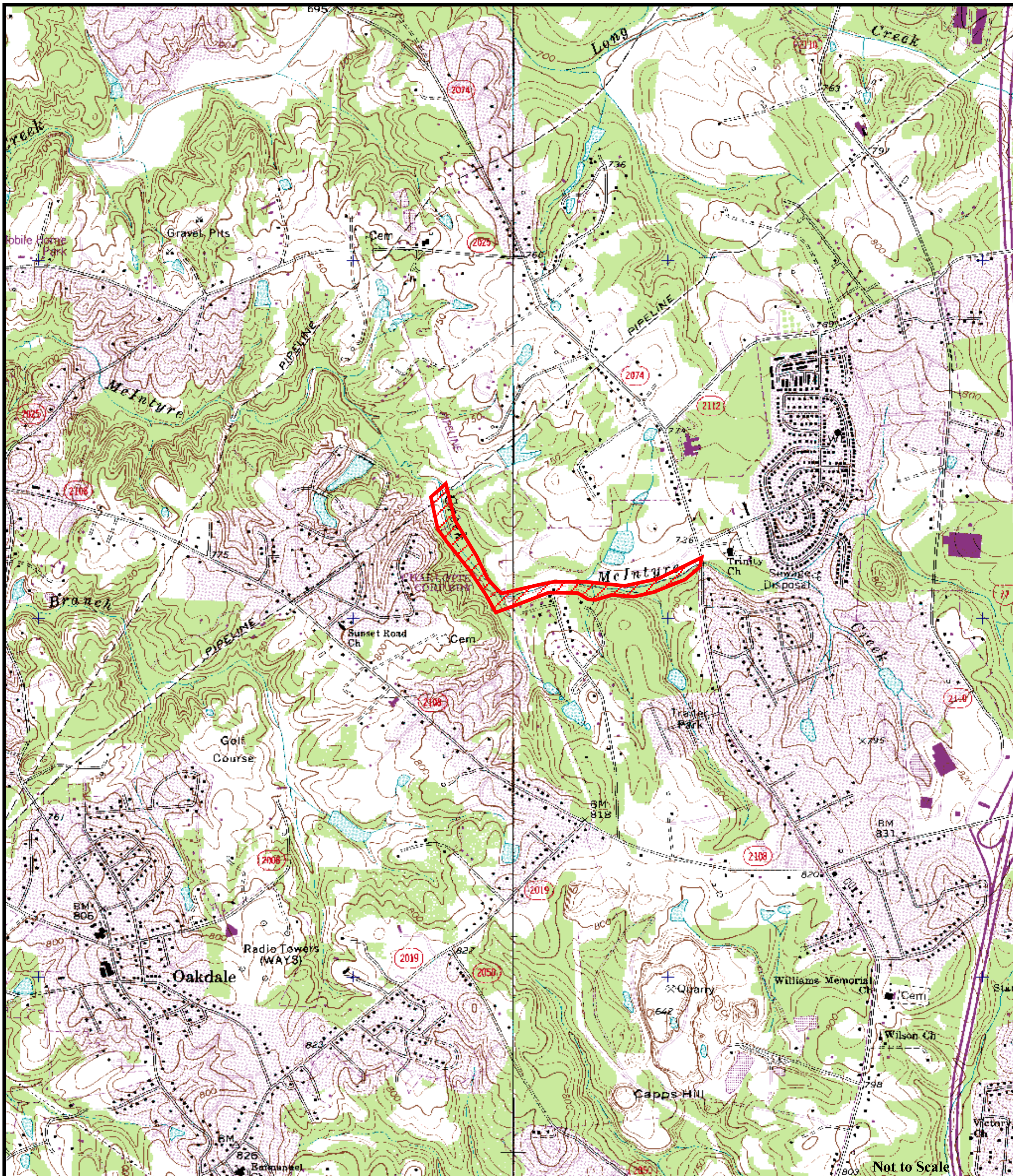

Figure 2: Local Topography Map

Approximate Project Reach

Derita and Mountain Island Lake Topo Quads

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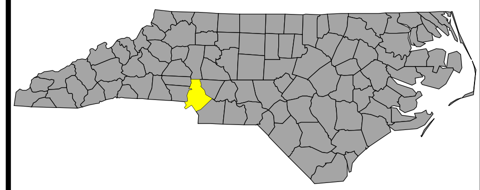

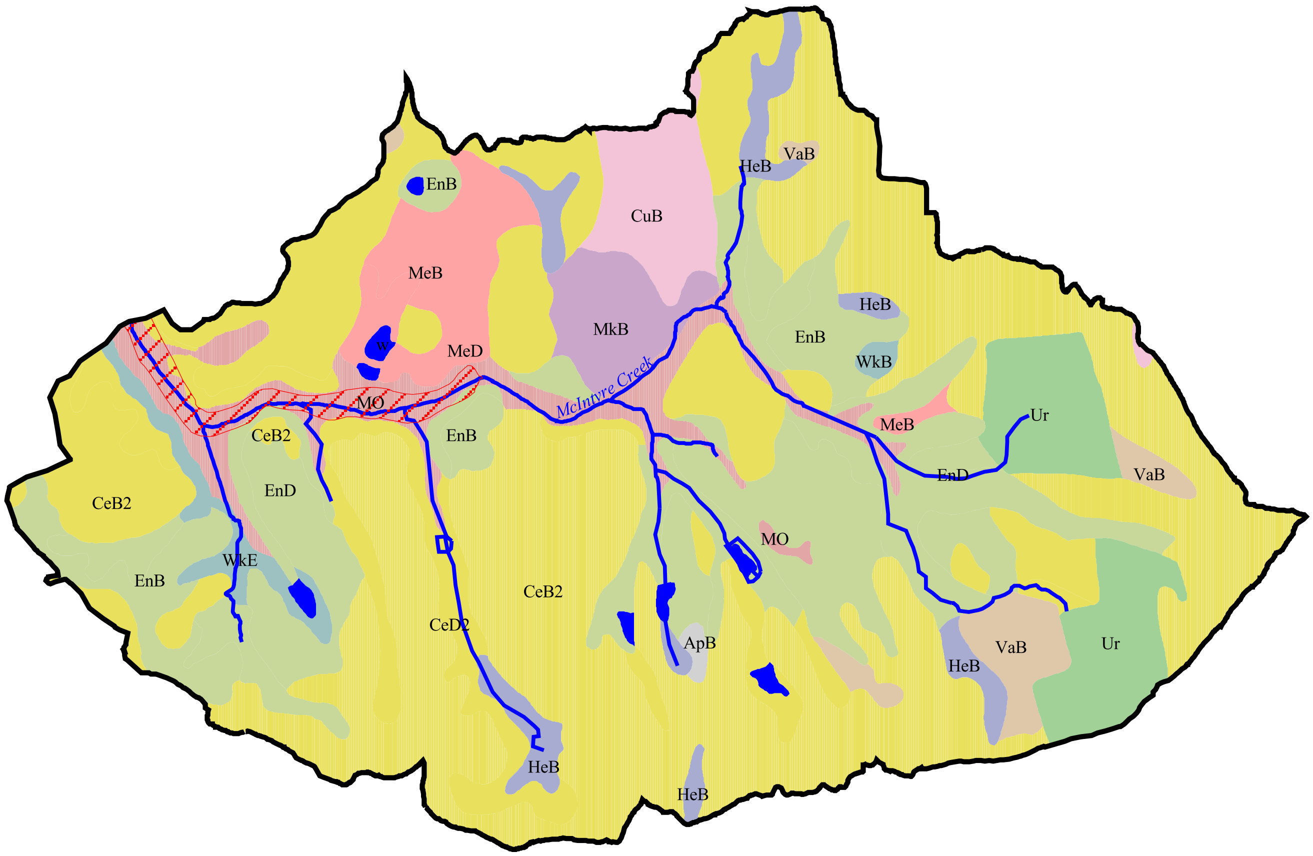

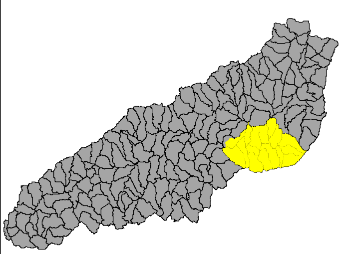

Long Creek Local Watershed

Source: Center for Geographic Information and Analysis

N

1000 0 1000 Feet

Figure 3: Watershed Soils

- Appling sandy loam (ApB)
- Cecil sandy clay loam (CeB, CeD)
- Cecil urban land complex (CuB)
- Enon (EnB, EnD)
- Helena sandy loam (HeB)
- Mecklenburg (Meb, MeD)
- Mecklenburg urban land (MkB)
- Monacan loam (MO)
- Urban land (Ur)
- Vance sandy loam (VaB)
- Wilkes loam (WkB, WkE)
- Water (w)
- Streams
- Project Reach
- Project Reach Drainage

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Cecil sandy clay loam is a well-drained soil commonly occurring on broad, smooth ridges on uplands. Slopes range from 2 to 15 percent. The surface layer (6 inches) is composed of yellowish red sandy clay. Organic matter content is low, and permeability is moderate. The subsoil (47 inches) is composed of red clay and red clay loam. The underlying material to a depth of 65 inches is red and yellow loam.

Enon sandy loam is a well-drained soil commonly occurring on broad ridges and side slopes on uplands. Slopes range from 2 to 15 percent. The surface layer (7 inches) is composed of brown sandy loam. Organic matter content is low, and permeability is slow. The subsoil (29 inches) is composed of yellowish-brown sandy clay loam, yellowish-brown clay, and yellowish-brown clay loam. The underlying material to a depth of 60 inches is olive brown clay loam and sandy loam.

Monacan loam is a somewhat poorly-drained, nearly level soil commonly occurring on floodplains. The surface layer is composed of brownish loam, fine sandy loam, or sandy loam. Organic matter content is low, and permeability is moderate. The subsoil is composed of reddish loam, brownish/grayish silty clay loam, fine sandy loam, sandy clay loam, and sandy clay. Although not classified as hydric, Monacan soils may contain hydric inclusions in poorly-drained areas and in depressions adjoining uplands.

2.1.4 Land Use

Land use within the watershed consists of 18% high-density urban, 33% low-density urban, 36% forest, 12% open space, and 1% water (Figure 4 & 5). Historical trends and current observations indicate that land use will continue to shift toward higher amounts of urban development and lower amounts of forest and open space.

2.2 Restoration Site

2.2.1 Site Description

The McIntyre Creek project reach includes a total of 4,730 linear feet of stream (main stem). Beginning at Beatties Ford Road (SR 2074), the stream flows west for 3,250 linear feet to a gas pipeline crossing, then northwest for 1,480 linear feet to a second pipeline crossing near Gemway Drive. Throughout this reach, McIntyre Creek flows adjacent to or within the boundaries of Hornet's Nest Park (Figure 6). Two tributaries and several other ephemeral channels join the stream within the project area. The first ("Tributary #1) joins at Station 21+30 (1,130 feet downstream of Beatties Ford Road). The second ("Tributary #2") flows into McIntyre Creek in the lower portion of the site near existing Station 43+20.

McIntyre Creek is situated in a Type-VIII valley (Rosgen, 1996). This valley type is defined as broad and gently sloping, with alluvial terraces. The floodplain of McIntyre Creek varies in width from approximately 300 feet to greater than 1,000 feet. The flood plain is generally narrower (300 to 600 feet) in the upper reach, and widens (500 to 1000+ feet) downstream of the second tributary.

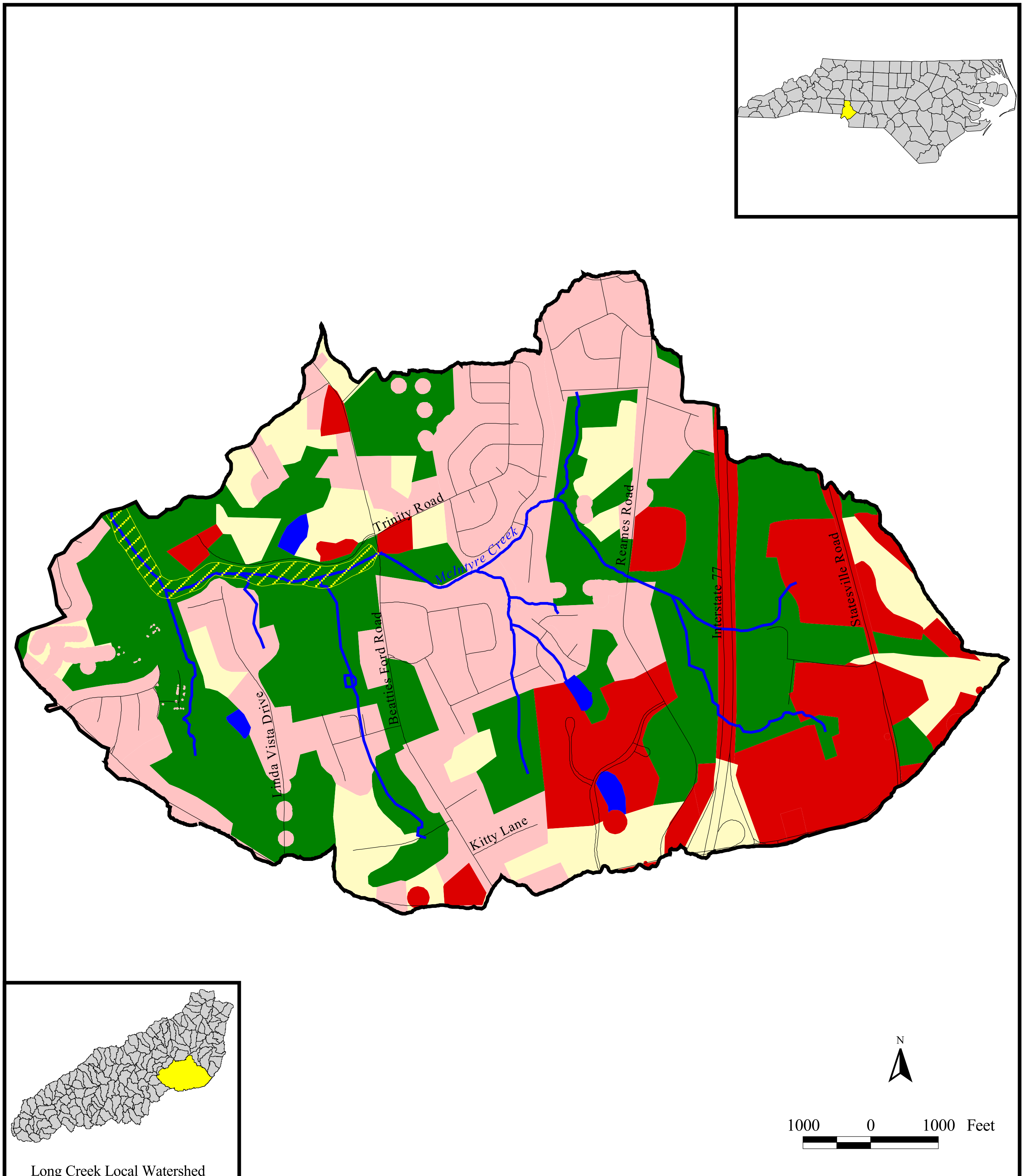

Figure 4. Watershed Existing Land Use/Land Cover

Open Space
Forest
Water
Urban High
Urban Low
Roads
Streams
Project Reach
Project Reach Drainage

Source: Mecklenburg County Engineering and Building Standards Department Mapping/GIS Services Division

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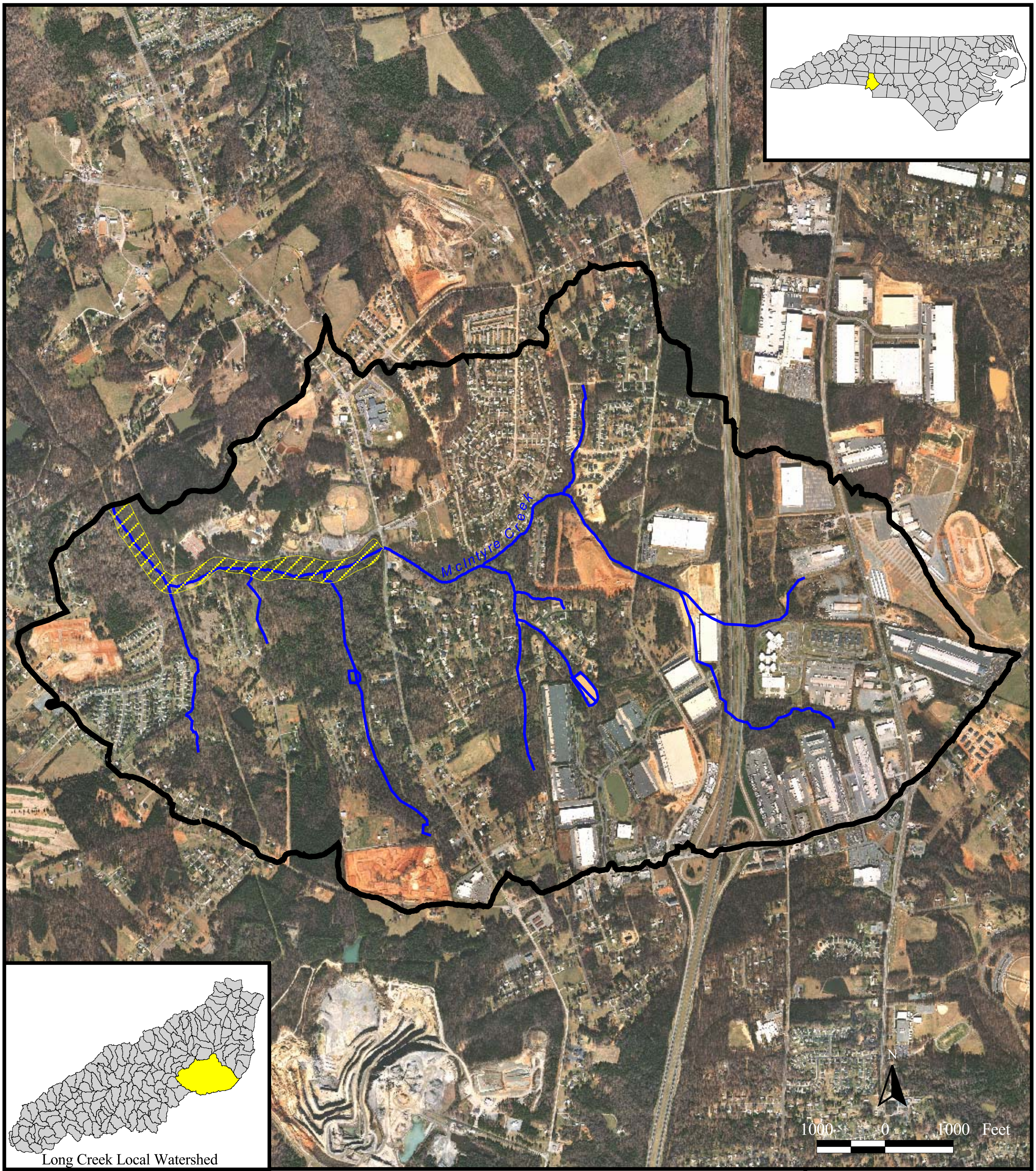

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Figure 5. Watershed 1999 Aerial

Project Reach
Streams
Project Reach Drainage
Watershed Area: 2.97 sq. miles

Source: Mecklenburg County Engineering and Building Standards Department Mapping/GIS Services Division

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Property Owners

1 - Timothy W. Kissee
2 - Mecklenburg County
3 - Mecklenburg County
4 - Belk B V Investment LTD
5 - Paul D. Blakley
6 - Paul D. Blakley
7 - Paul D. Blakley
8 - Tiara N. Mosley
9 - Kathleen T. Johnson
10 - Mary E. Mowry
11 - Selective Development LLC
12 - University Park Baptist Church
13 - Kerns Lee Monroe Trust (B/W)

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Figure 6. Project Reach Parcels

Project Reach
Streams
Parcels (June 2002)

N
300 0 300 Feet

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Source: Mecklenburg County Engineering and Building Standards Department Mapping/GIS Services Division

The predominant soil type in the project reach is Monacan loam, with some Cecil sandy clay loam (eroded) and Enon sandy loam occasionally present in the terrace areas. Refer to Section 2.1.3 for detailed descriptions.

