WETLAND MITIGATION AND STREAM RESTORATION PLAN

SPEIGHT BRANCH
Wake County, North Carolina

State Project No. 8.1402601
TIP Project No. R-2541

North Carolina Department of Transportation
Project Development and Environmental Analysis Branch

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STATE OF NORTH CAROLINA • DEPARTMENT OF TRANSPORTATION •

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April 1999

EXECUTIVE SUMMARY

The North Carolina Department of Transportation (NCDOT) proposes to construct the NC 55 Holly Springs Bypass (R-2541) on a new location from SR 1114 (Ralph Stevens Loop Road) to SR 1448 (Bobbitt Road) in Wake County. Construction of this project will result in unavoidable impacts to 1.28 hectares [ha] (3.17 acres [ac]) of wetlands and 528 meters [m] (1,733 feet [ft]) of streams which occur within the proposed corridor.

The Speight Branch Site has been selected as partial mitigation for these impacts. This site, 11.3 ha (28 ac) in size, is located in the northwestern quadrant of the intersection of SR 1152 and Swift Creek in central Wake County. The entire property has been altered by an extensive timber clearcut within the last five years. Many fallen trees and limbs were left behind, and heavy equipment has altered the microtopography of the site, leaving deep ruts and compacted soil. Emergent wetlands, dominated by soft rush, encompass 3.4 ha (8.3 ac). Speight Branch, a second order perennial stream, crosses the Burke Property and empties into Swift Creek.

Enhancement of the existing wetlands is proposed by removing the numerous downed trees and existing thick scrub and herbaceous vegetation and then planting with bottomland hardwood species. Also, grading three upland areas to the elevation of adjacent wetlands will create an additional 0.4 ha (1.0 ac) of wetlands.

Speight Branch, which has been channelized through the central portion of the property, will be restored within its floodplain and returned to its proper geometry. The project will restore 448 m (1,470 ft) of Speight Branch.

The site is located within the floodplain of Swift Creek, a stream that is under heavy development pressure from the urbanization of Wake County and targeted by several local resource agencies for protection. The property is located across Swift Creek from an 3.4 ha (8.4 ac) tract owned by the Triangle Land Conservancy. Although this site was protected primarily for the diverse flora found on its north-facing bluffs, it also contains a floodplain forest with a mature canopy of diverse species. The Triangle Land Conservancy has shown an interest in acquiring or leasing the Speight Branch Property. The Town of Cary has also shown interest in developing a Greenway trail on upland portions of the property.

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1.0 INTRODUCTION

The North Carolina Department of Transportation (NCDOT) proposes to construct the NC 55 Holly Springs Bypass (R-2541) on a new location from SR 1114 (Ralph Stevens Loop Road) to SR 1448 (Bobbitt Road) in Wake County (Figure 1). Construction of this project will result in unavoidable impacts to 1.28 ha (3.16 ac) of wetlands including bottomland hardwood forest (0.38 ha /0.94 ac), headwater forest (0.73 ha/1.80 ac), and disturbed emergent wetlands (0.17 ha/0.42 ac) which occur within the proposed corridor. Stream impacts totaling 528 m (1,733 ft) are anticipated. The Speight Branch Site will serve as partial mitigation for both the stream and wetland impacts.

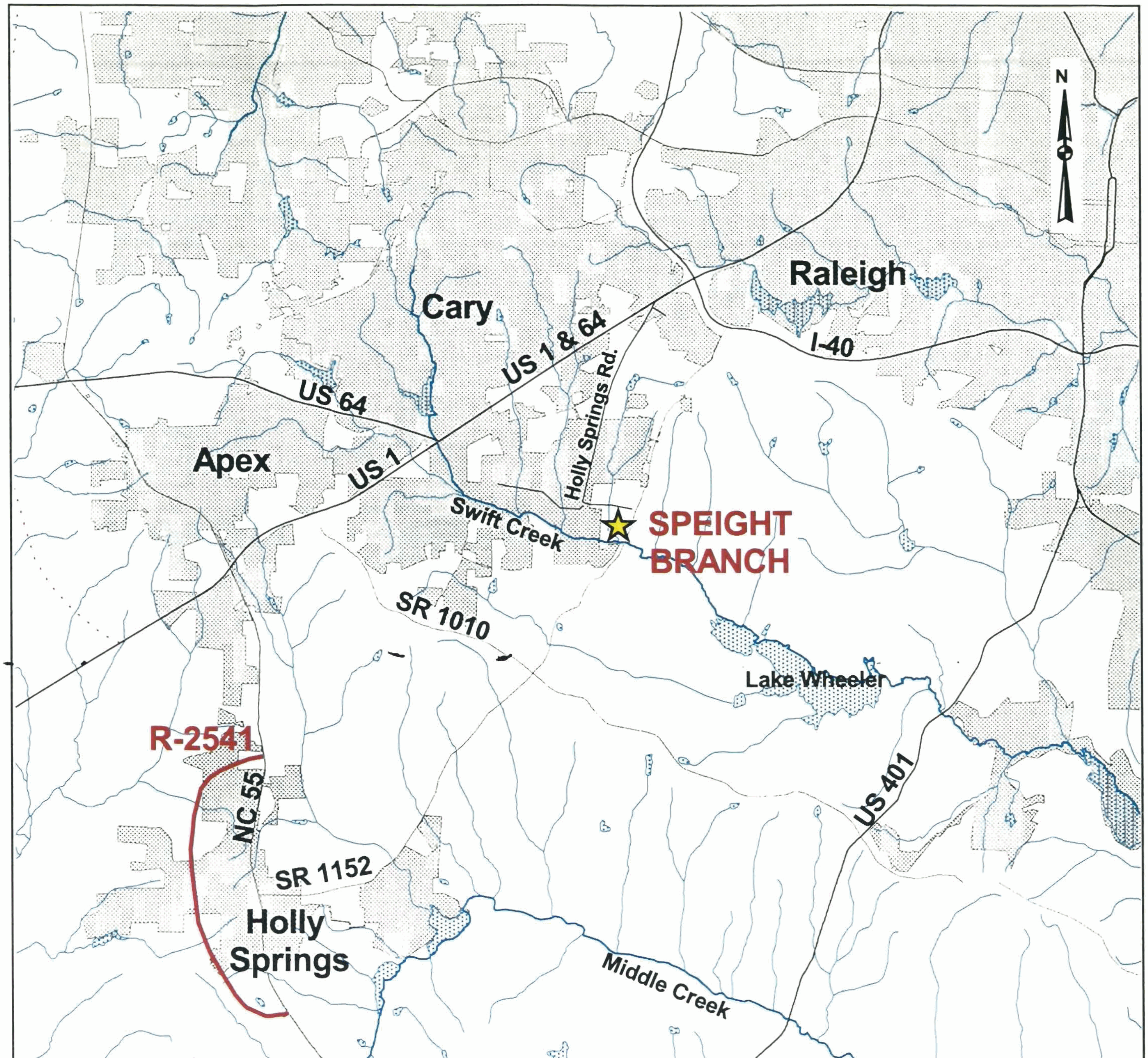
1.1 PROJECT DESCRIPTION

The Speight Branch Property, 11.4 ha (28.3 ac) in size, is located in the northwestern quadrant of the intersection of SR 1152 and Swift Creek in central Wake County (Figure 2). Most of the property is within the floodplain of Swift Creek. The entire property was altered from an extensive timber clearcut about five years ago. Many fallen trees and limbs were left behind, and heavy equipment altered the microtopography of the site by compacting the soil and creating tire ruts. Approximately 3.3 ha (8.3 ac) of the site consists of emergent wetlands and the rest of the property contains cutover uplands in various stages of vegetative succession. Speight Branch, a perennial, second order stream, crosses the property and empties into Swift Creek. The stream has been channelized and exhibits unstable channel dimension, pattern, and profile eroded stream banks, and poor aquatic habitat.

This restoration plan has two major components, 1) enhance existing wetlands and create additional wetland areas and 2) restore the stream to a stable dimension, pattern, and profile.

The existing wetlands will be enhanced by clearing the existing weedy vegetation and replanting with hardwoods. Hydrological enhancement will also occur through the filling of small drainage ditches.

The stream restoration will be a Priority 1 restoration (Rosgen,1997). Table 1 describes and summarizes the four priorities of incised river restoration (Hey, 1997). Normally a Priority 1 restoration would reestablish the stream at its original floodplain elevation. It is important to note Rosgen's priorities apply only to incised rivers. Speight Branch is only slightly incised at its confluence with Swift Creek. The proposed restoration restores the channel's pattern and provides grade control to prevent further entrenchment. Dr. Greg Jennings at North Carolina State University considers this a Priority 1 restoration because the project does restore a stable dimension, pattern, and profile, although re-attachment to the flood plain is not necessary.



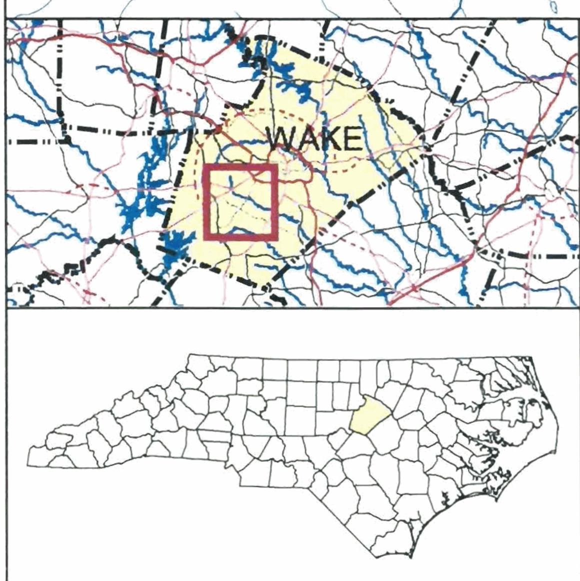


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FIGURE 1
Project Location Map
Speight Branch Mitigation Site
Wake County, North Carolina

1 0 1 2 3 Miles

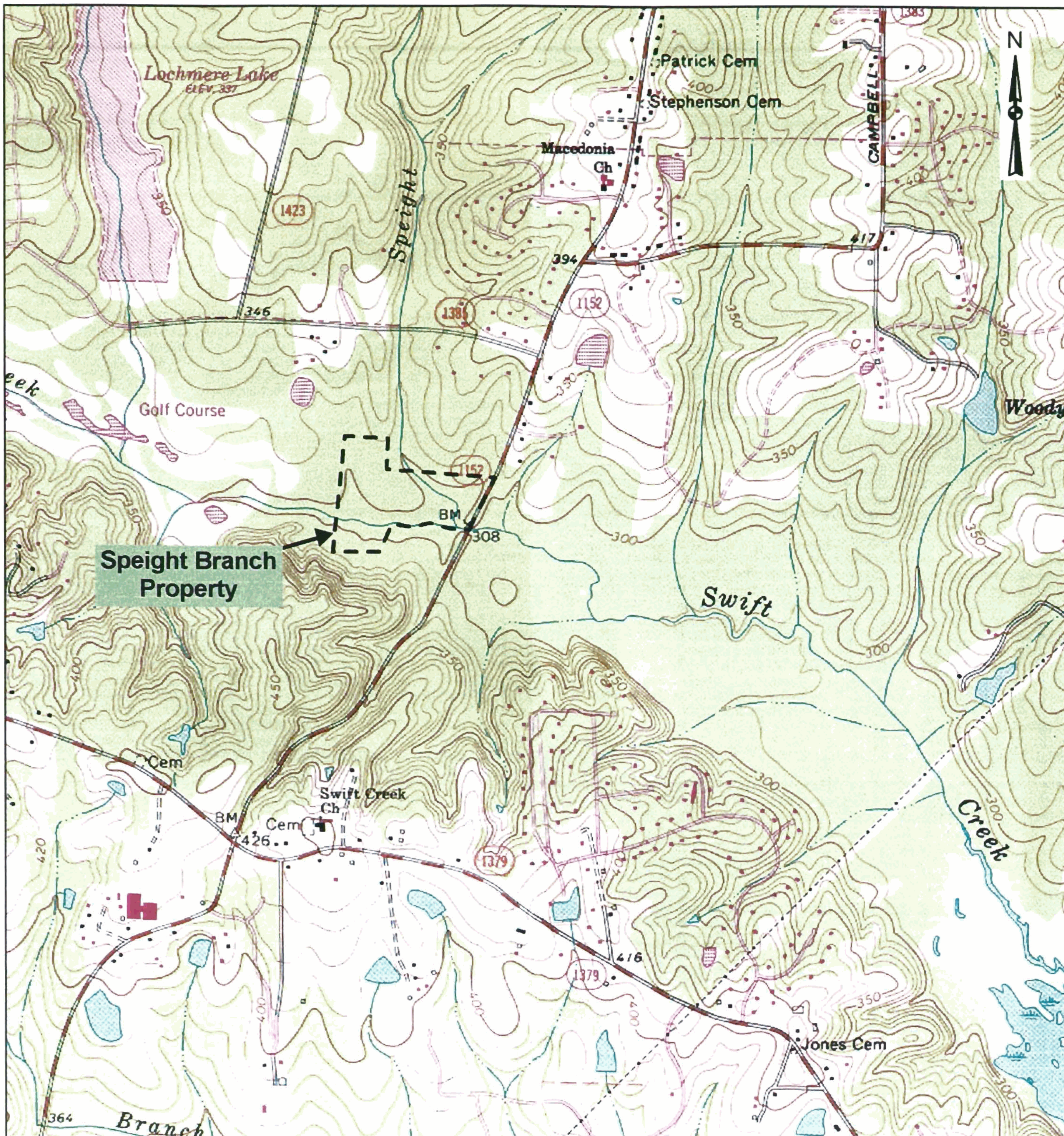

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FIGURE 2
Site Vicinity Map
Speight Branch Mitigation Site
Wake County, North Carolina

2000 0 2000 4000 Feet

SOURCE: USGS Topographic Quads:
Lake Wheeler, N.C. Photorevised 1987;
Apex, N.C. Photorevised 1987.

Table 1 Priorities, Description, and Summary For Incised River Restoration

DESCRIPTION	METHODS	ADVANTAGES	DISADVANTAGES
PRIORITY 1 Convert G and/or F stream types to C and/or E at previous elevation w/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 G and/or F stream types to C or E. Re-establishment of floodplain at existing 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 walls. End-hall 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 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 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 ratio.	1) reduces the amount of land needed to return the river to a stable form. 2) developments next to river need not be re-located due to flooding potential 3) decreases flood stage for the 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 stream bed and bank erosion, including concrete, gabions, boulders and bio-engineering methods	1) excavation volumes 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

1.2 GOALS AND OBJECTIVES

This project has the following goals and objectives:

1. Vegetatively and hydrologically enhance existing wetlands by removing existing timber debris, repairing microtopography, and filling small drainage ditches.
2. Create additional wetlands by minor grading of upland areas adjacent to existing wetlands and allow for hydrologic connection with Speight Branch and wetland areas.
3. Increase diversity and improve wetland function by planting hardwood species in enhanced and created wetlands.
4. Provide a stable stream channel that neither aggrades nor degrades while maintaining its dimension, pattern, and profile with the capacity to transport its watershed's water and sediment load.
5. Reduce bank erosion and filter pollutants through vegetative plants and buffers
6. Improve aquatic habitat by reducing the silt and clay fines in the stream bed caused by bank erosion.
7. Improve fish habitat with the use of natural material stabilization structures such as root wads and rock vanes and a riparian buffer.
8. Provide wildlife habitat through the preservation of riparian and upland land in the floodplain of Swift Creek.

1.3 PROJECT HISTORY

The Speight Branch Property (initially identified as the Burke Property) was brought to the attention of the NCDOT in the summer of 1997 by its owner (Figure 3). A site walkover was conducted with the US Army Corps of Engineers (USACE), US Fish and Wildlife Service (USFWS), NC Division of Water Quality (DWQ), and NC Wildlife Resources Commission on September 22, 1997. At that time agency personnel verbally indicated that the site appeared to be suitable as a mitigation enhancement site.

Following the walkover, a Feasibility Study of the property was conducted by Rust Environment & Infrastructure (now dba as Earth Tech) and issued to NCDOT in January 1998. The report concluded that approximately 37 percent of the site contained disturbed emergent wetlands, and that vegetative and hydrological enhancement of these wetland areas was possible. In addition, several upland areas on the site had potential for wetland creation via minor grading.

The feasibility study also concluded that approximately 300 linear meters (960 ft) (based on preliminary mapping) of Speight Branch had been channelized in the past and that increased development pressures upstream had caused degradation of water quality and loss of aquatic habitat. Restoration of the stream was possible but would require additional studies.

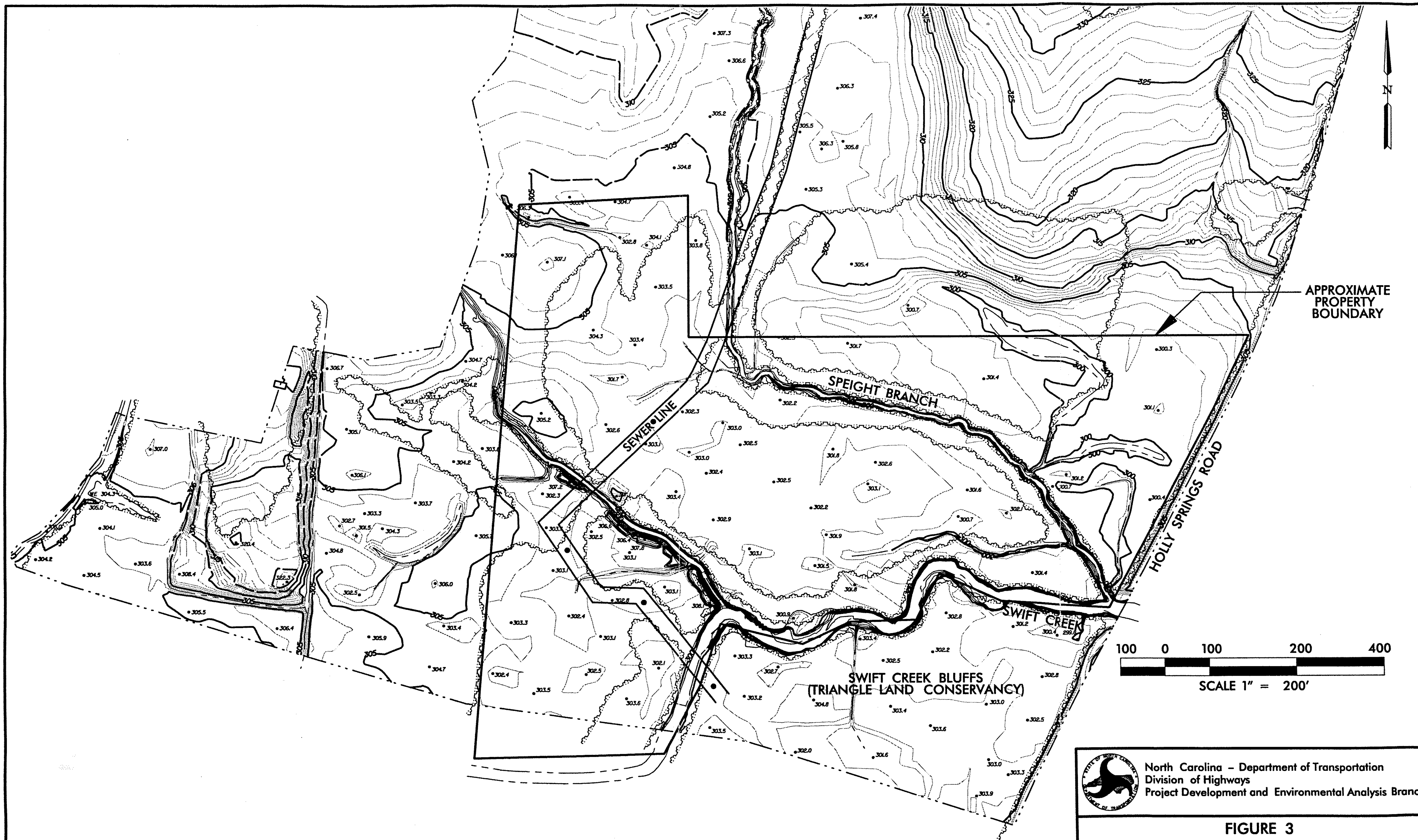

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FIGURE 3
Site Map
Speight Branch Mitigation Site
Wake County, North Carolina

The original size of the tract to be purchased was 15.3 ha (38 ac). The landowner wanted to retain about 2.4 ha (6 ac) of the upland area for a potential development. However, due to Wake County regulations, it was determined that subdividing any portion of land less than 4.0 ha (10 ac) could not easily be performed. Therefore it was decided that only 11.4 ha (28.2 ac) would be purchased by NCDOT and that the owner would retain 4.1 ha (10.1 ac) of primarily upland area.

2.0 EXISTING CONDITIONS

2.1 WATERSHED

2.1.1 Description

2.1.1.1 Swift Creek

Speight Branch is included in the Swift Creek Watershed and is located within the Piedmont Physiographic Province of the Neuse River Basin. The Swift Creek headwaters originate about 18 km (11 mi) northwest of the project area. This creek flows southeast for approximately 71 km (44 mi) to its confluence with the Neuse River. This portion of Swift Creek [Index #27-43-(1)] is classified as a Class WS-III NSW water body. Water supply III - (WS-III) waters are used as sources of water supply for drinking, culinary, or food processing purposes for those users where a more protective WS-I or II classification is not feasible. WS-III waters are generally in low to moderately developed watersheds. NSW is a supplemental classification intended for waters needing additional nutrient management due to their being subject to excessive growth of microscopic or macroscopic vegetation. In general, management strategies for point and non-point source pollution control require no increase in nutrients over background levels.

2.1.1.2 Speight Branch

Speight Branch, a second order stream, flows approximately 4.3 km (2.7 mi) south from its watershed boundaries to the confluence of Swift Creek. The watershed is approximately 405 ha (1000 ac) or 4.0 sq. km (1.6 sq. mi) and is oblong in shape (Figure 4). Within the watershed exists a mixture of residential and commercial properties as well as undeveloped land. Based on the existing soils and landuse, this watershed is characterized as having an SCS Curve Number of 64.

Holly Springs Road (SR 1152) and Tryon (SR 1009) to the east and Piney Plains Road (SR 1423) to the west are located along the ridgelines which serve as the eastern and western boundary of the watershed. The northern and southwestern boundaries follow topography to the Swift Creek confluence. The headwaters of Speight Branch originate in a heavily developed area to the north. A small unnamed tributary to the northeast flows into Speight Branch, which in turn empties into Lochmere Lake. Speight Branch flows south out of this lake and is joined by another small tributary in the lower third of the drainage area before eventually draining into Swift Creek (see Figure 4).

Topography of the area is characterized as rolling to hilly and contains steep slopes and flat floodplains adjacent to large drainageways. The watershed gradient is approximately 1.4%. Many of the higher elevation sites within the watershed have been developed or are currently being developed as residential areas.

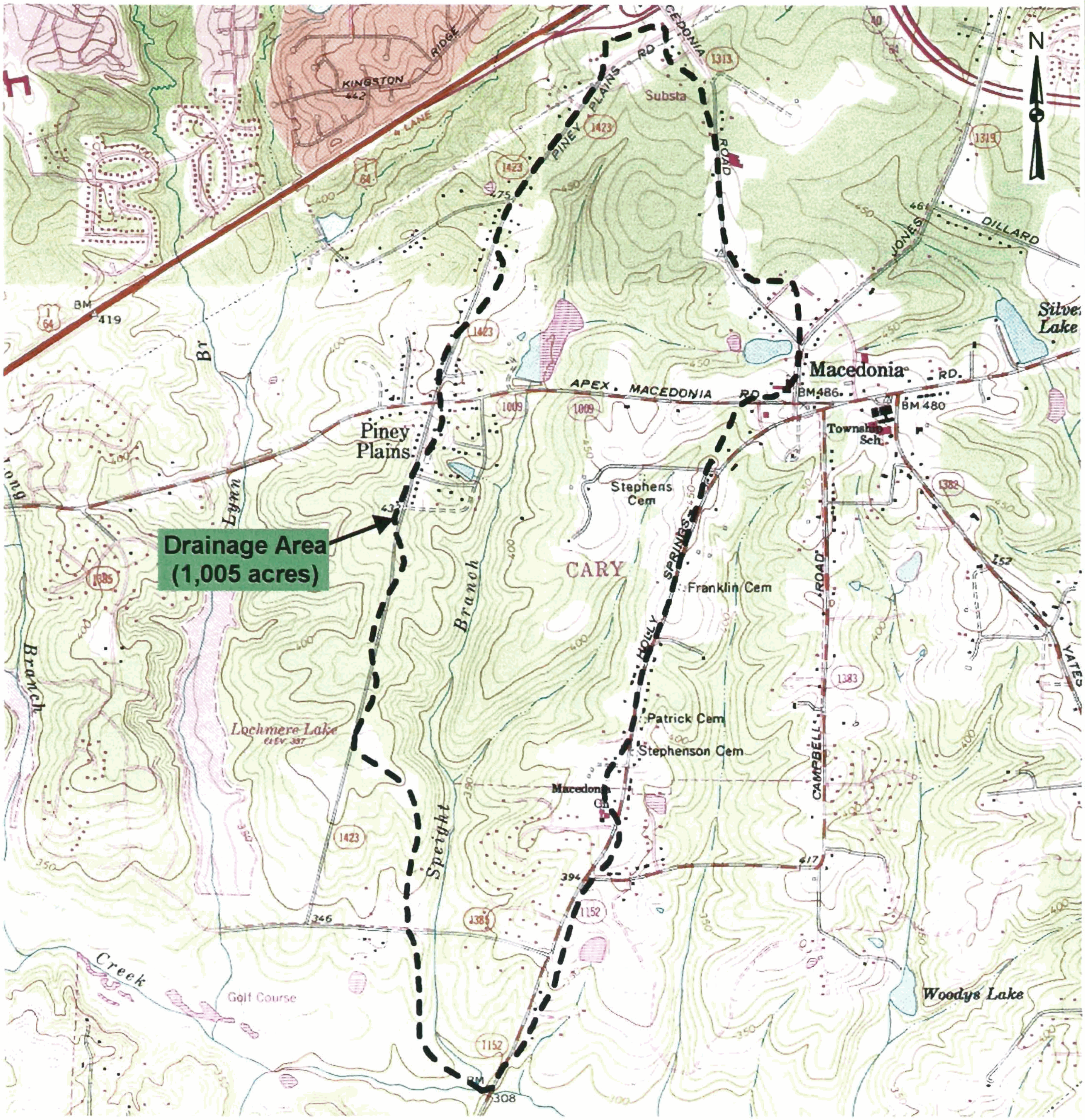

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FIGURE 4
Speight Branch Drainage Area
Speight Branch Mitigation Site
Wake County, North Carolina

2000 0 2000 4000 Feet

SOURCE: USGS Topographic Quads:
Lake Wheeler, N.C. Photorevised 1987;
Apex, N.C. Photorevised 1987.

Soils in upland areas of the watershed are mainly Appling sandy loams and Cecil sandy loams (Figure 5). These soils have variable slopes and many areas are eroded according to the Wake County Soil Survey (1970). Colfax sandy loams and Worsham sandy loams are prevalent in the upper portion of the watershed. Chewacla soils are dominant in drainageways and low-lying areas in the lower half of the watershed. Wehadkee silt loam is associated with the floodplain of Swift Creek and is present at the confluence of Speight Branch.

2.1.2 Landuse and Zoning

Landuses within the watershed area have been identified in the Wake County Planning Department Landuse Plan (May 1998) as Agriculture, Commercial, Industrial, Institutional, Office, and Residential (Figure 6). Some lots, including the project site, are designated as Vacant and a lot at the northern end of the watershed is listed as Unknown. The majority of the watershed is listed for residential landuse.

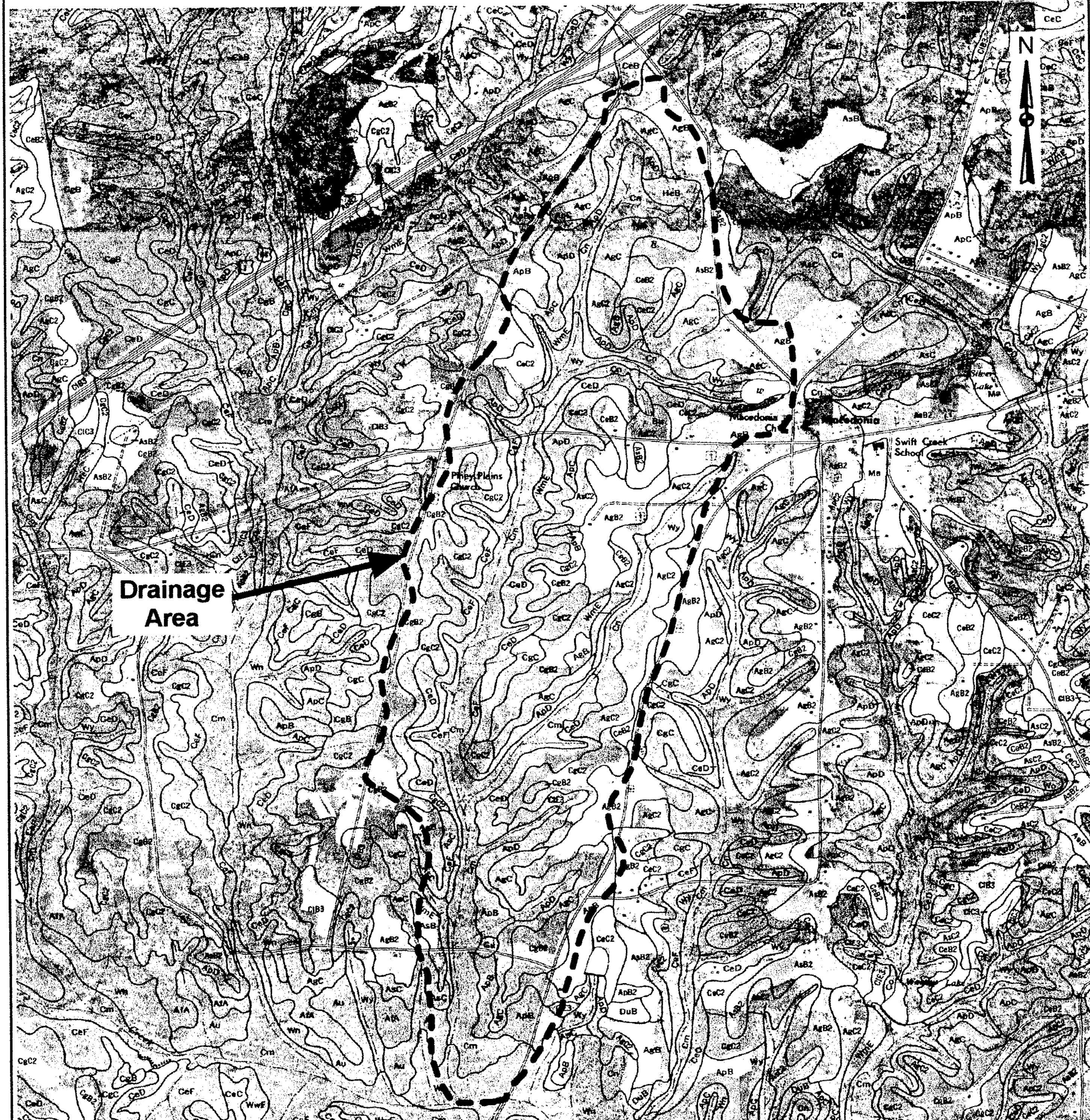
Zoning is primarily for residential use (Town of Cary Planning Department 1999) (Figure 7). Within the watershed exist three (3) primary district types: Residential, Office and Institutional, and Commercial. Approximately 364 ha (900 ac) or 90 % of the watershed area is zoned as Residential District R-8, R-10, R-30, and R-40 (Figure 7). Commercial District represents the second largest zoned area, with 36 ha (90 ac) or 10% of the watershed making up this district. Areas zoned Office and Institutional comprise only 1% or 4 ha (10 ac) of the watershed.

2.1.3 Development/Stability

Approximately 60 percent of the watershed has been developed, with the majority of development being single family residences (see Figure 7). The lower third of the watershed is currently vacant land totaling about 70 ha (170 ac) in size. A few houses currently occupy land within this zoned area. This entire area is zoned R-40 and will most likely be developed.

Land within the center of the watershed is zoned R-30 and R-40 and has been developed with single family residences. One block along Holly Springs Road, zoned R-40, is about 49 ha (120 ac) and is currently under development.

The northern portion of the watershed is zoned as B-2 Commercial and is occupied by several businesses. Some areas are also zoned as residential. One block, zoned as R-30, is approximately 45 ha (110 ac) in size and has not been developed.



LEGEND

AgB2 - Appling Gravelly Sandy Loam 2-6% slope, eroded
AgC - Appling Gravelly Sandy Loam 6-10% slope
ApB - Appling Sandy Loam 2-6% slope
ApC - Appling Sandy Loam 6-10% slope
ApD - Appling Sandy Loam 10-15% slope
Au - Augusta Fine Sandy Loam
CeB2 - Cecil Sandy Loam 2-6% slope, eroded
CeC2 - Cecil Sandy Loam 6-10% slope, eroded
CeD - Cecil Sandy Loam 10-15% slope
CeF - Cecil Sandy Loam 15-45% slope
CgB2 - Cecil Gravelly Sandy Loam 2-6% slope, eroded
CgC2 - Cecil Gravelly Sandy Loam 6-10% slope, eroded
Cm- Chewacla Soils
Cn - Colfax Sandy Loam
WmE - Wedowee Sandy Loam 15-25% slope
Wn - Wehadkee Silt Loam
Wy - Worsham Sandy Loam

SOURCE: USDA, NRCS, Soil Survey, Wake County, November 1970, Sheet Numbers 57 & 67.

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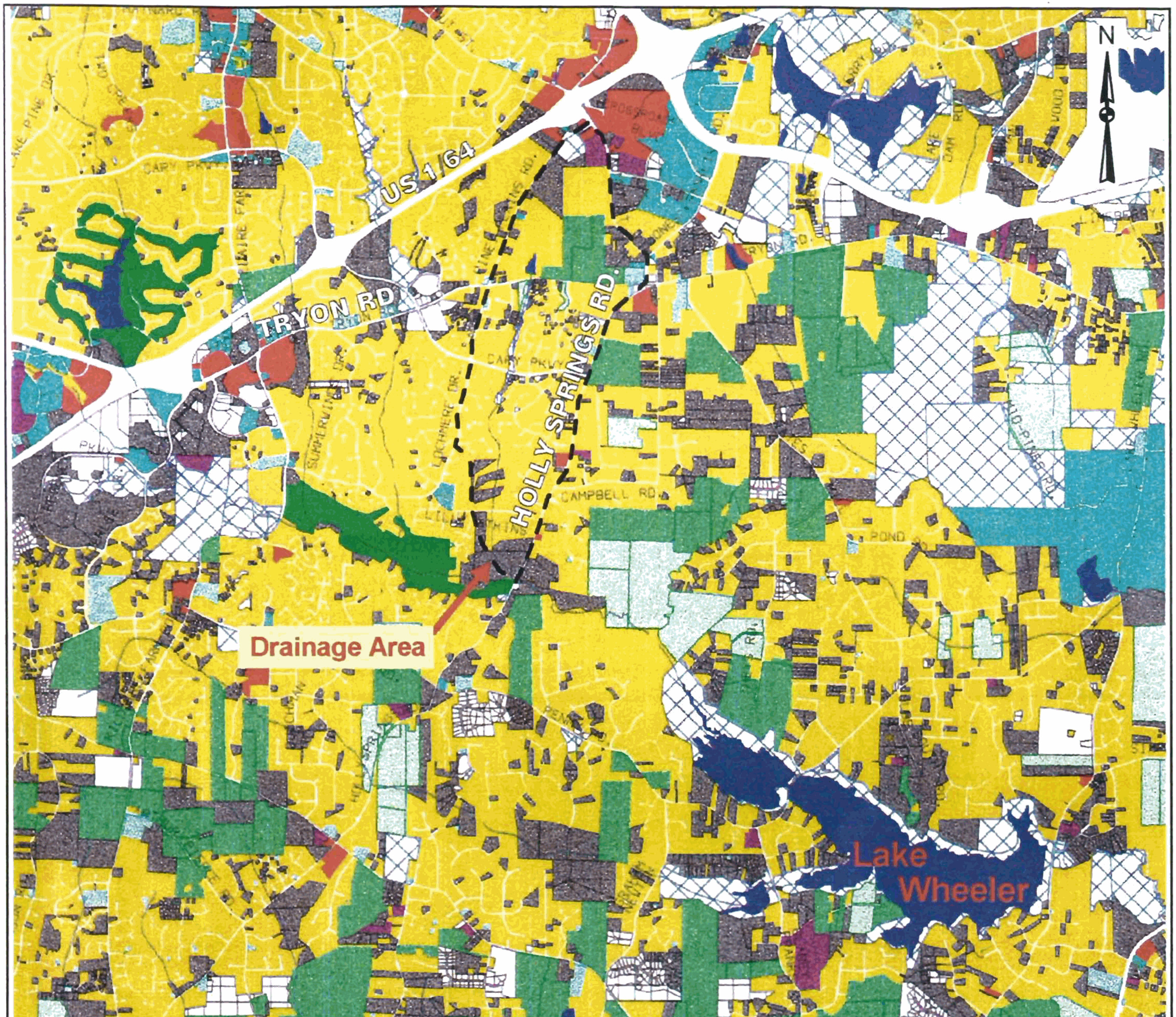
FIGURE 5
Soils of Watershed
Speight Branch Mitigation Site
Wake County, North Carolina

2000 0 2000 4000 Feet



LEGEND
LAND USE CATEGORIES

AGRICULTURE	LAKES
COMMERCIAL	FORESTRY
INDUSTRIAL	PARKS
INSTITUTIONAL	UNKNOWN
OFFICE	ERROR
RESIDENTIAL	UNIDENTIFIED
VACANT	CORPORATE LIMITS ETJ BOUNDARY

Source: Wake County Planning Department Land Use Plan, May 1998

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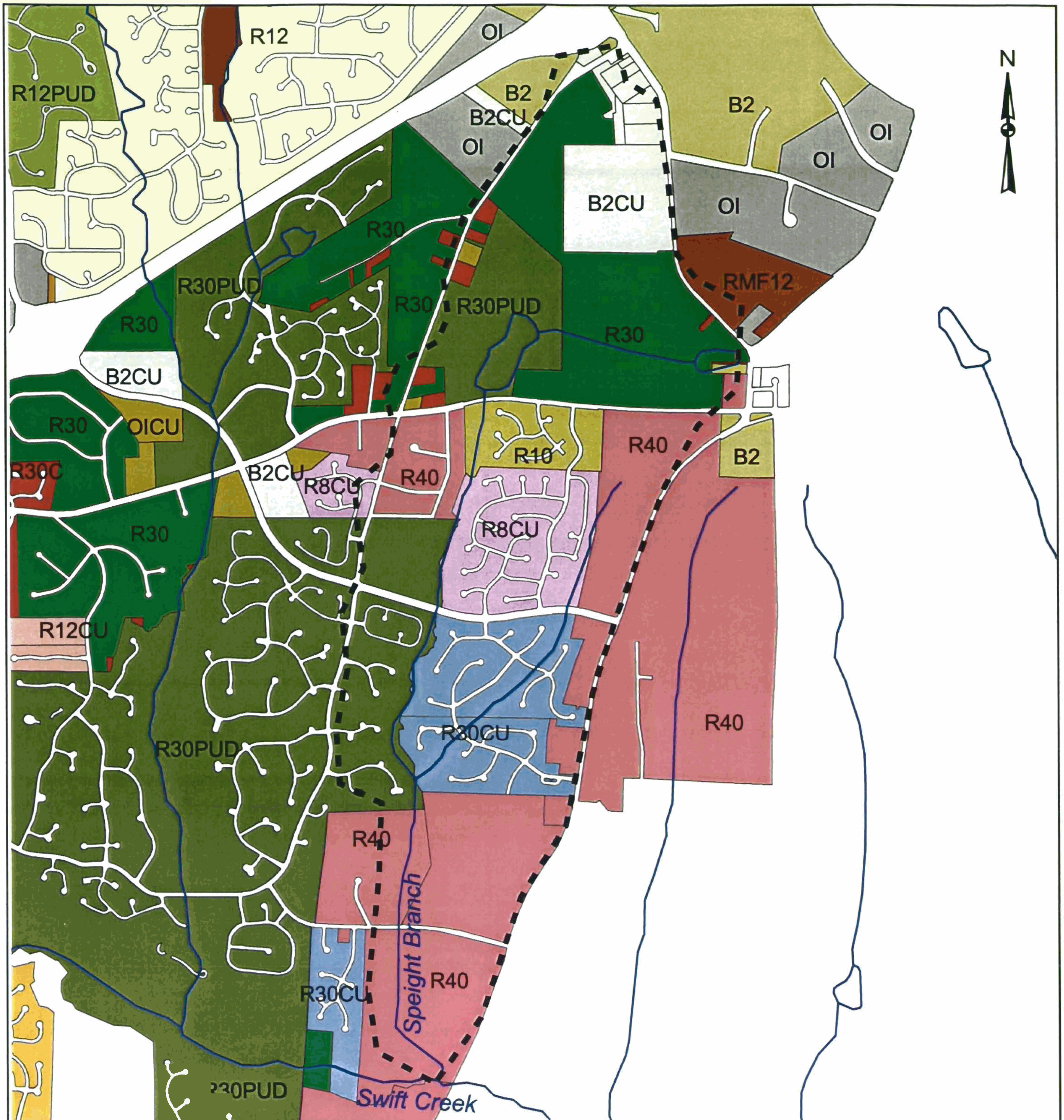
FIGURE 6
Land Use
Speight Branch Mitigation Site
Wake County, North Carolina

N o to scale



LEGEND

R - Residential District
B-2 - Commercial District
O&I - Office and Institutional District

SOURCE: Town of Cary Planning Department, GIS Data, 1999

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FIGURE 7
Zoning
Speight Branch Mitigation Site
Wake County, North Carolina

2000 0 2000 4000 Feet

2.2 PROJECT SITE

2.2.1 General Description

This site is situated in the northwestern quadrant of the intersection of Holly Springs Road (SR 1152) and Swift Creek in Wake County (see Figure 2). It is bounded on the east by Holly Springs Road, on the south by Swift Creek, on the west and north by woods. The entire property is approximately 11.4 ha (28.2 ac) in size.

The property is currently undeveloped and is covered with fallen timber left behind from a harvest in approximately 1995. Presently, a dense growth of herbaceous and shrubby plant species cover the site. The topography of the general area consists of rolling hills, with some steep slopes located along drainageways. The site topography slopes from northeast to southwest in the northeastern portion of the property and then flattens out into a broad floodplain of Swift Creek in the southwestern and northwestern portions. Higher elevations approximately 97.5 to 100.5 m (320 to 330 ft) above mean sea level [msl] occur in the northeast while lower elevations of 91 m (300 ft) above msl occur on the remainder of the property. Speight Branch enters the site on the north near the center of the property and drains into Swift Creek near the southeast corner of the site. A sewer line easement parallels Speight Branch and intersects a second sewer line in the southwestern portion of the property. There are several old logging roads on the property.

2.2.2 Soils

Based on a review of the Wake County Soil Survey (1970), soils on the property are primarily Wehadkee silt loam and Chewacla Soils. A small amount of Augusta fine sandy loam are present in the upland areas. Based on a field survey of the property, the soils were largely consistent with those mapped in the Soil Survey although the Wehadkee and Chewacla soils did not exhibit hydric characteristics throughout the entire site. The soils are shown on Figure 8.

Wehadkee silt loam (Wn) (0 to 2 % slopes) is a poorly drained soil which occurs on floodplains. This soil is flooded frequently for long periods. Surface runoff is slow to ponded, and permeability is moderate to moderately rapid. Wehadkee soils are listed as hydric by the NRCS. This soil is located within the floodplain of Swift Creek and covers the majority of the site.

Chewacla soils (Cm) (0 to 2 % slopes) are mapped in the north-central portion of the property and in the far southwestern corner of the property. Based on the Soil Survey, these soils are somewhat poorly drained and are located on floodplains. Permeability is moderate to moderately rapid, surface runoff is slow, and the seasonally high water table is at 0.46 m (1.5 ft) below the ground surface. These soils are frequently flooded. Chewacla soils are listed as hydric by the NRCS.

LEGEND

Au - Augusta Fine Sandy Loam
Cm- Chewacla Soils
Wn - Wehadkee Silt Loam

SOURCE: USDA, NRCS, Soil Survey, Wake County, November 1970, Sheet Numbers 57 & 67.

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FIGURE 8
Soils of Project Site
Speight Branch Mitigation Site
Wake County, North Carolina

500 0 500 1000 Feet

A narrow tongue of Augusta fine sandy loam (Au) (0 to 4 % slopes) is located in the northwestern corner of the property. Augusta fine sandy loam is described as nearly level and gently sloping. This soil is also located on low terraces. The soil is deep and somewhat poorly drained. Surface runoff is slow to medium and permeability is good.

2.2.3 Wetland Communities

Most of the natural communities on the property have been heavily disturbed by the past timber activities. For purposes of discussion the following communities have been identified on the property, emergent wetlands, cutover uplands, and floodplain forest. These communities are shown on Figure 9. The bottomland forest to the south of Swift Creek is also described for reference.

2.2.3.1 Emergent Wetlands

Emergent wetlands occur on the northern half of the site. Speight Branch divides the wetlands into two areas. The dominant plant species in this wetland are soft rush (*Juncus effusus*) and duckweed (*Polygonum* spp.). Other species present include saplings of sweetgum (*Liquidambar styraciflua*), sedges (*Carex* spp.), woolgrass (*Scirpus cyperinus*), seedbox (*Ludwigia alternifolia*), and blackberry (*Rubus* sp.). The easternmost extent of this community also includes scattered river birch (*Betula nigra*), American sycamore (*Platanus occidentalis*), tulip-poplar (*Liriodendron tulipifera*), and sweet pepperbush (*Clethra alnifolia*). The western extent of this community includes giant cane (*Arundinaria gigantea*), cattail (*Typha latifolia*), and asters (*Aster* spp). This community most closely resembles a freshwater marsh, however, due to extensive disturbance, this marsh is an early successional community and should eventually revert to a bottomland hardwood forest.

Soils in these areas generally consist of a (10 YR 6/1) loam. Pools of standing water and drainage patterns were observed throughout area during the site visit. Hummocks of dry ground were also present, indicating alteration of the natural topography.

The upland limits of wetlands on the northern portion of the property were delineated in 1990 prior to timbering of the tract. The entire property was delineated and surveyed again by Earth Tech in December 1998, and the emergent wetlands were found to encompass 3.4 ha (8.3 ac). The NWI map depicts the majority of the Speight Branch Property as palustrine forested, broad-leaved deciduous, seasonally flooded wetland (PFO1C), indicating that the site was a bottomland forest prior to timbering.

The ground surface within the wetlands has been altered by logging machinery as evidenced by numerous ruts, and the community is in a disturbed, early successional state. In its current state this is considered a low quality wetland, providing some water storage potential. Prior to logging the value of this wetland was likely much higher. The wetland rating for this emergent wetland area in its current condition is 46 (Appendix A).

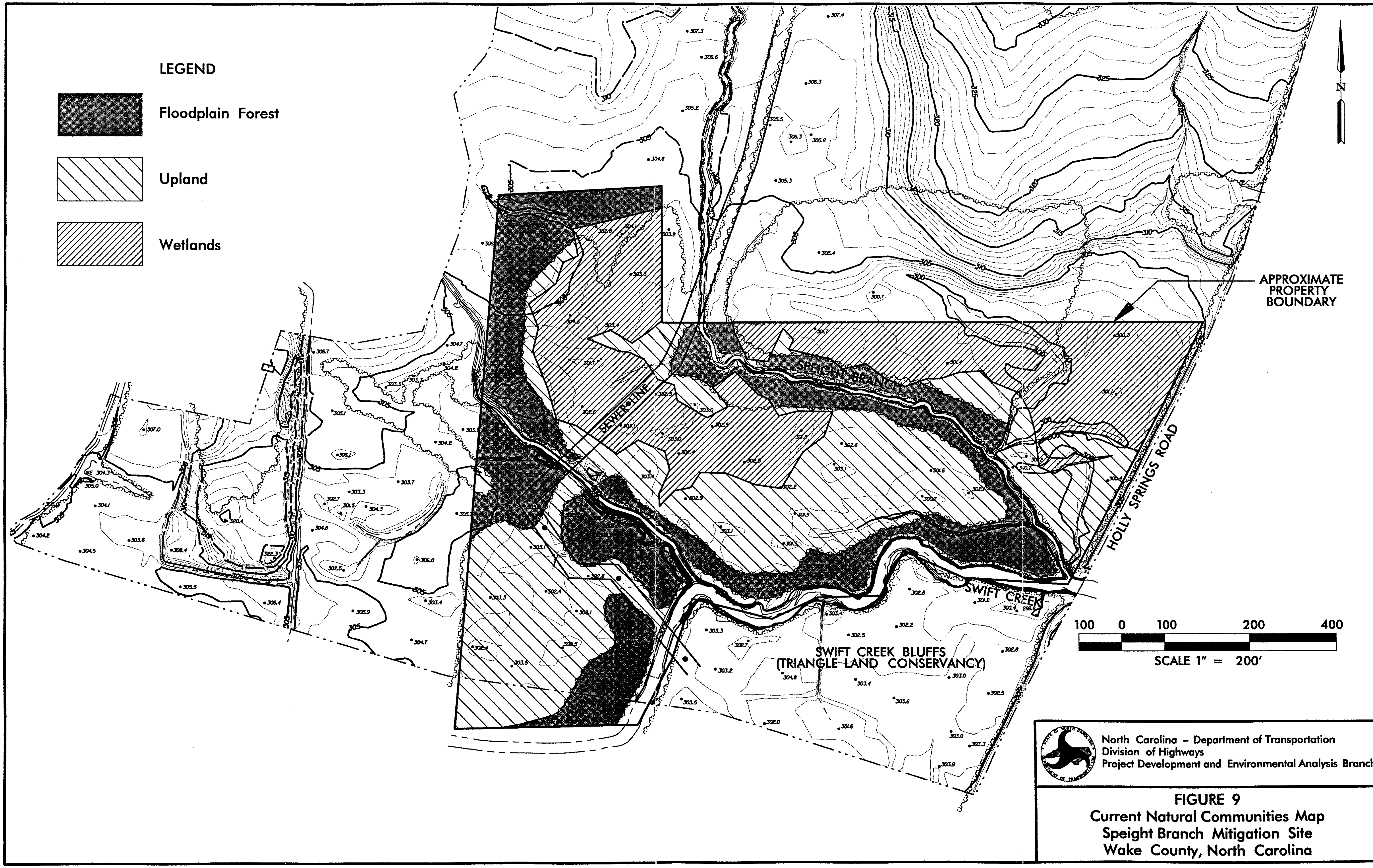

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FIGURE 9
Current Natural Communities Map
Speight Branch Mitigation Site
Wake County, North Carolina

2.2.3.2 Floodplain Forest

The area immediately adjacent to Speight Branch and Swift Creek was not timbered and some trees were left standing. However, during Hurricane Fran in September, 1996 many of the trees where knocked down by wind, so only a few trees remain standing. Dominant sapling species in this community include sweetgum, tulip-poplar (*Liriodendron tulipifera*), willow oak (*Quercus phellos*), ironwood (*Carpinus caroliniana*), and swamp chestnut oak (*Quercus michauxii*). Other species observed were Chinese privet (*Ligustrum sinense*), honeysuckle (*Lonicera japonica*), and Christmas fern (*Polystichum acrostichoides*).

2.2.3.3 Bottomland/Floodplain Forest

A floodplain forest community occurs on the floodplain Swift Creek (on the south side of the creek) on a tract of land owned by the Triangle Land Conservancy. This community has a diverse canopy and subcanopy including tulip-poplar, willow oak, swamp chestnut oak, overcup oak (*Quercus lyrata*), cherrybark oak (*Quercus falcata* var. *pagodifolia*), elm (*Ulmus americana*), bitternut hickory (*Carya cordiformis*), and river birch. Shrub species include American holly (*Ilex opaca*) and Chinese privet. Notes in the NHP files indicate that similar species were found on the north side of Swift Creek during a survey in 1981.

According to NHP files faunal species which likely utilize this area include barred owl (*Strix varia*), American woodcock (*Philohela minor*), and red-shouldered hawk (*Buteo lineatus*). Swainson's warblers (*Limnothylpis swainsonii*) reportedly bred in this Natural Area in the 1970's; it is not known if this species is still present.

2.2.3.4 Cutover Uplands

The upland communities on the Speight Branch Property are dominated by a mixture of saplings, shrubs, and forbs. The saplings and shrubs observed include red maple and sweetgum. Privet, blackberry, aster, and dog fennel (*Eupatorium* sp.) are the dominant forbs.

In the southeastern corner of the property between Swift Creek and Speight Branch, this community is dominated by shrubby species that are regenerating from the cutover. The upland areas in the northern portion of the property have been timbered more recently and are virtually devoid of vegetation. Most of the trees have been harvested or are in various stages of decay on the ground. A few loblolly pine (*Pinus taeda*) and tulip-poplar trees remain standing along the northern property line.

2.2.4 Site Hydrology

2.2.4.1 Swift Creek

The southern property boundary of the project sites incorporates approximately 400 m (1300 ft) of Swift Creek. About 30 m (100 ft) upstream of the Holly Springs Road bridge, Swift Creek is approximately 6 m (20 ft) wide at the base of the banks at water surface. From top of bank to bottom of bank is approximately 1.8 to 2.1 m (6 to 7 ft). The banks are eroded in some areas. The northern bank is vegetated by a narrow bank of hardwoods, dominated by river birch and tulip-poplar. The south bank is adjoins Swift Creek Bluffs, a nature preserve owned by the Triangle Land Conservancy. The creek meanders moderately through the area before reaching the Holly Springs Road bridge. Creek substrate is a mixture of silt, sand, and cobbles.

2.2.4.2 Speight Branch

The main drainage on the property is Speight Branch, a second order stream, which flows approximately 350 m (1150 ft) from the top of the property boundary to the confluence of Swift Creek. Bankfull width of this stream ranges between 2.7 to 4 m (9 to 13 ft) and mean depth ranges between 0.5 to 0.8 m (1.6 to 2.7 ft). Channel substrate consists of silt, sand, and pebbles.

The stream appears to have been previously channelized. Slight meandering occurs at the northern property boundary, but the remainder of the stream is relatively straight. The banks are eroded along most of the stream channel and vegetation consists mostly of privet and blackberry, with a few large trees along the banks near the Swift Creek confluence.

Four beaver dams presently exist within the stream and evidence of current beaver activity on the site has been noted. The stream also contains debris from logging activity and past storm damage.