The natural community identified in the riparian areas adjacent to McIntyre Creek is Piedmont Levee Forest (Schafale and Weakley, 1990). Common overstory tree species include red maple (*Acer rubrum*), boxelder (*Acer negundo*), sweetgum (*Liquidambar styraciflua*), American sycamore (*Platanus occidentalis*), and green ash (*Fraxinus pennsylvanica*). Understory trees and shrubs include slippery elm (*Ulmus rubra*), American elm (*Ulmus americana*), boxelder, silky dogwood (*Cornus amomum*), shagbark hickory (*Carya ovata*), pecan (*Carya illinoensis*), common spicebush (*Lindera benzoin*), and tall pawpaw (*Asimina triloba*). Diameter at breast height (DBH) of overstory trees ranged from 2 to 17 inches, with an average of 7 inches.

2.2.2 Bankfull Verification

The inter-related sequence that has become the standard methodology for natural channel design ("40 Steps," Rosgen, 2002) is based on the ability to select the appropriate bankfull discharge and generate the corresponding bankfull hydraulic geometry from a stable reference system. Thus, the determination of bankfull stage is the most critical component of the natural channel design (NCD) process.

Bankfull can be defined as "the stage at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of the channels," (Dunne and Leopold, 1978). Several characteristics that commonly indicate the bankfull stage include: incipient point of flooding, breaks in slope, changes in vegetation, highest depositional features (i.e. point bars), and highest scour line (indicator used at McIntyre Creek). Despite the relative ease with which this topic is discussed, the identification of bankfull stage, in general, let alone in a degraded urban system like the project reach, can be problematic. Therefore, verification measures must be taken to ensure the correct identification of the bankfull stage.

The two methods used to verify bankfull stage at McIntyre Creek were regional hydraulic geometry relationships (regional curves) and a pressure transducer / data logger combination gauge that monitored actual water level in McIntyre Creek throughout the study period.

Regional curves are typically utilized in ungauged areas to approximate bankfull discharge, area, width, and depth as a function of drainage area based on inter-related variables from other similar streams in the same hydrophysiographic province. Regional curves and corresponding equations from "Hydraulic Geometry Relationships for Urban Streams Throughout the Piedmont of North Carolina" (Doll et al, 2002) were used to verify bankfull at the project reach. McIntyre Creek plotted below the regressed power function line for bankfull cross-sectional area, however the data point plotted within the 95% confidence limits (Figure 7.).

Stream stage data (water levels) were collected in the lower portion of the project reach at a location near existing Station 45+50. Data was collected for three months (June through September) and water levels were correlated to an estimated discharge using a rating curve generated for the gauged section (Figure 8). Two significant flow events occurred during the monitoring period. On July 14th, McIntyre Creek in the vicinity of the gauge was discharging approximately 207 ft^3/s and on August 16th, it discharged approximately 235 ft^3/s. The second discharge had a maximum depth of 4.35 feet (3.75' above transducer) and reached a stage approximately 0.3 feet below the highest scour line (bankfull). Based on the monitoring data, the bankfull stage identified in the field is valid. In McIntyre Creek, the flood frequency curve has clearly shifted left and bankfull discharge is occurring on a more frequent basis than that typically experienced in rural watersheds (1.4 years, on average).

2.2.3 Existing Stream Characteristics

A Rosgen Level III assessment of McIntyre Creek was conducted in June 2002. Representative channel cross-sections were surveyed at four locations in McIntyre Creek, one location in Tributary 1 (riffle), and two locations in Tributary 2 (riffle and pool). These data are presented in Appendix 1 and are summarized in Table 1 below. Photo-documentation is included in Appendix 2.

Table 1. Summary of Existing Channel Morphology

LOCATION / PARAMETER	McIntyre XS-1, Riffle	McIntyre XS-2, Pool	McIntyre XS-3, Run	McIntyre XS-4, Riffle	Trib. 1 XS-1, Riffle	Trib. 2 XS-1, Riffle	Trib. 2 XS-2, Pool
A_{bkf} (sq ft)	42.1	44.2	64.9	58.6	7.0	11.6	13.9
W_{bkf} (ft)	17.0	14.1	23.7	23.8	6.4	9.1	8.8
W_{fpa} (ft)	> 100	>200	>200	>200	>50	11.1	12.3
d_{mbkf} (ft)	3.1	4.1	4.5	3.7	1.7	1.6	3.0
D_{bkf} (ft)	2.5	3.1	2.7	2.5	1.1	1.3	1.6
W/D ratio	6.9	4.5	8.6	9.7	5.8	7.0	5.5
Entrenchment Ratio	> 6	> 14	> 8	> 8	> 8	1.2	1.4
Bank Height Ratio	1.9	1.5	1.3	1.4	1.0	2.7	1.8
Local W. S. Slope (ft/ft)	0.004	0.003	0.002	0.003	0.005	0.005	0.002
Discharge (cfs)	190	190	260	260	23	43	37
D_{50} (mm)	0.3	0.2	0.3	0.3	< 0.1	0.2	0.1
Stream Type	E5	E5	E5	E5	E6	G5c	G5c

2.2.4 Stability Assessment

The Rosgen Level III assessment is also referred to as the "stream state or condition," stage in the hierarchy of river inventory (Rosgen, 1996). This technique assesses the stability of streams by investigating various parameters such as channel dimension and

Figure 7. McIntyre Creek/UTLJ Reference Reach Data Points Plotted on (North Carolina) Urban Piedmont Regional Curve

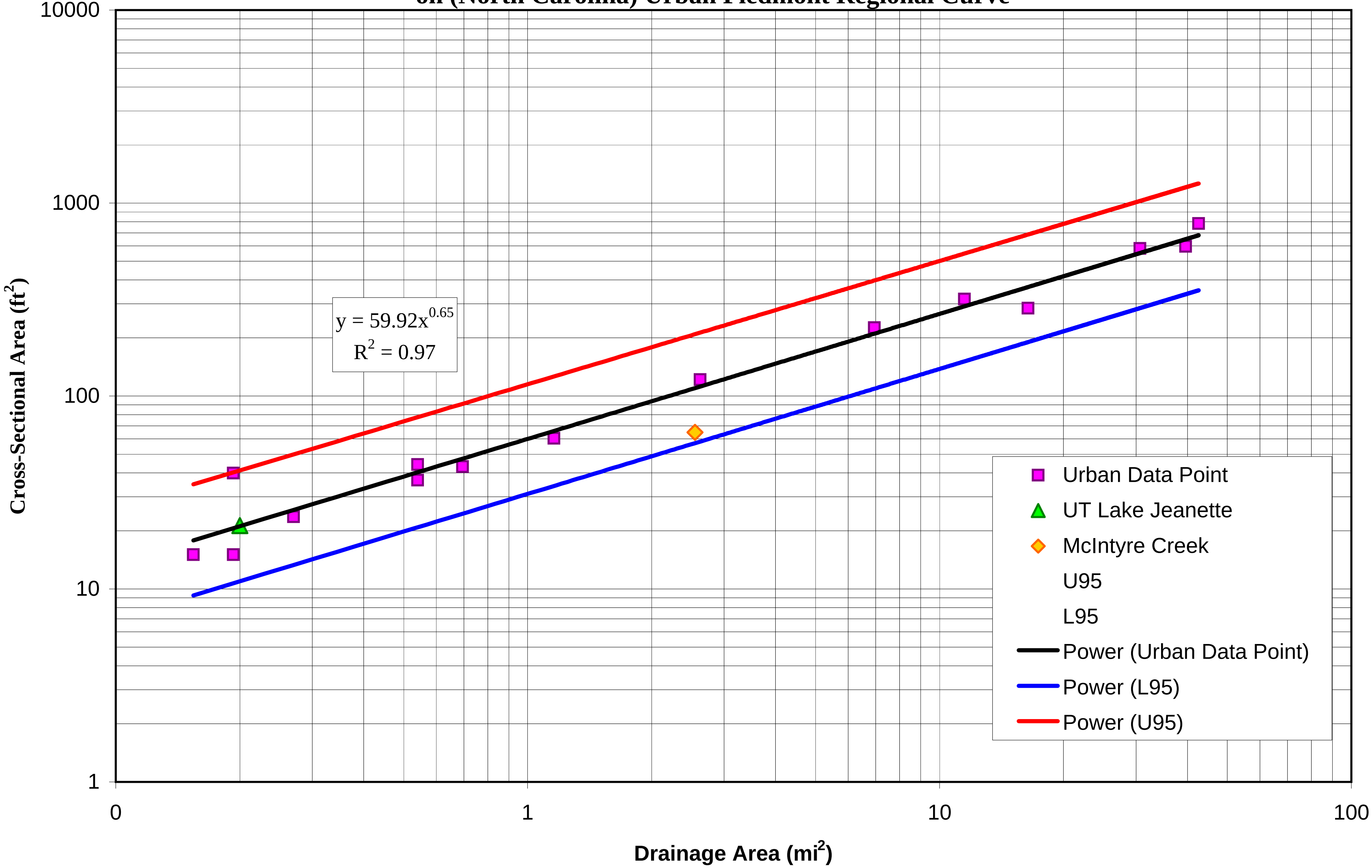
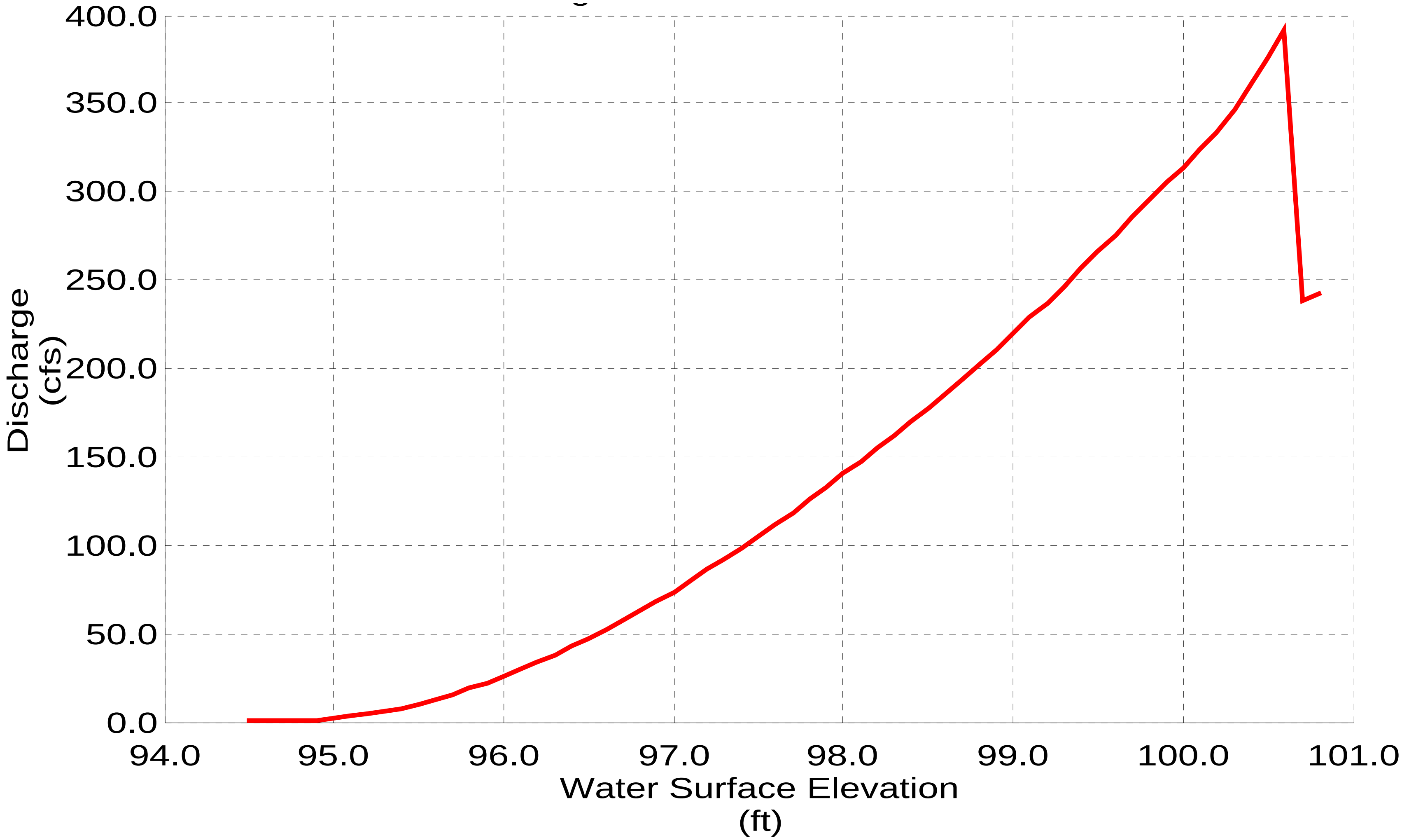


Figure 8. Rating Curve for McIntyre Creek Stream Gauge
Near Cross-Section #3



pattern (W/D_{site} compared with $W/D_{reference}$; Meander Width Ratio), lateral stability (BEHI), vertical stability (Bank Height Ratio), sediment supply and transport, and evolution scenario.

Width-to-depth ratio comparisons with reference reach values were consistently less than 1.0 in the upper portion of the project reach (0.55 - 0.85). Bank height ratios ranged from 1.4 to 1.9 in the same area indicating that bed degradation is occurring. In several areas, the stream has down cut to a dense clay layer, which has retarded bed degradation and headward migration. Several small head cuts (12 to 18 inches) were identified between Stations 10+00 and 30+00. They have also been slowed by the presence of dense clay or large woody debris temporarily acting as grade control. Base level lowering is present throughout the upper portion of the project reach as small feeder channels have head cuts that are actively moving up valley.

Bank Erosion Hazard Index (BEHI) scores ranged from 34 to 39 indicating a high potential for bank erosion and widening in the upper project reach. Sediment supply is high and sources include eroding banks and tributary inflows carrying fine materials from local construction sites. A potential stream evolutionary cycle in the upper portion of the project site indicates a change from an “E” to a “G,” which will eventually transition to an “F” before re-stabilizing as a “C” then an “E.” It is the intent of the restoration to create a stable “E5” channel type that accesses its floodplain on the adjacent terrace to the north.

Width-to-depth ratio comparisons with reference reach values suggest that the channel below the pipeline crossing (lower project reach) is approaching stability. Values ranging from 1.05 to 1.2 indicate that no significant widening or down cutting is occurring. Bank height ratios ranging from 1.2 to 1.4 indicate past problems of bed degradation, however the formation of new floodplain benches shows that the channel is beginning to recover. The channel is slightly more sinuous in the expanded belt width. BEHI scores (13 – 28) indicate low to moderate potential for erosion compared to high values above the pipeline. High sediment inputs from upstream are evident, however inputs from local bank erosion are reduced in this section. Over an unspecified period of time, it appears that this section will slowly expand its belt width and form a new channel and floodplain at a lower elevation.

2.2.5 Constraints

The following are a list of documented constraints that were considered in the development of a restoration strategy for McIntyre Creek in Hornet’s Nest Park (See Appendix 2 for photo-documentation):

- Presence of a subsurface sewer line that runs parallel and adjacent to the south bank of McIntyre Creek for the entire length of the project area. This line is associated with a 25-foot wide maintained easement corridor.
- A new sanitary sewer line was designed for the Mecklenburg County Parks and Recreation Department. This 8” line will cross McIntyre Creek, with an invert

elevation between 715.10’ and 715.15’ (top elevation approximately 716.00’) depending on the exact alignment of McIntyre Creek. Ted Sanchez of Cole Jenest and Stone stated that the proposed sewer line would be exposed in the existing bed of McIntyre Creek.

- Presence of a subsurface natural gas pipeline that crosses the stream channel near existing Station 42+30. Stream channel construction in the vicinity of the pipeline will require additional care.
- Presence of a black ABS conduit exposed in the south stream bank (near existing Station 10+00). It is likely that the conduit houses utility service lines.
- Presence of a flying disc golf course (2 disc catchers) immediately adjacent to the north stream bank between existing Stations 27+50 and 32+50.

2.2.6 Rare, Threatened, and Endangered Species

A review of the North Carolina Natural Heritage Program (NCNHP) database of rare species and unique habitats showed no occurrences of federally-protected species within one mile (1.0) of the project area (HDR, 2001).

3.0 REFERENCE REACH ANALYSIS

A reference reach is a channel with a stable dimension, pattern, and profile within a particular valley morphology. The reference reach is used to develop dimensionless morphological ratios (based on bankfull stage) that can be extrapolated to disturbed/unstable streams to restore a stream of the same type and disposition as the reference stream (Rosgen, 1998).

3.1 Unnamed Tributary to Lake Jeanette (UTLJ)

UTLJ, a first order urban stream located north of Greensboro, was selected as the reference reach for the restoration of McIntyre Creek. UTLJ flows south into the western end of Lake Jeanette (also referred to as Richland Lake; Figure 9). It drains approximately 0.2 square miles of predominantly low-density residential land use with the remaining land consisting primarily of forest.

This selection was based on: location in the same hydrophysiographic province, similar valley morphology, and similar sediment regime as the project site. The valley slope (0.55%) is marginally steeper (+0.2%) than at McIntyre Creek and the sediment distribution is nearly identical (d_{50}: 0.2 - 0.3 compared with 0.5 millimeters; d_{84}: 4 - 12 compared with 3 - 5 millimeters). Local topography is characterized by rolling hills, which is consistent with landforms found at McIntyre Creek and throughout the Piedmont province and the reference reach and the project site are both located in the Charlotte Belt.

Approximately 300 linear feet of the UTLJ were surveyed in August, 2002 (Appendix 3 contains supporting documentation from the field assessment). UTLJ was classified as

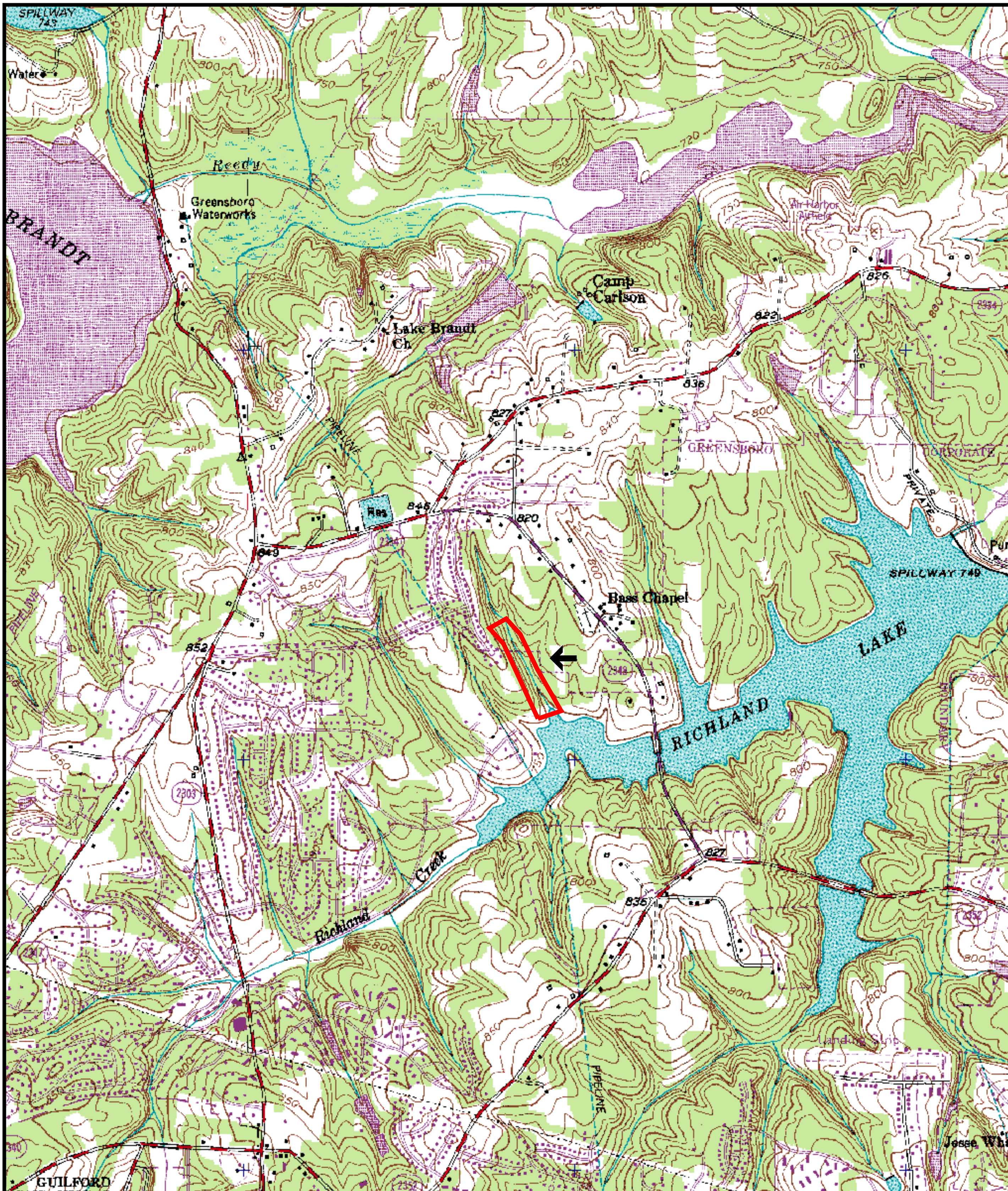


Figure 9. Reference Reach Location Map

UT to Lake Jeanette (Richland Lake) - Reference Reach

Lake Brandt Topo Quad

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an “E5” channel type. The morphological variables are included as part of Table 2 in the Natural Channel Design section of this report. Dimensionless hydraulic geometry relationships were developed from stable channel dimensions to facilitate the design of the proposed channel cross-sections for McIntyre Creek. Representations of the dimensionless relationships are depicted in Figure 10.