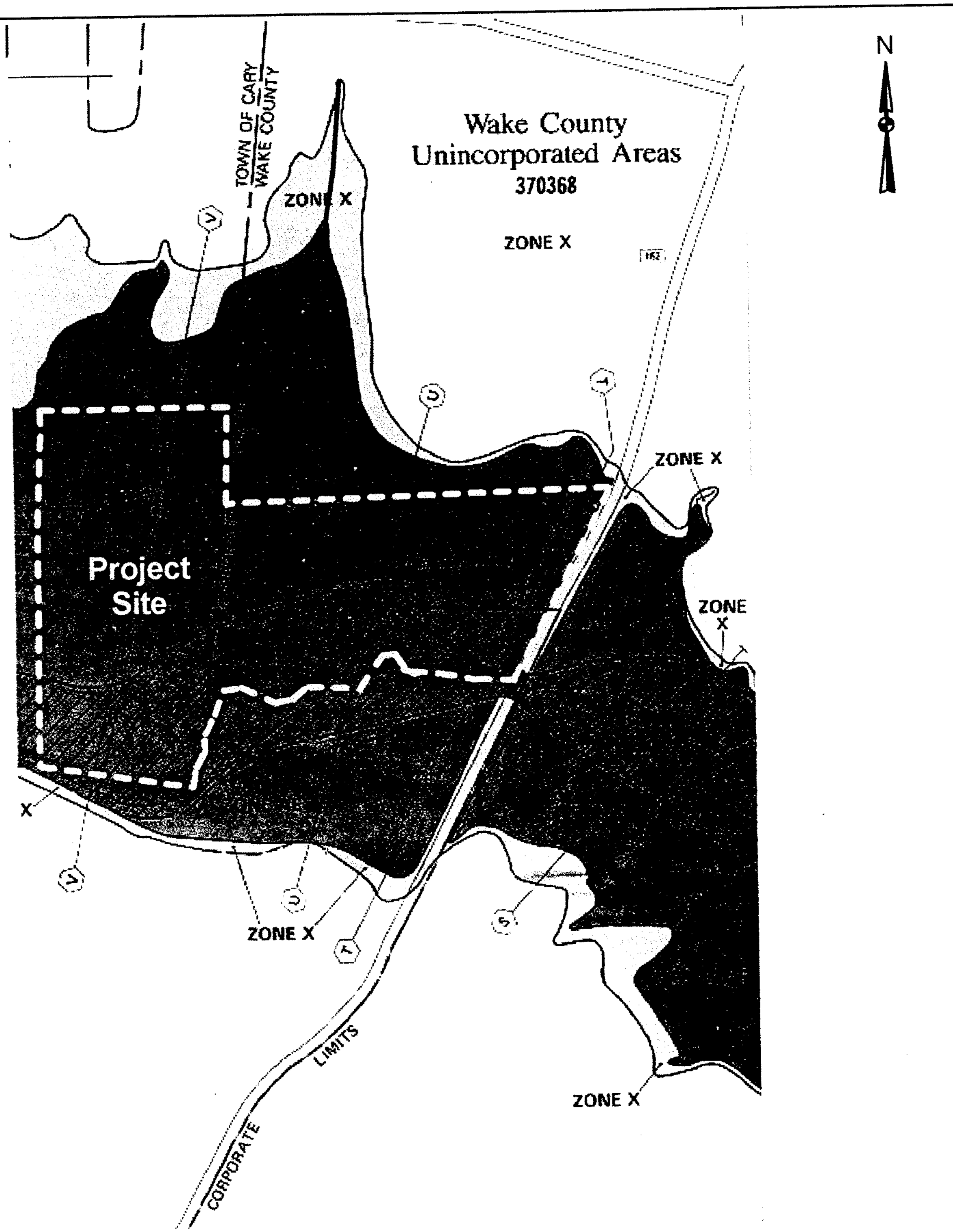
2.2.4.3 Wetland Hydrology

The wetlands north and east of Speight Branch appear to receive groundwater discharge from upland areas to the north. Standing water was observed in these wetlands throughout most of the year, with drying out of the surface only occurring in late summer and early fall. Typically 2.5 to 7.5 cm (1 to 3 in) of water has been observed on the surface. Excess water in this area is drained from the wetlands via several ditches that drain into Speight Branch.

The wetlands to the south and west of Speight Branch are not as "wet" as the wetlands to the north. Hydrology in these wetlands appear to be more surface water driven with inputs coming from precipitation, overbanking of Speight Branch and from several off-site drainage features. Several ditches throughout this wetland area drain excess water into Speight Branch and a ditch to the south of the wetlands.

2.2.4.4 National Flood Insurance Program Mapping

According to the NFIP mapping (1992) the majority of the Speight Branch Property is within Zone AE which indicates special flood hazard areas inundated by the 100-year flood where base flood elevations have been determined (Figure 10). The 100-year flood elevation is shown to be at about 93 m (306 ft) above msl on the eastern edge of the property. The 100-year floodplain of Swift Creek, which is approximately 300 m (1,000 ft) wide, or 152 m (500 ft) on each side of the creek, is designated as floodway areas in Zone AE. A narrow strip approximately 15 to 30 m (50 to 100 ft) wide adjacent to Zone AE is mapped as Zone X which indicates areas of the 500-year flood. This area is slightly wider ranging from 121 to 152 m (400 to 500 ft) in the northern portion of the property adjacent to Speight Branch. The upland area in the northeastern corner is beyond the 500-year flood boundary.



LEGEND

Zone AE - 100-Year Floodplain

Zone X - 500-Year Floodplain

FEMA Flood Insurance Rate Map 37183C0506 E, March 3, 1992

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FIGURE 10
Flood Insurance Rate Map
Speight Branch Mitigation Site
Wake County, North Carolina

NOT TO SCALE

3.0 METHODOLOGY

3.1 WETLAND SURVEYS

Prior to conducting field activities, information concerning the site and surrounding area was collected. This information included the following:

- U.S. Geological Survey Lake Wheeler (1987) topographic quadrangle map
- U.S. Fish and Wildlife Service National Wetlands Inventory Map Lake Wheeler (1995)
- NCDOT color aerial photography of the property and surrounding area 1"= 100' (November 1997)
- Topographic survey of property 1"=100', 1 ft contour intervals, provided by NCDOT
- Wake County Tax Office aerial photograph of the project areas (1"=200; 1981)
- Natural Resource Conservation Service soil survey for Wake County, 1970
- U.S. Fish and Wildlife Service (FWS) list of protected species
- North Carolina Natural Heritage Programs (NCNHP) database of uncommon species and unique habitats
- FEMA floodplain maps of the project area

Water resource information was obtained from publications of the North Carolina Department of Environment, Health, and Natural Resources (DEHNR, 1993), Division of Water Quality (DWQ). The NCNHP files were reviewed for documented occurrences of state or federally listed species and locations of significant natural areas and Natural Heritage Priority Areas.

3.1.1 Field Surveys

General field surveys of the Speight Branch Site were conducted by Earth Tech biologists during several visits in the Fall of 1998. Water resources were identified and their physical characteristics were recorded. Plant communities and their associated wildlife were identified using a variety of observation techniques, including active searching, visual observations, and identifying characteristic signs of wildlife (sounds, tracks, scats, and burrows). Terrestrial community classifications generally follow Schafale and Weakley (1990) where appropriate, and plant taxonomy follows Radford *et al.* (1968). Animal taxonomy follows Robbins *et al.* (1966), Martof *et al.* (1980), Thompson (1985), Palmer and Braswell (1995), and Webster *et al.* (1985). Vegetative communities were mapped utilizing aerial photography of the project site and confirmed during a site walkover. Wildlife community composition was described based on observations in the field and predictions of habitat based on existing vegetative communities.

3.1.2 Wetland Delineation

Jurisdictional wetlands were delineated on October 19, 1998 based on criteria established in the U.S. Army Corps of Engineer's "1987 Corps of Engineers Wetland Delineation Manual". The wetland boundaries were flagged in the field and surveyed in with a Global Positioning System unit. Following the delineation, Eric Alsmeyer, USACE, made a Jurisdictional Determination on January 7, 1999. Copies of the Wetland Delineation sheets can be found in Appendix B. Wetlands were classified based on Cowardin *et al.* (1979). Wetland functions and values were evaluated based upon the best professional judgement of the wetland scientists and the DWQ "Guidance for Rating the Value of Wetlands in North Carolina" (Fourth Version). The DWQ Wetlands Rating Worksheets can be found in Appendix A.

3.1.3 Groundwater Monitor Wells

The hydrology of the existing wetlands and potential creation areas was evaluated through the installation of shallow groundwater monitor wells. The wells were installed in accordance with the Corps of Engineers Technical Guidance (HY-1A-3.1). Five wells were installed across the site, two in existing wetlands and three in potential creation areas. The location of the wells is shown on Figure 11 and hydrographs can be found in Appendix C. Precipitation data was obtained from the NC State Climate Office. The closest station was Lake Wheeler Road station.

3.2 STREAM SURVEYS

Field surveys of the existing stream channel were conducted on November 6, 1998 and January 19, 1999. These field measurements are critical to the classification and assessment of the existing stream type and provide data to classify the stream using the Rosgen classification method, Levels I and II (Rosgen 1996).

To establish arbitrary relative elevations for the field measurements, a temporary benchmark was established at the Holly Springs Road Bridge over Swift Creek.

A longitudinal survey of the stream began at the northern portion of the property and continued along the stream length to the confluence with Swift Creek. The total length measured 430 m (1400 ft). Five (5) cross sections of the existing channel were established; across four riffles and one pool. A representative pebble count was taken to determine channel bed materials for classification.

3.2.1 Stream Delineation Criteria

Stream channels are delineated using five criteria: width/depth ratio, entrenchment ratio, slope, sinuosity, and channel materials.

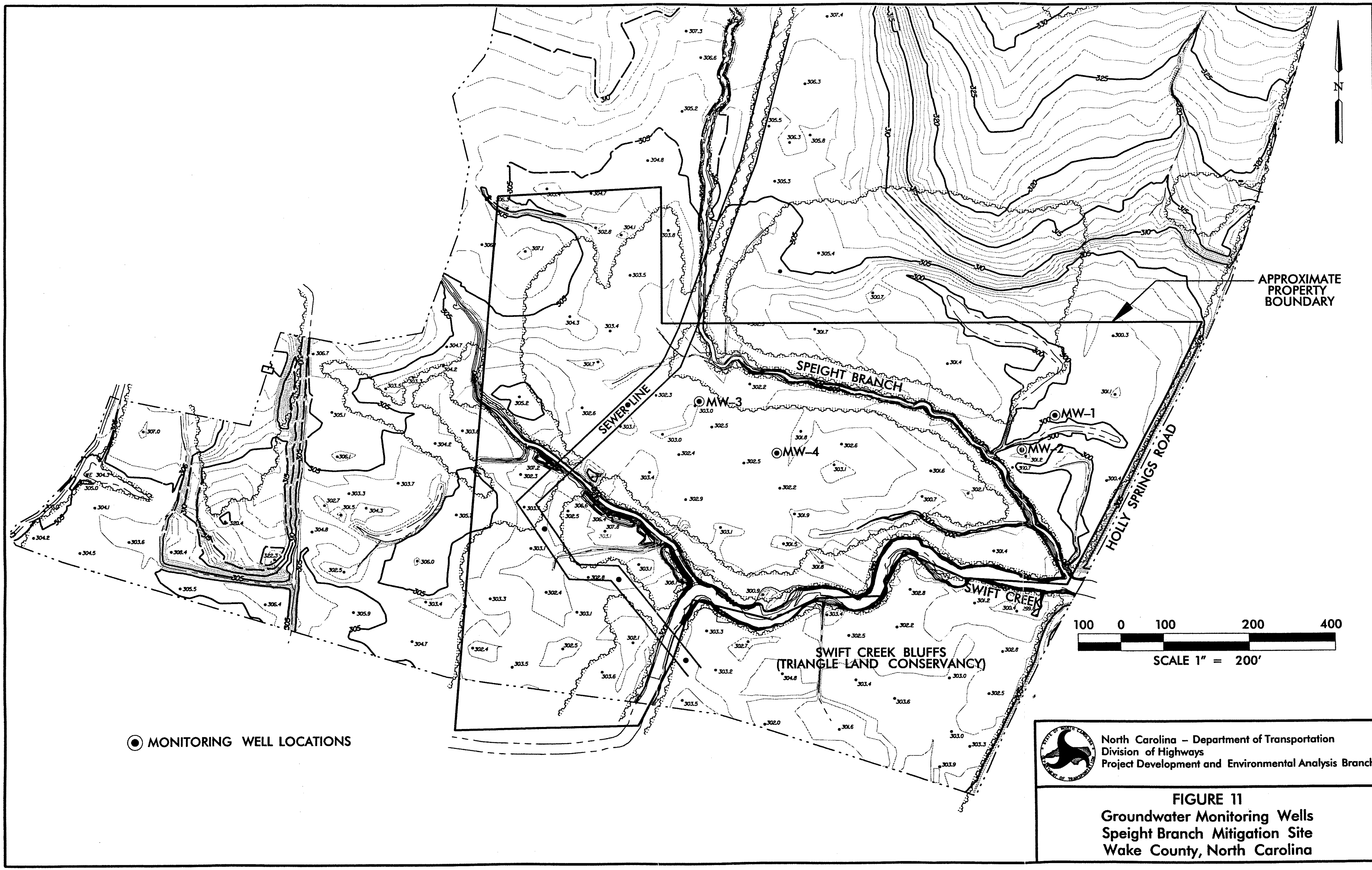

FIGURE 11
Groundwater Monitoring Wells
Speight Branch Mitigation Site
Wake County, North Carolina

Width/Depth Ratio

The width/depth ratio is defined as the ratio of the bankfull surface width to the mean depth of the bankfull channel. Measurement of the width/depth ratio is important in describing the channel's cross-section shape. The width/depth (W/D) ratio is also the key to understanding energy distribution and sediment transport within the channel (Rosgen 1996).

In Chapter 5 of *Applied River Morphology*, author Dave Rosgen discusses the relationship between the width/depth ratio, energy, and sediment transport:

> *The distribution of energy within channels having high W/D ratios (i.e., shallow and wide channels) is such that stress is placed within the near bank region. As the W/D ratio value increases (i.e., the channel grows wider and more shallow), the hydraulic stress against the banks also increases and bank erosion is accelerated. The accelerated erosion process is generally the result of high velocity gradients and high boundary stress, as mean velocity, stream power, and shear stress decrease in the presence of an increase in width/depth ratio values. Increases in the sediment supply to the channel develop from bank erosion, which - by virtue of becoming an over widened channel - gradually loses its capacity to transport sediment. Deposition occurs, further accelerating bank erosion, and the cycle continues.*

Entrenchment

Entrenchment is defined as the vertical containment of a stream and the degree to which it is incised in the valley floor. To measure entrenchment, the Rosgen methodology employs a dimensionless ratio (the entrenchment ratio) to quantify entrenchment. The entrenchment ratio is calculated by dividing the width of the floodprone area by the bankfull width. The flood prone area is defined as the area flooded by a stage twice the maximum depth between the bankfull stage and the thalweg of a riffle.

Slope

Slope of the water surface is defined as the change in water surface elevation per unit stream length. Stream length is measured in the channel's thalweg. The slope is measured by a longitudinal survey of the stream length. Slope measurements should be taken for at least 20 bankfull widths or a distance equal to two meander wavelengths.

Sinuosity

Sinuosity is the ratio of stream length to valley length. It can also be calculated as the ratio of valley slope to stream slope.

Channel Materials

Channel bed and bank materials influence the cross section, plan view, and longitudinal profile of the stream. They also determine the extent of sediment transport and provide the means of resistance to hydraulic stress. Field classification of the channel materials is done through a pebble count. The pebble count uses a systematic sampling system over a distance of at least 20-30 bankfull widths or two meander wavelengths. Ten sites with ten observations (100 samples total) are done proportionally in riffles and pool areas. In order to avoid an unrepresentative sampling, the materials are selected using a blind touch method.

The segmented particle size data is then added together for a composite total for stream classification purposes. The data is plotted on log-normal graph paper. The D-50 (50 % of the sampled population is equal to or finer than the representative particle size) is used to classify the bed materials.

3.2.2 Bankfull Verification

The bankfull stage was determined in the field using physical indicators. The following is a list of commonly used indicators (Rosgen, 1996):

- The presence of a floodplain at the elevation of incipient flooding.
- The elevation associated with the top of the highest depositional feature (e.g. point bars, central bars within the active channel). These depositional features are especially good stage indicators for channels in the presence of terrace or adjacent colluvial slopes.
- A break in slope of the bank and/or a change in the particle size distribution, since finer material is associated with deposition by overflow, rather than deposition of coarser material within the active channel.
- Evidence of an inundation feature such as small benches below bankfull.
- Staining of rocks.

The most common method of verifying bankfull stage is to compare the field determined bankfull stage with measured stages at a stream gage. This calibration can be performed if there is a stream gage within the study area's hydrophysiographic region. One gage was identified in the Swift Creek Watershed. Station Number 02087580 was located near Apex, North Carolina. This gage was not used to verify bankfull indicators because it was on Swift Creek and not Speight Branch. Due to the difference in stream types and watershed areas the gage was not used to verify bankfull.

In ungaged areas, Dave Rosgen recommends verifying bankfull with the development of regional curves. The regional curves normally plot bankfull discharge (Q), cross-sectional area, width, and depth as a function of drainage area. The cross sectional areas of the Speight Branch and the reference reaches used for this report were plotted on the

North Carolina regional curve developed by the North Carolina State University (NCSU) Water Quality Group, 1998 (Figure 12). All three plotted points are within the confidence region of the regional curve, verifying the field observation of bankfull.

3.2.3 Existing Stream Characteristics

The data for the existing channel is included in Appendix D. The stream had the following characteristics:

Width /Depth Ratio:	4.0
Entrenchment Ratio:	3.6
Slope:	0.005
Sinuosity:	1.15*
Channel Materials (D-50):	0.5 mm
Stream Type:	**E-5**

*Note: E stream types normally have a sinuosity of greater than 1.5, which can vary by +/- 0.2. Due to the strong vegetation growth in North Carolina, it is common for "straight Es" to occur.

DRAFT

NC Rural Piedmont Regional Curve

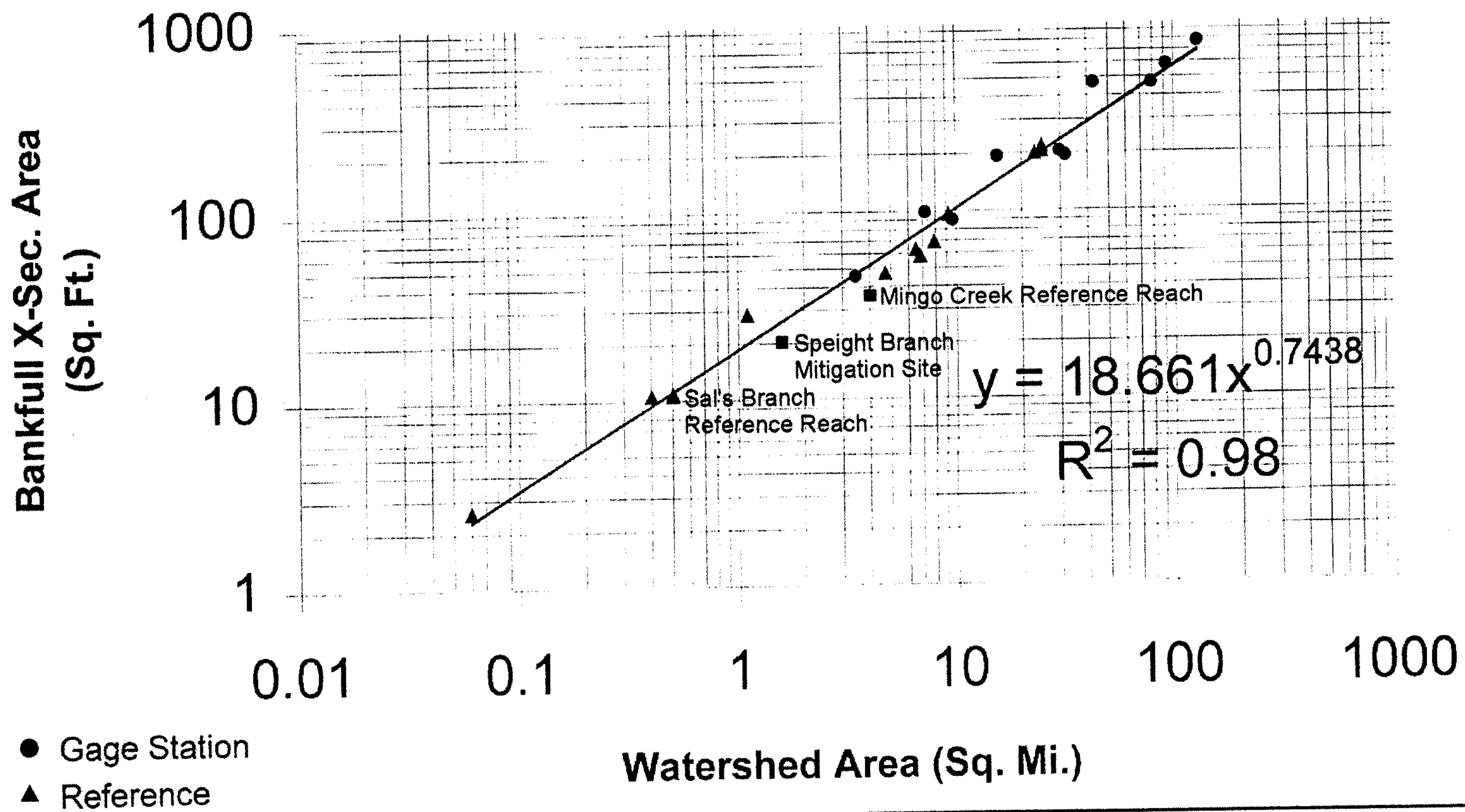

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FIGURE 12
NC Rural Piedmont Regional Curve
Speight Branch Mitigation Site
Wake County, North Carolina

Log Scale

SOURCE: NCSU Water Quality Group, August 7, 1998.

4.0 REFERENCE REACHES

4.1 MINGO CREEK

Mingo Creek, a third order stream, is located approximately 1.3 km (0.8 mi) south of the US 64 and 1.3 km (0.8 mi) north of Old Faison Road in eastern Wake County (Figure 13). Beginning just north of Knightdale, it flows southwest approximately 6 km (4 mi) before emptying into the Neuse River. Mean width of the stream channel is approximately 2 m (6 ft) and mean depth is about 23 cm (9 in). The section of the stream measured for reference was 105 m (345 ft) in length. Longitudinal profile, cross-sections, and the pebble count for this reference reach are located in Appendix E.

The watershed is approximately 1,030 ha (2,550 ac) or 10.3 sq. km. (4.0 sq. mi.) and encompasses several newly constructed as well as formerly established dense subdivisions, industrial and retail buildings associated with the town of Knightdale, and large tracts of undeveloped wooded land near the Neuse River confluence. This watershed includes about 18 small tributaries and 14 ponds. It is bounded to the north by US 64, to the south and east by Old Faison Road, and to the west by Hodge Road and Norfolk Southern Railway. A small portion in the southwest corner follows a ridgeline to the Neuse River.

Development exists in various stages throughout this watershed. New housing developments are currently being built along the upper reach of the creek near Knightdale and middle reach east of Hodge Road. An older development exists in the northwest corner. Some subdivisions exist along the southern edge of the watershed, but the majority of this land is open farm pastures. To the extreme southwest corner along the lower reach lies undeveloped wooded acreage.

4.2 SAL'S BRANCH

Sal's Branch is a first order stream located in Umstead Park in western Wake County approximately 0.3 km (0.2 mi) southwest of US 70. The stream drains from a pond and flows south adjacent to the park access road for approximately 1.6 km (1.0 mi) and drains into Pots Branch. Mean width of the stream channel is approximately 2.1 m (7 ft) and mean depth is about 0.6 m (2.0 ft). The section measured for reference was 58 m (190 ft) in length. Longitudinal profile, cross-sections, and the pebble count for this reference reach are located in Appendix F.

The watershed is approximately 53 ha (130 ac) or 0.5 sq. km. (0.2 sq. mi.) and is oval in shape (Figure 14). It is bounded to the northeast by US 70 and generally follows topographic ridgelines to complete the watershed boundary. Nearly all of the watershed is located within Umstead Park and is heavily wooded. Only a small portion along the US 70 boundary is developed with commercial businesses. This is a stable watershed.

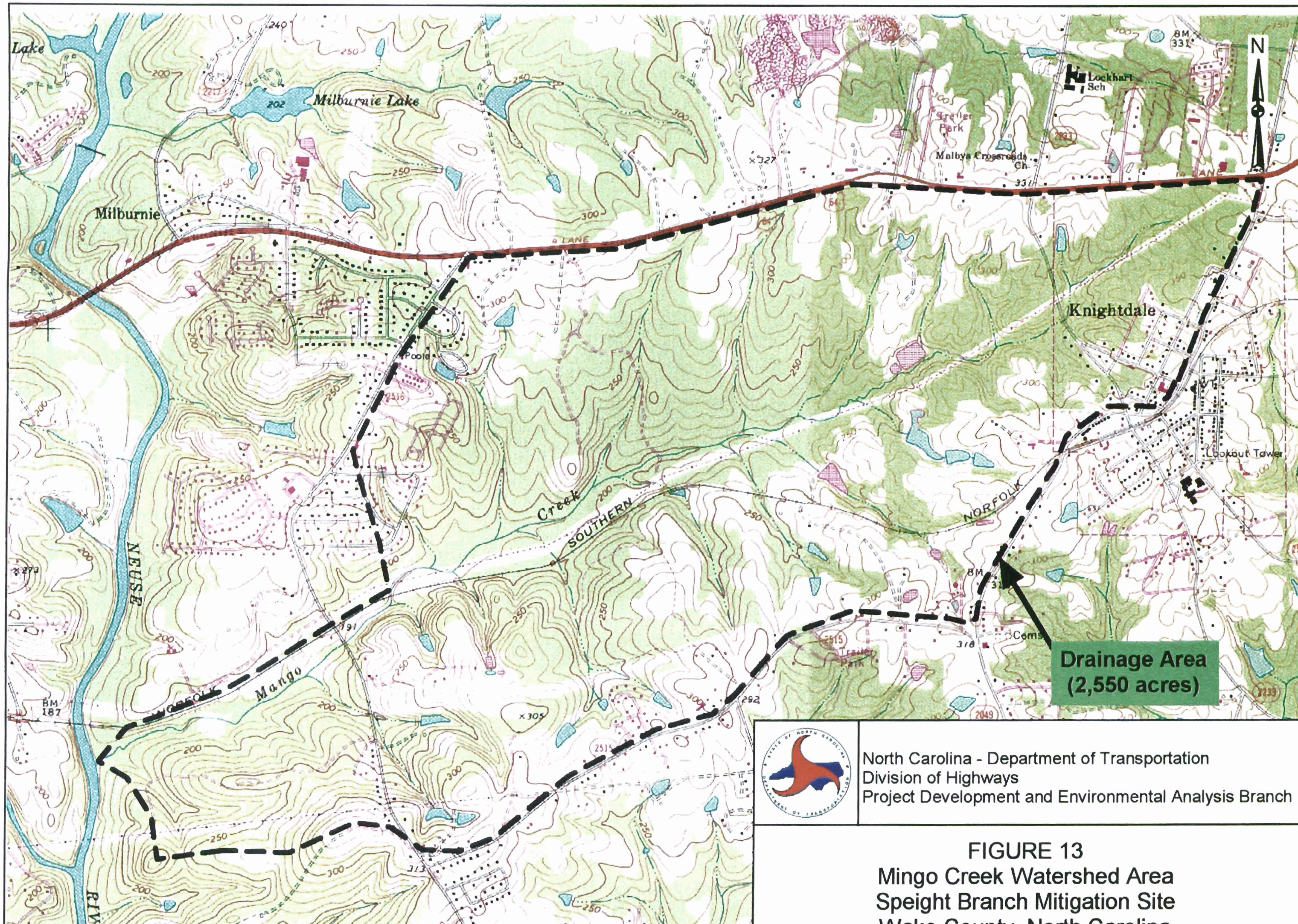

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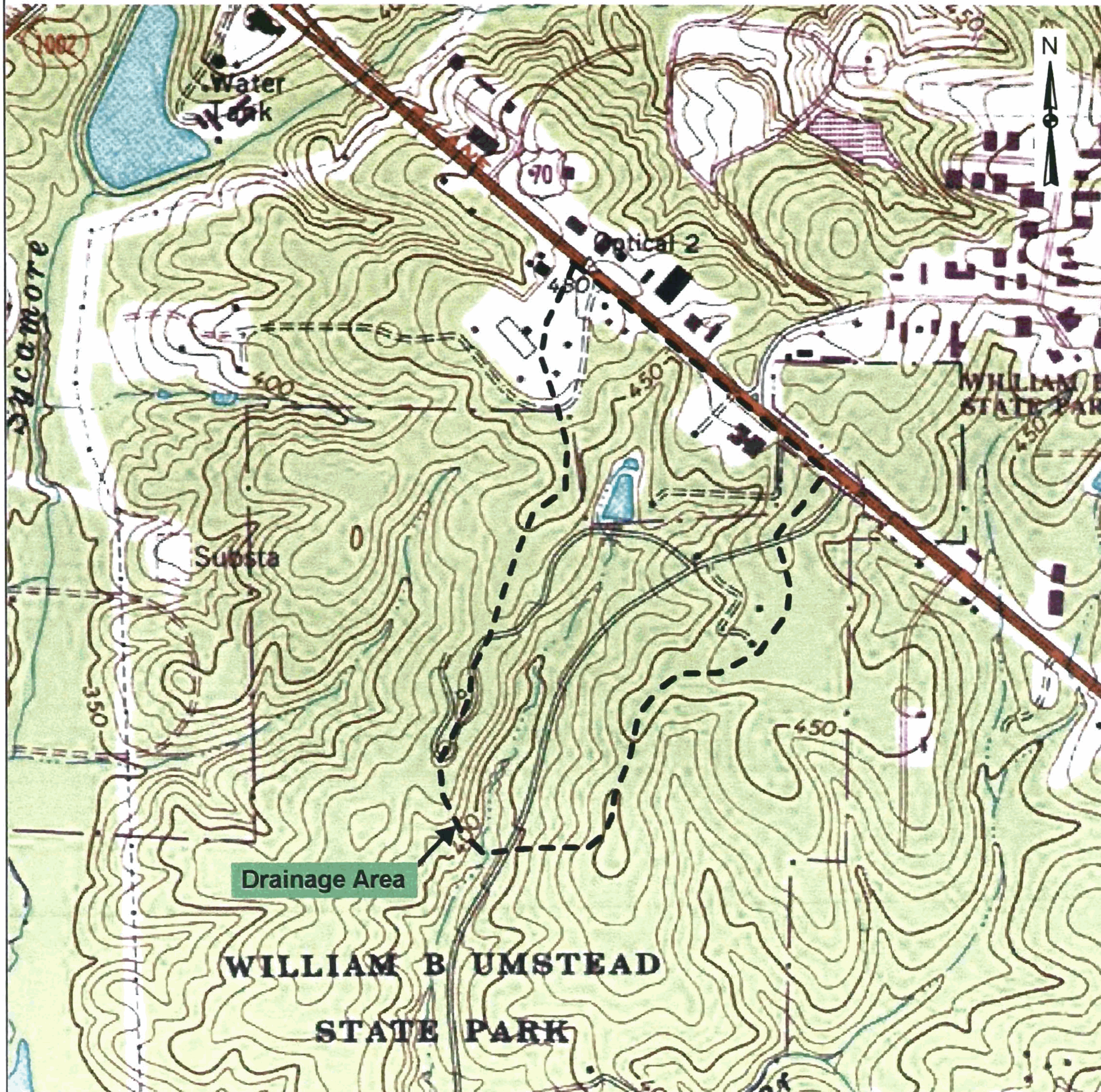
FIGURE 13
Mingo Creek Watershed Area
Speight Branch Mitigation Site
Wake County, North Carolina

2000 0 2000 4000 Feet

SOURCE: U.S. GEOLOGICAL SURVEY MAP:
7.5 MINUTE QUADRANGLE: RALEIGH WEST, NC (1987)



SOURCE: USGS Topographic Quads: Southeast Durham, N.C., 1973, Photorevised 1987, Bayleaf, N.C. 1967, Photorevised 1987 "Maptech® U.S. Terrain Series , ©Maptech®, Inc. 603-433-8500".

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FIGURE 14
Sal's Branch Watershed Area
Speight Branch Mitigation Site
Wake County, North Carolina

1000 0 1000 2000 Feet

5.0 WETLAND MITIGATION PLAN

The mitigation plan for the site will consist of vegetative and hydrological enhancement of 3.4 ha (8.3 ac) of degraded cutover wetlands and creation of an additional 0.4 ha (1 ac) of wetlands (Figure 15).

Benefits of this wetland mitigation plan include:

- Water quality benefits to Swift Creek and Lake Wheeler.
- Increase flood storage.
- Increase and preserve wildlife habitat in a rapidly developing segment of Wake County.
- Preservation of riparian buffer and uplands along Swift Creek.

5.1 HYDROLOGICAL ENHANCEMENT

Hydrological enhancement will consist of filling many of the small ditches and drainage features that have been dug on the site. This will reduce run-off and allow for surface water to remain on the site longer.

5.2 WETLAND CREATION

Creation of three small wetland areas, totaling 0.4 ha (1 ac), is also proposed. These wetlands will be created by grading upland areas to elevations similar or slightly lower than the adjacent wetlands. These locations are shown on Figure 15.

Groundwater monitor wells were installed in two of the three upland areas (MW-2 and MW-3). Readings obtained from these wells from early December 1998 through February, 1999 show that groundwater elevations are 30 to 50 cm (12 to 20 in) below the groundwater elevations in nearby wells within the wetlands. In well MW-1 (in a wetland) water is at or immediately below the ground surface. In well MW-2, 33 m (110 ft) to the southwest in an upland area, the groundwater is about 58 cm (23 in) below the ground surface, briefly rising to higher elevations with rainfall. A similar situation can be found in comparing MW-3 (in an upland) and MW-4. Data collection for these wells will continue through the growing season to verify that hydrological conditions are similar during this time period.

These upland areas will be graded to the same or slightly shallower elevation of the adjacent wetlands. By grading to a lower elevation (about 15 cm/6 in) a shallow swale or depression will be created to help retain surface water. The exact location and shape of the swales will be determined during final design of the site. The depressions will be a maximum of 1 foot deep in the middle, and will gradually slope to the existing ground surface. Several of these swales will be a widening or a continuation of swales that are already present on the site.

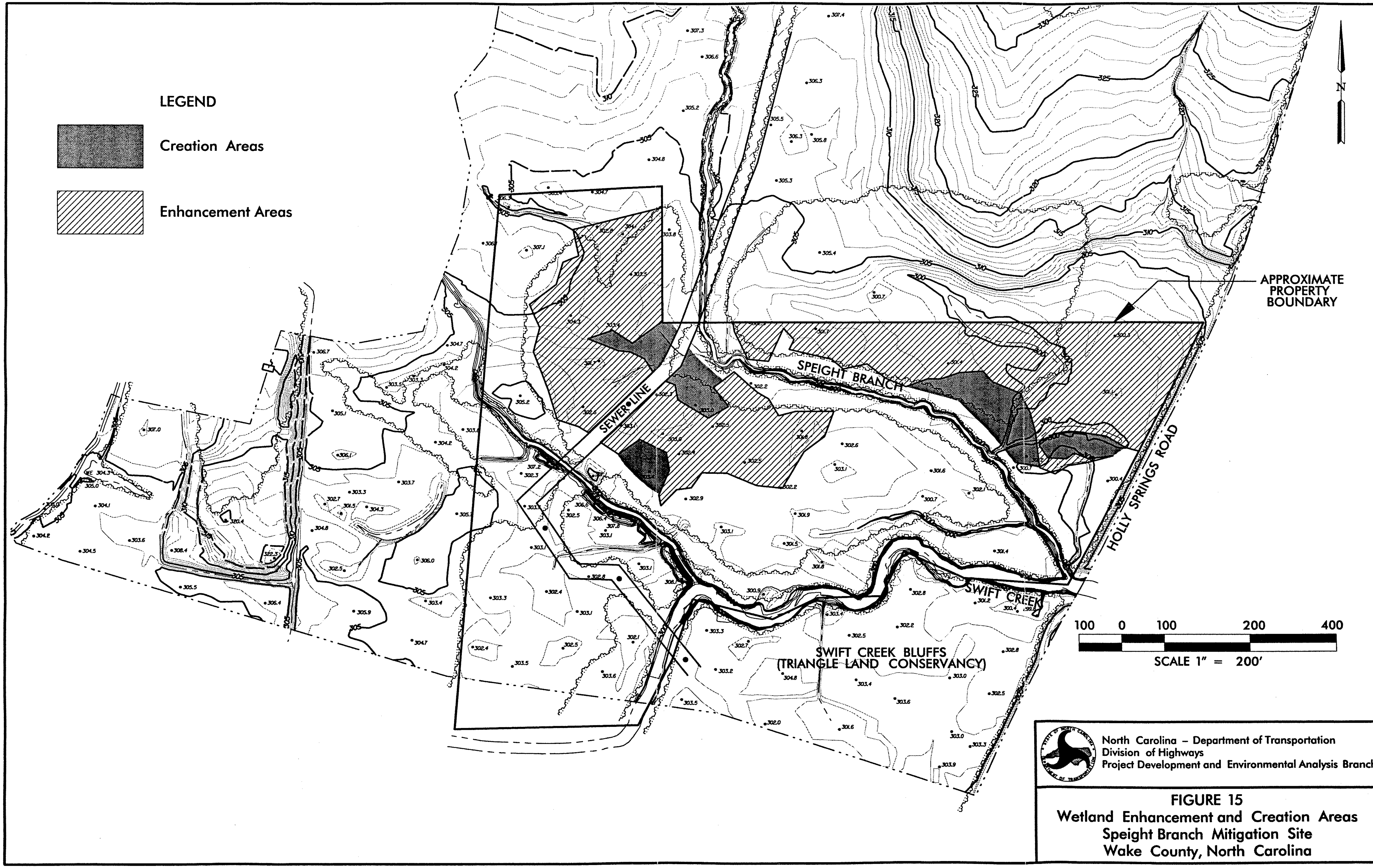

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FIGURE 15
Wetland Enhancement and Creation Areas
Speight Branch Mitigation Site
Wake County, North Carolina

5.3 REFORESTATION

Due to the extensive disturbance, tree regeneration on the site has been very slow. The purpose of the reforestation plan is to by-pass the early successional stage of regeneration and promote bottomland hardwood growth. Due to its thick growth, the existing vegetation is inhibiting tree regeneration. Therefore, prior to planting, the enhancement areas will be cleared of the existing thick herbaceous and scrub vegetation. This will be accomplished through, bush hogging, burning, herbicides, or other acceptable methods. Large woody debris and slash remaining after initial site clearing will be removed or chipped if practicable.

In wetter areas it may be necessary to form shallow raised beds to help facilitate survival of the planted trees. Once the site has been prepared it will be replanted with bottomland hardwoods.

The target community for the site is a Piedmont bottomland hardwood forest as described by Shafale and Weakley (1990). This classification also corresponds with the I.B.2.N.d.210 *Quercus (michauxii, pagoda, shumardii)-Liquidambar styraciflua* Temporarily Flooded Forest Alliance as described in *The Nature Conservancy International Classification of Ecological Communities: Terrestrial Vegetation of the Southeastern United States* (Weakley, *et al.* 1998), which has recently been adopted as the standard land cover classification by the Federal Geographic Data Committee. Based on availability, species to be planted include the following:

Tree Species	**Wetland Indicator Status**
Overcup oak (*Quercus lyrata*)	OBL
Cherrybark oak (*Quercus pagoda*)	FAC+
Swamp chestnut oak (*Quercus michauxii*)	FACW-
Willow oak (*Quercus phellos*)	FACW-
Water oak (*Quercus nigra*)	FAC
Green ash (*Fraxinus pennsylvanica*)	FACW
Black gum (*Nyssa sylvatica*)	FAC
Sycamore (*Platanus occidentalis*)	FACW-
River birch (*Betula nigra*)	FACW

Prior to planting the soil will be tested and amended as necessary with lime to achieve a pH between 5.5 and 7. Any disturbance of the site will be seeded with rye grain to help stabilize the soil after initial site alterations and prior to planting of tree seedlings. Bare root seedlings of tree species will be planted at a density of 680 stems per acre on approximately 8-foot centers. Seedlings will be at least one season old and 12 to 18 inches in height.

Planting will be performed between December and March 31 to allow plants to stabilize during the dormant period and set root during the spring season.

6.0 STREAM CHANNEL DESIGN

The design was based upon Dave Rosgen's natural channel design methodology. This 40-step design procedure is provided in Appendix G. Morphological characteristics were measured on the existing stream and reference reaches to determine a range of values for the stable dimension, pattern, and profile of the proposed channel. The measured and proposed morphological characteristics are shown in Table 2.

A conceptual design was developed from the range of values listed in Table 2. Figure 16 shows the plan view of the proposed channel. Figure 17 shows a typical cross section of a riffle and pool. Figure 17a shows a typical bedform with the locations of riffles, polls runs, and glides. The riffles are located at the inflection points between meanders while pools are located on the outside bend of the meander.

6.1 SEDIMENT TRANSPORT

A stable stream has the capacity to move its sediment load without aggrading or degrading. The total load of sediment can be divided into bed load and wash load. Wash load is normally composed of fine sands, silts and clay and transported in suspension at a rate that is determined by availability and not hydraulically controlled. Bed load is transported by rolling, sliding, or hopping (saltating) along the bed. At higher discharges, some portion of the bed load can be suspended, especially if there is a sand component in the bed load. Bed material transport rates are essentially controlled by the size and nature of the bed material and hydraulic conditions (Hey 1997).

The shear stress placed on the sediment particles is the force that entrains and moves the particles. The critical shear stress for the proposed channel has to be sufficient to move the D_{84} of the bed material. The critical shear stress was calculated and plotted on Shield's curve to determine the approximate size of particles that will be moved (Figure 18). Based on Shield's curve, particles from 15 mm to 50 mm could be moved with an average value 28 mm. The D_{84} of the existing stream is 6 mm. Therefore, the proposed design has sufficient shear stress to move the stream's bed load.

6.2 FLOODING ANALYSIS

The project's location was identified on the Federal Emergency Management Agency's Flood Insurance Rate Map, as shown in Figure 10. The project is located within the limits of the 100-year floodplain for Swift Creek.

The proposed project reestablishes the correct pattern of Speight Branch by constructing a more sinuous channel at the existing floodplain elevation. The floodplain itself is not altered in any way. There will be no obstructions in the floodplain to alter current flood elevations. To model Speight Branch would be trivial since in is inundated by floodwaters from Swift Creek.

Table 2: Morphological Characteristics
Existing, Reference, and Proposed Reaches

Variables	Existing Channel	Reference Reaches Sal's Branch	Mingo Creek	Upper Speight	Proposed Reach
1 Stream type (Rosgen)	E5	E4	E5	E5	E5
2 Drainage area (Sq. Mi.)	1.6	0.20	4.0	1.4	1.6
3 Bankfull width (W_{bkf}) ft	8.9	8.7	15.2	12.7	12.0
4 Bankfull mean depth (d_{bkf}) ft	2.2	1.20	2.4	2.3	2.0
5 Width/depth ratio (W_{bkf}/d_{bkf})	4.0	7.3	6.4	5.5	6.0
6 Bankfull cross-sectional area (A_{bkf}) sq ft	19.8	10.4	36.1	28.7	24.0
7 Bankfull mean velocity (V_{bkf}) fps	7.1	3.8	2.6	5.2	5.8
8 Bankfull discharge (Q_{bkf}) cfs from Manning	140	40	95	150	140
9 Bankfull maximum depth (d_{max}) ft	3.7	2.4	2.9	3.0	4.0
10 Width of flood prone area (W_{fpa}) ft	32.0	33.0	86.0	>32.3	40.0
11 Entrenchment ratio (W_{fpa}/W_{bkf})	3.6	3.3	5.7	>10	3.3
12 Meander Length (L_m) ft	n/a	47.0	89 -195	50-100	72 -120
13 Ratio of meander length to bankfull width (L_m/W_{bkf})	n/a	5.4	5.9 - 12.8	4 - 8	6 - 10
14 Radius of curvature (R_c) ft	n/a	12 -35	29 - 53	15 - 35	14 - 42
15 Ratio of radius of curvature to bankfull width (R_c/W_{bkf})	n/a	1.2 - 3.5	1.9 - 3.5	1.2 - 2.8	1.2 - 3.5
16 Belt width (W_{blt}) ft	n/a	28 - 41	42 - 67	30 - 70	29 - 66
17 Meander width ratio (W_{blt}/W_{bkf})	n/a	2.8 - 4.1	2.8 - 4.4	2.4 - 5.5	2.4 - 5.5
18 Sinuosity (stream length / valley length) (k)	1.2	1.7	1.44	1.3	1.4
19 Valley slope (S_{valley})	0.005	0.028	0.003	0.009	0.005
20 Average slope (S_{ave}) = (S_{valley}/k)	0.004	0.016	0.002	0.007	0.004
21 Pool slope (S_{pool})	0.0	0.0	0.0	0.0	0.0

Table 2: Morphological Characteristics (continued)
Existing, Reference, and Proposed Reaches

Variables	Existing Channel	Reference Reaches Sal's Branch	Mingo Creek	Upper Speight	Proposed Reach
22 Ratio pool slope to average slope (S_{pool}/S_{ave})	0	0	0	0	0
23 Maximum pool depth (d_{pool}) ft	3.8	2.2	3.0	5.0	4.0 - 6.0
24 Ratio of pool depth to ave. bankfull depth (d_{pool}/d_{bkf})	1.7	4.0	1.9	2.2	2.0 - 3.0
25 Pool width (W_{pool}) ft	13.2	8 - 11	15.2	9 - 12	12 - 14
26 Ratio of pool width to bankfull width (W_{pool}/W_{bkf})	1.5	.8 - 1.1	1.0	0.7 - 0.9	1.0 - 1.2
27 Pool/pool spacing (p-p) ft	30 - 75	38 - 48	65 -110	30 - 60	36 -60
28 Ratio of p-p spacing to bankfull width ($p\text{-}p/W_{bkf}$)	3.4 - 8.4	3.8 - 4.8	4.3 - 7.2	2.4 - 4.7	3.0 - 5.0
Materials:					
Particle size distribution of channel material (mm)					
D 16	<.062	3.0	0.13		
D 35	0.12	8.0	0.4		
D 50	0.5	10.0	0.7		
D 84	6.0	21.0	2.0		
D 95	15.0	33.0	4.0		

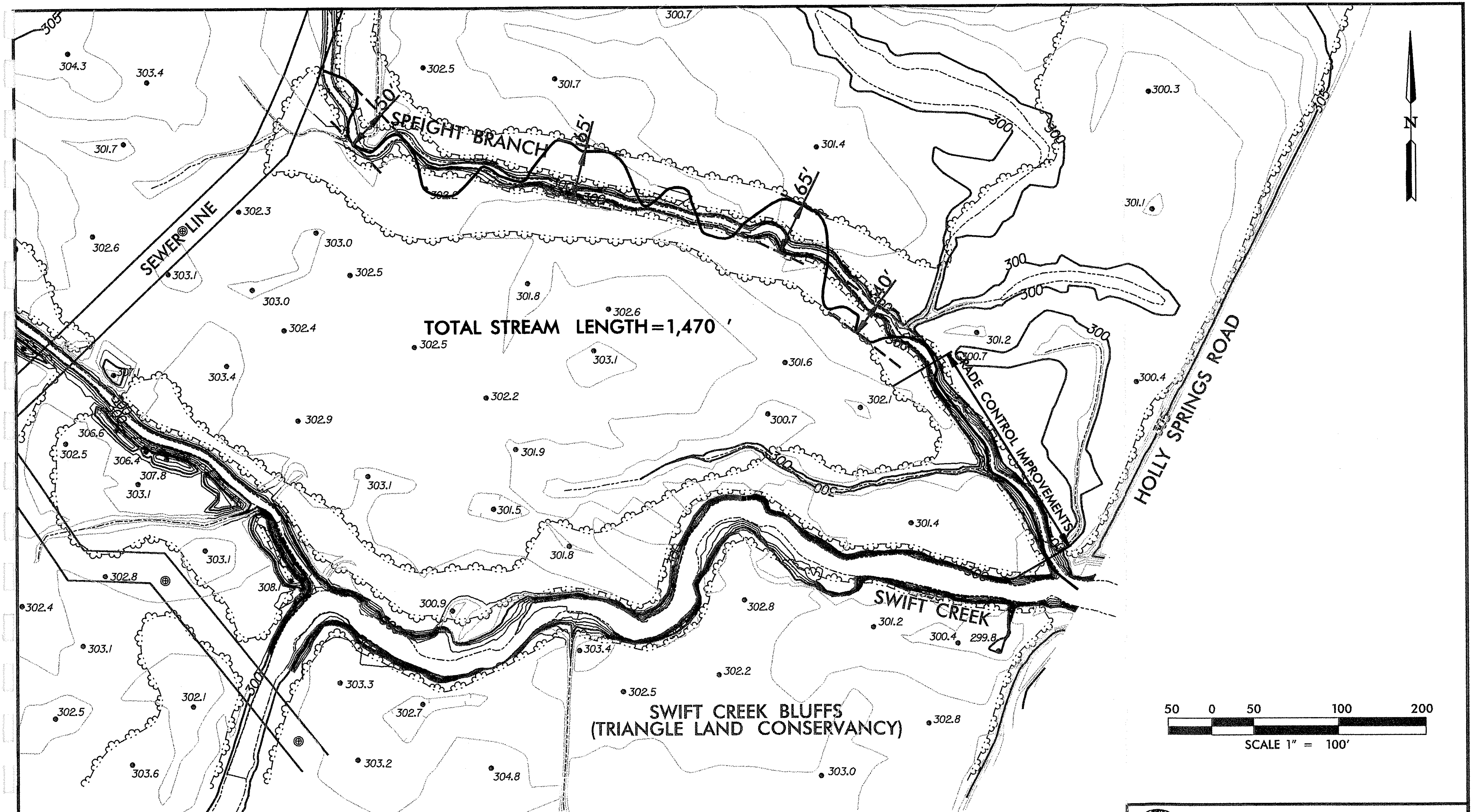

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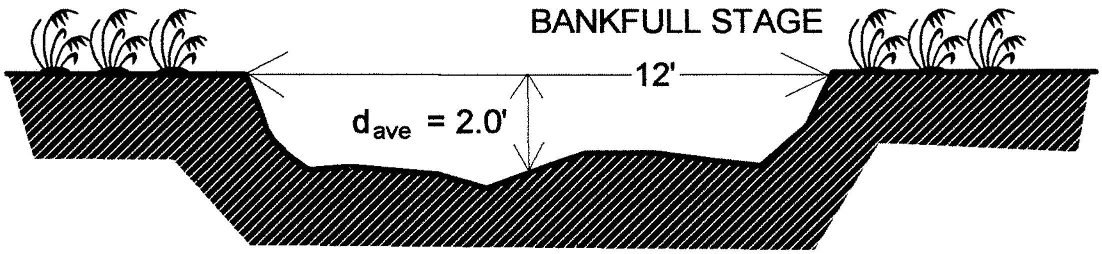
FIGURE 16
Stream Restoration Plan View
Speight Branch Mitigation Site
Wake County, North Carolina

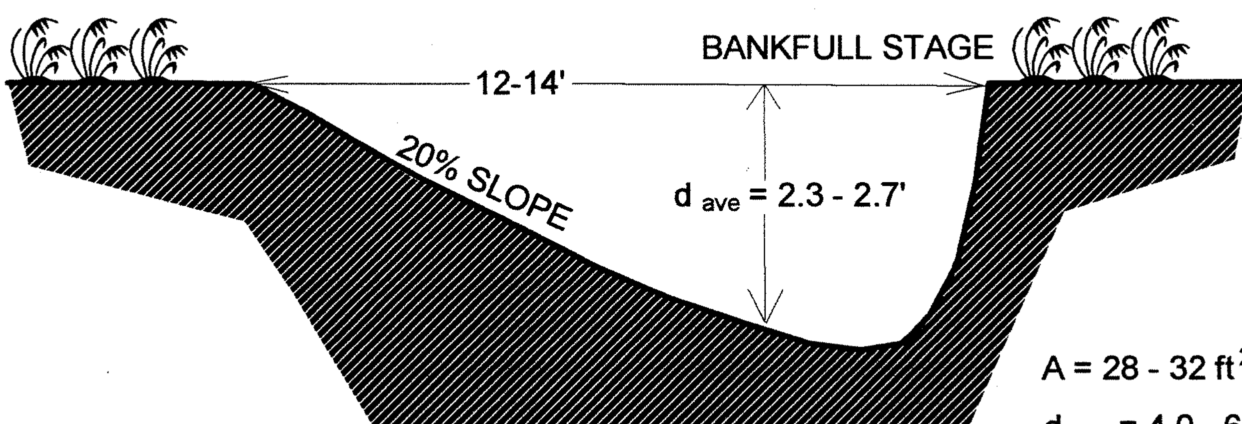
TYPICAL CROSS SECTION - RIFFLE



A = 24 ft^2

d_{max} = 2.7 - 3.2'

TYPICAL CROSS SECTION - POOL



A = 28 - 32 ft^2

d_{max} = 4.0 - 6.0'

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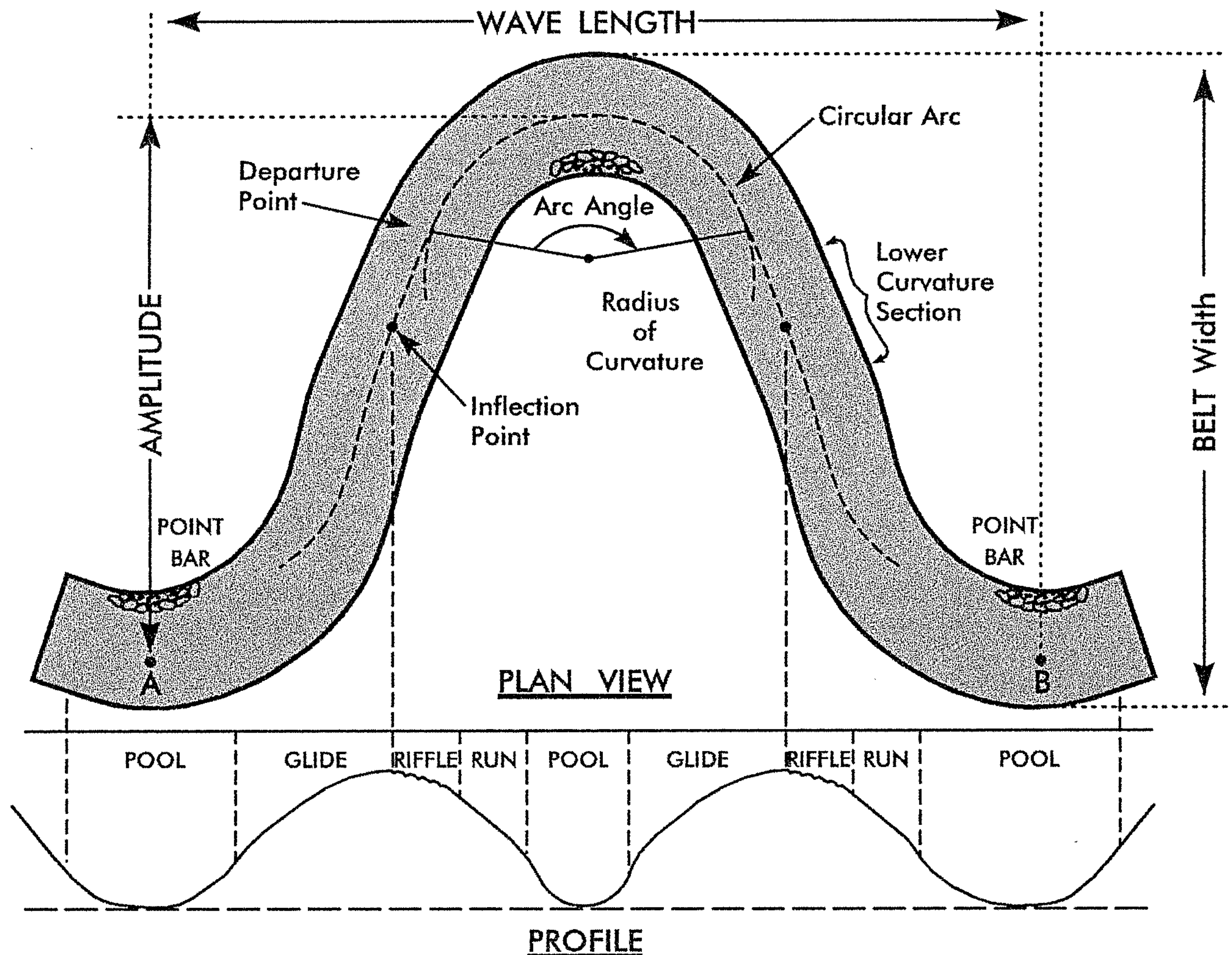
FIGURE 17
Typical Cross Sections
Speight Branch Mitigation Site
Wake County, North Carolina

NOT TO SCALE



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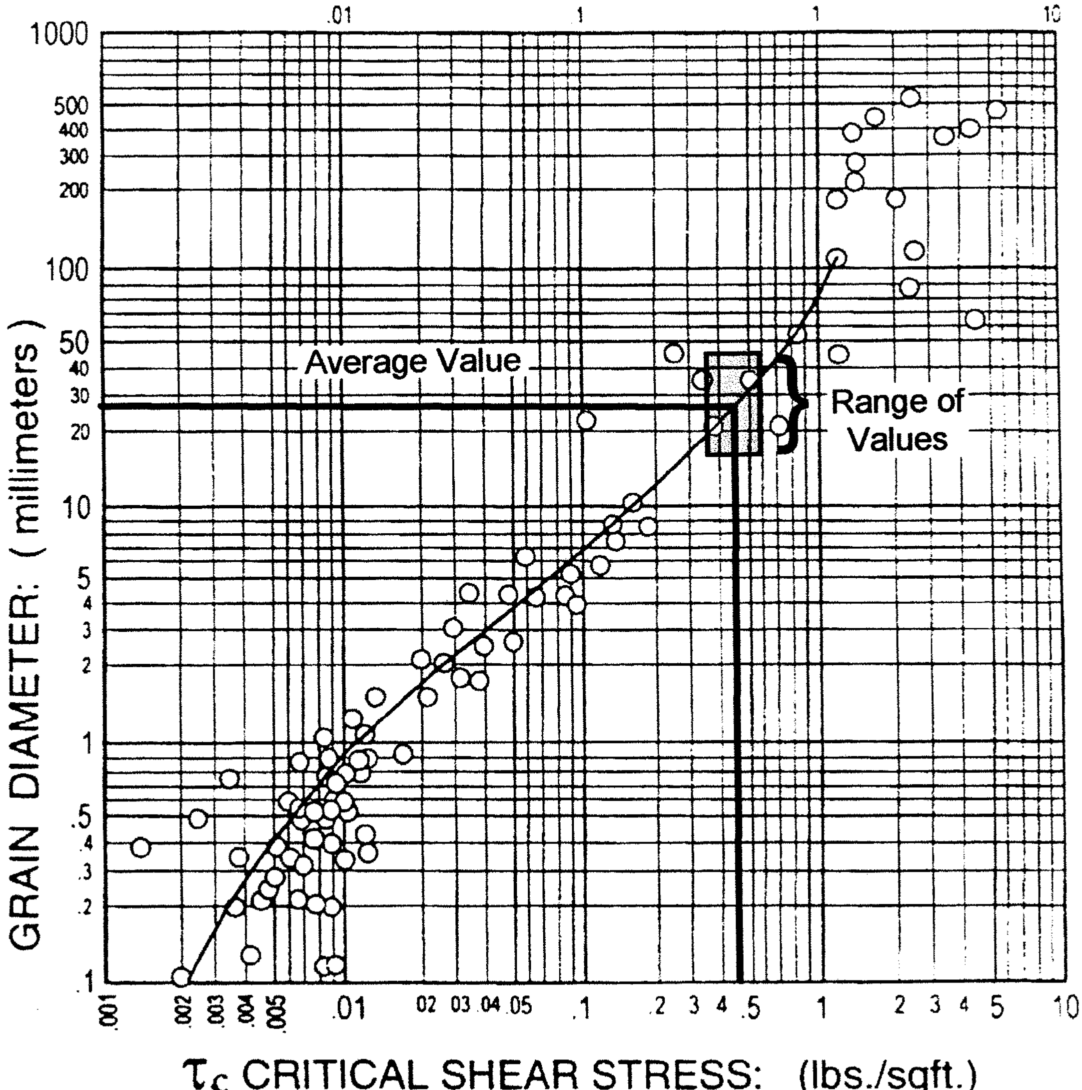
Project Development and Environmental Analysis Branch

FIGURE 17a
Bedform
Speight Branch Mitigation Site
Wake County, North Carolina



Laboratory and field data on critical shear stress required to initiate movement of grains (Leopold, Wolman, & Miller 1964). The solid line is the Shields curve of the threshold of motion transposed from the θ versus R_* form into the present form, in which critical shear stress is plotted as a function of grain diameter.