4.0 NATURAL CHANNEL DESIGN

4.1 Design Methodology

Different scenarios require different approaches with respect to stream restoration design in degraded systems. In “A Geomorphological Approach to Restoration of Incised Rivers (Rosgen, 1997),” four priority levels of restoration are described with accompanying explanations of channel type conversion and the advantages and disadvantages of each method. Refer to Figure 11.

4.2 McIntyre Creek Restoration Design

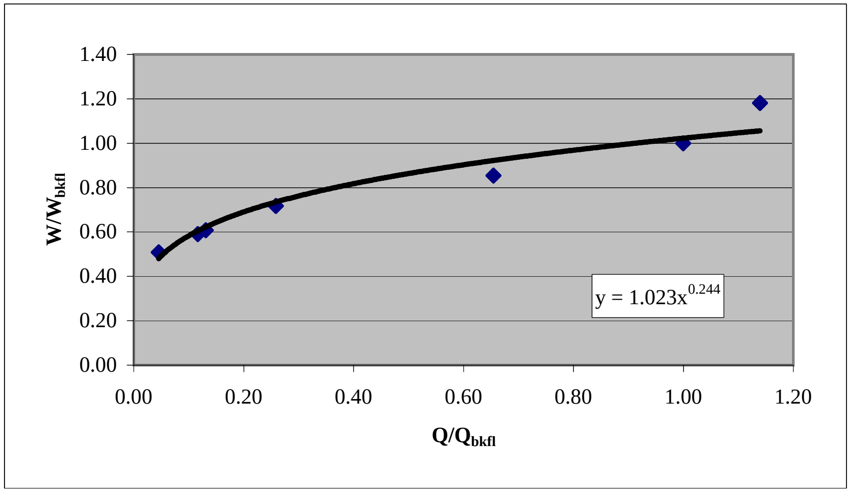
The restoration design of McIntyre Creek is based on a Priority Level 1 approach. The design proposes constructing a new meandering channel on the McIntyre Creek floodplain (currently a terrace within the flood prone area of the existing channel). Refer to Figures 12 (a.-e.) for the proposed channel pattern and profile.

The design bankfull stage will equal the floodplain elevation in the new channel (bank height ratio = 1.0). The channel dimensions reflect slightly wider and shallower cross-sections, as the width-depth ratio increases from 4 - 7 to 8.1 in the degrading upper portion of the project reach. The proposed bankfull widths are 18.7 and 22.9 feet respectively (upper/lower sections) and the mean / maximum depths are 2.3 / 3.3 - 3.5 and 2.8 / 4.0 feet (Figure 13). The range of dimensionless ratios for meander length (5.0 – 10.0) and radius of curvature (2.0 - 3.0) have been increased resulting in longer meander lengths and higher meander radii of curvature. This shift is necessary to accommodate for the absence of immediate mature vegetation to stabilize stream banks (these ratios are slightly lower in the reference reach, which has extensive mature woody vegetation in the riparian zone). The re-establishment of a riffle-pool sequence and appropriate pool spacing with respect to the channel pattern will be addressed in the profiling of the design channel. Refer to Table 2 for detailed morphological criteria.

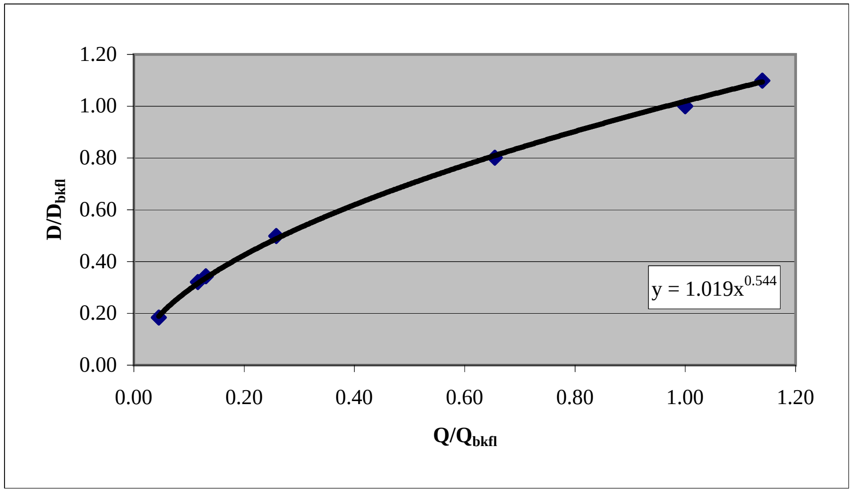
In-stream structures have also been incorporated to reduce the burden of energy dissipation on the channel geometry. Cross-Vanes, J-Hook Vanes (J-Vanes), and J-Vane/Log Combination Structures will be used to stabilize the restored channel. These structures are designed to reduce bank erosion and the influence of secondary circulation in the near-bank region of stream bends. The structures further promote efficient sediment transport and produce/enhance in-stream habitat. Cross-vanes will serve as grade control in the restored channel. Figure 14 depicts design details for the in-stream structures.

Figure 10. Dimensionless Hydraulic Geometry
UT to Lake Jeanette
"E5" Stream Type
DA = 0.2 mi^2 Qbkfl = 82 ft^3/s

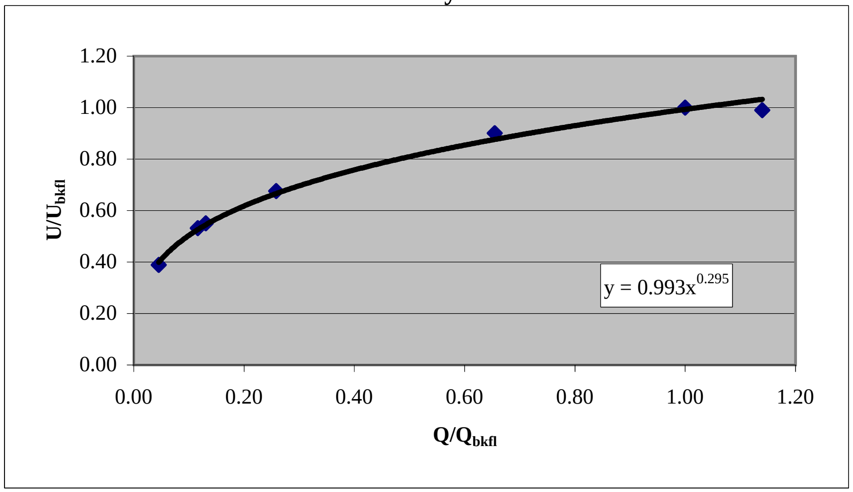
Width



Depth



Velocity



Area

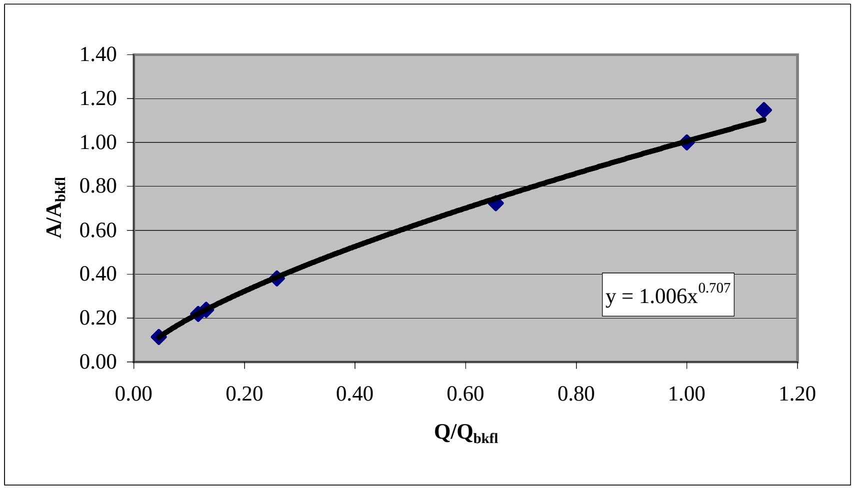
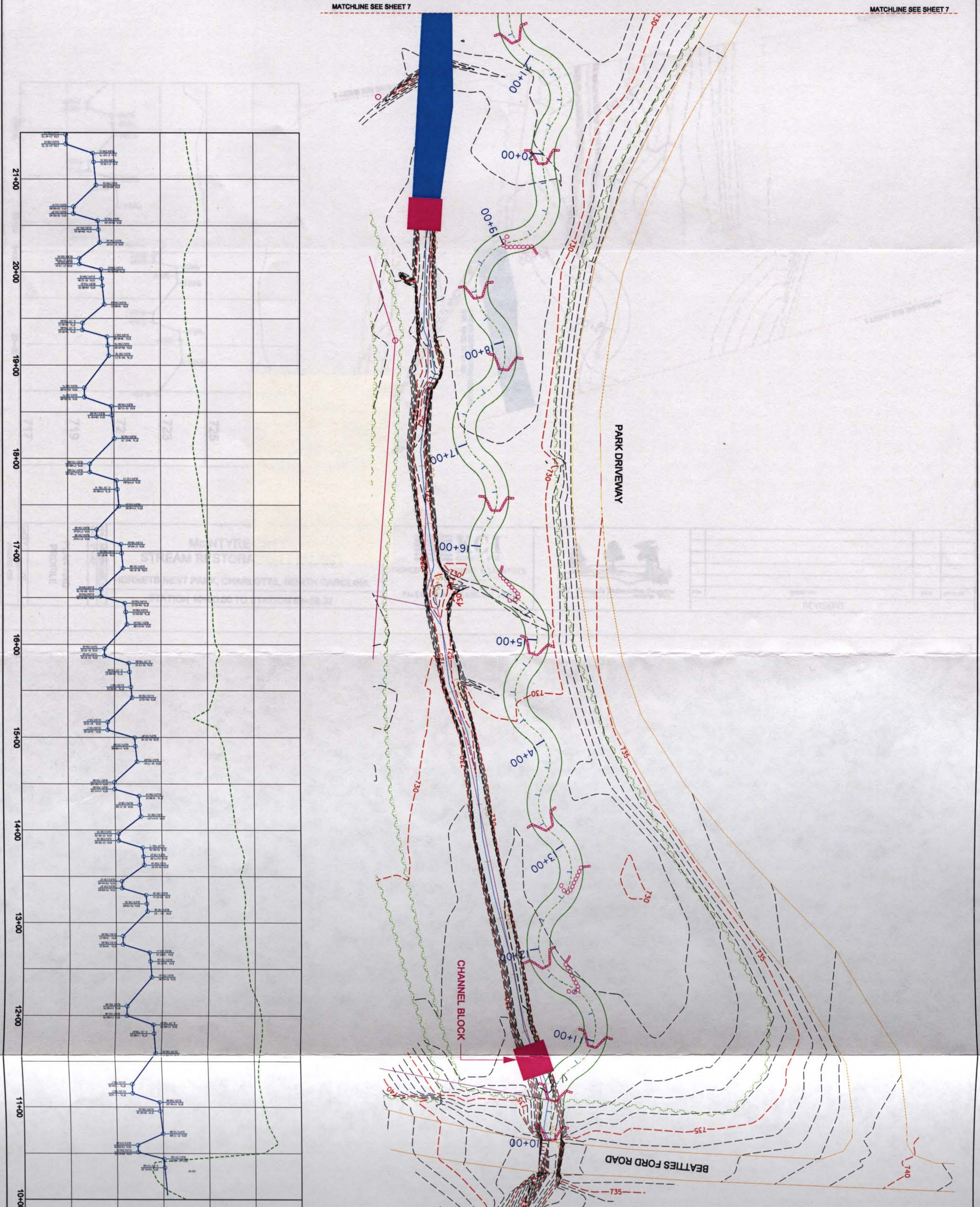


Figure 11. Priority Levels of Incised River Restoration.

DESCRIPTION	METHODS	ADVANTAGES	DISADVANTAGES
PRIORITY 1 Convert G and/or F stream types to C or E at previous elevation with floodplain.	Re-establish channel on previous floodplain using relic channel or construction of new bankfull discharge channel. Design new channel for dimension, pattern, and profile characteristic of stable form. Fill in existing incised channel or with discontinuous oxbow lakes level with new floodplain elevation.	Re-establishment of floodplain and stable channel: 1) reduces bank height and streambank erosion, 2) reduces land loss, 3) raises water table, 4) decreases sediment, 5) improves aquatic and terrestrial habitats, 6) improves land productivity, and 7) improves aesthetics.	1) Floodplain re-establishment could cause flood damage to urban, agricultural, and industrial development. 2) Downstream end of project could require grade control from new to previous channel to prevent head-cutting.
PRIORITY 2 Convert F and/or G stream types to C or E. Re-establishment of floodplain at existing level or higher, but not at original level.	If belt width provides for the minimum meander width ratio for C or E stream types, construct channel in bed of existing channel, convert existing bed to new floodplain. If belt width is too narrow, excavate streambank halls. End-haul material or place in streambed to raise bed elevation and create new floodplain in the deposition.	1) Decreases bank height and streambank erosion, 2) Allows for riparian vegetation to help stabilize banks, 3) Establishes floodplain to help take stress off of channel during flood, 4) Improves aquatic habitat, 5) Prevents wide-scale flooding of original land surface, 6) Reduces sediment, 7) Downstream grade transition for grade control is easier.	1) Does not raise water table back to previous elevation. 2) Shear stress and velocity higher during flood due to narrower floodplain. 3) Upper banks need to be sloped and stabilized to reduce erosion during flood.
PRIORITY 3 Convert to a new stream type without an active floodplain, but containing a floodprone area. Convert G to B stream type, or F to Bc.	Excavation of channel to change stream type involves establishing proper dimension, pattern, and profile. To convert a G to B stream involves an increase in width/depth and entrenchment ratio, shaping upper slopes and stabilizing both bed and banks. A conversion from F to Bc stream type involves a decrease in width/depth ratio and an increase in entrenchment ration.	1) Reduces the amount of land needed to return the river to a stable form. 2) Developments next to river need not be relocated due to flooding potential. 3) Decreases flood stage for same magnitude flood. 4) Improves aquatic habitat.	1) High cost of materials for bed and streambank stabilization. 2) Does not create the diversity of aquatic habitat. 3) Does not raise water table to previous levels.
PRIORITY 4 Stabilize channel in place.	A long list of stabilization materials and methods have been used to decrease streambed and streambank erosion, including concrete, gabions, boulders, and bioengineering methods.	1) Excavation volumes are reduced. 2) Land needed for restoration is minimal.	1) High cost for stabilization. 2) High risk due to excessive shear stress and velocity. 3) Limited aquatic habitat depending on nature of stabilization methods used.

Source: Rosgen, 1997, “A Geomorphological Approach to Restoration of Incised Rivers”.



McINTYRE CREEK STREAM RESTORATION PROJECT

HORNETS NEST PARK, CHARLOTTE, NORTH CAROLINA

STATION 10+00.00 TO STATION 63+58.37

PLAN AND PROFILE

DATE: NOVEMBER, 2002

SCALE: 1" = 40'

SHEET OF

FIGURE 12A

KCI ASSOCIATES OF NC

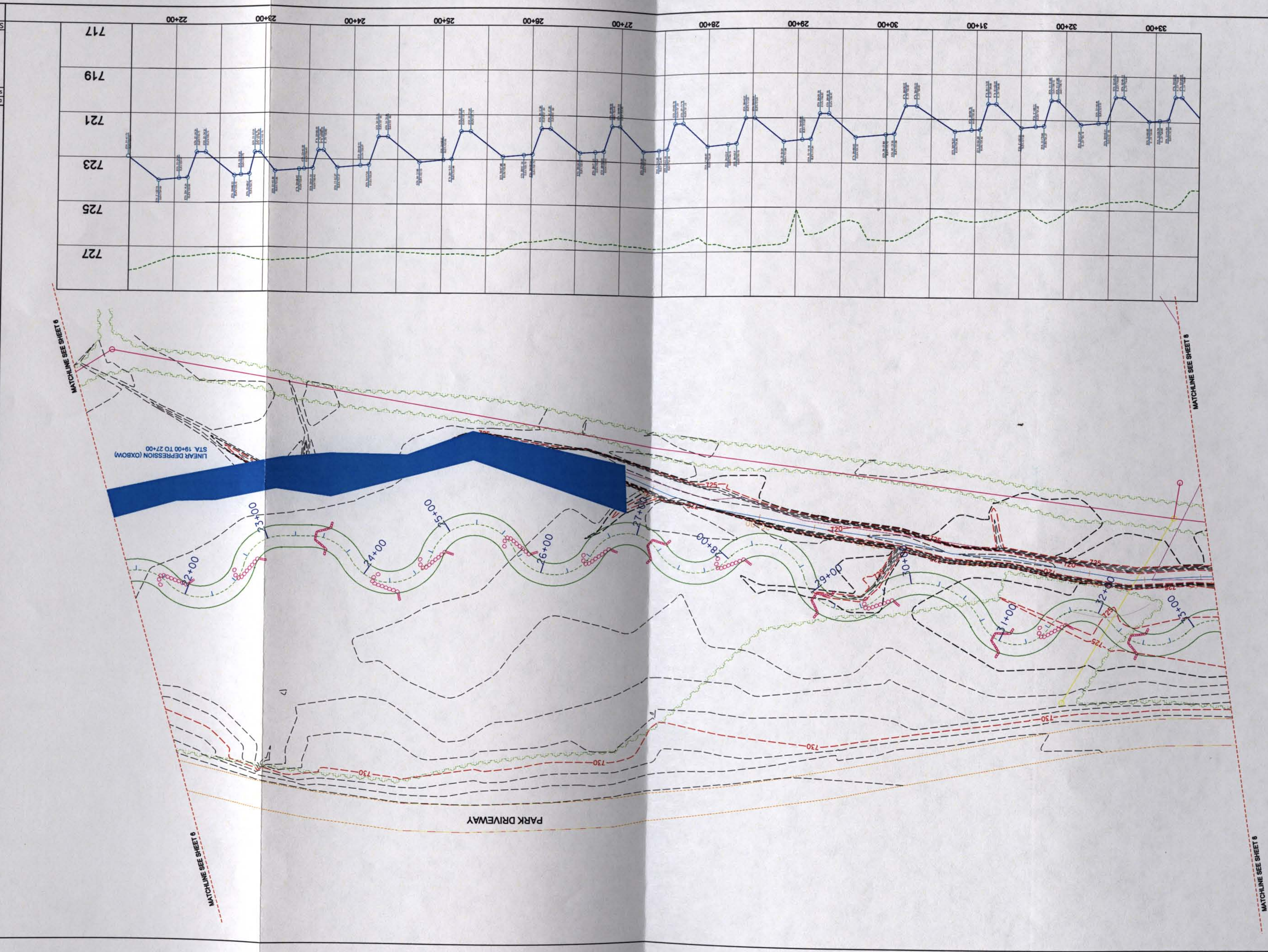
ENGINEERS • PLANNERS • SCIENTISTS

4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

N.C. Wetlands Restoration Program

SYM.	DESCRIPTION	DATE	APPROVED

REVISIONS



McINTYRE CREEK
STREAM RESTORATION PROJECT
HORNETS NEST PARK, CHARLOTTE, NORTH CAROLINA
STATION 10+00.00 TO STATION 63+58.37

PLAN AND PROFILE

DATE: NOVEMBER, 2002
SCALE: 1" = 40'
SHEET OF
FIGURE 12B

KCI ASSOCIATES OF NC
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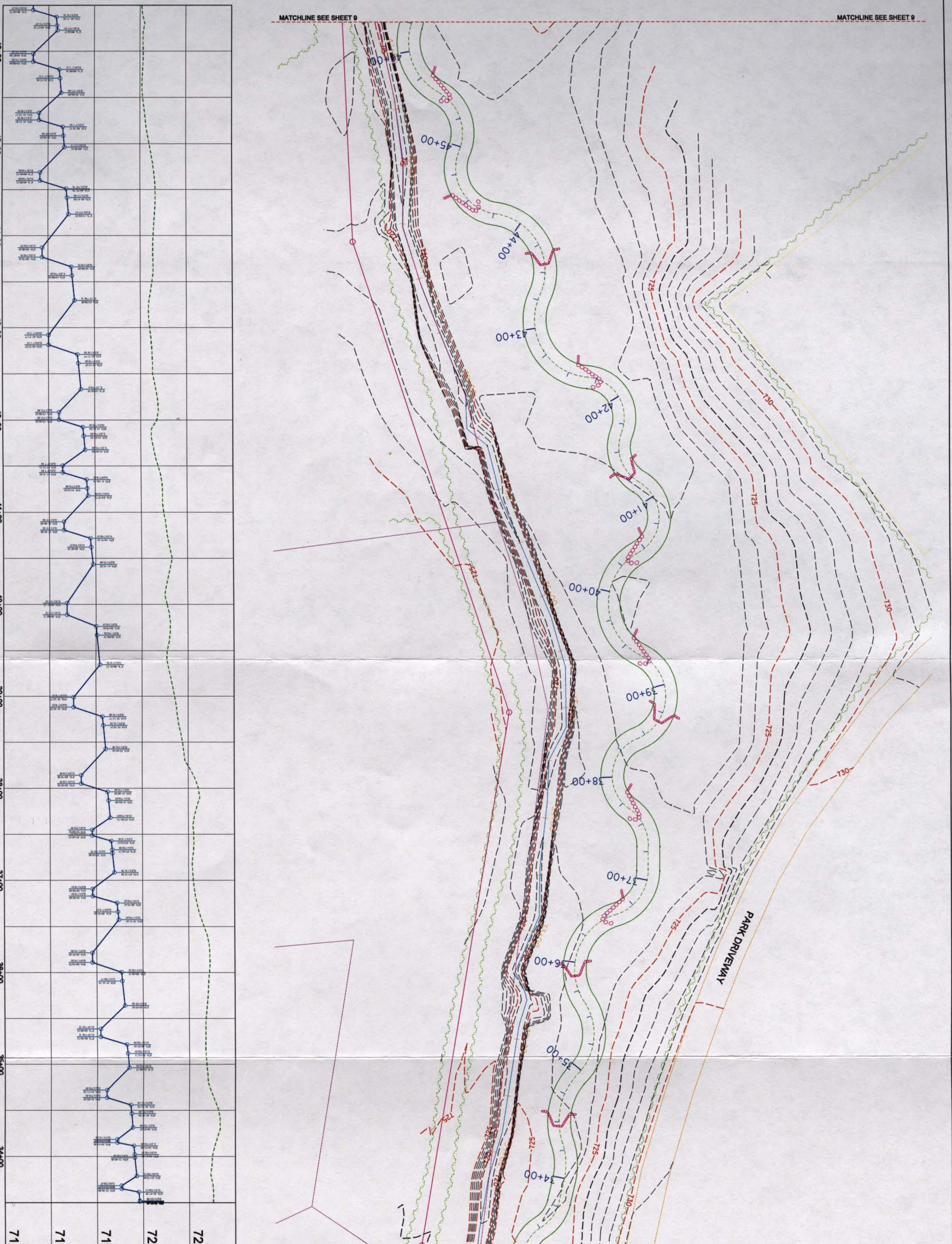
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

N.C. Wetlands Restoration Program

SYM.	DESCRIPTION	DATE	APPROVED

REVISIONS



SHEET	OF
FIGURE 12C	

PLAN AND PROFILE

DATE: NOVEMBER 2002
SCALE: 1" = 40'

McINTYRE CREEK
STREAM RESTORATION PROJECT

HORNETS NEST PARK, CHARLOTTE, NORTH CAROLINA

STATION 10+00.00 TO STATION 63+58.37

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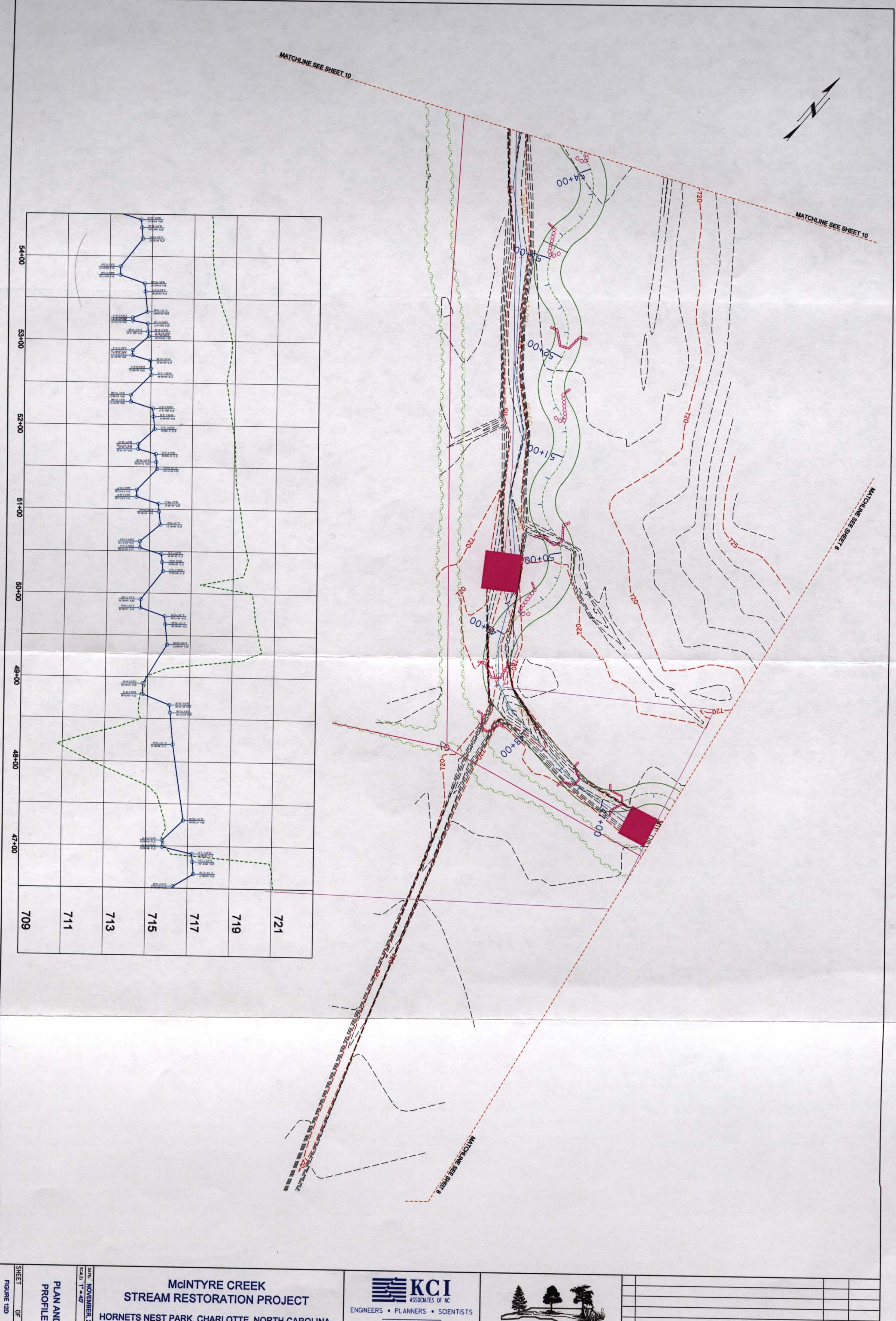
RALEIGH, NORTH CAROLINA 27609

N.C. Wetlands Restoration Program
NCDENR DWQ

SYM.	DESCRIPTION	DATE	APPROVED

REVISIONS



McINTYRE CREEK
STREAM RESTORATION PROJECT
HORNETS NEST PARK, CHARLOTTE, NORTH CAROLINA
STATION 10+00.00 TO STATION 63+58.37

DATE: NOVEMBER 2002
SCALE: 1" = 40'

PLAN AND PROFILE

SHEET OF
FIGURE 12D

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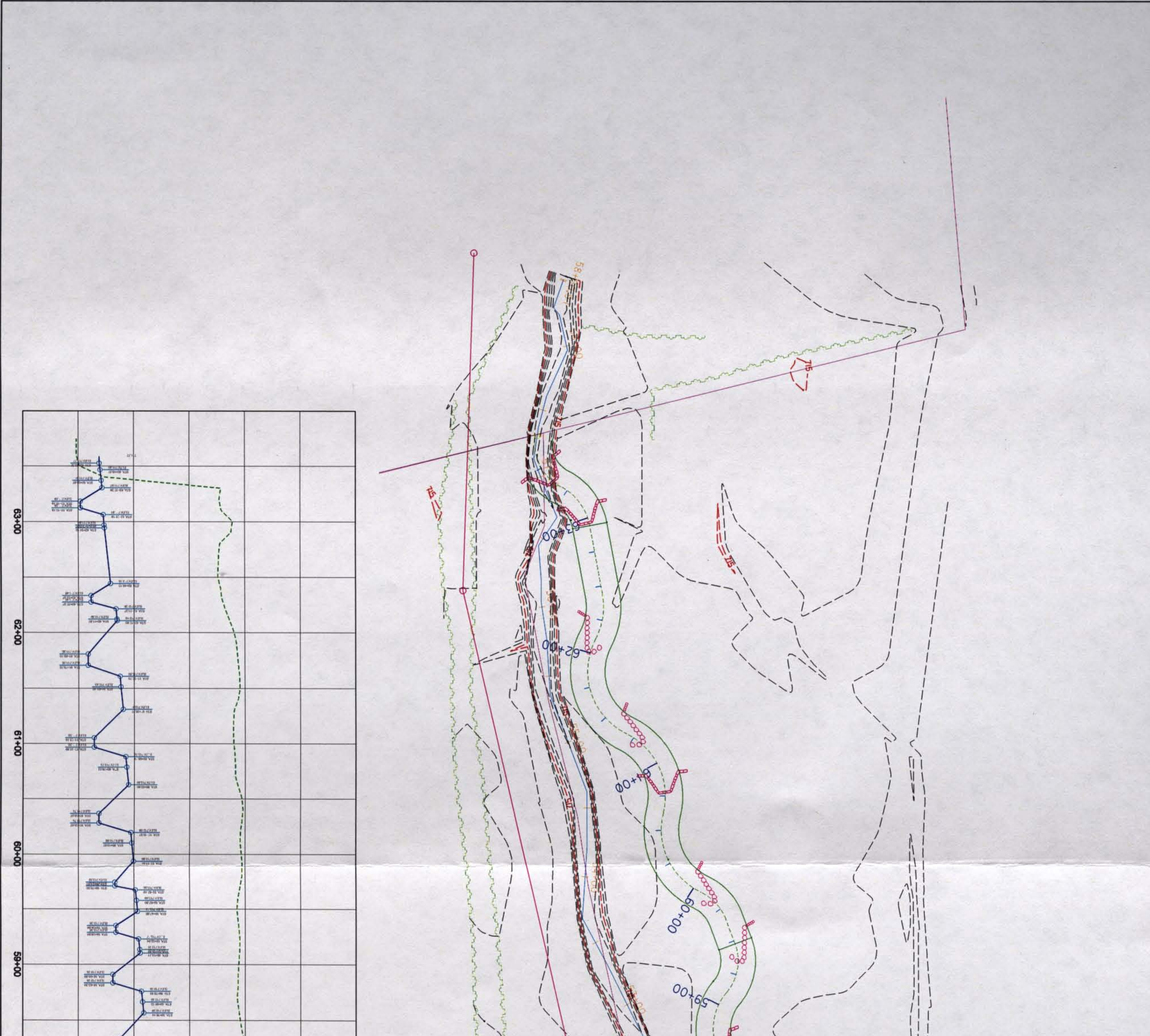
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

N.C. Wetlands Restoration Program

SYM.	DESCRIPTION	DATE	APPROVED

REVISIONS



SYM.	DESCRIPTION	DATE	APPROVED

REVISIONS

N.C. Wetlands Restoration Program
NCDENR DWQ

KCI ASSOCIATES OF NC
ENGINEERS • PLANNERS • SCIENTISTS
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

McINTYRE CREEK STREAM RESTORATION PROJECT

HORNETS NEST PARK, CHARLOTTE, NORTH CAROLINA

STATION 10+00.00 TO STATION 63+58.37

DATE: NOVEMBER 2002
SCALE: 1" = 40'