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FIGURE 18
Shields Curve
Speight Branch Mitigation Site
Wake County, North Carolina

6.3 STRUCTURES

Three different structure types made of natural materials will be installed in the stream channel. These structures include cross vanes, j-hook rock vanes, and root wads. These will be made from natural materials either on-site or from off-site locations.

6.3.1 Cross Vanes

This structure serves to maintain the integrity of the upstream riffle while promoting scouring in the downstream pool (Figure 19). The design shape is roughly that of the letter "U" with the apex located on the upstream side at the foot of the riffle. Footer rocks are placed in the channel bottom for stability. Rocks or logs are then placed on these footer rocks in the middle of the channel at approximately the same elevation as the riffle. On either side of the channel, rocks or logs are placed at an angle to the stream bank, gradually inclining in elevation until they are located above the bankfull surface directly adjacent to the stream bank (see Profile view, Figure 19). Water flowing downstream is forced over the vane towards the middle of the channel on either side of the structure, effectively scouring out a pool below. Rocks placed at the apex hold back stream bed material and prevent them from washing downstream. A cross vane is primarily used for grade control and to protect both stream banks. Since this site has a significant number of cut logs on site, some cross vanes will use logs as well as rocks.

6.3.2 J-Hook Rock Vanes

This structure is designed to break up the secondary circulation cells which cause stress in the near bank region (Figure 20). It also forces the thalweg and shear stress away from the bank and towards the middle of the stream channel. Similar in design to the cross vane, these structures are placed on the outside of curve meanders. Footer rocks are placed on one side of the channel bottom for stability. More rocks are then placed at an angle to the stream bank, gradually inclining in elevation until they are located above the bankfull surface directly adjacent to the stream bank (see Profile view, Figure 20). Additional rocks are placed to give the structure a "J" shape. These extra rocks are added to help create fish habitat. The j-hook vane helps relieve stress on the near bank region and provides fish habitat.

6.3.3 Root Wads

The objectives of these structure placements are to: (1) protect the stream bank from erosion; (2) provide in-stream and overhead cover for fish; (3) provide shade, detritus, terrestrial insect habitat; (4) look natural, and (5) provide diversity of habitats (Rosgen 1996). A footer log and boulder are placed on the channel bottom and abut the stream bank along an outside meander (Figure 21). This provides support for the root wad and additionally stability to the bank. A large tree root wad is then placed on the stream bank

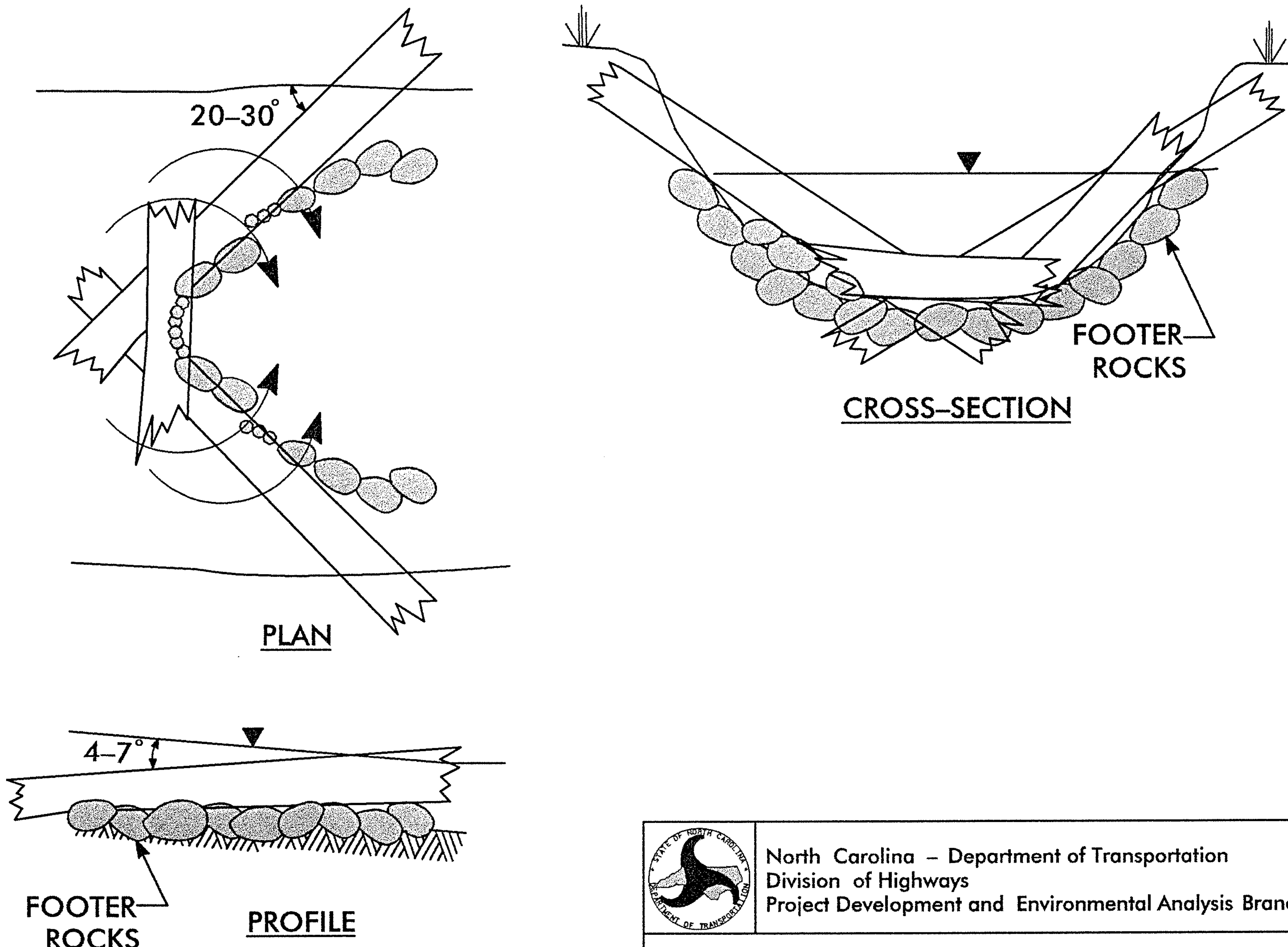

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FIGURE 19
Natural Material Structure – Log Vane
Speight Branch Mitigation Site
Wake County, North Carolina

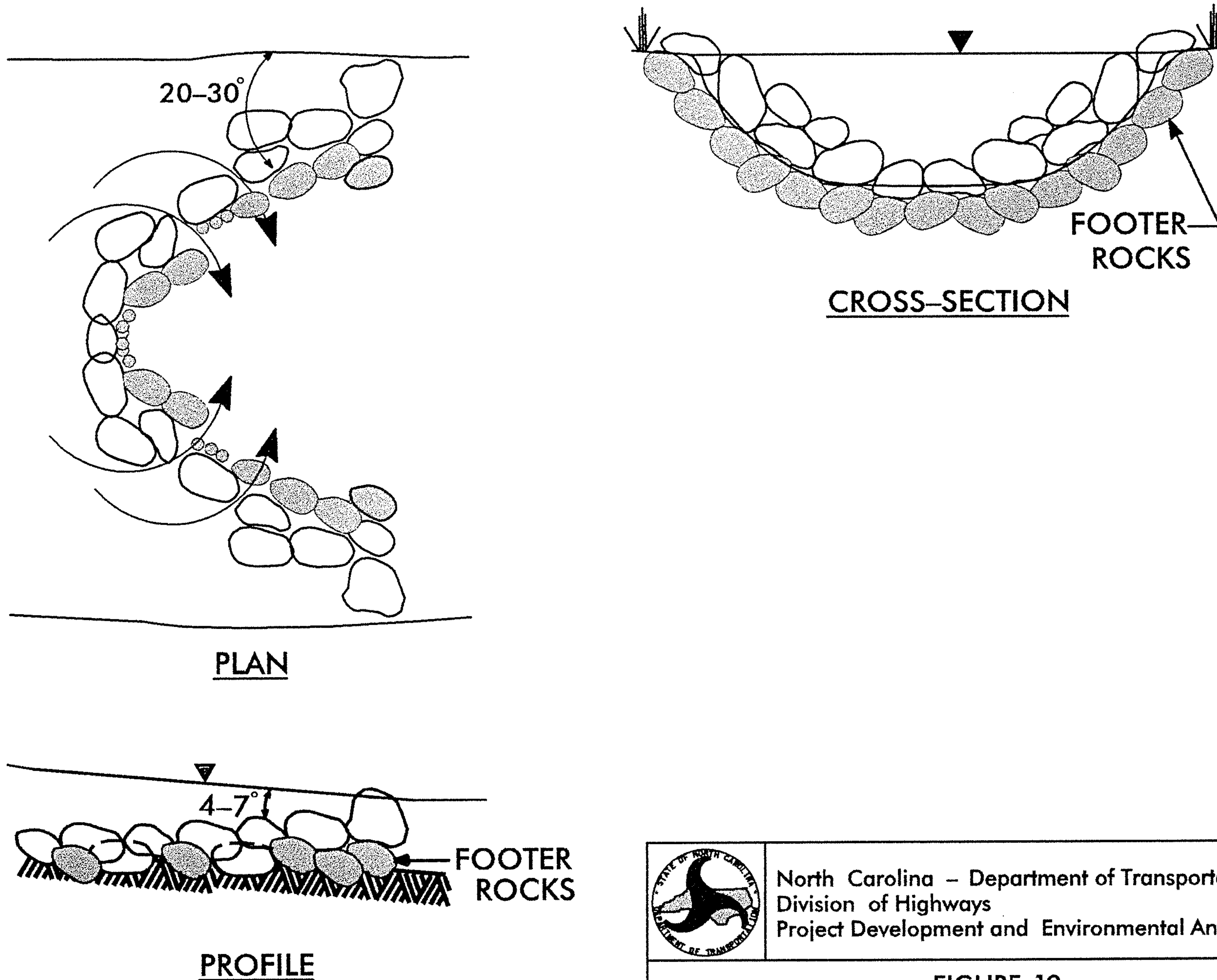

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FIGURE 19a
Natural Material Structure – Cross Vane
Speight Branch Mitigation Site
Wake County, North Carolina

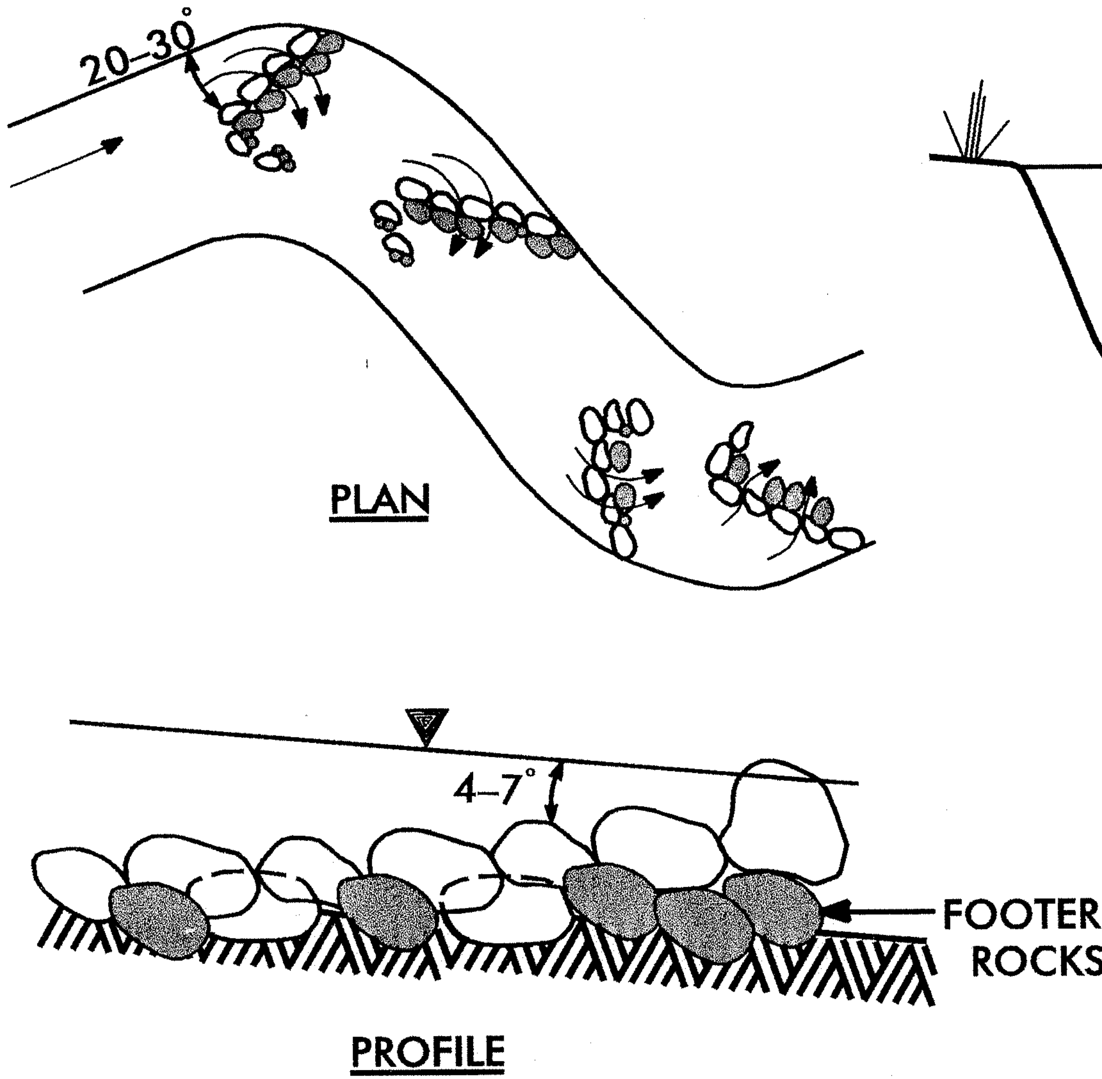

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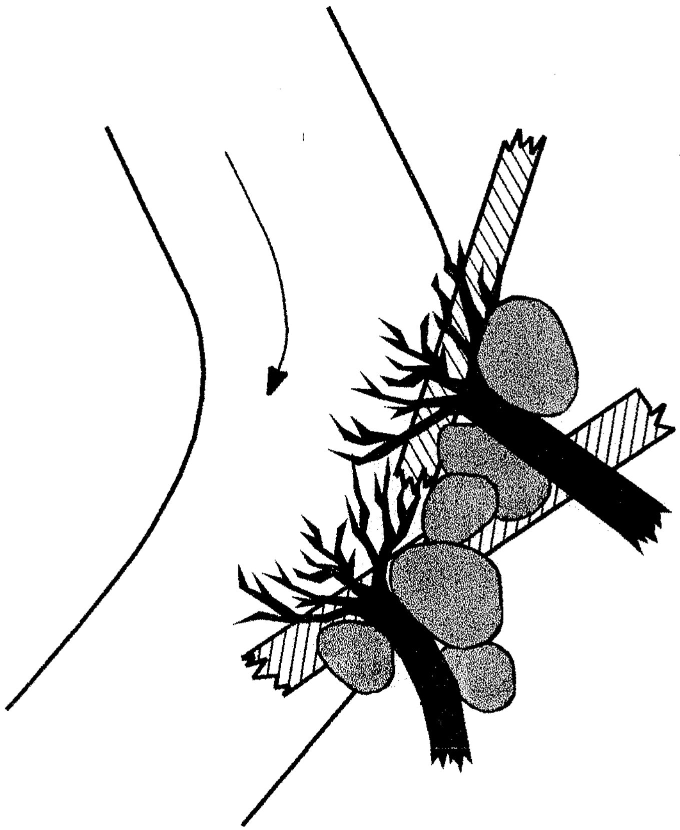
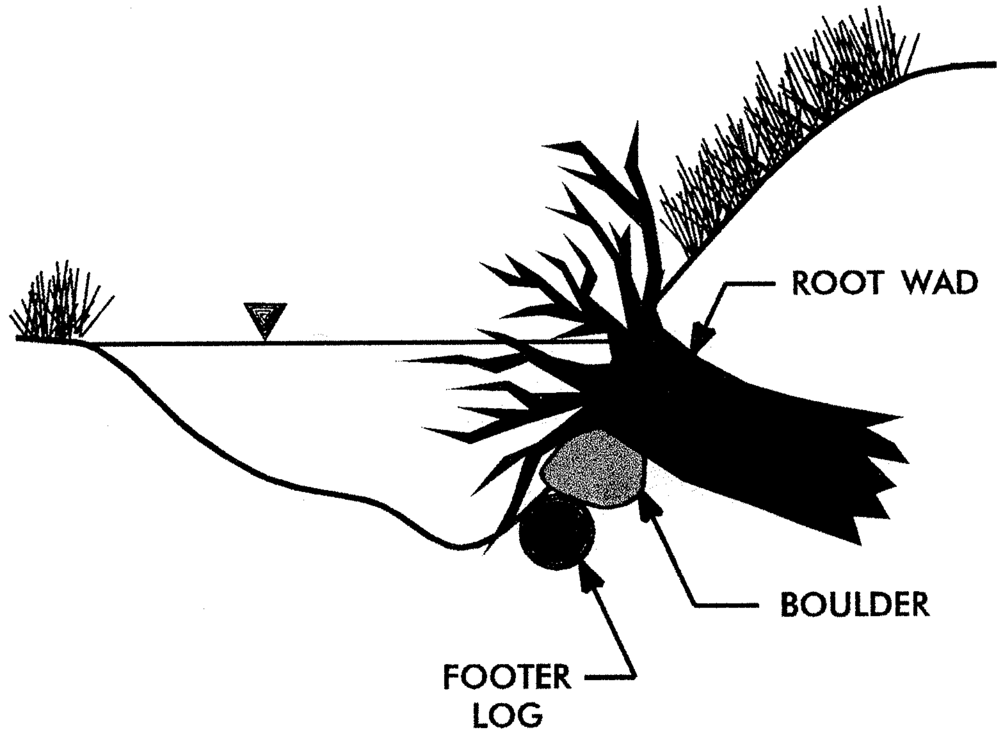
FIGURE 20
Natural Material Structure – J–Hook Rock Vane
Speight Branch Mitigation Site
Wake County, North Carolina



PLAN



CROSS–SECTION

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FIGURE 21
Natural Material Structure – Root Wad
Speight Branch Mitigation Site
Wake County, North Carolina

with additional boulders and rocks on either side for stability. Flowing water is deflected away from the bank and towards the center of the channel.

Specific location of these structures will be determined during final design.

6.4 RIPARIAN BUFFER

A 15 meter (50 feet) riparian buffer, encompassing 1.2 ha (2.9 ac), will be established on either side of the new stream channel (Figure 22). Revegetation of this area will occur in conjunction with the wetland enhancement and creation portion of this project. Where appropriate, wetlands will serve as the riparian buffer (see Figure 15). The target vegetation community for this buffer will be a Piedmont Bottomland Forest (Schafale and Weakley 1990). This classification also corresponds with the I.B.2.N.d.210 *Quercus (michauxii, pagoda, shumardii)-Liquidambar styraciflua* Temporarily Flooded Forest Alliance. Currently, the buffer zone is vegetated with a thick layer of privet and blackberry with a few small and large trees bordering the stream. Areas of the buffer zone that are not disturbed from construction activities will be drum-chopped to remove existing scrub/shrub species and will be revegetated with hardwoods. Existing large trees on the site will not be disturbed. Additionally, abandoned portions of the stream channel will be filled in and revegetated. Proposed species to be planted in these areas include the following:

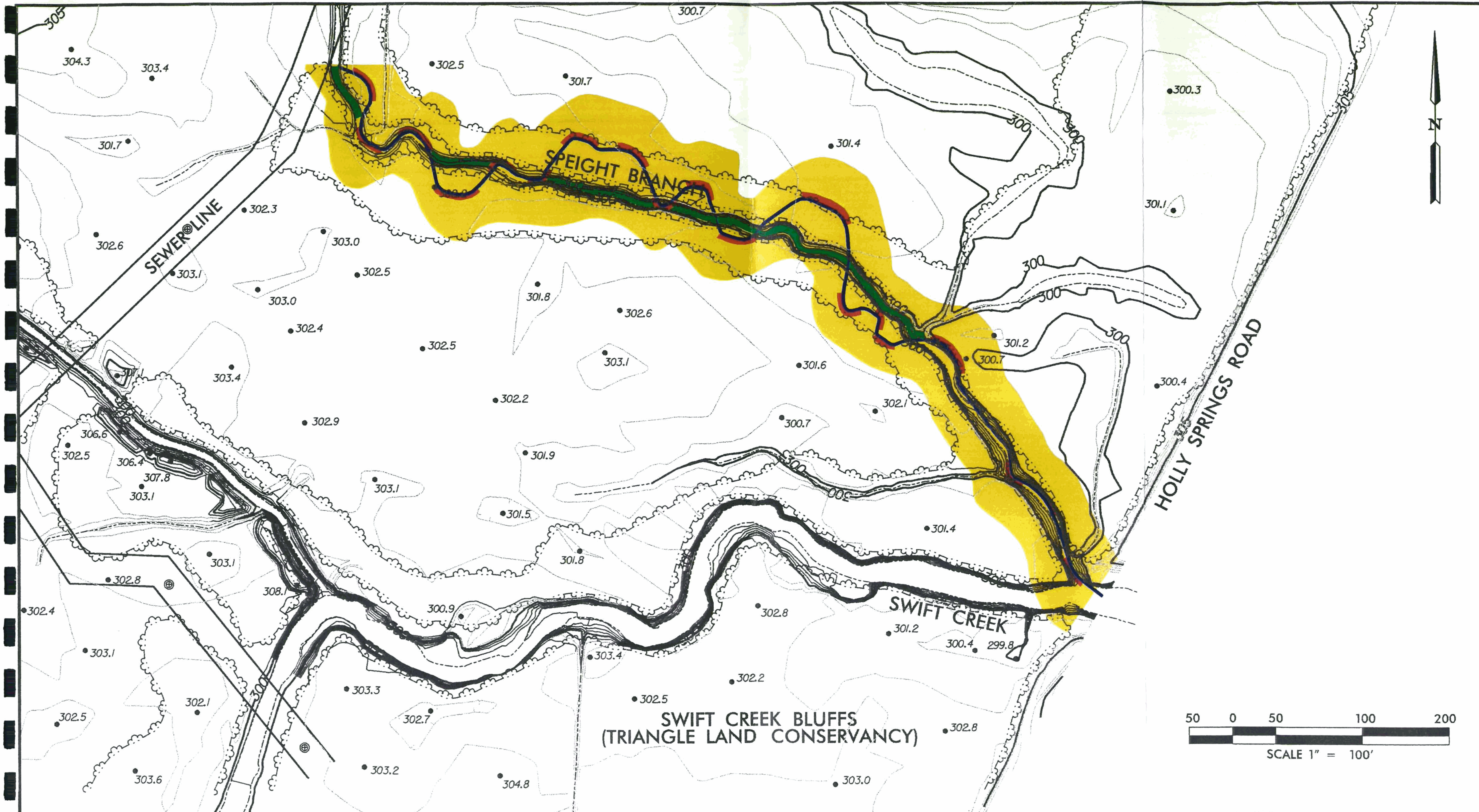
Bitternut hickory (*Carya cordiformis*)
Black walnut (*Juglans nigra*)
Green Ash (*Fraxinus pennsylvanica*)
River Birch (*Betula nigra*)
Sycamore (*Platanus occidentalis*)
Tulip-poplar (*Liriodendron tulipifera*)

Areas where these species are proposed are shown on Figure 22. Areas that are currently vegetated will remain undisturbed and succession allowed to proceed naturally.

6.5 STREAM BANK VEGETATION

Vegetation that develops a quick canopy, extensive rooting, and substantial plant structure is needed to help stabilize slopes of the new channel in order to reduce stream scour and runoff erosion. In riparian environments, pioneer plants that provide those functions are alder, birch, dogwood, and willow. Once established, these trees can create the environment required for succession of plant species including ash, maples, sycamores, and other riparian species.

Because the existing site vegetation is a privet/blackberry shrub thicket and is a harsh environment for tree-seedling germination, the vgetation will be removed and replanted with hardwood species. However, some small bands of existing shrub vegetation will be



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Division of Highways
Project Development and Environmental Analysis Branch

FIGURE 22
Stream Revegetation
Speight Branch Mitigation Site
Wake County, North Carolina

left in place along the outside of current and newly created meanders, with additional plantings of hardwood species to help stabilize the stream bank at those points. Hardwood trees currently standing along the stream bank will not be disturbed. Proposed species to be planted in these areas include the following:

River birch (*Betula nigra*)
Red maple (*Acer rubrum*)
Tag alder (*Alnus serrulata*)
Black willow (*Salix nigra*)

The total area of stream bank stabilization plantings is 0.05 ha (0.12 ac). These planting areas are shown on Figure 22.