PLAN AND PROFILE

SHEET OF

FIGURE 12E

Figure 13. Typical Cross-Section Design Details

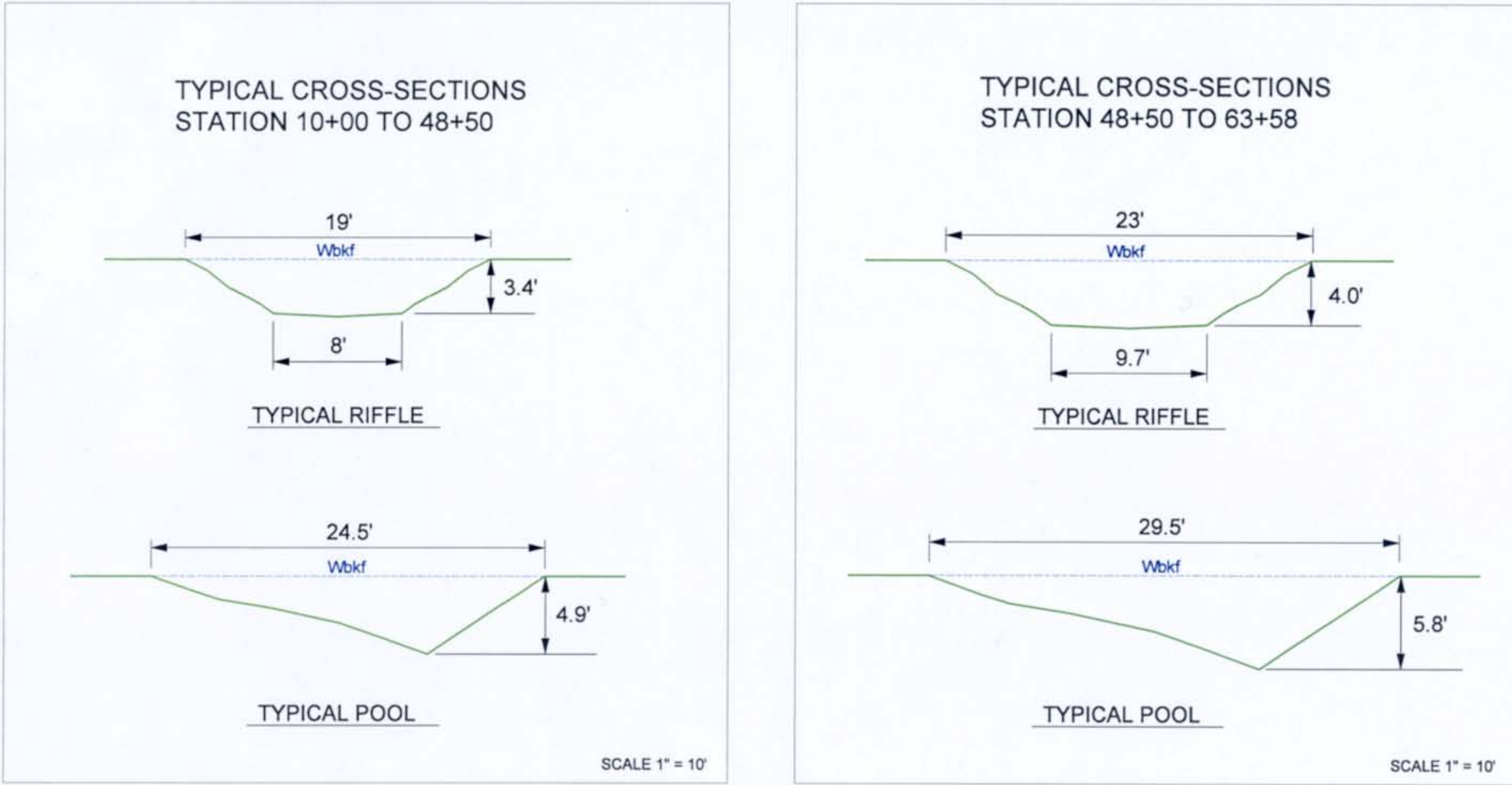


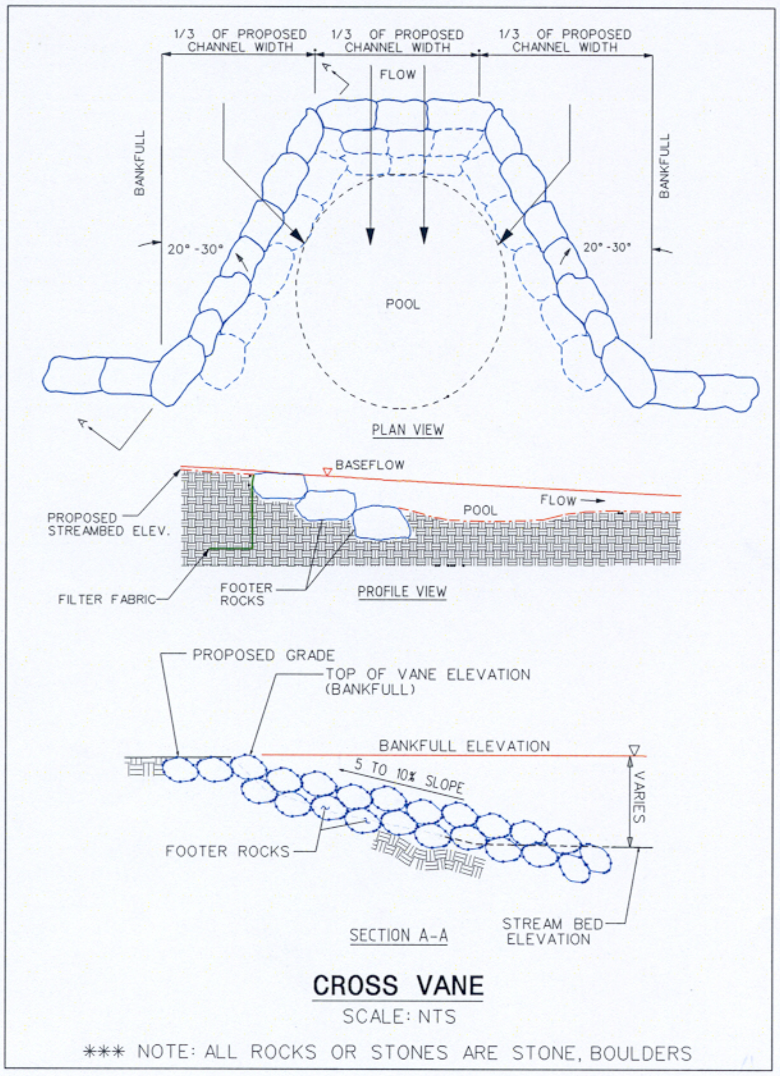
Table 2. Morphological Design Criteria

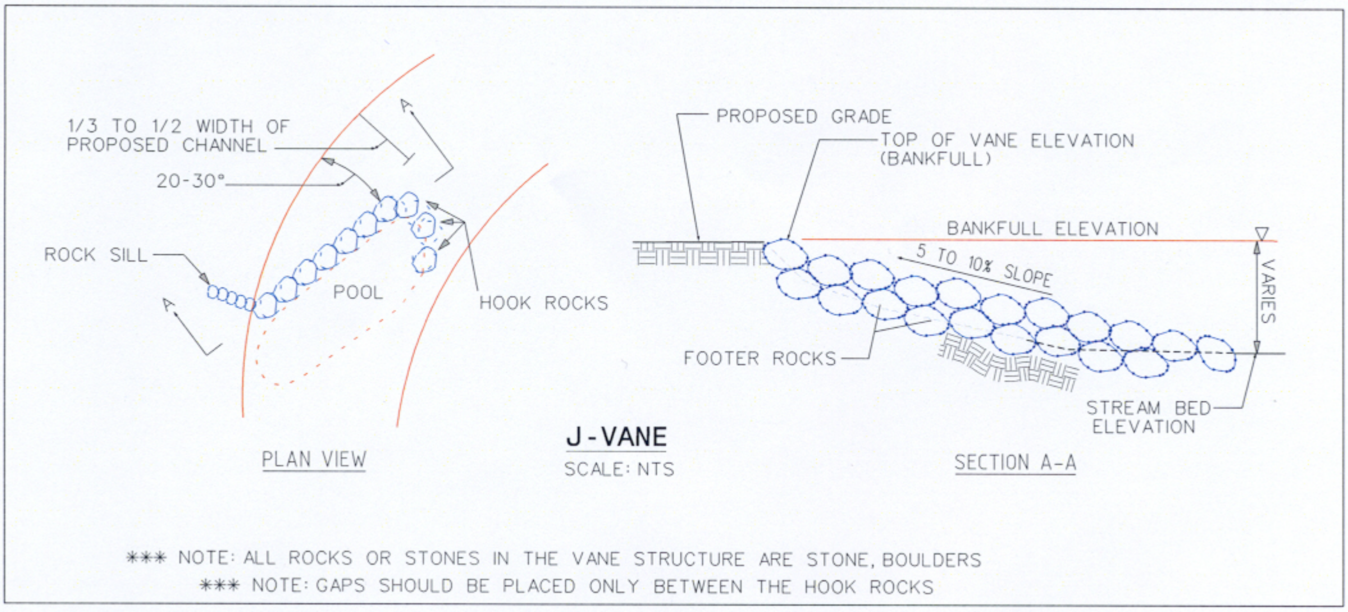
	Variables	Project Site Existing Channel**		Reference Reach	Project Site Restored Reach**	
	Stream Type	Modified E5		E5	E5	E5
	Drainage Area (mi^2)	1.79	2.55	0.2	1.79	2.5
	Bankfull Width (W_{bkf})	17.0’	23-24’	13.1’	18.7’	22.9’
	Bankfull Mean Depth (d_{bkf})	2.5’	2.5-2.7’	1.62’	2.3’	2.8’
	Bankfull Cross-Sectional Area (A_{bkf}) (ft^2)	40-45	58-68	21.3	42-50	64-70
	Width/Depth Ratio (W_{bkf}/d_{bkf})	4-7	8-9	8.1	8.1	8.1
	Bankfull Max Depth (d_{mbkf})	3-4’	3.5-4.5’	2.83’	3.3-3.5’	4.0’
	Width of Floodprone Area (W_{fpa})	100-300’	100-300’	77’	100-300’	100-300’
	Entrenchment Ratio (ER)	6.0-17.5	4.5-12.5	5.9	5.0-16.0	4.0-13.0
	Low Bank Height Ratio (LBHR)	1.5-1.9	1.3-1.4	1.0-1.08	1.0	1.0
	Channel Materials (D50) (mm)	0.2-0.3	0.2-0.3	0.5	0.3	0.3
	Water Surface Slope (S)	0.21%	0.27%	0.44%	0.21-0.25%	
	Sinuosity (K)	1.1	1.22*	1.25	1.3-1.5	1.3-1.5
Dimension	Pool Depth (dp)	4.1’	4.1’	1.64’	2.9’	3.4’
	Riffle Depth (dr)	2.5’	2.5-2.7’	1.62’	2.83’	3.37’
	Ratio - Max. Pool Depth: Mean Bkf. Depth	1.64 (=4.1/2.5)		2.0 (=3.25/1.62)	2.0	2.0
	Bankfull mean velocity (u) (ft./sec.)	4.5	4.0	3.87	4.2-4.4	4.0
	Bankfull discharge (Q) (CFS)	180-210	250-280	68-83	180-210	250-280
Pattern	Meander Length (L_m)	96-172’*		60-71’	90-190’	110-230’
	Radius of Curvature (R_c)	60.3-148.1’*		10.3-25.6’	37-56’	45-70’
	Belt Width (W_{blt})	34-58’*		38’	95’	115’
	Meander Width Ratio (MWR)	1.4-2.5*		2.9	5.0	5.0
	Ratio- Rad. of Curv.: Bkf Width (R_c/W_{bkf})	2.6-6.3 *		0.8-2.0	2.0-4.0	2.0-4.0
	Ratio- Meander Length:Bkf Width (L_m/W_{bkf})	4.1-7.3*		4.6-5.4	5.0-10.0	5.0-10.0
Profile	Valley Slope (ft./ft.)	0.33%	0.33%	0.55%	0.33%	0.33%
	Water Surface Slope (ft./ft.)	0.21%	0.27%	0.44%	0.21-0.25%	
	Riffle Slope (ft./ft.)	0.3-0.6%		0.50-1.1%	0.25-0.65%	
	Pool Slope (ft./ft.)	0.1-0.2%		0.00-0.25%	0.00-0.13%	
	Pool to Pool Spacing (ft.)	-	-	11-45’	46-94’	57-115’
	Pool Length (ft.)	-	-	7-18’	12-32’	15-37’
	Ratio - Pool Slope:Water Surface Slope	0.4-1.0	0.4-1.0	0.0-0.57	0.0-0.57	0.0-0.57
	Ratio - Pool to Pool Spacing:Bkf width	-	-	0.8-3.4	2.5 – 5.0	2.5 – 5.0

*The pattern data for the existing channel was measured in the lower portion of the project reach (stabilizing section).

**The morphological parameters/design criteria are separated based on location relative to the confluence of the main thread and the tributary channel (Existing Sta. 43+20). The drainage area below the confluence increases to 2.55 sq. miles.

Figure 14. In-Stream Structure Design Details





The confluences of the two tributaries within the project reach will be stabilized with grade control structures and step sequences where necessary to match the proposed grade of the restored main channel. A vegetated buffer and bank stabilization measures will also be incorporated in these short connections.

Excavated materials from the design channel will be used to backfill the majority of the existing channel, however a linear depression (oxbow) will remain in the existing channel belt width (from Stations 19+00 to 27+00). This feature will be connected to the restored channel by a low gradient drainage feature above the design bankfull stage. It will improve flood storage and aquatic habitat in the floodplain and it will provide a mechanism to stabilize numerous small tributaries (intermittent and ephemeral) that have been influenced by base level lowering in the McIntyre Creek watershed. With continued development in the watershed (including the recently constructed University Park Baptist Church and parking lot), this feature will induce primary settlement reducing sediment inputs to McIntyre Creek, and subsequently will improve water quality.

4.3 Riparian Buffers

The McIntyre Creek floodplain in the project reach is predominantly forested with hardwood species (Refer to Section 2.1.1). The restoration project will require the clearing of a forty (40) to sixty (60) foot belt width through which the new channel will be excavated. Several large trees that have fallen or are at risk of falling due to bank and bed erosion of the existing channel will also be removed. The cleared areas will be re-vegetated with native woody and herbaceous plant materials. Following the re-vegetation, riparian buffers associated with the McIntyre Creek restoration will extend over fifty (50) feet on both sides of the stream for the majority of the project reach.

The re-vegetated zone will consist of the following trees and shrubs: American sycamore, cherrybark oak (*Quercus falcata* var. *pagodifolia*), green ash, river birch (*Betula nigra*), tulip poplar (*Liriodendron tulipifera*), American elm, slippery elm, silky dogwood, spicebush, witch hazel (*Hamamelis virginiana*) and box elder. Herbaceous vegetation shall consist of a native grass mix that may include: bluestem (*Andropogon glomeratus*), deertongue (*Panicum clandestinum*), orchardgrass (*Dactylis glomerata*), switchgrass (*panicum virgatum*), and Virginia wildrye (*Elymus virginicus*). Rye grain (*Secale cereale*) and/or brown top millet (*Pennisetum glaucum*) will be used for temporary stabilization.

In addition to the native seed mix and stabilization seeding, live stakes shall be installed to assist in stabilizing the stream banks. The following species may be used for live staking: black willow (*Salix nigra*), elderberry (*Sambucus canadensis*), silky willow (*Salix sericea*), and silky dogwood.

Four hundred thirty-six (436) trees per acre (based on a 10’ X 10’ plant spacing) will be planted to achieve a mature survivability of three hundred twenty (320) trees per acre in the riparian zone (DENR, 2001). Woody vegetation shall be installed between November and March when the plants are dormant.

5.0 SEDIMENT TRANSPORT

A stable channel is able to move the sediment supplied by its watershed without aggrading or degrading. The restored channels must be competent and have sufficient transport capacity. Competency is the channel's ability to move particles of a certain size. Capacity is the channel's ability to move a specific volume of sediment (sediment discharge). Sediment discharge is the amount of sediment moving through a cross section over a specified period of time (lbs/s).

5.1 Competency

The initiation of particle movement (entrainment) is the first stage in sediment transport. Prediction of sediment entrainment typically relies on hydraulic conditions reaching a "critical state." Critical shear stress (tractive force) is the most commonly used relationship to approximate the particle size that can be entrained.

The composition of the McIntyre Creek streambed is predominantly sand (d_{50}= 0.2 - 0.3 millimeters). In many cases, the shear stress (> 0.01 lbs/ft^2) in a channel, at the bankfull stage, is considerably higher than that required to move even the largest sand particle (2.0 millimeters). Thus, competency is not usually the primary consideration related to sediment transport in sand bed streams because nearly all, if not all of the sediment (bed material) moves at bankfull.

To validate this theory-based explanation, scour chains were placed in the streambed and at the base of the upper and lower thirds of a depositional bar in the lower portion of the project reach. Following an approximately 200 ft^3/s discharge, the chains were evaluated to determine the mobility of the bed material in McIntyre Creek. The chains indicated that up to six inches (6") of the bed material moved during this event (75% of the bankfull discharge).

5.2 Capacity

A sediment transport capacity analysis was used to predict whether the McIntyre Creek design channel would transport the same volume of sediment, at bankfull, as the stabilizing section in the downstream portion of the project reach. A spreadsheet model of the Ackers and White Equations (1973) was developed to predict sediment discharge (lbs/s) for various discharge rates (flow) in a particular section. This model incorporated three separate components that influence sediment transport: particle size (D_{gr} based on the D_{50} channel material), particle mobility (F_{gr} based on shear stress and immersed sediment weight), and a transport parameter (G_{gr} based on stream power).

The sediment transport calculator estimated a total load transport of 30.3 pounds per second at bankfull in the stabilizing section. The sediment transport calculator estimated a total load transport of 34.8 pounds per second at the bankfull stage in the proposed design channel. This comparison provides evidence that the restored channel will have sufficient sediment transport capacity to accommodate the total sediment load to

McIntyre Creek. In addition, the reconnection of the design channel with the McIntyre Creek floodplain exhibited a significant change (flattened) in the sediment discharge curve above bankfull compared with discharges above bankfull in the existing degraded reaches (upper section). Floods confined within the incising channels have resulted in excess stream power and subsequent erosion and degradation. Refer to Appendix 4 for supporting sediment transport calculations.

6.0 FLOODING ANALYSIS

McIntyre Creek in Hornet's Nest Park is located in a Federal Emergency Management Agency (FEMA) 100-Year Floodzone. As such, any modifications to the stream that would result in the increase of the 100-year flood elevation would require a Conditional Letter of Map Revision. It is the intent of the restoration design to maintain the 100-year flood elevation at the current level following restoration.

Mecklenburg County Storm Water Services provided an existing conditions HEC-RAS (River Analysis System) model. The model parameters were reviewed to verify that the conditions represented a benchmark hydraulic condition that could be compared to post-restoration conditions. The existing conditions model will be revised to reflect changes to the channel and floodplain as a result of the restoration. A proposed hydrology and hydraulics (H&H) summary will be submitted with a letter indicating that an increase in the 100-year flood elevation is not anticipated (No-Rise Certification).

7.0 MONITORING AND EVALUATION

Monitoring shall consist of the collection and analysis of stream stability and riparian/stream bank vegetation survivability data to assist in the evaluation of the project in meeting established restoration objectives. Specifically, the success of channel modification, erosion control and re-vegetation parameters will be assessed using measurements of stream dimension, pattern, and profile, site photographs, and vegetation sampling.

7.1 Duration

The first scheduled monitoring will be conducted six (6) months after restoration is complete or after the first bankfull (or greater) event, whichever occurs first. Monitoring shall subsequently be conducted annually for a period of five (5) years.

7.2 Reporting

Annual monitoring reports will be prepared and submitted after all monitoring tasks for each year are completed. Each report will provide the new monitoring data and compare the new data against previous findings. Data tables, cross sections, profiles, photographs and other graphics will be included in the report as necessary. Each report will include a discussion of any significant deviations from the as-built survey and previous annual measurements, as well as evaluations as to whether the changes indicate a stabilizing or de-stabilizing condition.

7.3 Stream Stability

The purpose of monitoring is to evaluate the stability of the restored stream. Following the procedures established in the USDA Forest Service Manual, *Stream Channel Reference Sites* (Harrelson, et.al, 1994) and the methodologies utilized in the Rosgen stream assessment and classification system (Rosgen, 1994 and 1996), data collected will consist of detailed dimension and pattern measurements, a longitudinal profile, and bed materials sampling. Width/depth ratio, entrenchment ratio, low bank height ratio, sinuosity, meander width ratio, radius of curvature (on newly constructed meanders during 1st year monitoring only), pool-to-pool spacing as well as the average, riffle and pool water slopes will be calculated from the collected data. Pebble count data will be plotted by size distribution in order to assess the D50 and D84 size class.

7.3.1 Dimension

Four permanent cross-sections, two riffle and two pool, will be established and used to evaluate stream dimension. At least one riffle and one pool cross-section will be located within the area also surveyed as part of the longitudinal profile. Permanent monuments will be established by either conventional survey or GPS. The cross-section surveys shall provide a detailed measurement of the stream and banks, to include points on the adjacent floodplain, at the top of bank, bankfull, at all breaks in slope, the edge of water, and thalweg. Subsequently, width/depth ratios, entrenchment ratios and bank height ratios will be calculated for each cross-section.

Cross-section measurements should show little or no change from the as-built cross-sections. If changes do occur, they will be evaluated to determine whether they are minor adjustments associated with settling and increased stability or whether they indicate movement toward an unstable condition.

7.3.2 Pattern

Measurements associated with the restored channel pattern will include belt width, meander length, and radius of curvature (on newly constructed meanders only for the first year). Subsequently, sinuosity, meander width ratio and radius of curvature and meander length/bankfull width ratios will be calculated.

7.3.3 Profile

Longitudinal profiles of representative reaches of the restored channel, above and below the confluence with the main tributary, will be surveyed. The profiles will extend a minimum of 20 bankfull widths. Measurements will include slopes (average, pool, riffle), as well as calculations of pool-to-pool spacing. Annual measurements should indicate stable bedform features with little change from the as-built survey. The pools should maintain their depth with lower water surface slopes, while the riffles should remain shallower and steeper.

7.3.4 Materials

Pebble counts will be conducted at each representative cross-section, as well as across the overall study reach (based upon percentage of riffles and pools) for the purpose of repeated classification and to evaluate sediment transport.

7.4 Photograph Reference Points (PRP)

PRP will be established to assist in characterizing the site and to allow qualitative evaluation of the site conditions. The location and bearing/orientation of each photo point will be permanently marked in the field and documented to allow for repeated use.

7.4.1 Cross-section Photograph Reference Points

Four (4) photographs will be taken at each permanent cross section, as follows: 1) from the left bank permanent monument/pin showing the right bank, 2) from the right bank permanent monument/pin showing the left bank, 3) from downstream of the cross-section looking upstream, and 4) from upstream of the cross-section looking downstream. The survey tape will be centered in each photograph and the water line will be located near the lower edge. Effort will be made to consistently show the same area in each photograph.

7.4.2 Longitudinal Photograph Reference Points

Ten (10) permanent points will be established longitudinally throughout the project site to allow further photo-documentation of the restored stream channel condition.

7.4.3 Additional Photograph Locations

Additional PRP will be located, as needed, to document the condition of specific in-stream structures such as J-Vanes, cross vanes, and combination structures, as well as infrastructure associated with the stream such as utility crossings.

7.5 Bank and Riparian Vegetation Monitoring

The success of the bank and riparian buffer plantings will be evaluated using ten (10) fifty by one hundred foot (50’ x 100’) vegetative sampling plots. The corners of each monitoring plot will be permanently marked in the field. The monitoring will consist of a physical inventory within each plot and a subsequent statistical analysis in order to determine the following: 1) composition and number of surviving species, 2) differentiation between planted individuals and volunteers, and 3) total number of stems per acre. Additionally, photographs will be taken from the center of each monitoring plot, starting due north to create a 360-degree view of the sample site. Riparian vegetation must meet a minimum survival success rate of 320 stems/acre after five years. If monitoring indicates that the specified survival rate is not being met, appropriate corrective actions will be developed, to include invasive species control, the removal of dead/dying plants and replanting.

7.6 Biological Monitoring

In-stream biological monitoring, to include benthic macroinvertebrate sampling, will be conducted if specifically required by permit conditions. If required, this data collection shall be completed in accordance with the *Interim, Internal Technical Guide: Benthic Macroinvertebrate Monitoring Protocols for Compensatory Stream Restoration Projects* (NC Division of Water Quality, 401/Wetlands Unit, May 2001).

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APPENDIX 1

McIntyre Creek Stream Restoration Project
Existing Conditions

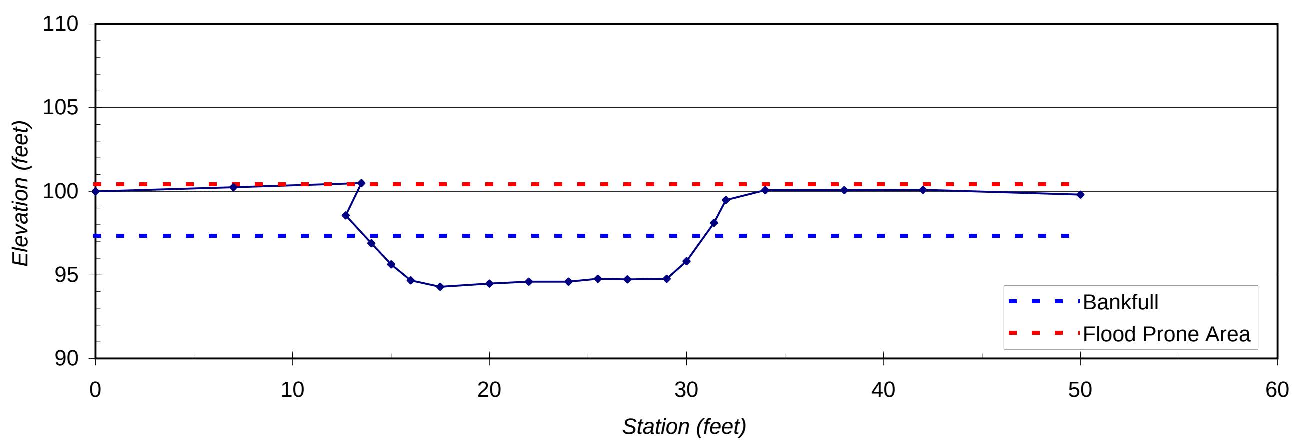
River Basin:	Catawba
Watershed:	McIntyre Creek
XS ID	X-Sec 1, Riffle
Drainage Area (sq mi):	1.79
Date:	6/11/2002
Field Crew:	G. Myrncza, P. Landis, B. Greco

Station	Rod Ht.	Elevation
0.0	4.82	100.00
7.0	4.59	100.23
13.5	4.34	100.48
12.7	6.27	98.55
14.0	7.93	96.89
15.0	9.20	95.62
16.0	10.15	94.67
17.5	10.53	94.29
20.0	10.34	94.48
22.0	10.23	94.59
24.0	10.22	94.60
25.5	10.06	94.76
27.0	10.10	94.72
29.0	10.05	94.77
30.0	9.01	95.81
31.4	6.70	98.12
32.0	5.34	99.48
34.0	4.75	100.07
38.0	4.75	100.07
42.0	4.73	100.09
50.0	5.02	99.80

SUMMARY DATA	
Bankfull Elevation:	97.35
Bankfull Cross-Sectional Area:	42.10
Bankfull Width:	17.00
Flood Prone Area Elevation:	100.41
Flood Prone Width:	N/A
Max Depth at Bankfull:	3.06
Mean Depth at Bankfull:	2.48
W / D Ratio:	6.9
Entrenchment Ratio:	N/A
Bank Height Ratio:	2.02
Slope (ft/ft):	0.004
Discharge (cfs)	190

Stream Type:	E5

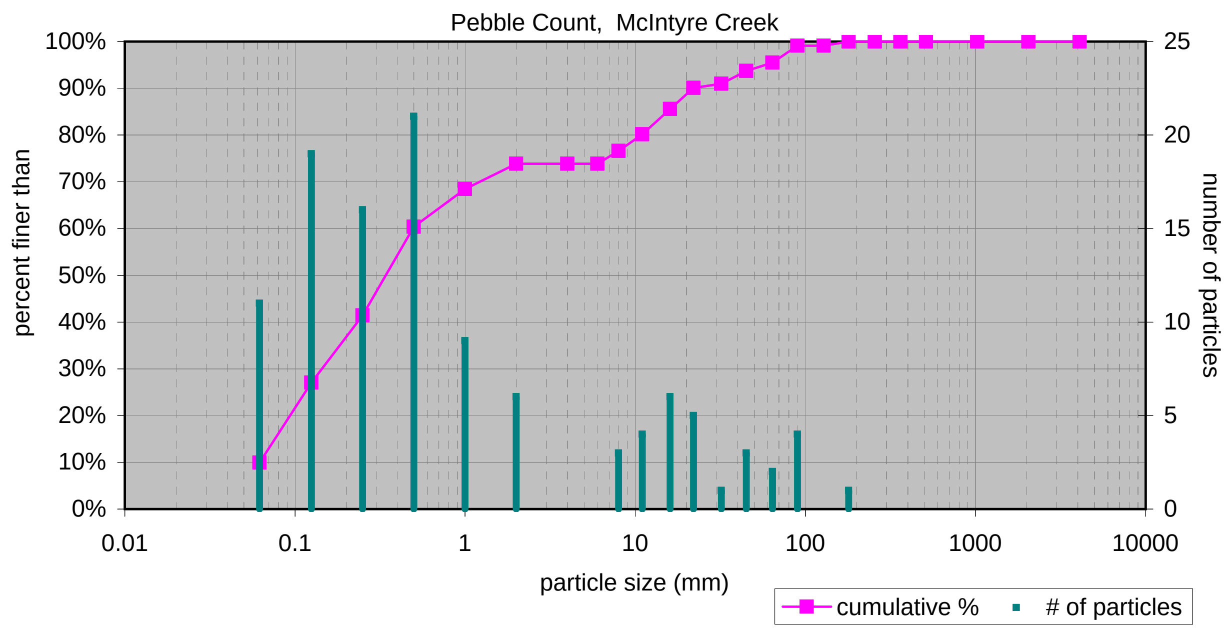
Catawba River Basin, McIntyre Creek, X-Sec 1, Riffle



Pebble Count of Channel Reach

	McIntyre Creek
	Long Creek
	X-sec 1, Hornet's Nest Park, Charlotte, NC
Note:	

Material	Size Range (mm)		Count
silt/clay	0	0.062	
very fine sand	0.062	0.13	
fine sand	0.13	0.25	
medium sand	0.25	0.5	
coarse sand	0.5	1	
very coarse sand	1	2	
very fine gravel	2	4	
fine gravel	4	6	
fine gravel	6	8	
medium gravel	8	11	
medium gravel	11	16	
coarse gravel	16	22	
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:		111



bedrock		
clay hardpan		
detritus/wood		
artificial		
	total count:	111

	size percent less than (mm)						particle size distribution		
	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
based on sediment particles only	0.080	0.18	0.3	1	14	58	23.1	1.1	13.4

	percent by substrate type								
	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
based on total count	10%	64%	22%	5%	0%	0%	0%	0%	0%

Bank Erodibility Hazard Rating Guide

Stream: McIntyre Creek **Reach:** 1, left bank **Date:** 6/11/02 **Crew:** GM, BG, PL

Bank Erosion Potential

Bank Height (ft): / Bankfull Height (ft):		Bank Height/ Bankfull Ht	Root Depth/ Bank Height	Root Density %	Bank Angle (Degrees)	Surface Protection%
VERY LOW	Value Range	1.0 1.1	0.9 1.0	80 100	0.0 20.0	80 100
	Index Range	1.0 1.9	1.0 1.9	1.0 1.9	1.0 1.9	1.0 1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value Range	1.11 1.19	0.5 0.89	55 79	21.0 60.0	55 79
	Index Range	2.0 3.9	2.0 3.9	2.0 3.9	2.0 3.9	2.0 3.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
MODERATE	Value Range	1.2 1.5	0.3 0.49	30 54	61.0 80.0	30 54
	Index Range	4.0 5.9	4.0 5.9	4.0 5.9	4.0 5.9	4.0 5.9
	Choice	V: I:	V: I:	V: I:	**V: 68.0 I: 4.7**	V: I:
HIGH	Value Range	1.6 2.0	0.15 0.29	15 29	81.0 90.0	15 29
	Index Range	6.0 7.9	6.0 7.9	6.0 7.9	6.0 7.9	6.0 7.9
	Choice	**V: 2.0 I: 7.9**	**V: 0.24 I: 6.7**	**V: 20.0 I: 7.2**	V: I:	**V: 20.0 I: 7.2**
VERY HIGH	Value Range	2.1 2.8	0.05 0.14	5 14	91.0 119.0	10 14
	Index Range	8.0 9.0	8.0 9.0	8.0 9.0	8.0 9.0	8.0 9.0
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
EXTREME	Value Range	>2.8	<0.05	<5	>119	<10
	Index Range	10	10	10	10	10
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:

V = value, I = index

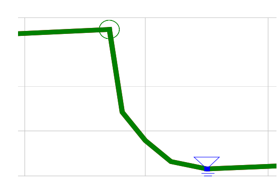
SUB-TOTAL (Sum one index from each column) 33.7

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

Bank Sketch



BANK MATERIAL ADJUSTMENT 5

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 0

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.9	10-19.9	20-29.9	30-39.9	40-45.9	46-50

Bank location description (check one)

Straight Reach X Outside of Bend

GRAND TOTAL 38.7

BEHI RATING HIGH

McIntyre Creek Stream Restoration Project
Existing Conditions

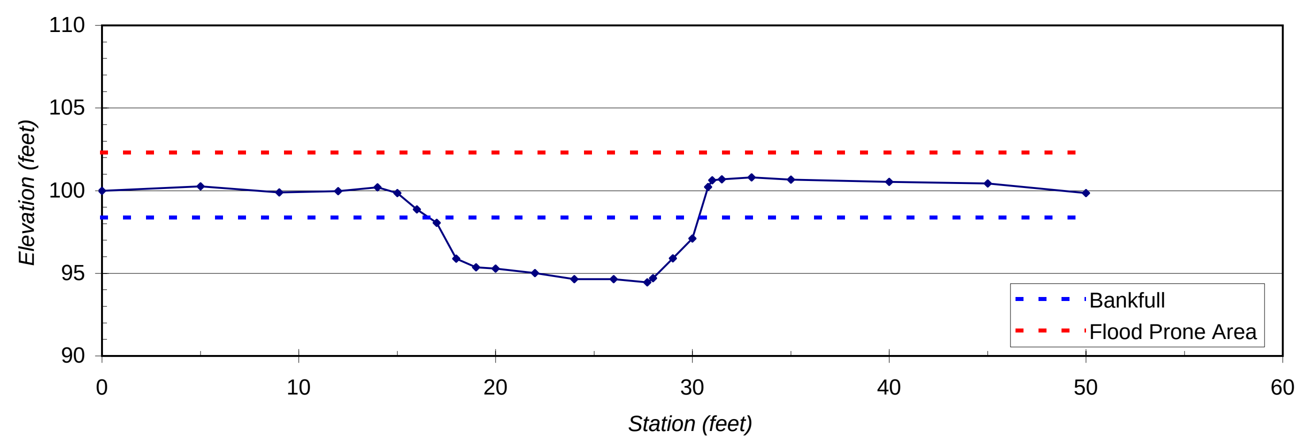
River Basin:	Catawba
Watershed:	McIntyre Creek
XS ID	X-Sec 2, Pool
Drainage Area (sq mi):	1.79
Date:	6/11/2002
Field Crew:	G. Myrncza, P. Landis, B. Greco

Station	Rod Ht.	Elevation
0.0	5.46	100.00
5.0	5.20	100.26
9.0	5.57	99.89
12.0	5.48	99.98
14.0	5.25	100.21
15.0	5.60	99.86
16.0	6.60	98.86
17.0	7.40	98.06
18.0	9.57	95.89
19.0	10.10	95.36
20.0	10.18	95.28
22.0	10.45	95.01
24.0	10.82	94.64
26.0	10.82	94.64
27.7	11.00	94.46
28.0	10.76	94.70
29.0	9.56	95.90
30.0	8.35	97.11
30.8	5.24	100.22
31.0	4.84	100.62
31.5	4.78	100.68
33.0	4.65	100.81
35.0	4.79	100.67
40.0	4.93	100.53
45.0	5.02	100.44
50.0	5.61	99.85

SUMMARY DATA	
Bankfull Elevation:	98.39
Bankfull Cross-Sectional Area:	41.30
Bankfull Width:	13.74
Flood Prone Area Elevation:	102.32
Flood Prone Width:	N/A
Max Depth at Bankfull:	3.93
Mean Depth at Bankfull:	3.01
W / D Ratio:	4.6
Entrenchment Ratio:	N/A
Bank Height Ratio:	1.47
Slope (ft/ft):	0.003
Discharge (cfs)	190

Stream Type:	E5

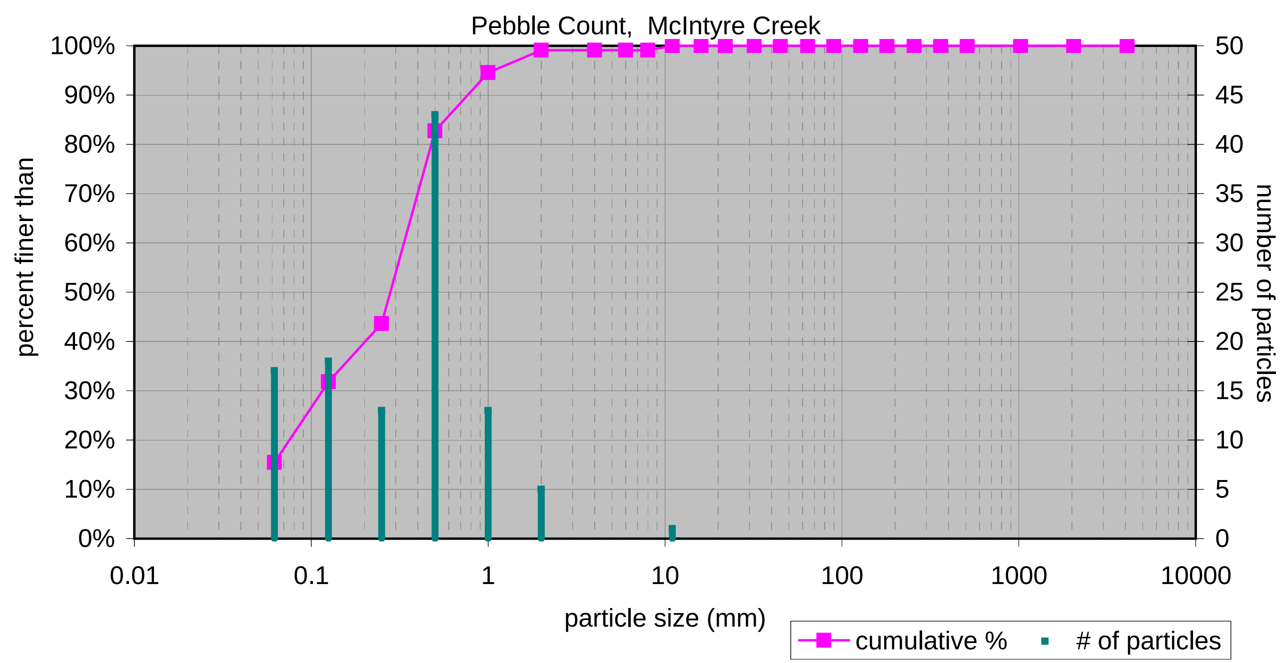
Catawba River Basin, McIntyre Creek, X-Sec 2, Pool



Pebble Count,

Material	Size Range (mm)		Count
silt/clay	0	0.062	
very fine sand	0.062	0.13	
fine sand	0.13	0.25	
medium sand	0.25	0.5	
coarse sand	0.5	1	
very coarse sand	1	2	
very fine gravel	2	4	
fine gravel	4	6	
fine gravel	6	8	
medium gravel	8	11	
medium gravel	11	16	
coarse gravel	16	22	
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:	110

	McIntyre Creek
	Long Creek
	X-sec 2, Hornet's Nest Park, Charlotte, NC
Note:	



bedrock	
clay hardpan	
detritus/wood	
artificial	
total count:	110

based on sediment particles only	size percent less than (mm)						particle size distribution		
	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
	0.063	0.15	0.3	0	1	1	3.2	0.2	2.9

based on total count	percent by substrate type								
	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
	15%	84%	1%	0%	0%	0%	0%	0%	0%

Bank Erodibility Hazard Rating Guide

Stream: McIntyre Creek **Reach:** 2, right bank **Date:** 6/11/02 **Crew:** GM, BG, PL

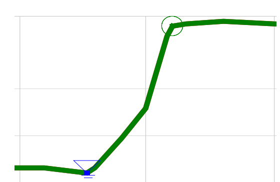
Bank Erosion Potential	Bank Height (ft): Bankfull Height (ft):	Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value Range	1.0	1.1	0.9	1.0	80	100	0.0	20.0	80	100
	Index Range	1.0	1.9	1.0	1.9	1.0	1.9	1.0	1.9	1.0	1.9
	Choice	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
LOW	Value Range	1.11	1.19	0.5	0.89	55	79	21.0	60.0	55	79
	Index Range	2.0	3.9	2.0	3.9	2.0	3.9	2.0	3.9	2.0	3.9
	Choice	**V:**	**I:**	**V: 0.61**	**I: 3.4**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
MODERATE	Value Range	1.2	1.5	0.3	0.49	30	54	61.0	80.0	30	54
	Index Range	4.0	5.9	4.0	5.9	4.0	5.9	4.0	5.9	4.0	5.9
	Choice	**V: 1.5**	**I: 5.6**	**V:**	**I:**	**V: 35.0**	**I: 5.5**	**V: 61.7**	**I: 4.1**	**V: 35.0**	**I: 5.5**
HIGH	Value Range	1.6	2.0	0.15	0.29	15	29	81.0	90.0	15	29
	Index Range	6.0	7.9	6.0	7.9	6.0	7.9	6.0	7.9	6.0	7.9
	Choice	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
VERY HIGH	Value Range	2.1	2.8	0.05	0.14	5	14	91.0	119.0	10	14
	Index Range	8.0	9.0	8.0	9.0	8.0	9.0	8.0	9.0	8.0	9.0
	Choice	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
EXTREME	Value Range	>2.8		<0.05		<5		>119		<10	
	Index Range	10		10		10		10		10	
	Choice	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
V = value, I = index									**SUB-TOTAL (Sum one index from each column)**		**24.1**

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

Bank Sketch



BANK MATERIAL ADJUSTMENT **5**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT **5**

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.9	10-19.9	20-29.9	30-39.9	40-45.9	46-50

Bank location description (check one)

Straight Reach [ ] Outside of Bend [X]

GRAND TOTAL **34.1**

BEHI RATING **HIGH**

McIntyre Creek Stream Restoration Project
Existing Conditions

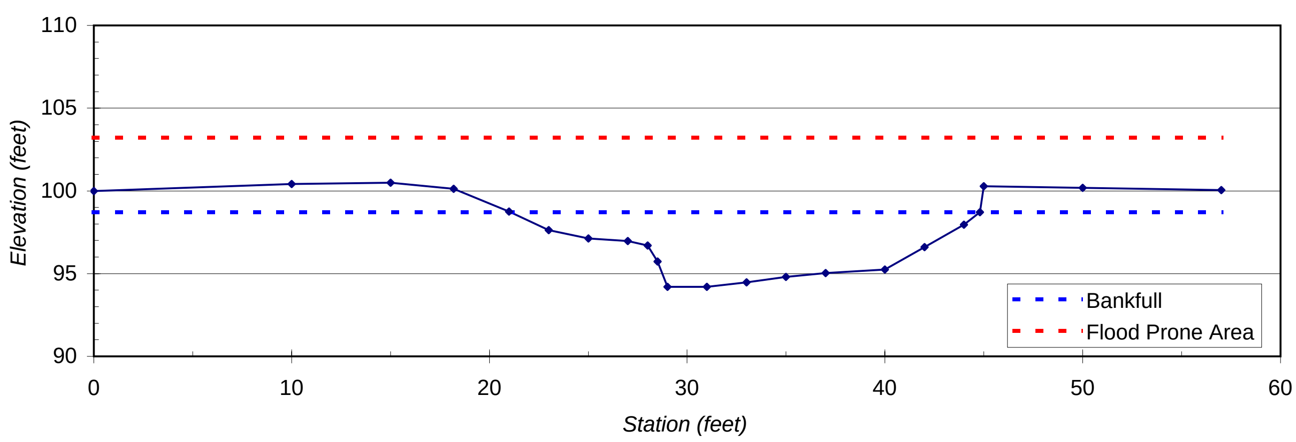
River Basin:	Catawba
Watershed:	McIntyre Creek
XS ID	X-Sec 3, Run
Drainage Area (sq mi):	2.55
Date:	6/12/2002
Field Crew:	G. Myrncza, P. Landis, B. Greco

Station	Rod Ht.	Elevation
0.0	5.35	100.00
10.0	4.93	100.42
15.0	4.85	100.50
18.2	5.23	100.12
21.0	6.59	98.76
23.0	7.72	97.63
25.0	8.22	97.13
27.0	8.38	96.97
28.0	8.65	96.70
28.5	9.61	95.74
29.0	11.15	94.20
31.0	11.14	94.21
33.0	10.87	94.48
35.0	10.55	94.80
37.0	10.31	95.04
40.0	10.10	95.25
42.0	8.75	96.60
44.0	7.40	97.95
44.8	6.64	98.71
45.0	5.06	100.29
50.0	5.16	100.19
57.0	5.30	100.05

SUMMARY DATA	
Bankfull Elevation:	98.71
Bankfull Cross-Sectional Area:	64.90
Bankfull Width:	23.71
Flood Prone Area Elevation:	103.22
Flood Prone Width:	N/A
Max Depth at Bankfull:	4.51
Mean Depth at Bankfull:	2.74
W / D Ratio:	8.7
Entrenchment Ratio:	N/A
Bank Height Ratio:	1.31
Slope (ft/ft):	0.002
Discharge (cfs)	260

Stream Type:	E5

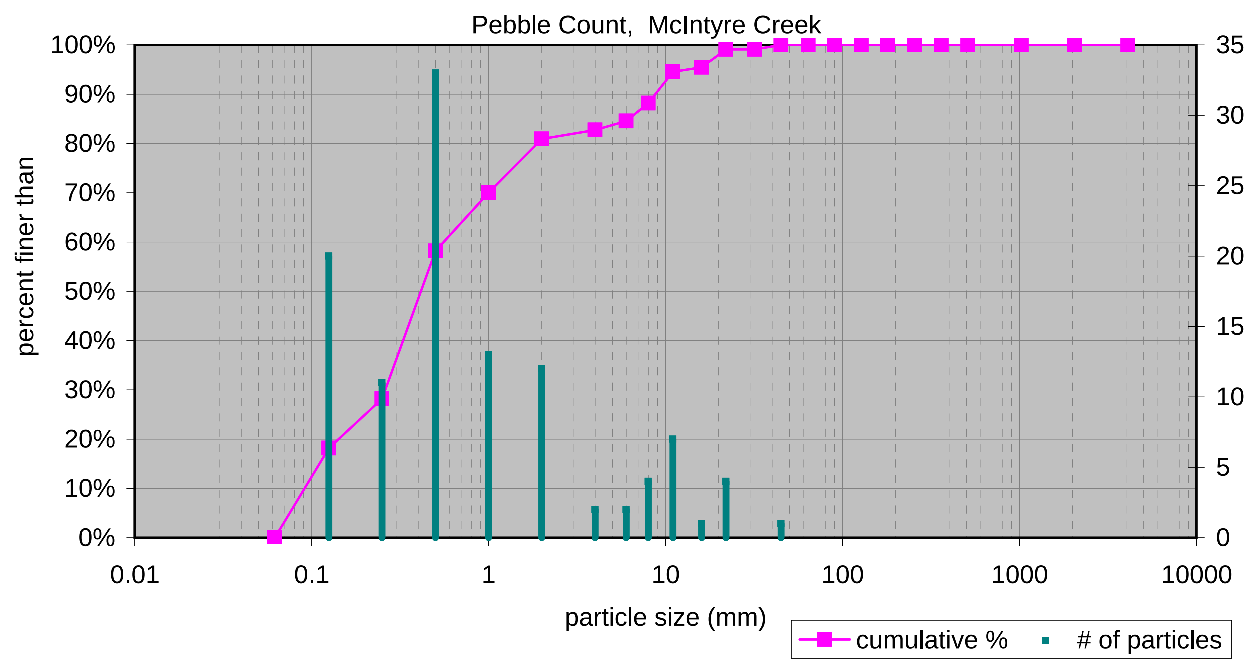
Catawba River Basin, McIntyre Creek, X-Sec 3, Run