Planting will be performed between November and March to allow plants to stabilize during the dormant period and set root during the spring season.

7.0 OTHER CONSIDERATIONS

7.1 MONITORING

7.1.1 WETLAND MONITORING AND SUCCESS CRITERIA

Monitoring of the wetland mitigation will be performed until success criteria are met. Monitoring is proposed of both vegetation and hydrology. The monitoring plan has been designed in accordance with the US Army Corps of Engineers Compensatory Hardwood Mitigation Guidelines (1993a). The enhancement areas will only be monitored for vegetation while the creation areas will be monitored for both vegetation and wetland hydrology.

7.1.1.1 Vegetation

Prior to planting, the site will be inspected and checked for proper elevation and suitability of soils. Availability of acceptable, good quality plant species will be determined. The site will be inspected at completion of planting to determine proper planting methods, including proper plant spacing, density, and species composition.

During the first year, vegetation will receive a cursory, visual examination to evaluate the degree of overtopping of the saplings by herbaceous plants. Quantitative sampling of the vegetation will be performed between August 1 and November 30 at the end of the first year and after each growing season until the vegetation criteria is met.

In preparation for the quantitative sampling, 50 by 50 ft (0.05-acre) vegetative plots will be established in the reforested area. Plots will be evenly distributed throughout the wetland mitigation site. Sample plot distribution will be correlated with the hydrological monitoring locations to help correlate data between vegetation and hydrology parameters. For each plot, species composition and density will be reported. Photo points will be taken within each zone. Monitoring will take place once each year for five years.

Success will be determined by survival of target species within the sample plots. A minimum of 240 trees/acre must survive for at least five years after initial planting. At least six different representative tree species should be present on the entire site. If the vegetative success criteria are not met, the cause of failure will be determined and appropriate corrective action will be taken.

7.1.1.2 Hydrology

Hydrological monitoring is only proposed for the creation areas. Monitoring wells will be installed in the creation areas to monitor site hydrology. Monitoring wells will be installed in accordance with USACE guidelines (USACE 1993b). The site will be considered successful if the soil is ponded, flooded, or saturated within 12 inches of the surface for at least 5 percent of the growing season under average climatic conditions.

7.1.2 STREAM MONITORING

The NCDOT proposes to monitor the stream mitigation site for one year. Two types of monitoring are planned: vegetation and channel/stream bank stability. The NCDOT will establish photo reference points at the stream mitigation site. The photo reference sites will be located using Global Positioning System and included on the "As-Built" plan for the mitigation site. The NCDOT will submit a brief report with these photographs to the resource agencies regarding these two aspects of monitoring upon completion of the one year monitoring period.

The NCDOT will implement quarterly visits over one year after completion of the mitigation work to ensure channel/bank stability. Photographs of the vegetation will be taken at the end of the growing season. Photographs will show coverage/survivability of the vegetation and channel/stream bank stability. Any remediation action that is necessary will be initiated as soon as possible with consideration given to seasonal constraints. The NCDOT will contact the US Army Corps of Engineers about the remediation. Monitoring period extensions will be addressed on a case by case basis.

7.2 DISPENSATION OF PROPERTY

NCDOT will maintain ownership of the property until all mitigation activities are completed and the site is determined to be successful. Although no plan for dispensation of the Speight Branch mitigation site has been developed, NCDOT will deed the property to a resource agency (public or private) acceptable to the appropriate regulatory agencies. Covenants and/or restrictions on the deed will insure adequate management and protection of the site in perpetuity.

7.3 MITIGATION CREDITS

This mitigation plan is proposed to partially fulfill compensatory mitigation requirements for wetland and stream impacts associated with Holly Springs Bypass (TIP Project No. R-2541). Construction of this project will result in unavoidable impacts to 1.28 ha (3.16 ac) of wetlands including bottomland hardwood forest (0.38 ha /0.94 ac), headwater forest (0.73 ha/1.80 ac), and disturbed emergent wetlands (0.17 ha/0.42 ac) which occur within the proposed corridor.

The project will also impact 433 m (1,421 ft) of surface waters. Of the 433 m (1,421 ft) of stream impact, 129 m (422 ft) will be relocated using a natural channel design reducing the impacts to 304 m (999 ft). Based on a 2:1 mitigation ratio, the NCDOT needs to mitigate 609 m (1,998 ft). In association with the relocation of Technology Drive at the north end of the project, the NCDOT is restoring 81 m (265 ft) of stream channel that is currently culverted under a parking lot. Subtracting this restoration from the total required leaves the NCDOT with 543 m (1,733 ft) of required stream mitigation.

Mitigation on the Speight Branch site will include the following:

- Enhancement of 8.3 acres of wetland (See Figure 15)
- Creation of 1 acre of wetland (See Figure 15)
- 1,470 feet of stream restoration of Speight Branch
- Restoration and preservation of 1.2 ha (2.9 acres) of riparian buffer on Speight Branch (both sides, see Figure 22)
- Preservation of 1,200 linear feet of riparian buffer on Swift Creek (not shown on any figures)
- Preservation of 19 acres of upland buffer and wildlife habitat on Swift Creek adjacent to the Swift Creek Bluffs, owned by the Triangle Land Conservancy.

Wetland and stream functions restored by this plan include wildlife habitat and water quality improvements.

Appropriate mitigation ratios are often difficult to determine. Draft guidelines published by the EPA (1992) recommends the following "general guidance" ratios: 2:1 for restoration, 3:1 for creation, 4:1 for enhancement and 10:1 for preservation. However, slightly lower ratios are proposed for Speight Branch. Because the site is located within the floodplain of Swift Creek, a stream that is under heavy development pressure from the urbanization of Wake County it has been targeted by several local resource agencies for protection. Additionally, both upland (19 acres) and riparian (2.9 acres) buffer is being protected. Therefore, a total of 3.3 credits are proposed for wetland mitigation based on the following ratios:

	Ratio	**Acreage**	**Credits**
Enhancement	3:1	8.3	2.8 credits
Creation	2:1	1	0.5 credits
		Total	**3.3 credits**

8.0 REFERENCES

Cowardin, L.M., V. Carter, F.C. Golet and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. Prepared for the U.S. Fish and Wildlife Service, United States Department of the Interior, Washington DC.

Environmental Laboratory. 1987. U.S. Army Corps of Engineers Wetlands Delineation Manual, Technical Report Y-87-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Hey, Richard and Dave Rosgen. 1997. Fluvial Geomorphology for Engineers. Wildland Hydrology, Pagosa Springs, Colorado.

Martof, B. S., W. M. Palmer, J. R. Bailey, and J. R. Harrison III. 1980. Amphibians and Reptiles of the Carolinas and Virginia. University of North Carolina Press, Chapel Hill, NC.

Palmer, W. M., and A. L. Brasswell. 1995. Reptiles of North Carolina. The University of North Carolina Press, Chapel Hill

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

Robbins, C.S. and H.S. Zim. 1996. A Guide to Field Identification of Birds of North America. Western Publishing, Racine, Wisconsin.

Rosgen, Dave. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colorado.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the Natural Communities of North Carolina, Third Approximation. North Carolina Natural Heritage Program, Division of Parks and Recreation, Dept. of Environment, Health and Natural Resources, Raleigh, NC.

Town of Cary, 1999. Zoning Map.

United States Army Corps of Engineers, 1993. Installing Monitoring Wells/Piezometers in Wetlands. WRP Technical Note HY-IA-3.1

United States Army Corps of Engineers, 1993. Compensatory Hardwood Mitigation Guidelines.

United States Department of Agriculture, Soil Conservation Service. 1970. Soil Survey of Wake County, North Carolina.

Wake County Planning Department, 1988. Land Use Plan

Webster, W. D., J. F. Parnell, and W. C. Biggs, Jr. 1985. Mammals of the Carolinas, Virginia, and Maryland. The University of North Carolina Press, Chapel Hill.

Weakley A.S., K.D. Patterson, S. Landaal, M. Pyne and others, compilers. 1998. International Classification of Ecological Communities: Terrestrial Vegetation of the Southeastern United States. The Nature Conservancy, Southeast Regional Office, Southern Conservation Science Department: Chapel Hill, NC.

APPENDIX A

DWQ RATING SHEETS

WETLAND RATING WORKSHEET Fourth Version

Project Name Burke Property - Emergent Wetlands Nearest Road Holly Springs Road
County Wake Wetland Area 14-15 acres Wetland Width 300-400 feet
Name of evaluator L. Woerner, B. Gruver Date 12/11/97

Wetland Location

- ___ on pond or lake
- X on perennial stream
- ___ on intermittent stream
- ___ within interstream divide
- ___ other ______

Soil series Wehadkee

- ___ predominantly organic - humus, muck, or peat
- X predominantly mineral - non-sandy
- ___ predominantly sandy

Hydraulic factors

- ___ steep topography
- X ditched or channelized
- X total wetland width ≥100 feet (in northeastern corner of property)

Adjacent land use
(within 1/2 mile upstream, upslope, or radius)

- X forested/natural vegetation 65 %
- X agriculture, urban/suburban 30 %
- X impervious surface 5 %

Dominant vegetation

(1) Juncus effusus
(2) Carex sp.
(3) Liquidambar styraciflua (saplings)

Flooding and wetness

- X semipermanently to permanently flooded or inundated
- ___ seasonally flooded or inundated
- ___ intermittanly flooded or temporary surface water
- ___ no evidence of flooding or surface water

Wetland type (select one)*

- ___ Bottomland hardwood forest
- ___ Headwater forest
- ___ Swamp forest
- ___ Wet flat
- ___ Pocosin
- ___ Bog forest
- ___ Pine savanna
- X Freshwater marsh
- ___ Bog/fen
- ___ Ephemeral wetland
- ___ Carolina Bay
- ___ Other ______

*the rating system cannot be applied to salt or brackish marshes or stream channels

			weight		
R	Water storage	3	x 4.00 =	12	Wetland Rating
A	Bank/Shoreline stabilization	2	x 4.00 =	8	
T	Pollutant removal	2	* x 5.00 =	10	46
I	Wildlife habitat	1	x 2.00 =	2	
N	Aquatic life value	3	x 4.00 =	12	
G	Recreation/Education	2	x 1.00 =	2	

*Add 1 point if in sensitive watershed and >10% nonpoint disturbance within 1/2 mile upstream, upslope, or radius

APPENDIX B

USACE WETLAND DETERMINATION FORMS

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site:	*Speight Branch*	Date:	*10/19/98*
Applicant/Owner:	*NCDOT*	County:	*Wake*
Investigation:	*Ron Johnson/Karen Hall*	State:	*North Carolina*

Do Normal Circumstances exist on the site?	Yes X No ___	Community ID:	*Wetland 1*
Is the site significantly disturbed (Atypical Situation)?	Yes X No ___	Transect ID:	
Is the area a potential Problem Area? (If needed, explain in remarks.)	Yes ___ No X	Plot ID:	*Flag A8*

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
Sambucus canadensis	*Shrub*	*FACW-*			
Juncus effusus	*Herb*	*FACW+*			
Polygonum arifolium	*Herb*	*OBL*			
Scirpus cyperinus	*Herb*	*OBL*			
Ludwigia alternifolia	*Herb*	*OBL*			
Saururus cernuus	*Herb*	*OBL*			

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-) 100

Remarks:

HYDROLOGY

Recorded Data (Describe in Remarks:)
___ Stream, Lake or Tide Gauge
___ Aerial Photographs
___ Other
___ No Recorded Data Available

Field Observations:

Depth of Surface Water: 2 (in.)

Depth to Free Water in Pit: ___ (in.)

Depth to Saturated Soil: ___ (in.)

Wetland Hydrology Indicators:

Primary Indicators:
X Inundated
X Saturated in Upper 12 inches
___ Water Marks
___ Drift Lines
___ Sediment Deposits
___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):
X Oxidized Root Channels in Upper 12 in.
X Water-Stained Leaves
X Local Soil Survey Data
___ FAC-Neutral Test
___ Other (Explain in Remarks)

Remarks:

Community ID: *Wetland 1*
Transect ID:
Plot ID: *Flag A8*

SOILS

Map Unit Name (Series and Phase): *Chewacla*

Drainage Class: *frequently flooded*

Confirm Mapped Type?
X Yes
___ No

Taxonomy Subgroup:

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-2	*A*	*7.5 YR 4/4*			*silty clay loam*
3-12	*B1*	*7.5 YR 5/3*			*Silty clay loam*
5-18	*B2*	*10 YR 4/2*	*10 YR 5/3*	*30%*	*silty clay*

Hydric Soil Indicators:

___ Histosol
___ Histic Epipedon
___ Sulfidic Odor
X Aquic Moisture Regime
___ Reducing Conditions
X Gleyed or Low-Chroma Colors

___ Concretions
___ High Organic Content in Surface Layer in Sandy Soils
___ Organic Streaking in Sandy Soils
X Listed on Local Hydric Soils List
X Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	X Yes	___ No
Wetland Hydrology Present?	X Yes	___ No
Hydric Soils Present?	X Yes	___ No
Is this Sampling Point Within a Wetland?	X Yes	___ No

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site:	*Speight Branch*	Date: *10/19/98*
Applicant/Owner:	*NCDOT*	County: *Wake*
Investigation:	*Ron Johnson/Karen Hall*	State: *North Carolina*

Do Normal Circumstances exist on the site?	Yes X	No ___	Community ID: *Wetland 1*
Is the site significantly disturbed (Atypical Situation)?	Yes X	No ___	Transect ID:
Is the area a potential Problem Area?	Yes ___	No X	Plot ID: *Flag B3*
(If needed, explain in remarks.)			

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
Juncus effusus	*Herb*	*FACW+*			
Ludwigia alternifolia	*Herb*	*OBL*			
Polygonum arifolium	*Herb*	*OBL*			
Scirpus cyperinus	*Herb*	*OBL*			

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-) 100

Remarks:

HYDROLOGY

Recorded Data (Describe in Remarks:)
___ Stream, Lake or Tide Gauge
___ Aerial Photographs
___ Other
___ No Recorded Data Available

Field Observations:

Depth of Surface Water: *0* (in.)

Depth to Free Water in Pit: *3* (in.)

Depth to Saturated Soil: *0* (in.)

Wetland Hydrology Indicators:
Primary Indicators:
___ Inundated
X Saturated in Upper 12 inches
___ Water Marks
___ Drift Lines
___ Sediment Deposits
___ Drainage Patterns in Wetlands
Secondary Indicators (2 or more required):
X Oxidized Root Channels in Upper 12 in.
___ Water-Stained Leaves
X Local Soil Survey Data
___ FAC-Neutral Test
___ Other (Explain in Remarks)

Remarks:

Community ID: *Wetland 1*
Transect ID:
Plot ID: *Flag B3*

SOILS

Map Unit Name (Series and Phase): *Chewacla*

Drainage Class: *frequently flooded*

Confirm Mapped Type?
X Yes
___ No

Taxonomy Subgroup: ___

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-8		*2.5 Y 4/2*	*2.5 Y 4/6*	*50%*	*silty clay loam*
3-12		*10 YR 5/2*	*10 YR 4/6 50%*	*50%*	*Silty clay loam*

Hydric Soil Indicators:

___ Histosol
___ Histic Epipedon
___ Sulfidic Odor
___ Aquic Moisture Regime
___ Reducing Conditions
X Gleyed or Low-Chroma Colors

___ Concretions
___ High Organic Content in Surface Layer in Sandy Soils
___ Organic Streaking in Sandy Soils
X Listed on Local Hydric Soils List
X Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present? X Yes ___ No
Wetland Hydrology Present? X Yes ___ No
Hydric Soils Present? X Yes ___ No
Is this Sampling Point Within a Wetland? X Yes ___ No

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site:	*Speight Branch*	Date: *10/19/98*
Applicant/Owner:	*NCDOT*	County: *Wake*
Investigation:	*Ron Johnson/Karen Hall*	State: *North Carolina*

Do Normal Circumstances exist on the site?	Yes X	No ___	Community ID: *Wetland 1*
Is the site significantly disturbed (Atypical Situation)?	Yes X	No ___	Transect ID: ___
Is the area a potential Problem Area? (If needed, explain in remarks.)	Yes ___	No X	Plot ID: *Flag C9*

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
Alnus serrulata	*Shrub*	*FACW+*			
Juncus effusus	*Herb*	*FACW+*			
Polygonum arifolium	*Herb*	*OBL*			
Carex sp.	*Herb*	*FACW*			

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-) 100

Remarks:

HYDROLOGY

Recorded Data (Describe in Remarks:)
___ Stream, Lake or Tide Gauge
___ Aerial Photographs
___ Other
___ No Recorded Data Available

Field Observations:

Depth of Surface Water: *3-4* (in.)

Depth to Free Water in Pit: ___ (in.)

Depth to Saturated Soil: ___ (in.)

Wetland Hydrology Indicators:
Primary Indicators:
X Inundated
X Saturated in Upper 12 inches
___ Water Marks
___ Drift Lines
___ Sediment Deposits
___ Drainage Patterns in Wetlands
Secondary Indicators (2 or more required):
___ Oxidized Root Channels in Upper 12 in.
___ Water-Stained Leaves
X Local Soil Survey Data
___ FAC-Neutral Test
___ Other (Explain in Remarks)

Remarks:

Community ID: *Wetland 1*
Transect ID:
Plot ID: *Flag C9*

SOILS

Map Unit Name (Series and Phase): *Chewacla*

Drainage Class: *frequently flooded*

Confirm Mapped Type? X Yes ___ No

Taxonomy Subgroup: ___

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-2		*10 YR 4/3*			*silty clay loam*
3-12		*10 YR 5/1*			*Silty clay loam*

Hydric Soil Indicators:

___ Histosol
___ Histic Epipedon
___ Sulfidic Odor
___ Aquic Moisture Regime
___ Reducing Conditions
X Gleyed or Low-Chroma Colors
___ Concretions
___ High Organic Content in Surface Layer in Sandy Soils
___ Organic Streaking in Sandy Soils
X Listed on Local Hydric Soils List
X Listed on National Hydric Soils List
___ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

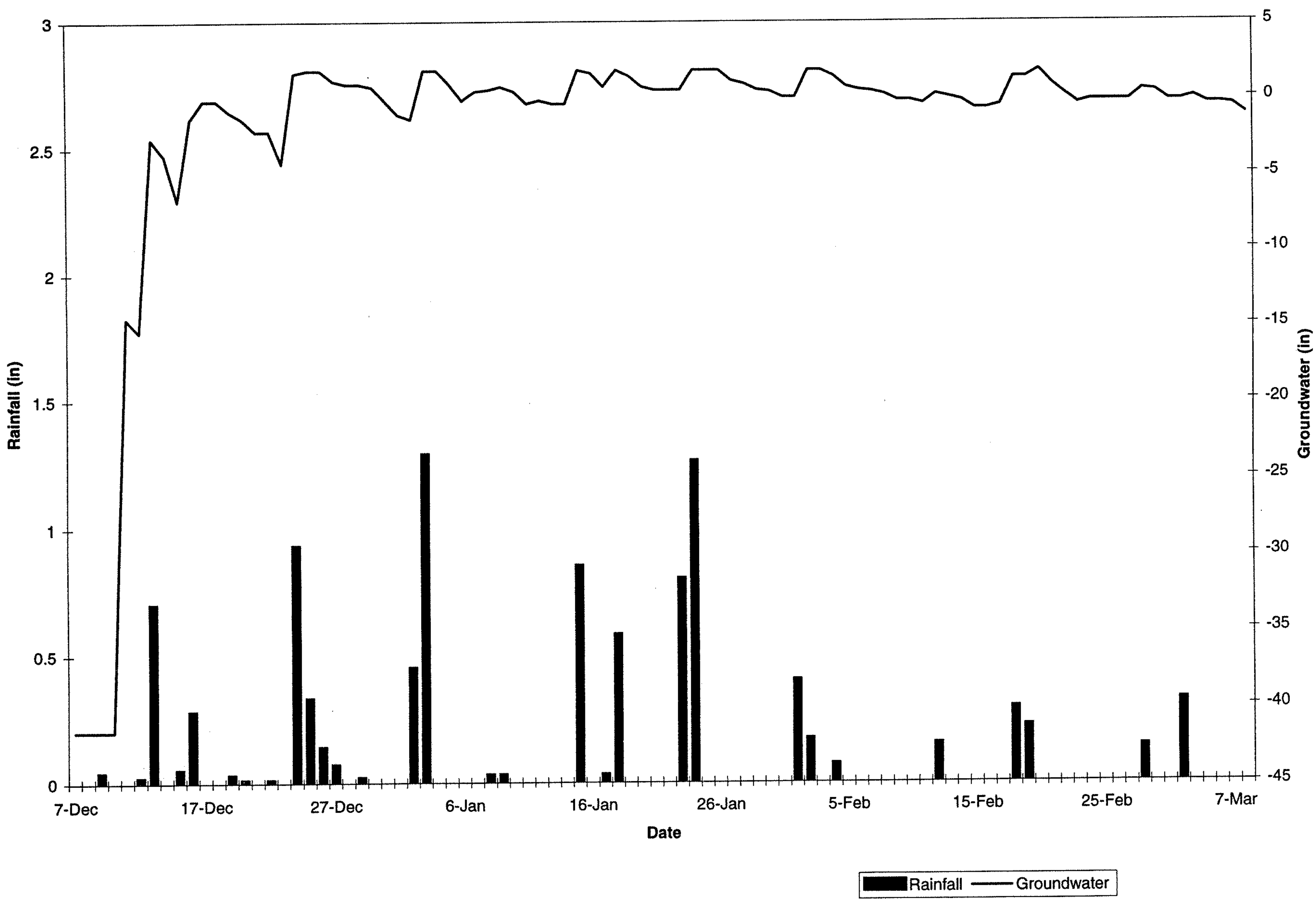
Hydrophytic Vegetation Present? X Yes ___ No
Wetland Hydrology Present? X Yes ___ No
Hydric Soils Present? X Yes ___ No
Is this Sampling Point Within a Wetland? X Yes ___ No

Remarks:

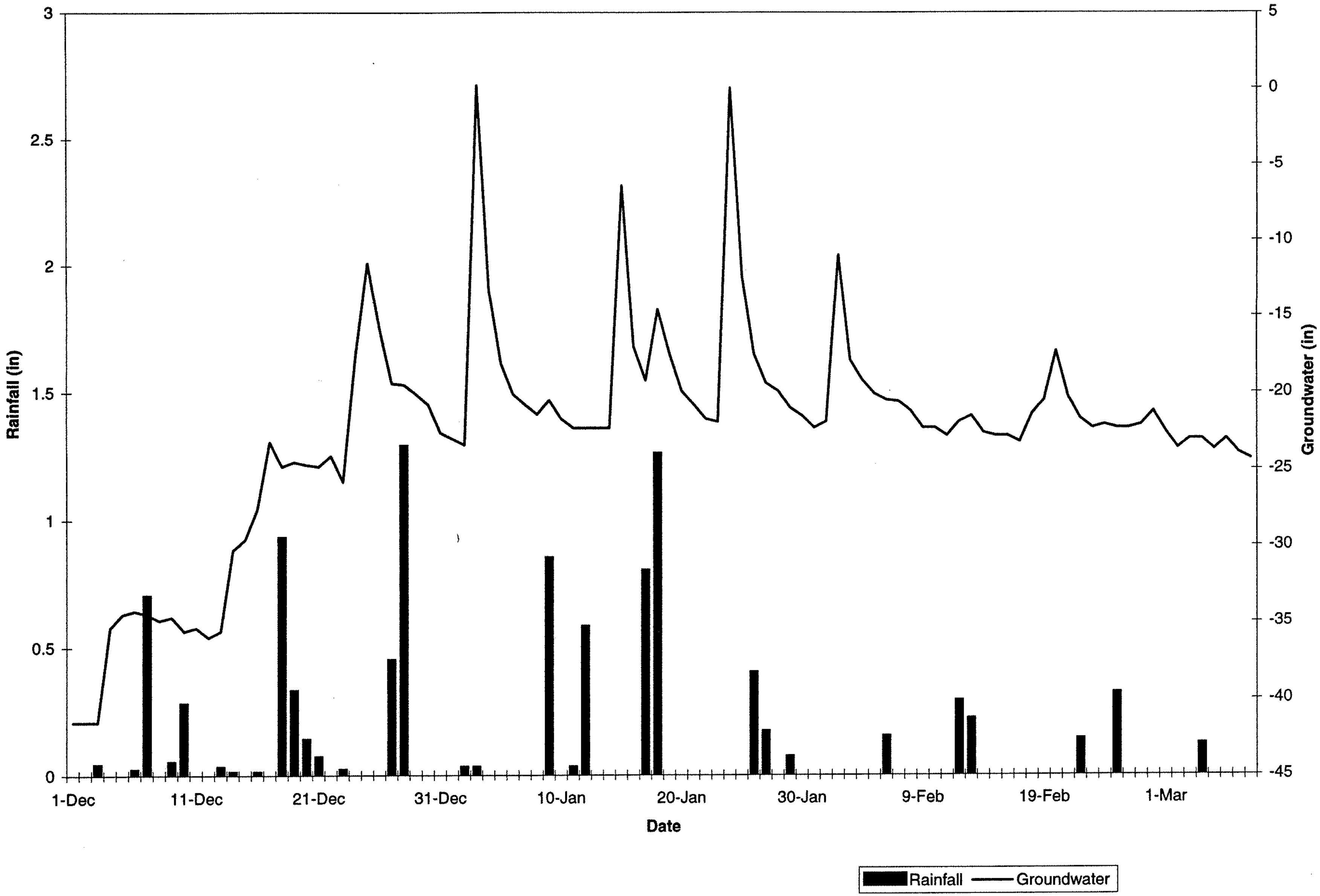
APPENDIX C

MONITOR WELL HYDROGRAPHS

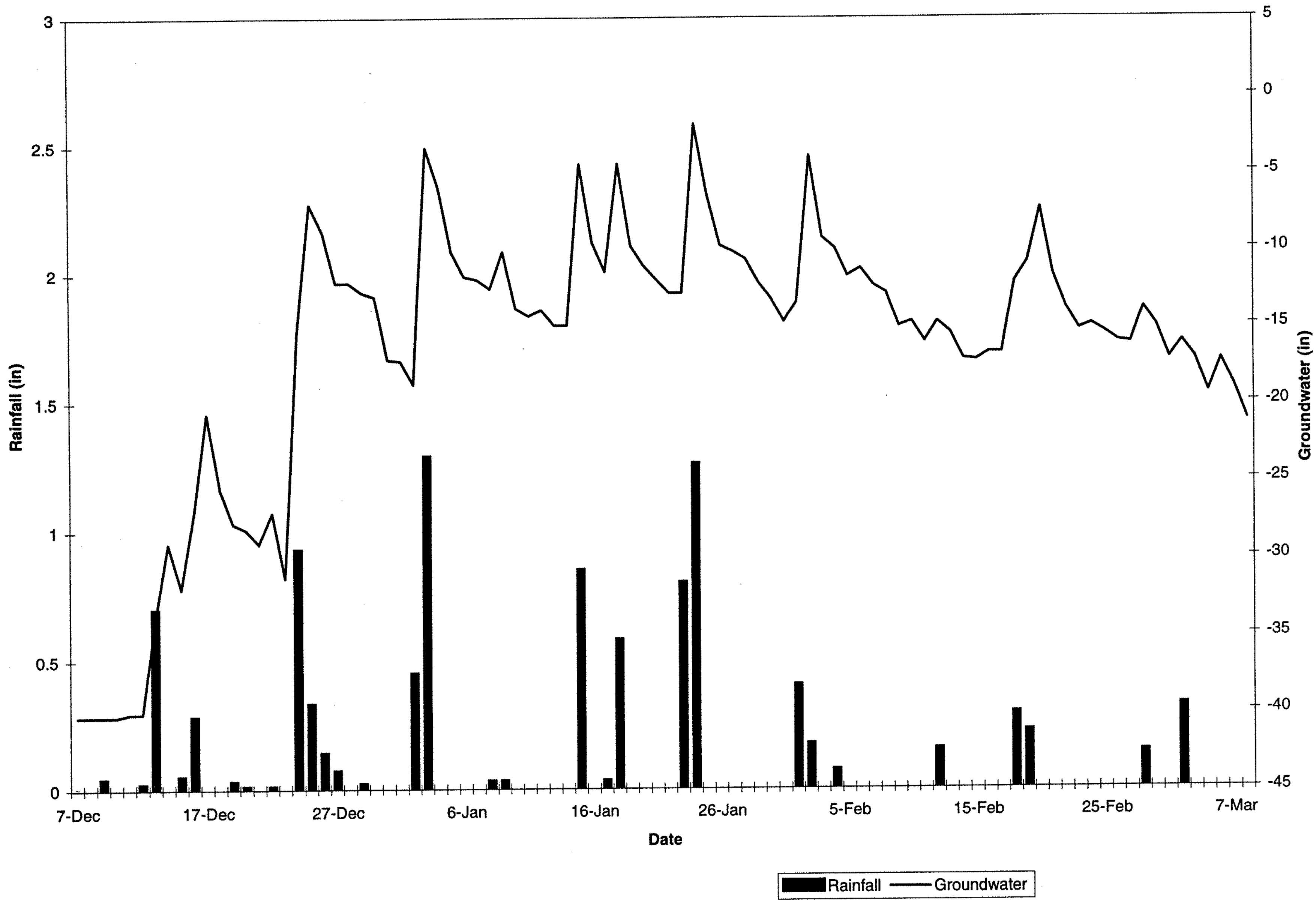
Speight Branch Rainfall and Groundwater Levels
Groundwater Well #1