Pebble Count,

Material	Size Range (mm)		Count
silt/clay	0	0.062	
very fine sand	0.062	0.13	
fine sand	0.13	0.25	
medium sand	0.25	0.5	
coarse sand	0.5	1	
very coarse sand	1	2	
very fine gravel	2	4	
fine gravel	4	6	
fine gravel	6	8	
medium gravel	8	11	
medium gravel	11	16	
coarse gravel	16	22	
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:	110
bedrock			
clay hardpan			
detritus/wood			
artificial			
		total count:	110

	McIntyre Creek
	Long Creek
	X-sec 3, Hornet's Nest Park, Charlotte, NC
Note:	



based on sediment particles only	size percent less than (mm)						particle size distribution		
	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
	0.115	0.29	0.4	1	5	13	8.2	0.8	6.8

based on total count	percent by substrate type								
	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
	0%	81%	19%	0%	0%	0%	0%	0%	0%

Bank Erodibility Hazard Rating Guide

Stream: McIntyre Creek **Reach:** 3, left bank **Date:** 6/11/02 **Crew:** GM, BG, PL

Bank Erosion Potential

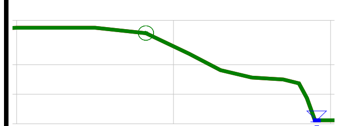
Bank Height (ft): / Bankfull Height (ft):		Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value Range	1.0	1.1	0.9	1.0	80	100	0.0	20.0	80	100
	Index Range	1.0	1.9	1.0	1.9	1.0	1.9	1.0	1.9	1.0	1.9
	Choice	**V: 1.1**	**I: 1.7**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
LOW	Value Range	1.11	1.19	0.5	0.89	55	79	21.0	60.0	55	79
	Index Range	2.0	3.9	2.0	3.9	2.0	3.9	2.0	3.9	2.0	3.9
	Choice	**V:**	**I:**	**V: 0.68**	**I: 3.0**	**V:**	**I:**	**V: 28.3**	**I: 2.4**	**V: 75.0**	**I: 2.3**
MODERATE	Value Range	1.2	1.5	0.3	0.49	30	54	61.0	80.0	30	54
	Index Range	4.0	5.9	4.0	5.9	4.0	5.9	4.0	5.9	4.0	5.9
	Choice	**V:**	**I:**	**V:**	**I:**	**V: 50.0**	**I: 4.3**	**V:**	**I:**	**V:**	**I:**
HIGH	Value Range	1.6	2.0	0.15	0.29	15	29	81.0	90.0	15	29
	Index Range	6.0	7.9	6.0	7.9	6.0	7.9	6.0	7.9	6.0	7.9
	Choice	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
VERY HIGH	Value Range	2.1	2.8	0.05	0.14	5	14	91.0	119.0	10	14
	Index Range	8.0	9.0	8.0	9.0	8.0	9.0	8.0	9.0	8.0	9.0
	Choice	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
EXTREME	Value Range	>2.8		<0.05		<5		>119		<10	
	Index Range	10		10		10		10		10	
	Choice	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
V = value, I = index										**SUB-TOTAL (Sum one index from each column)**	13.7

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

Bank Sketch



BANK MATERIAL ADJUSTMENT 0

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 0

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.9	10-19.9	20-29.9	30-39.9	40-45.9	46-50

Bank location description (check one)

Straight Reach X Outside of Bend

GRAND TOTAL 13.7

BEHI RATING LOW

McIntyre Creek Stream Restoration Project

Existing Conditions

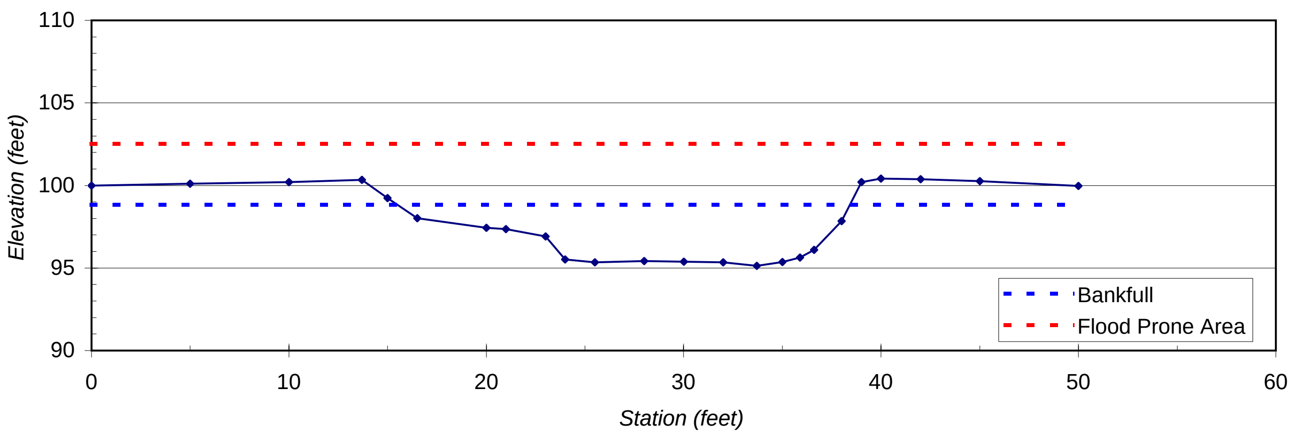
River Basin:	Catawba
Watershed:	McIntyre Creek
XS ID	X-Sec 4, Riffle
Drainage Area (sq mi):	2.55
Date:	6/12/2002
Field Crew:	G. Myrncza, P. Landis, B. Greco

Station	Rod Ht.	Elevation
0.0	2.74	100.00
5.0	2.63	100.11
10.0	2.54	100.20
13.7	2.40	100.34
15.0	3.51	99.23
16.5	4.72	98.02
20.0	5.30	97.44
21.0	5.38	97.36
23.0	5.82	96.92
24.0	7.23	95.51
25.5	7.40	95.34
28.0	7.32	95.42
30.0	7.35	95.39
32.0	7.39	95.35
33.7	7.61	95.13
35.0	7.38	95.36
35.9	7.10	95.64
36.6	6.65	96.09
38.0	4.89	97.85
39.0	2.54	100.20
40.0	2.33	100.41
42.0	2.36	100.38
45.0	2.47	100.27
50.0	2.76	99.98

SUMMARY DATA	
Bankfull Elevation:	98.83
Bankfull Cross-Sectional Area:	58.60
Bankfull Width:	23.79
Flood Prone Area Elevation:	102.53
Flood Prone Width:	N/A
Max Depth at Bankfull:	3.70
Mean Depth at Bankfull:	2.46
W / D Ratio:	9.7
Entrenchment Ratio:	N/A
Bank Height Ratio:	1.41
Slope (ft/ft):	0.003
Discharge (cfs)	260

Stream Type:	E5

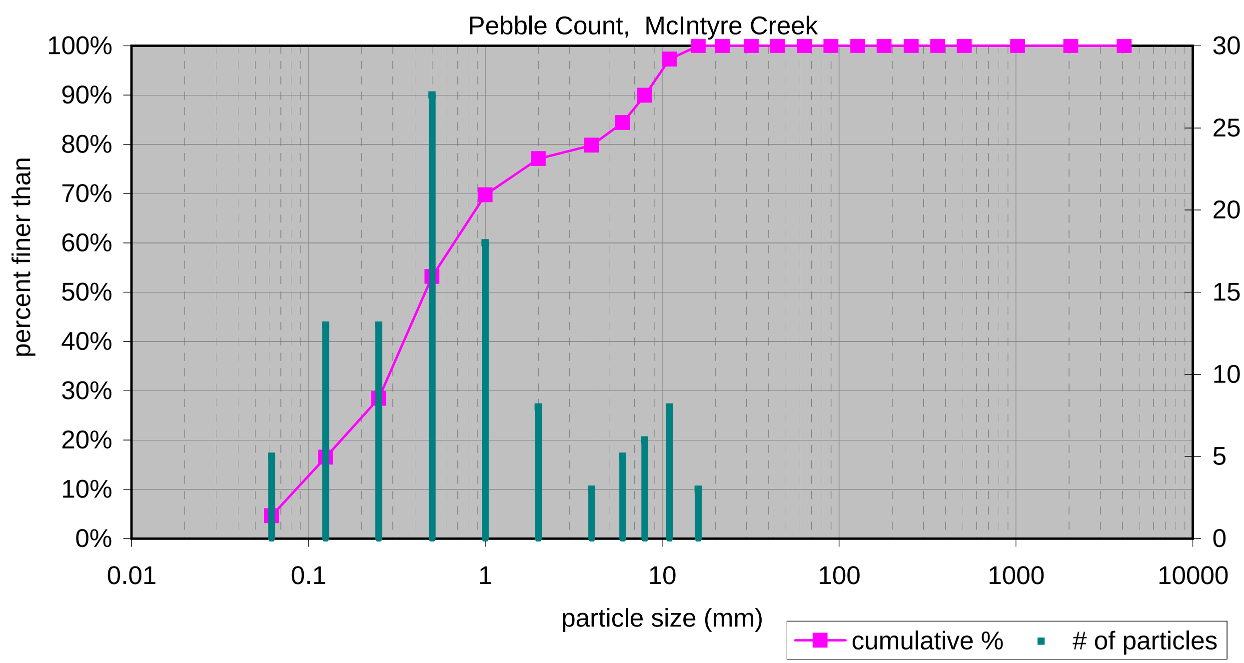
Catawba River Basin, McIntyre Creek, X-Sec 4, Riffle



Pebble Count,

Material	Size Range (mm)		Count
silt/clay	0	0.062	
very fine sand	0.062	0.13	
fine sand	0.13	0.25	
medium sand	0.25	0.5	
coarse sand	0.5	1	
very coarse sand	1	2	
very fine gravel	2	4	
fine gravel	4	6	
fine gravel	6	8	
medium gravel	8	11	
medium gravel	11	16	
coarse gravel	16	22	
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:	109

McIntyre Creek
Long Creek
X-sec 4, Hornet's Nest Park, Charlotte, NC
Note:



bedrock		
clay hardpan		
detritus/wood		
artificial		
	total count:	109

	size percent less than (mm)						particle size distribution		
based on sediment particles only	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
	0.121	0.30	0.5	1	6	10	8.2	0.8	6.9

	percent by substrate type								
based on total count	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
	5%	72%	23%	0%	0%	0%	0%	0%	0%

Bank Erodibility Hazard Rating Guide

Stream: McIntyre Creek **Reach:** 4, right bank **Date:** 6/12/02 **Crew:** GM, BG, PL

Bank Erosion Potential

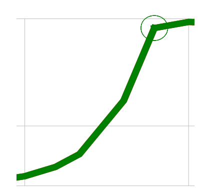
Bank Height (ft): / Bankfull Height (ft):		Bank Height/ Bankfull Ht		Root Depth/ Bank Height		Root Density %		Bank Angle (Degrees)		Surface Protection%	
VERY LOW	Value Range	1.0	1.1	0.9	1.0	80	100	0.0	20.0	80	100
	Index Range	1.0	1.9	1.0	1.9	1.0	1.9	1.0	1.9	1.0	1.9
	Choice	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
LOW	Value Range	1.11	1.19	0.5	0.89	55	79	21.0	60.0	55	79
	Index Range	2.0	3.9	2.0	3.9	2.0	3.9	2.0	3.9	2.0	3.9
	Choice	**V:**	**I:**	**V: 0.50**	**I: 3.9**	**V:**	**I:**	**V: 43.4**	**I: 3.1**	**V:**	**I:**
MODERATE	Value Range	1.2	1.5	0.3	0.49	30	54	61.0	80.0	30	54
	Index Range	4.0	5.9	4.0	5.9	4.0	5.9	4.0	5.9	4.0	5.9
	Choice	**V: 1.4**	**I: 5.1**	**V:**	**I:**	**V: 35.0**	**I: 5.5**	**V:**	**I:**	**V: 35.0**	**I: 5.5**
HIGH	Value Range	1.6	2.0	0.15	0.29	15	29	81.0	90.0	15	29
	Index Range	6.0	7.9	6.0	7.9	6.0	7.9	6.0	7.9	6.0	7.9
	Choice	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
VERY HIGH	Value Range	2.1	2.8	0.05	0.14	5	14	91.0	119.0	10	14
	Index Range	8.0	9.0	8.0	9.0	8.0	9.0	8.0	9.0	8.0	9.0
	Choice	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
EXTREME	Value Range	>2.8		<0.05		<5		>119		<10	
	Index Range	10		10		10		10		10	
	Choice	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**	**V:**	**I:**
V = value, I = index						**SUB-TOTAL (Sum one index from each column)**				**23.1**	

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

Bank Sketch



BANK MATERIAL ADJUSTMENT **5**

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT **0**

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.9	10-19.9	20-29.9	30-39.9	40-45.9	46-50

Bank location description (check one)

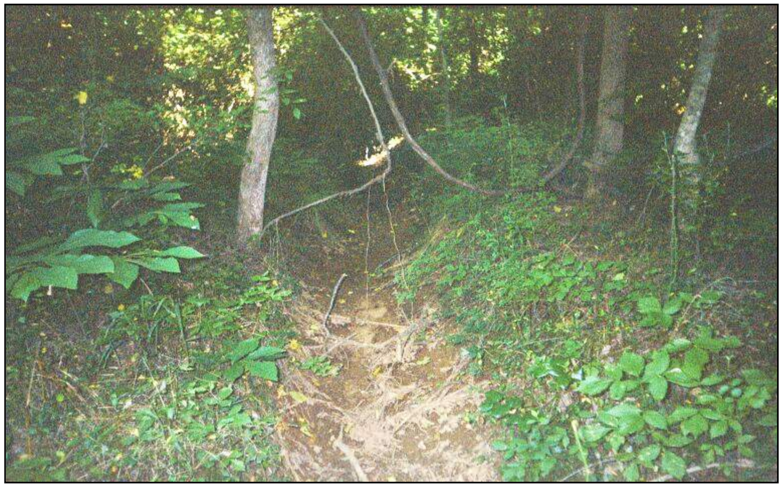
Straight Reach [ ] Outside of Bend [X]

GRAND TOTAL **28.1**

BEHI RATING **MODERATE**

McIntyre Creek Stream Restoration Project
Existing Conditions

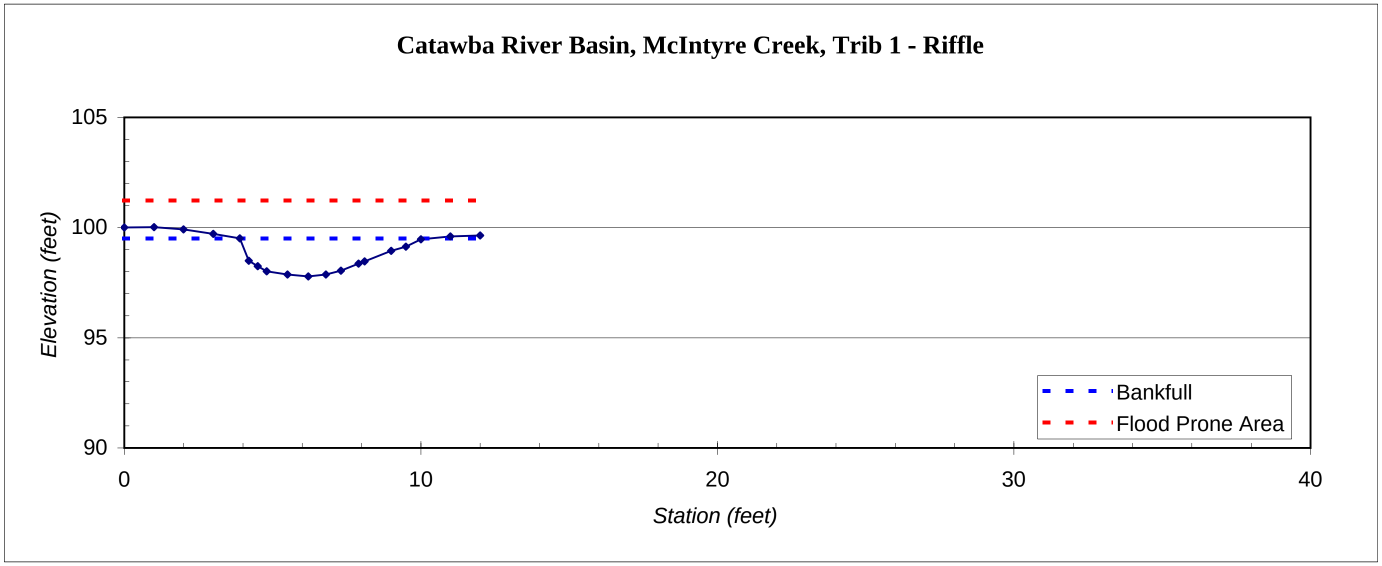
River Basin:	Catawba
Watershed:	McIntyre Creek
XS ID	Trib 1 - Riffle
Drainage Area (sq mi):	0.34
Date:	6/12/2002
Field Crew:	D. Redgate, K. Nimmer



Station	Rod Ht.	Elevation
0.0	0.08	100.00
1.0	0.06	100.02
2.0	0.16	99.92
3.0	0.36	99.72
3.9	0.57	99.51
4.2	1.59	98.49
4.5	1.83	98.25
4.8	2.06	98.02
5.5	2.21	97.87
6.2	2.29	97.79
6.8	2.21	97.87
7.3	2.03	98.05
7.9	1.71	98.37
8.1	1.62	98.46
9.0	1.13	98.95
9.5	0.95	99.13
10.0	0.61	99.47
11.0	0.48	99.60
12.0	0.44	99.64

SUMMARY DATA	
Bankfull Elevation:	99.51
Bankfull Cross-Sectional Area:	7.0
Bankfull Width:	6.4
Flood Prone Area Elevation:	101.23
Flood Prone Width:	N/A
Max Depth at Bankfull:	1.7
Mean Depth at Bankfull:	1.1
W / D Ratio:	5.8
Entrenchment Ratio:	N/A
Bank Height Ratio:	1.0
Slope (ft/ft):	0.005
Discharge (cfs)	23

Stream Type:	E6

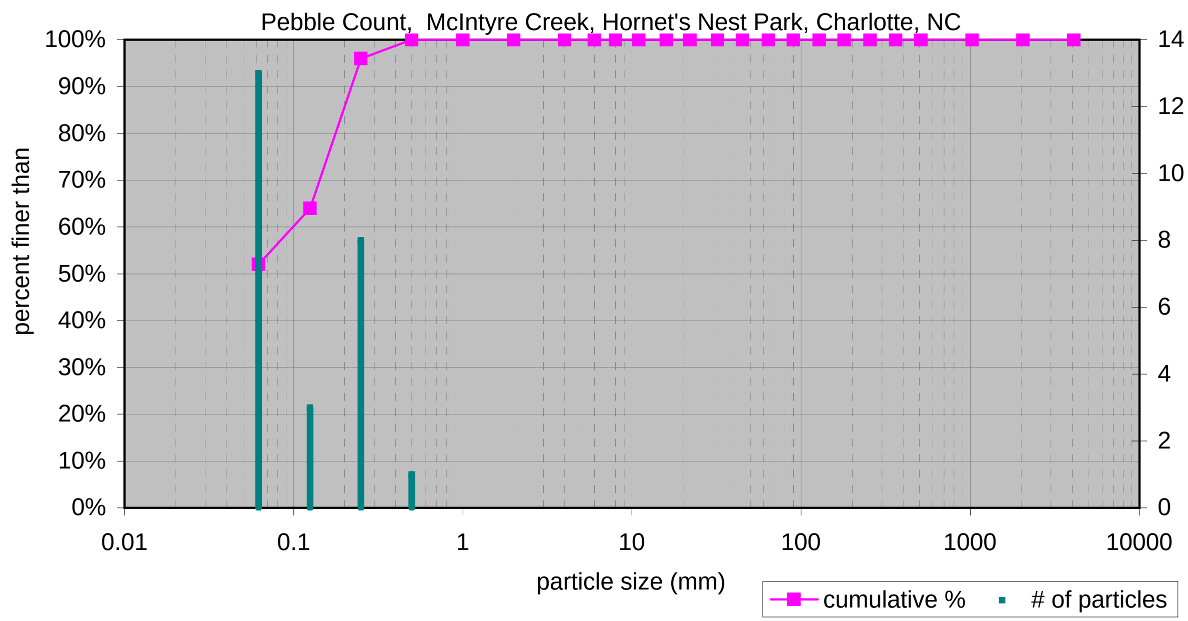


Pebble Count of Channel Reach

Material	Size Range (mm)		Count	
silt/clay	0	0.062		52%
very fine sand	0.062	0.13		64%
fine sand	0.13	0.25		96%
medium sand	0.25	0.5		100%
coarse sand	0.5	1		100%
very coarse sand	1	2		100%
very fine gravel	2	4		100%
fine gravel	4	6		100%
fine gravel	6	8		100%
medium gravel	8	11		100%
medium gravel	11	16		100%
coarse gravel	16	22		100%
coarse gravel	22	32		100%
very coarse gravel	32	45		100%
very coarse gravel	45	64		100%
small cobble	64	90		100%
medium cobble	90	128		100%
large cobble	128	180		100%
very large cobble	180	256		100%
small boulder	256	362		100%
small boulder	362	512		100%
medium boulder	512	1024		100%
large boulder	1024	2048		100%
very large boulder	2048	4096		100%
	total particle count:		25	

bedrock		
clay hardpan		
detritus/wood		
artificial		
	total count:	25

Pebble Count,
McIntyre Creek, Hornet's Nest Park, Charlotte, NC
Long Creek
Tributary #1, Riffle
Note:



based on sediment particles only	size percent less than (mm)						particle size distribution		
	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
	0.062	0.06	0.1	0	0	0	2.1	0.1	1.8

based on total count	percent by substrate type								
	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
	52%	48%	0%	0%	0%	0%	0%	0%	0%

McIntyre Creek Stream Restoration Project

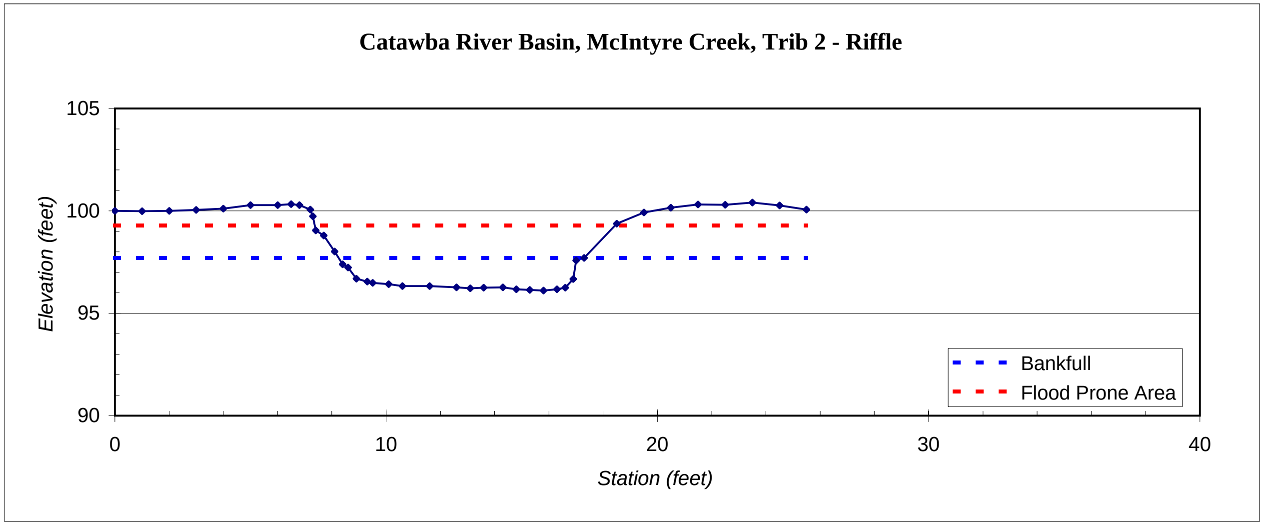
Existing Conditions

River Basin:	Catawba
Watershed:	McIntyre Creek
XS ID	Trib 2 - Riffle
Drainage Area (sq mi):	0.31
Date:	6/11/2002
Field Crew:	D. Redgate, K. Nimmer

Station	Rod Ht.	Elevation
0.0	0.46	100.00
1.0	0.47	99.99
2.0	0.46	100.00
3.0	0.42	100.04
4.0	0.35	100.11
5.0	0.18	100.28
6.0	0.18	100.28
6.5	0.13	100.33
6.8	0.18	100.28
7.2	0.40	100.06
7.3	0.73	99.73
7.4	1.42	99.04
7.7	1.66	98.80
8.1	2.45	98.01
8.4	3.07	97.39
8.6	3.22	97.24
8.9	3.78	96.68
9.3	3.91	96.55
9.5	3.97	96.49
10.1	4.04	96.42
10.6	4.13	96.33
11.6	4.13	96.33
12.6	4.20	96.26
13.1	4.24	96.22
13.6	4.21	96.25
14.3	4.19	96.27
14.8	4.29	96.17
15.3	4.32	96.14
15.8	4.35	96.11
16.3	4.29	96.17
16.6	4.21	96.25
16.9	3.79	96.67
17.0	2.88	97.58
17.3	2.76	97.70
18.5	1.09	99.37
19.5	0.54	99.92
20.5	0.30	100.16
21.5	0.15	100.31
22.5	0.16	100.30
23.5	0.06	100.40
24.5	0.20	100.26
25.5	0.39	100.07

SUMMARY DATA	
Bankfull Elevation:	97.70
Bankfull Cross-Sectional Area:	11.6
Bankfull Width:	9.1
Flood Prone Area Elevation:	99.29
Flood Prone Width:	11.1
Max Depth at Bankfull:	1.6
Mean Depth at Bankfull:	1.3
W / D Ratio:	7.0
Entrenchment Ratio:	1.2
Bank Height Ratio:	2.7
Slope (ft/ft):	0.005
Discharge (cfs)	43

Stream Type:	G5c



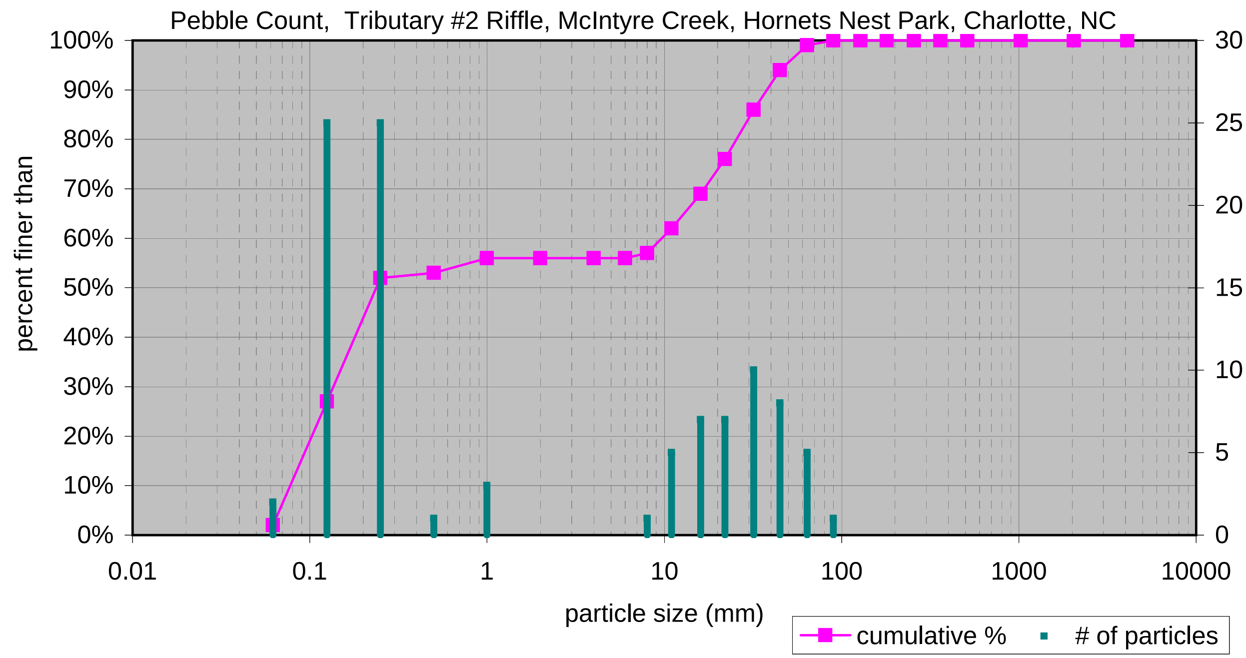
Pebble Count of Channel Reach

Pebble Count,

Material	Size Range (mm)		Count
silt/clay	0	0.062	
very fine sand	0.062	0.13	
fine sand	0.13	0.25	
medium sand	0.25	0.5	
coarse sand	0.5	1	
very coarse sand	1	2	
very fine gravel	2	4	
fine gravel	4	6	
fine gravel	6	8	
medium gravel	8	11	
medium gravel	11	16	
coarse gravel	16	22	
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:			100

bedrock		
clay hardpan		
detritus/wood		
artificial		
total count:		100

	Tributary #2 Riffle, McIntyre Creek, Hornets Nest Park, Charlotte, NC
	Long Creek
	Tributary #2, Riffle
Note:	



based on sediment particles only	size percent less than (mm)						particle size distribution		
	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
	0.092	0.16	0.2	13	30	48	64.1	1.7	18.0

based on total count	percent by substrate type								
	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
	2%	54%	43%	1%	0%	0%	0%	0%	0%

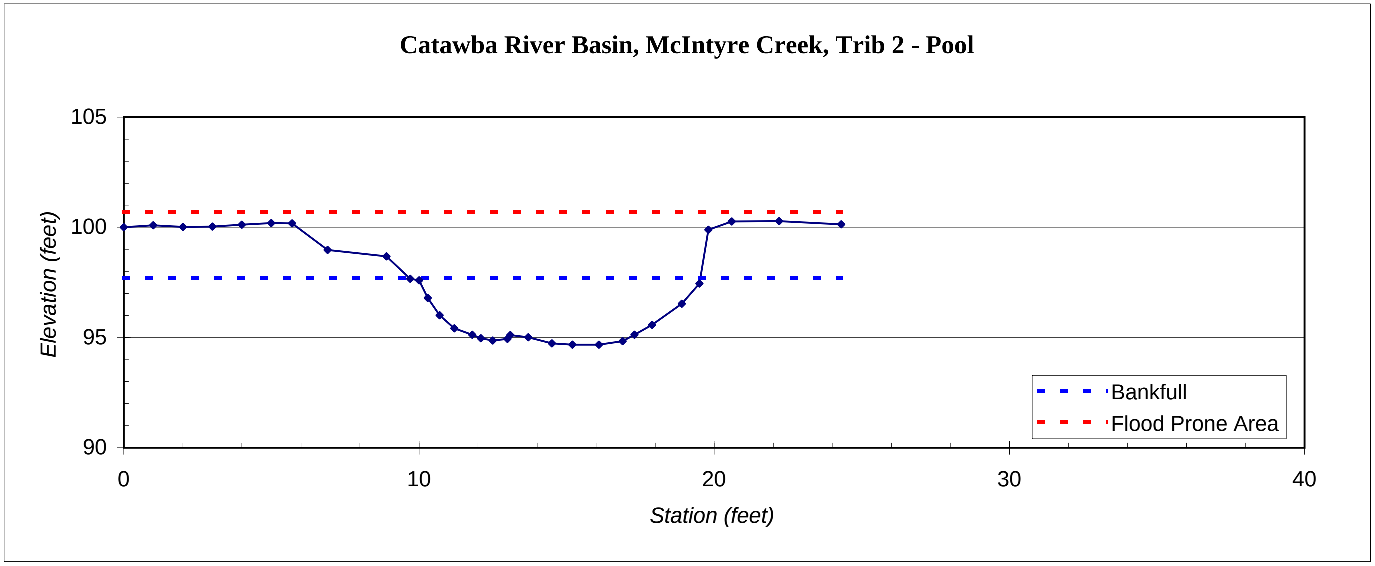
McIntyre Creek Stream Restoration Project
Existing Conditions

River Basin:	Catawba
Watershed:	McIntyre Creek
XS ID	Trib 2 - Pool
Drainage Area (sq mi):	0.31
Date:	6/11/2002
Field Crew:	D. Redgate, K. Nimmer

Station	Rod Ht.	Elevation
0.0	0.44	100.00
1.0	0.35	100.09
2.0	0.42	100.02
3.0	0.40	100.04
4.0	0.32	100.12
5.0	0.25	100.19
5.7	0.26	100.18
6.9	1.47	98.97
8.9	1.76	98.68
9.7	2.78	97.66
10.0	2.85	97.59
10.3	3.65	96.79
10.7	4.43	96.01
11.2	5.03	95.41
11.8	5.32	95.12
12.1	5.47	94.97
12.5	5.58	94.86
13.0	5.51	94.93
13.1	5.33	95.11
13.7	5.43	95.01
14.5	5.70	94.74
15.2	5.76	94.68
16.1	5.76	94.68
16.9	5.61	94.83
17.3	5.32	95.12
17.9	4.87	95.57
18.9	3.91	96.53
19.5	2.99	97.45
19.8	0.55	99.89
20.6	0.17	100.27
22.2	0.16	100.28
24.3	0.3	100.14

SUMMARY DATA	
Bankfull Elevation:	97.70
Bankfull Cross-Sectional Area:	13.9
Bankfull Width:	8.8
Flood Prone Area Elevation:	100.72
Flood Prone Width:	12.3
Max Depth at Bankfull:	3.0
Mean Depth at Bankfull:	1.6
W / D Ratio:	5.5
Entrenchment Ratio:	1.4
Bank Height Ratio:	1.8
Slope (ft/ft):	0.002
Discharge (cfs)	37

Stream Type:	G5c

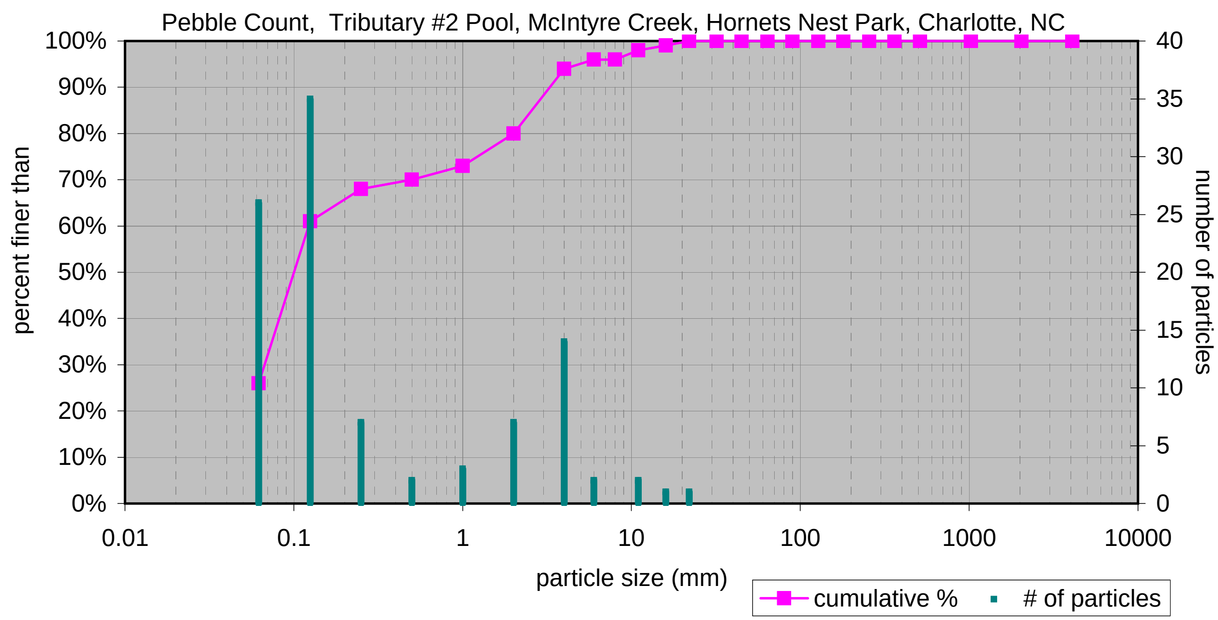


Pebble Count of Channel Reach

Pebble Count,

Material	Size Range (mm)		Count	
silt/clay	0	0.062		26%
very fine sand	0.062	0.13		61%
fine sand	0.13	0.25		68%
medium sand	0.25	0.5		70%
coarse sand	0.5	1		73%
very coarse sand	1	2		80%
very fine gravel	2	4		94%
fine gravel	4	6		96%
fine gravel	6	8		96%
medium gravel	8	11		98%
medium gravel	11	16		99%
coarse gravel	16	22		100%
coarse gravel	22	32		100%
very coarse gravel	32	45		100%
very coarse gravel	45	64		100%
small cobble	64	90		100%
medium cobble	90	128		100%
large cobble	128	180		100%
very large cobble	180	256		100%
small boulder	256	362		100%
small boulder	362	512		100%
medium boulder	512	1024		100%
large boulder	1024	2048		100%
very large boulder	2048	4096		100%
		total particle count:	100	
bedrock				
clay hardpan				
detritus/wood				
artificial				
		total count:	100	

	Tributary #2 Pool, McIntyre Creek, Hornets Nest Park, Charlotte, NC
	Long Creek
	Tributary #2, Pool
Note:	



based on sediment particles only	size percent less than (mm)						particle size distribution		
	D16	D35	D50	D65	D84	D95	gradation	geo mean	std dev
	0.062	0.07	0.1	0	2	5	13.0	0.4	6.3

based on total count	percent by substrate type								
	silt/clay	sand	gravel	cobble	boulder	bedrock	hardpan	wood/det	artificial
	26%	54%	20%	0%	0%	0%	0%	0%	0%

APPENDIX 2

Photo 1: View of McIntyre Creek looking upstream at the Beatties Ford Bridge.

Photo 2: Cross section #1, looking downstream.

Photo 3: View of debris jam, near Station 14+75. Numerous debris jams exist throughout the project reach, as a result of fallen trees caused by bank erosion.

Photo 4: Small knickpoint (approximately 14" high) indicating limit of headward erosion in this reach. (Approximate location = Station 14+00.)

Photo 5: Small tributary entering McIntyre Creek from the south. Note: The baselevel of the tributary is lowering with headward migration up the valley.

Photo 6: Large debris jam, near station 38+00, disrupts flow in McIntyre Creek at this location.

Photo 7: High BEHI scores are common in the upper portion of the project reach.

Photo 8: Cross section #2, looking downstream.

Photo 9: Rip rap channel extending downstream from gas pipeline crossing. This point divides the project reach into upper/lower portions.

Photo 10: Large scour hole at the confluence of McIntyre Creek with tributary #2.

Photo 11: View looking upstream at a bar sampling location.

Photo 12: View looking downstream of the tributary #2 confluence (lower portion of the project reach.)

Photo 13: Cross section #3 near existing station 45+50.

Photo 14: Water level-logging instrument installed at cross section #3 to gauge discharges in McIntyre Creek.

Constraints Photograph Log
McIntyre Creek

Photo 1. Exposed ABS conduit near the upstream project limits.

Photo 2. Hole 7 of the flying disc golf course adjacent to the right bank near existing Station 32+00.

Photos 4-5. View of private properties adjacent to the left bank from existing Station 34+00 to Station 41+00.

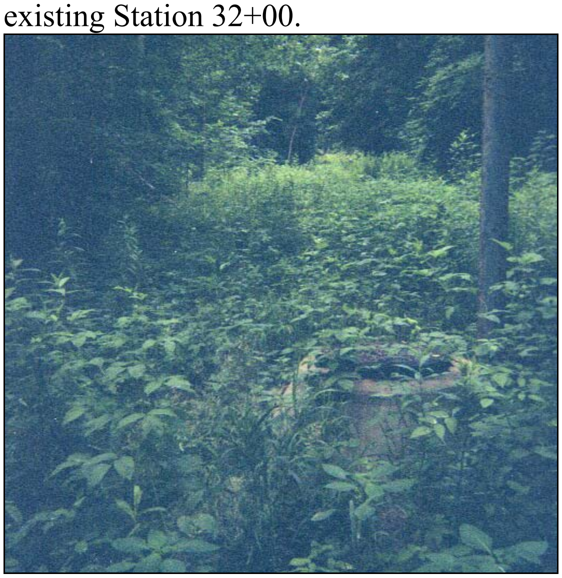


Photo 3. View of sanitary sewer easement that parallels the left bank of the entire upstream portion of the site.

Photo 6. Gas pipeline crossing near existing Station 42+30 in the downstream portion of the project site.

APPENDIX 3

APPENDIX 4