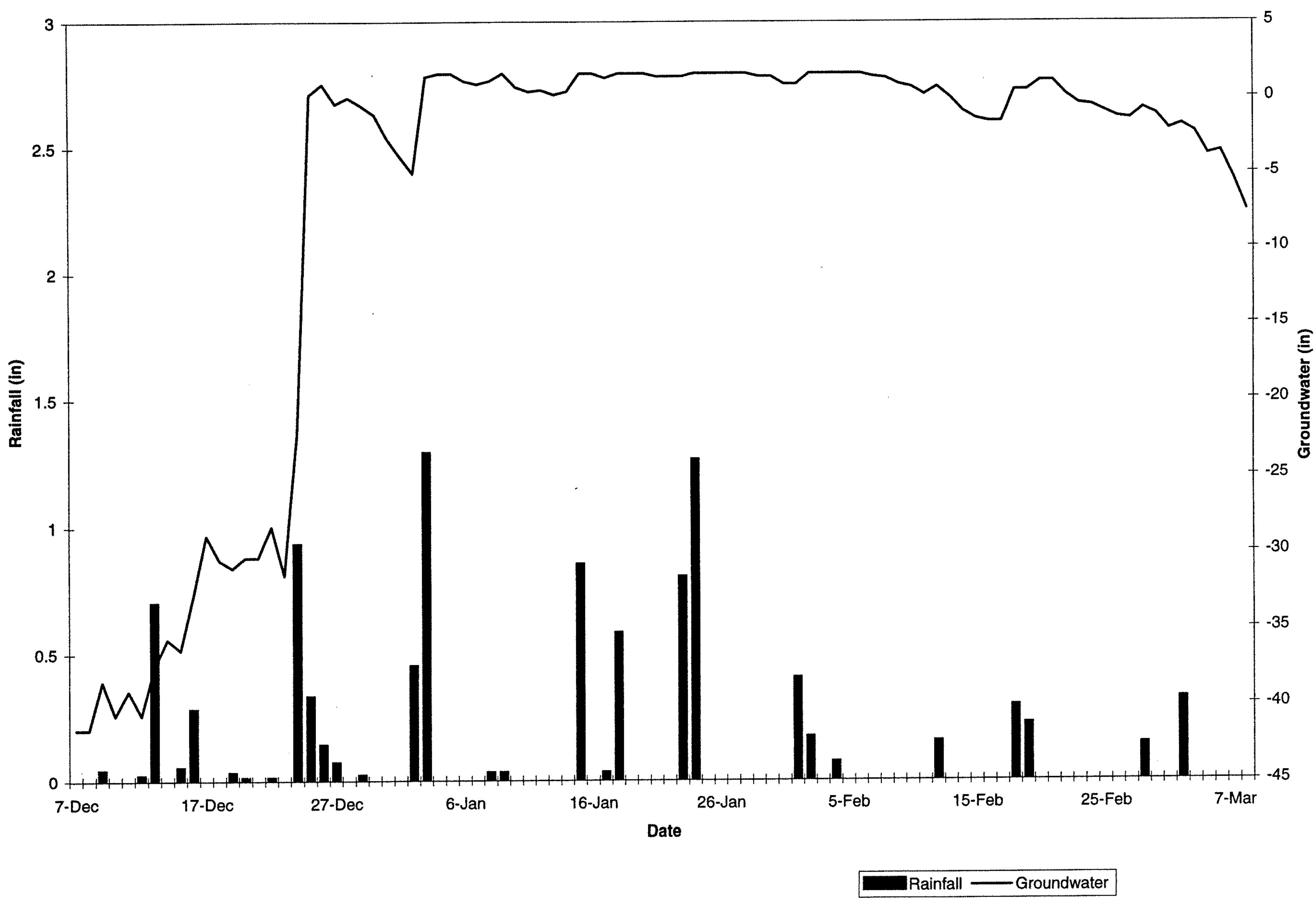
Speight Branch Rainfall and Groundwater Levels
Groundwater Well #2



Speight Branch Rainfall and Groundwater Levels
Groundwater Well #3

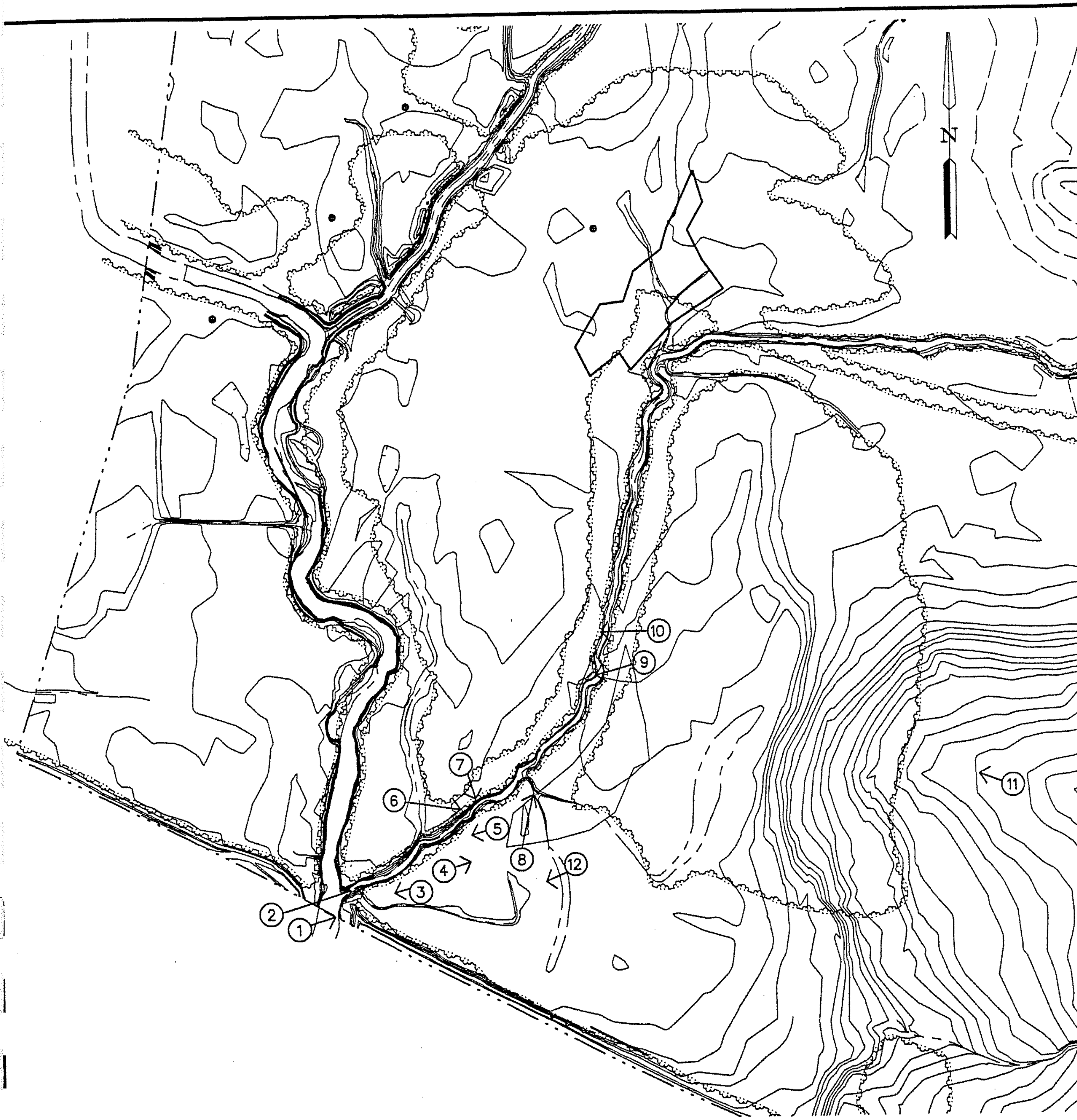


Speight Branch Rainfall and Groundwater Levels
Groundwater Well #4



APPENDIX D

EXISTING STREAM CONDITIONS



North Carolina – Department of Transportation
Division of Highways
Project Development and Environmental Analysis Branch

FIGURE A–1
Photo Locations
Speight Branch Stream Restoration
Wake County, North Carolina

SPEIGHT BRANCH STREAM RESTORATION PHOTOLOG

1-Confluence of Speight Branch and Swift Creek

2-Facing Upstream-Speight Branch at confluence of Swift Creek

3-Downstream

4-Upstream at Birch cross section

5-Downstream at birch cross section

6-Beaver dam 1


7-Beaver dam 2


8-Beaver dam 3


9-Looking downstream

10-Central Bar

11-Wetlands

12-Wetlands

Longitudinal Profile
Speight Branch Stream Restoration

Station	Elevation-thalweg	Elevation-water surface
0	95.3	95.9
20	93.9	95.9
58	94.2	95.8
85	95.0	95.7
140	94.0	95.6
170	94.6	95.6
230	94.6	95.1
255	92.4	95.0
312	94.2	94.8
342	92.3	94.8
359	93.8	94.8
380	94.1	94.6
395	92.9	94.2
415	92.5	94.2
437	93.7	94.1
462	92.5	93.9
500	93.1	93.8
527	92.2	93.7
546	93.4	93.8
571	93.1	93.8
605	92.8	93.8
620	92.6	93.7
653	91.7	93.8
686	92.0	93.7
718	91.8	93.7
741	91.8	93.7
753	89.1	92.3
771	91.8	92.2
795	91.1	92.2
835	91.5	92.1
875	91.5	92.1
905	90.2	92.1
922	89.2	92.1
945	91.0	92.1
957	89.6	92.1
975	90.9	92.1
987	90.8	92.1
1006	89.8	92.0
1036	90.3	92.1
1072	90.5	92.1
1089	89.9	92.1
1115	90.3	92.1
1138	91.6	92.0
1139	89.9	90.9
1147	88.9	90.9
1172	89.4	90.9
1212	88.1	90.6
1237	89.7	90.6
1245	87.1	89.2
1275	88.3	89.3

Survey Dates: November 6, 1998 and January 19, 1999

Survey Party: Jim Buck, Karen Hall,
Will Harman, Greg Jennings

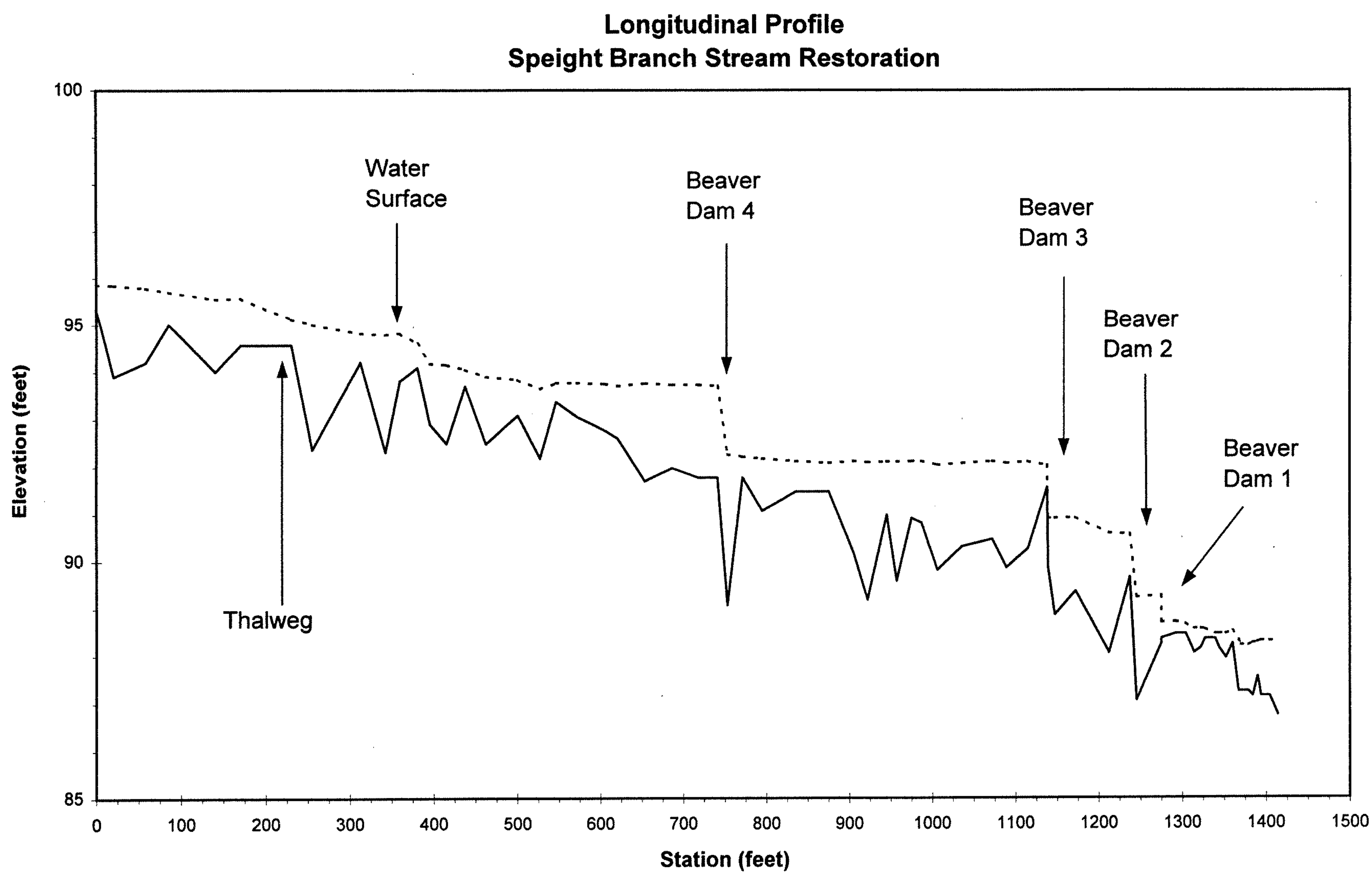
Jim Buck - Instrument
Karen Hall - Recorder/Photographer
Greg Jennings - Rod/Instrument
Will Harman - Rod/Recorder

TBM - End bent of bridge (Holly Springs Rd.)
TBM - Elevation = 100 feet

Water Surface Slope: **0.005**

Stream Length (ft): 1100
Valley Length (ft) 950

Sinuosity: **1.16**



Longitudinal Profile
Speight Branch Stream Restoration
Water
Surface
Beaver
Dam 4
Beaver
Dam 3
Beaver
Dam 2
Beaver
Dam 1
Thalweg
100
95
90
85
Elevation (feet)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
Station (feet)

Cross Section Station 0+85
Speight Branch
Stream Restoration

Basin: Neuse River
Reach: Speight Branch
Date: 11/6/1998 and 1/19/99
Crew: Will, Greg, Jim, Karen
Purpose: Data Collection for Stream Classification and Restoration

Permanent Cross Section: Station 0+85

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	103.21	3.88	99.3	LPIN-TOP
0.0		4.9	98.3	LPIN-GRD
4.0		5.2	98.0	
7.0		5.0	98.2	
8.0		5.1	98.1	LTOB
8.5		**5.2**	**98.0**	**LBKF**
10.0		**6.7**	**96.5**	
10.7		**7.3**	**95.9**	**LEW**
12.0		**8.1**	**95.1**	
14.0		**8.2**	**95.0**	**TW**
16.0		**7.9**	**95.3**	
18.0		**7.8**	**95.4**	
19.9		**7.5**	**95.7**	**REW**
20.8		**5.9**	**97.3**	
21.2		**5.2**	**98.0**	**RBKF**
22.0		4.8	98.4	RTOB
24.0		4.8	98.4	
32.3		5.3	97.9	RPIN-GRD
32.3		4.5	98.7	RPIN-TOP

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0	0.0	0.0
1.5	1.5	1.1
0.7	2.1	1.3
1.3	2.9	3.2
2.0	3.0	5.9
2.0	2.7	5.7
2.0	2.6	5.3
1.9	2.3	4.7
0.9	0.7	1.4
0.4	0.0	0.1
12.7		28.7

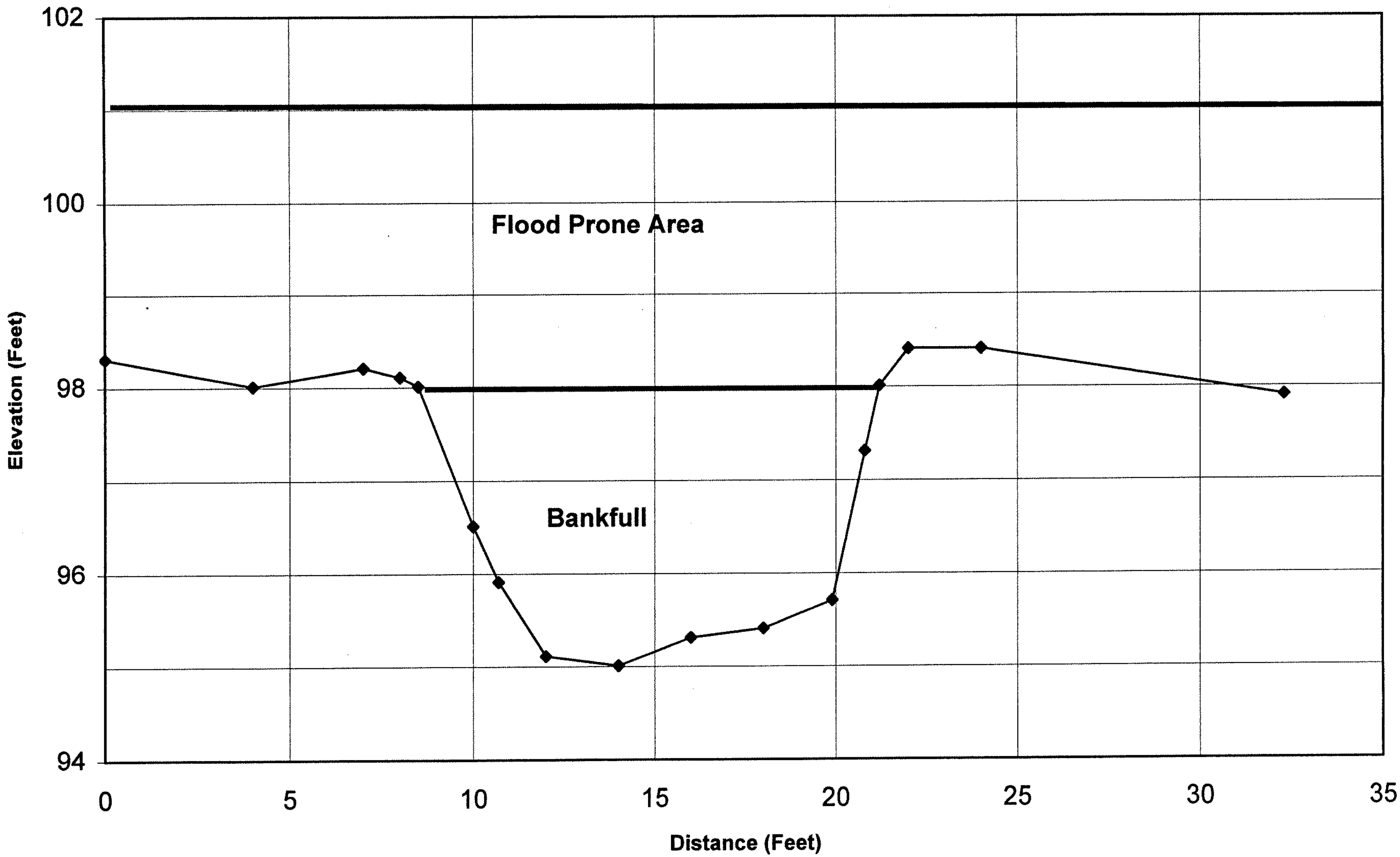
Summary Data

BKF A	28.7
BKF W	12.7
Max d	3.0
Mean d	2.3
W/D Ratio	5.6
FP W	>32.3
ER	>2.2
Str. Type	E5

Regional Curve (Rural)

Watershed Size	1.6
Bkf A (Rural Curve)	25
Bkf W (Rural Curve)	17
Bkf D (Rural Curve)	1.6

Cross Section - Station 0+85
Speight Branch Stream Restoration



Cross Section Station 5+71
Speight Branch
Stream Restoration

Basin: Neuse River
Reach: Speight Branch
Date: 11/6/1998 and 1/19/99
Crew: Will, Greg, Jim, Karen
Purpose: Data Collection for Stream Classification and Restoration

Permanent Cross Section: Station 0+85

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.7	101.07	3.11	98.0	LPIN-TOP
0.7		5.7	95.4	LPIN-GRD
10.0		5.3	95.8	
20.0		5.1	96.0	
29.0		4.7	96.4	
31.0		5.1	96.0	LTOB
32.0		**5.7**	**95.4**	**LBKF**
33.0		**6.6**	**94.5**	
33.2		**7.7**	**93.4**	**LEW**
34.0		**8.0**	**93.1**	**TW**
36.0		**7.9**	**93.2**	
38.0		**7.8**	**93.3**	
40.0		**7.8**	**93.3**	
41.7		**7.4**	**93.7**	
41.7		**7.3**	**93.8**	**REW**
42.5		**6.1**	**95.0**	
44.0		**5.7**	**95.4**	**RBKF**
45.0		5.7	95.4	RTOB
48.0		5.6	95.5	
54.0		5.4	95.7	
60.0		5.5	95.6	
73.0		5.7	95.4	RPIN-GRD
73.0		2.9	98.1	RPIN-TOP

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0	0.0	0.0
1.0	0.9	0.4
0.2	2.0	0.3
0.8	2.3	1.7
2.0	2.2	4.5
2.0	2.1	4.3
2.0	2.1	4.2
1.7	1.7	3.2
0.0	1.6	0.0
0.8	0.4	0.8
1.5	0.0	0.3
12.0		19.8

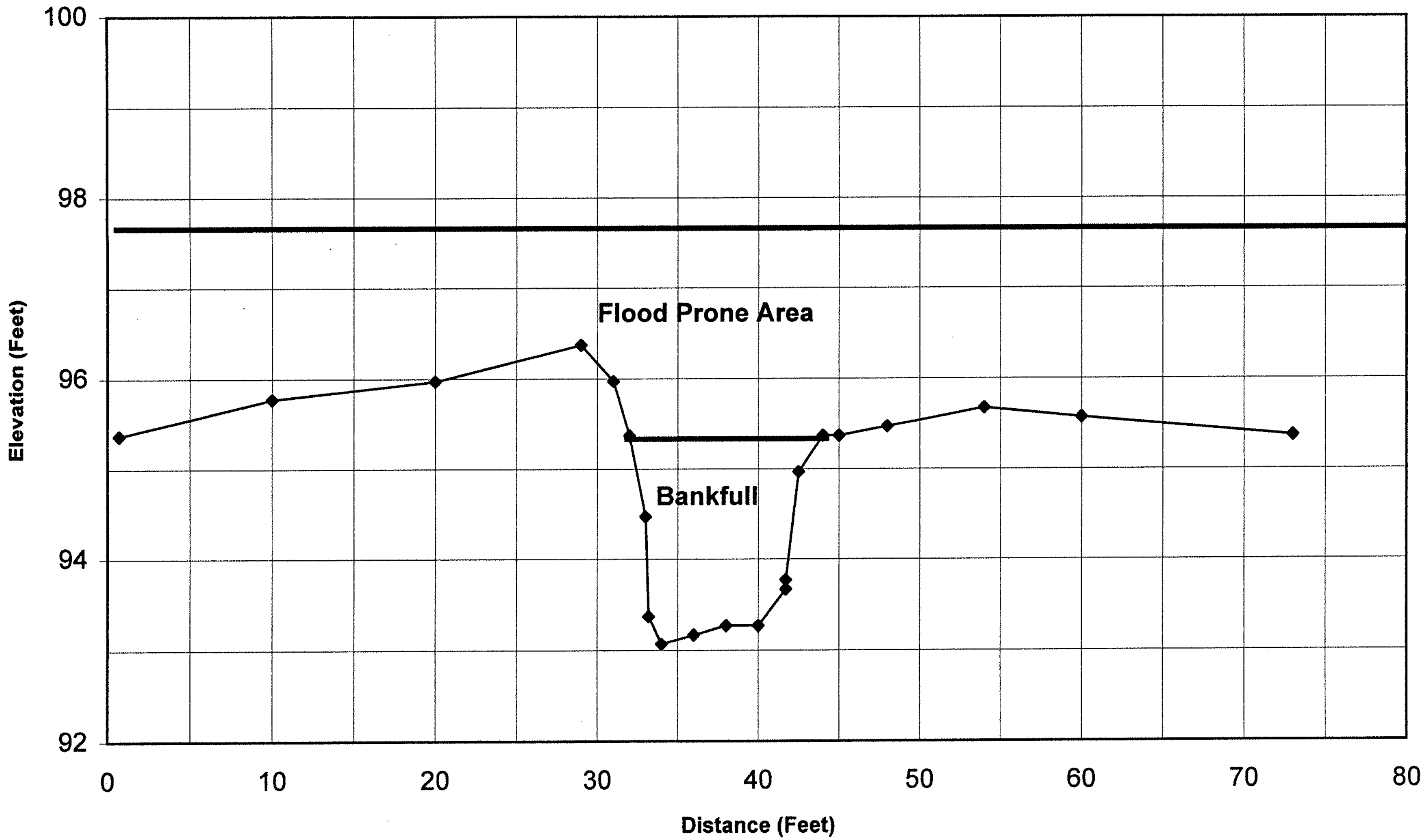
Summary Data

BKF A	19.8
BKF W	12.0
Max d	2.3
Mean d	1.6
W/D Ratio	7.3
FP W	>73
ER	>2.2
Str. Type	E5

Regional Curve (Rural)

Watershed Size	1.6
Bkf A (Rural Curve)	25
Bkf W (Rural Curve)	17
Bkf D (Rural Curve)	1.6

Cross Section - Station 5+71
Speight Branch Stream Restoration



Cross Section Station 9+75
Speight Branch
Stream Restoration

Basin: Neuse River
Reach: Speight Branch
Date: 11/6/1998 and 1/19/99
Crew: Will, Greg, Jim, Karen
Purpose: Data Collection for Stream Classification and Restoration

Permanent Cross Section: Station 9+75

Station	HI Feet	FS Feet	Elevation Feet	Notes
1.0	99.11	3.51	95.6	LPIN-TOP
1.0		4.6	94.5	LPIN-GRD
10.0		4.6	94.5	
16.0		4.4	94.7	
20.0		4.3	94.8	LTOB
21.5		4.8	94.3	
22.0		**5.2**	**93.9**	**LBKF**
24.0		**5.4**	**93.7**	
25.7		**5.8**	**93.3**	
26.3		**6.9**	**92.2**	**LEW**
27.0		**8.1**	**91.0**	
28.0		**8.1**	**91.0**	
30.0		**8.5**	**90.6**	
31.0		**8.9**	**90.2**	
32.0		**9.0**	**90.1**	**TW**
33.0		**8.6**	**90.5**	
34.0		**8.0**	**91.1**	
34.7		**7.0**	**92.1**	**REW**
35.2		**5.2**	**93.9**	**RBKF**
35.7		4.3	94.8	RTOB
38.0		4.2	94.9	
45.0		4.7	94.4	
53.0		5.3	93.8	
60.0		5.4	93.7	
65.0		5.2	93.9	RPIN-GRD
65.0		3.3	95.9	RPIN-TOP

BKF Hydraulic Geometry

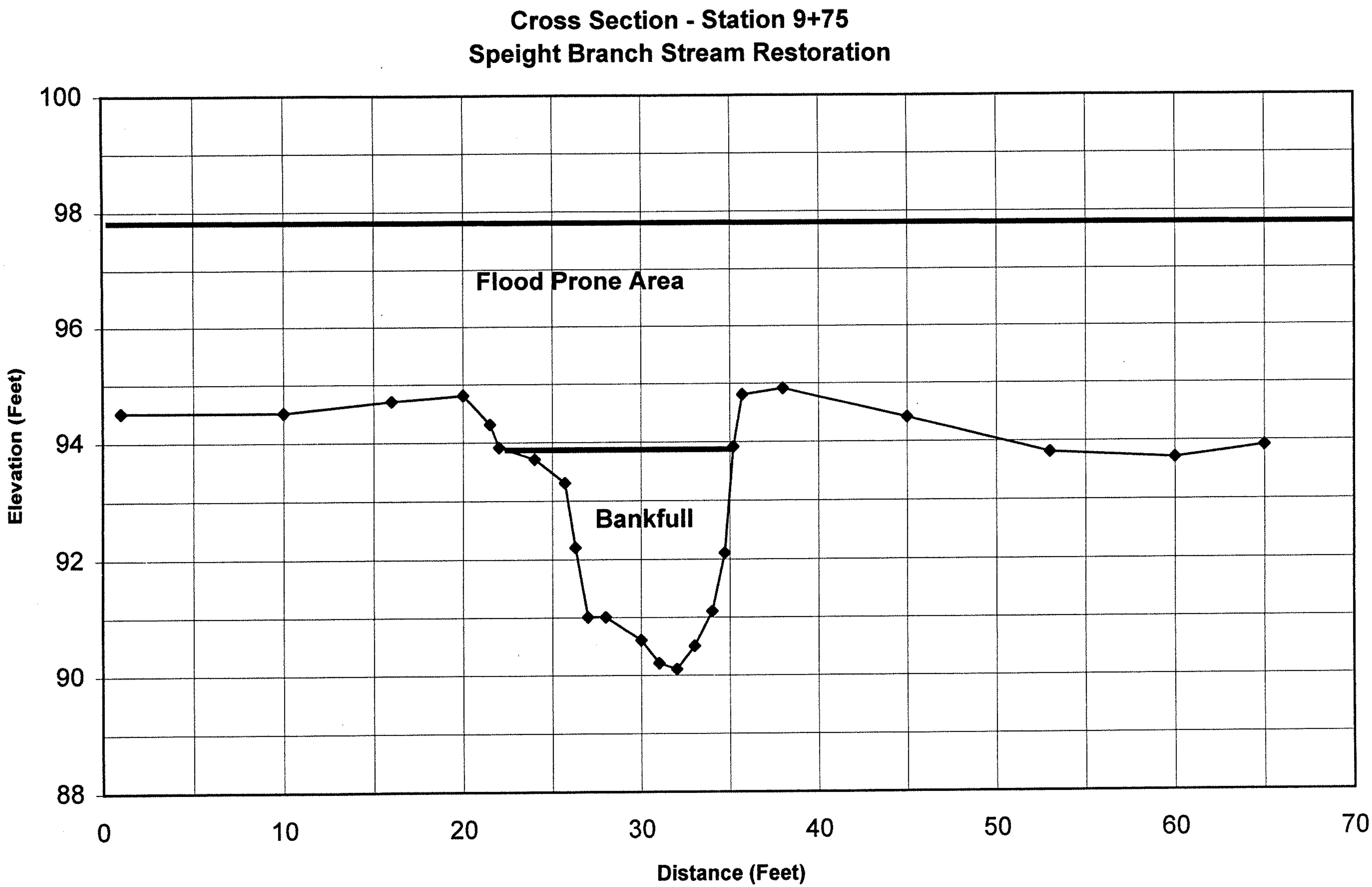
Width Feet	Depth Feet	Area Sq. Ft.
0	0.0	0.0
2.0	0.2	0.2
1.7	0.6	0.7
0.6	1.7	0.7
0.7	2.9	1.6
1.0	2.9	2.9
2.0	3.3	6.2
1.0	3.7	3.5
1.0	3.8	3.8
1.0	3.4	3.6
1.0	2.8	3.1
0.7	1.8	1.6
0.5	0.0	0.4
13.2		28.3

Summary Data

BKF A	28.3
BKF W	13.2
Max d	3.8
Mean d	2.1
W/D Ratio	6.2
FP W	>65
ER	>2.2
Str. Type	E5

Regional Curve (Rural)

Watershed Size	1.6
Bkf A (Rural Curve)	25
Bkf W (Rural Curve)	17
Bkf D (Rural Curve)	1.6


Cross Section - Station 9+75
Speight Branch Stream Restoration
100
98
96
94
92
90
88
Elevation (Feet)
0
10
20
30
40
50
60
70
Distance (Feet)
Flood Prone Area
Bankfull

Cross Section Station 12+75
Speight Branch
Stream Restoration

Basin: Neuse River
Reach: Speight Branch
Date: 11/6/1998 and 1/19/99
Crew: Will, Greg, Jim, Karen
Purpose: Data Collection for Stream Classification and Restoration

Permanent Cross Section: Station 12+75

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	97.27	2.34	94.9	LPIN-TOP
0.0		3.6	93.7	LPIN-GRD
10.0		3.4	93.9	
20.0		3.4	93.9	
30.0		3.3	94.0	
35.0		3.4	93.9	
38.0		3.4	93.9	
40.0		3.6	93.7	
41.0		4.0	93.3	
42.0		4.5	92.8	
44.0		**5.7**	**91.6**	**LBKF**
45.0		**7.6**	**89.7**	
45.6		**8.6**	**88.7**	**LEW**
47.0		**9.0**	**88.3**	**TW**
48.0		**8.9**	**88.4**	
50.0		**8.8**	**88.5**	
51.4		**8.7**	**88.6**	**REW**
52.3		**8.5**	**88.8**	
53.0		**7.4**	**89.9**	
53.0		**5.7**	**91.6**	**RBKF**
54.3		4.8	92.5	RTOB
58.0		5.0	92.3	
61.0		4.8	92.5	
62.4		4.3	93.0	
64.0		3.5	93.8	
67.7		2.9	94.4	
70.0		2.8	94.5	
74.0		2.9	94.4	
79.0		2.8	94.5	
86.0		2.9	94.4	
92.0		2.9	94.4	
97.0		3.0	94.3	
99.8		3.1	94.2	RPIN-GRD
99.8		1.9	95.4	RPIN-TOP

BKF Hydraulic Geometry

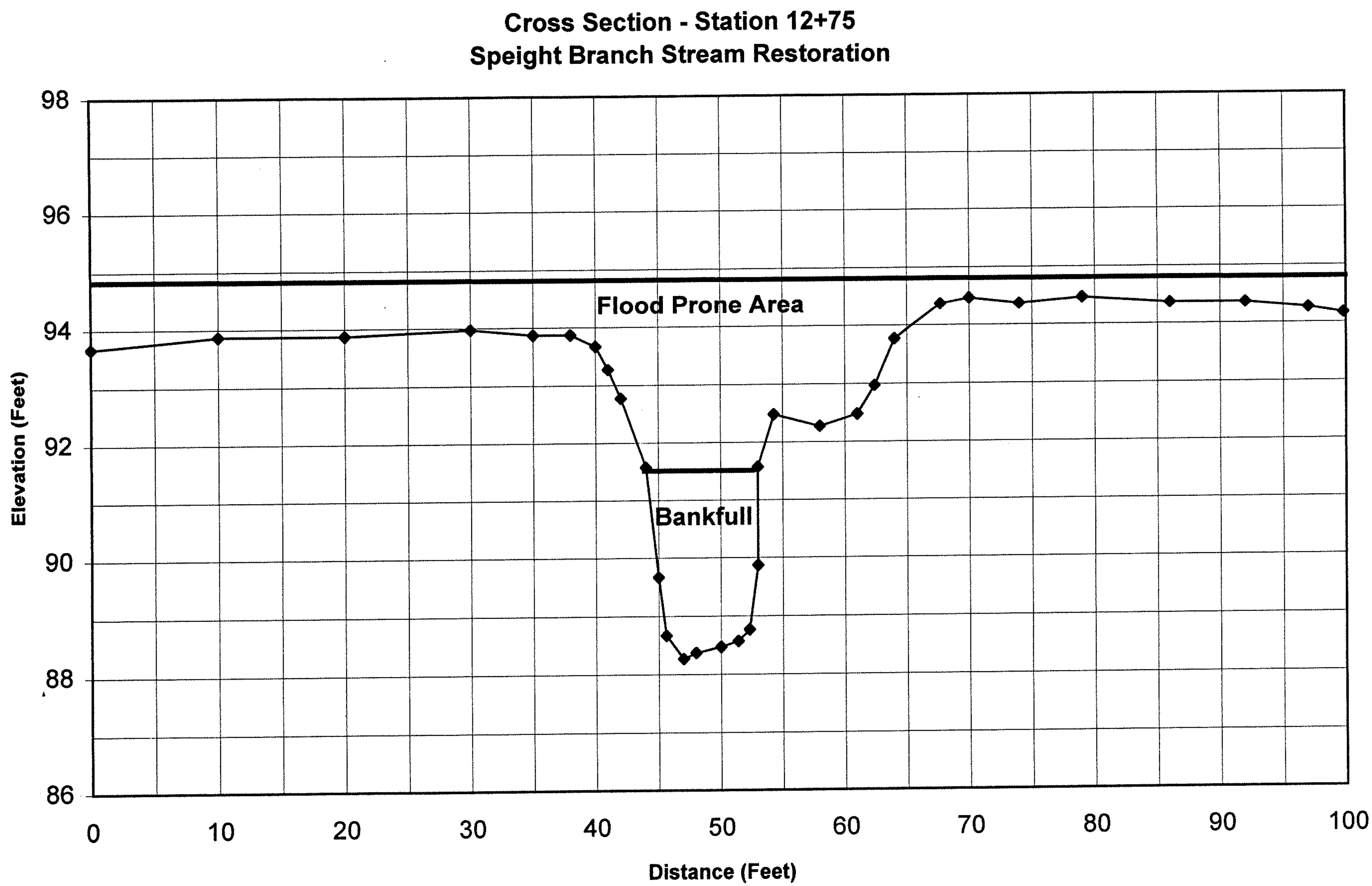
Width Feet	Depth Feet	Area Sq. Ft.
0	0.0	0.0
1.0	1.9	0.9
0.6	2.9	1.4
1.4	3.3	4.3
1.0	3.2	3.3
2.0	3.1	6.3
1.4	3.0	4.3
0.9	2.8	2.6
0.7	1.7	1.6
0.0	0.0	0.0
9.0		24.7

Summary Data

BKF A	24.7
BKF W	9.0
Max d	3.3
Mean d	2.7
W/D Ratio	3.3
FP W	>99..8
ER	>2.2
Str. Type	E5

Regional Curve (Rural)

Watershed Size	1.6
Bkf A (Rural Curve)	25
Bkf W (Rural Curve)	17
Bkf D (Rural Curve)	1.6


Cross Section - Station 12+75
Speight Branch Stream Restoration
Flood Prone Area
Bankfull
Elevation (Feet)
98
96
94
92
90
88
86
Distance (Feet)
0
10
20
30
40
50
60
70
80
90
100

Cross Section Station 13+79
Speight Branch
Stream Restoration

Basin: Neuse River
Reach: Speight Branch
Date: 11/6/1998 and 1/19/99
Crew: Will, Greg, Jim, Karen
Purpose: Data Collection for Stream Classification and Restoration

Permanent Cross Section: Station 13+79

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.16	3.76	96.4	LPIN-TOP
0.0		4.7	95.5	LPIN-GRD
7.0		5.1	95.1	
11.0		5.9	94.3	
13.0		7.2	93.0	
14.0		7.8	92.4	
15.0		8.1	92.1	
16.0		7.8	92.4	
18.0		7.1	93.1	
20.0		6.6	93.6	
22.0		6.8	93.4	
23.0		7.0	93.2	LTOB
24.0		7.8	92.4	
25.0		8.8	91.4	
26.0		**9.3**	**90.9**	**LBKF**
27.0		**9.9**	**90.3**	
28.0		**10.4**	**89.8**	
29.0		**11.0**	**89.2**	
29.3		**12.0**	**88.2**	**LEW**
30.0		**13.0**	**87.2**	**TW**
31.0		**12.9**	**87.3**	
32.0		**12.8**	**87.4**	
33.0		**12.8**	**87.4**	
33.8		**12.7**	**87.5**	**REW**
34.0		**10.3**	**89.9**	
34.9		**9.3**	**90.9**	**RBKF**
35.7		8.5	91.7	
36.8		7.9	92.3	
39.0		6.9	93.3	
43.0		5.9	94.3	
47.0		5.7	94.5	
50.0		5.8	94.4	RPIN-GRD
50.0		4.5	95.7	RPIN-TOP

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0	0.0	0.0
1.0	0.6	0.3
1.0	1.1	0.9
1.0	1.7	1.4
0.3	2.7	0.7
0.7	3.7	2.2
1.0	3.6	3.7
1.0	3.5	3.6
1.0	3.5	3.5
0.8	3.4	2.8
0.2	1.0	0.4
0.9	0.0	0.4
8.9		19.8

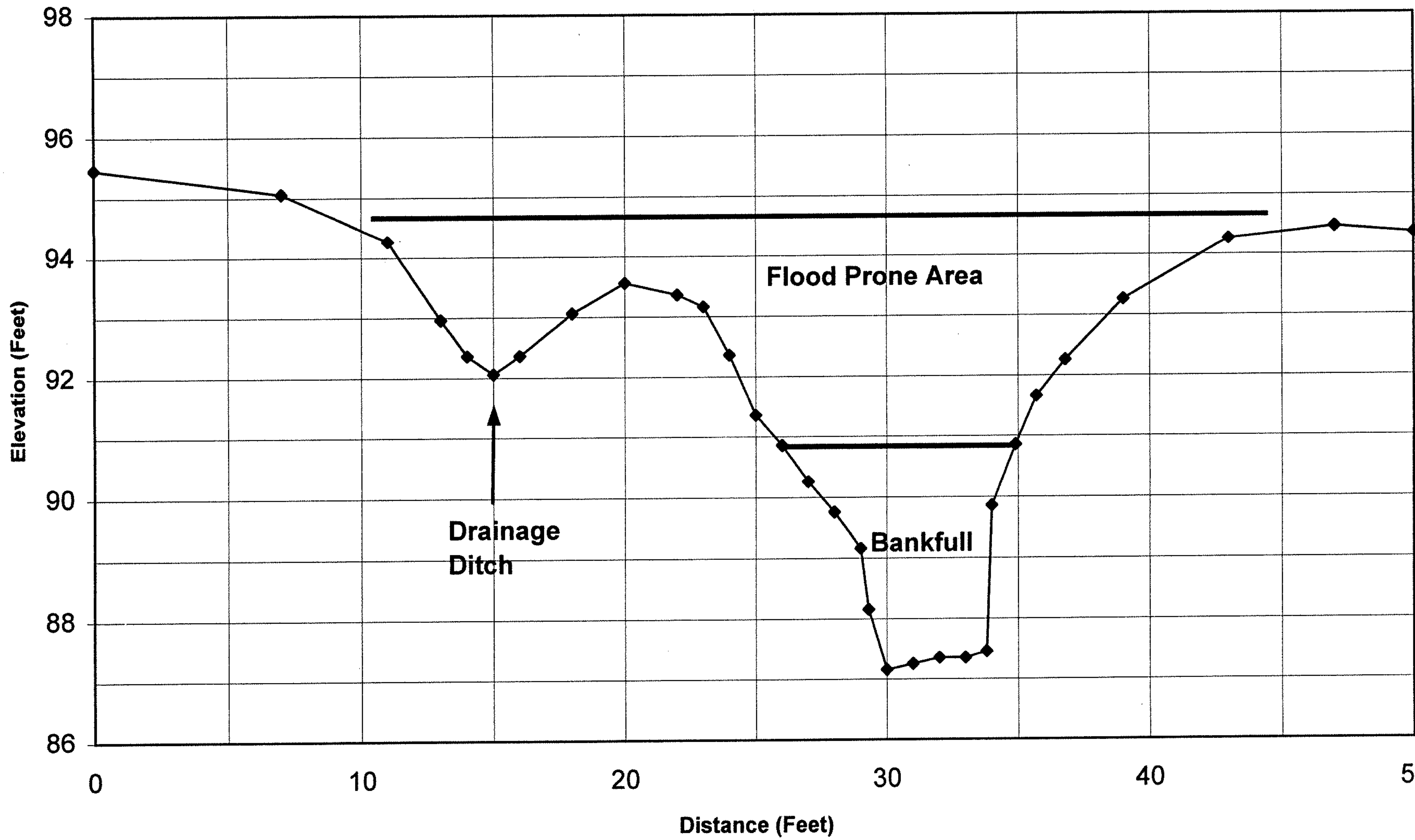
Summary Data

BKF A	19.8
BKF W	8.9
Max d	3.7
Mean d	2.2
W/D Ratio	4.0
FP W	32.0
ER	3.6
Str. Type	E5

Regional Curve (Rural)

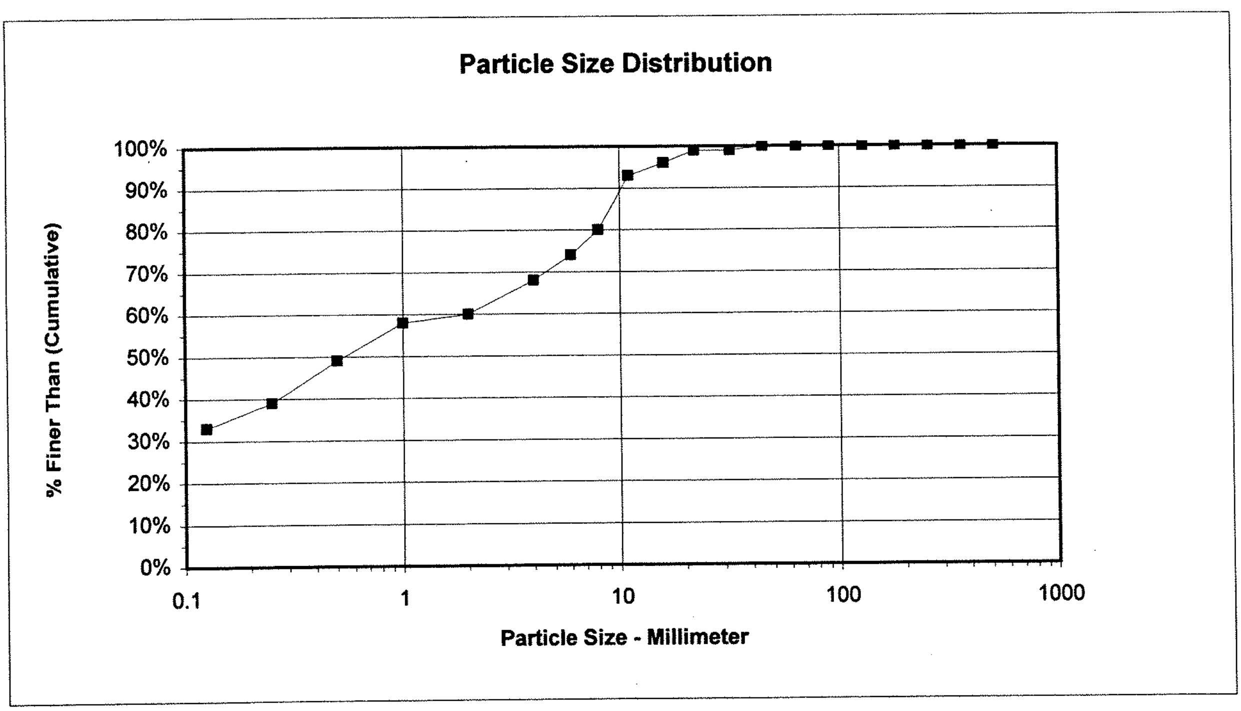
Watershed Size	1.6
Bkf A (Rural Curve)	25
Bkf W (Rural Curve)	17
Bkf D (Rural Curve)	1.6

Cross Section - Station 13+79
Speight Branch Stream Restoration



Pebble Count
Speight Branch Stream Restoration

PEBBLE COUNT								
Site: Speight Branch						Date: 2-9-99		
Party: Karen Hall, Jane Almon						Reach: Speight Branch		
				Particle Counts				
Inches	Particle	Millimeter		Riffles	Pools	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	11	12	23	23%	23%
	Very Fine	.062 - .125	S	1	9	10	10%	33%
	Fine	.125 - .25	A	0	6	6	6%	39%
	Medium	.25 - .50	N	1	9	10	10%	49%
	Coarse	.50 - 1.0	D	2	7	9	9%	58%
.04 -.08	Very Coarse	1.0 - 2.0	S	1	1	2	2%	60%
.08 - .16	Very Fine	2.0 - 4.0		4	4	8	8%	68%
.16 - .22	Fine	4.0 - 5.7	G	5	1	6	6%	74%
.22 - .31	Fine	5.7 - 8.0	R	3	3	6	6%	80%
.31 - .44	Medium	8.0 - 11.3	A	8	5	13	13%	93%
.44 - .63	Medium	11.3 - 16.0	V	1	2	3	3%	96%
.63 - .89	Coarse	16.0 - 22.6	E	3	0	3	3%	99%
.89 - 1.26	Coarse	22.6 - 32.0	L	0	0	0	0%	99%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	1	0	1	1%	100%
1.77 - 2.5	Very Coarse	45.0 - 64.0		0	0	0	0%	100%
2.5 - 3.5	Small	64 - 90	C	0	0	0	0%	100%
3.5 - 5.0	Small	90 - 128	O	0	0	0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0	0	0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0	0	0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0	0	0	0%	100%
14.3 - 20	Small	362 - 512	L	0	0	0	0%	100%
20 - 40	Medium	512 - 1024	D	0	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0	0	0	0%	100%
	Bedrock		BDRK		0	0	0%	100%
			Totals	**41**	**59**	**100**	**100%**	**100%**



APPENDIX E

MINGO CREEK REFERENCE REACH

Longitudinal Profile
Mingo Creek Reference Reach

Basin:	Neuse River
Reach:	Mingo Creek
Date:	10/1/98
Crew:	Karen Hall, Will Harman, Greg Jennings, and Ron John
Purpose:	Site Characterization for Reference Reach

Longitudinal Profile

Station	Elevation-thalweg	Elevation-water surface
0	96.3	96.7
84	95.9	96.6
93	96.0	96.6
101	96.1	96.6
127	96.1	96.6
148	95.9	96.2
175	95.7	96.2
198	94.6	96.1
230	95.8	96.2
265	95.4	96.1
317	95.3	96.0
345	95.6	96.0

Water Surface Slope **0.0022**

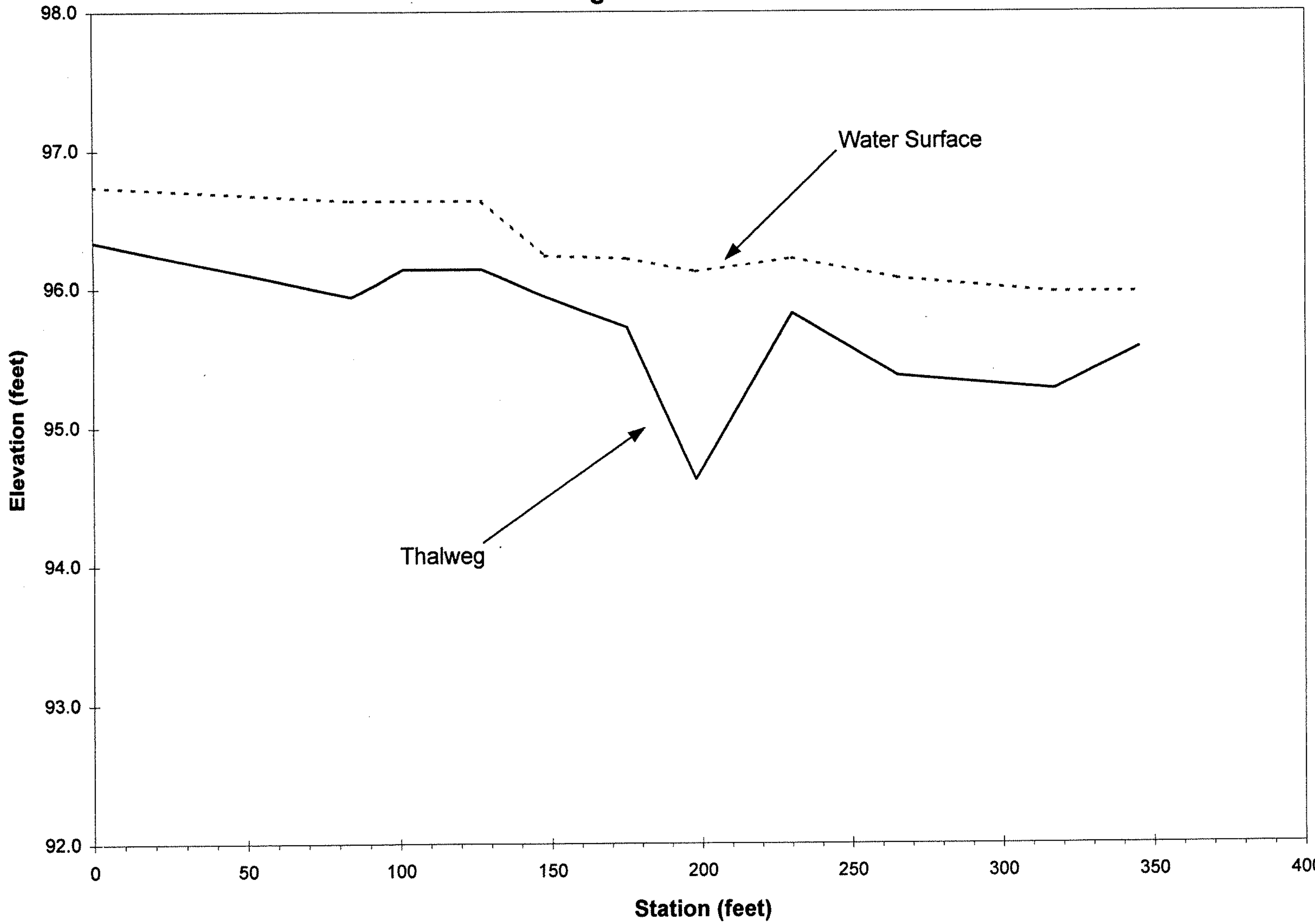
Stream Length (ft) 345
Valley Length (ft) 240

Sinuosity **1.44**

Channel Pattern:

Meander Length (ft) 89 - 195
Belt Width (ft) 42 - 67
Radius of Curvature (ft) 29 - 53

Longitudinal Profile
Mingo Creek Reference Reach



Cross Section - Station 0+84
Mingo Creek Reference Reach

Basin: Neuse River
Reach: Mingo Creek
Date: 10/1/98
Crew: Karen Hall, Will Harman, Greg Jennings, and Ron Johnson
Purpose: Site Characterization for Reference Reach

Permanent Cross Section 0+84

Station	HI Feet	FS Feet	Elevation Feet	Notes
0	102.64	3.8	98.8	LBKF
0.5		4.0	98.6	
0.9		6.0	96.6	LEW
5.0		6.2	96.4	
10.0		6.5	96.1	
12.0		6.7	95.9	TW
14.8		6.1	96.5	REW
15.2		3.8	98.8	RBKF

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0	0	0.0
0.5	0.2	0.1
0.4	2.2	0.5
4.1	2.4	9.4
5.0	2.7	12.8
2.0	2.9	5.6
2.8	2.3	7.3
0.4	0.0	0.5
15.2		36.1

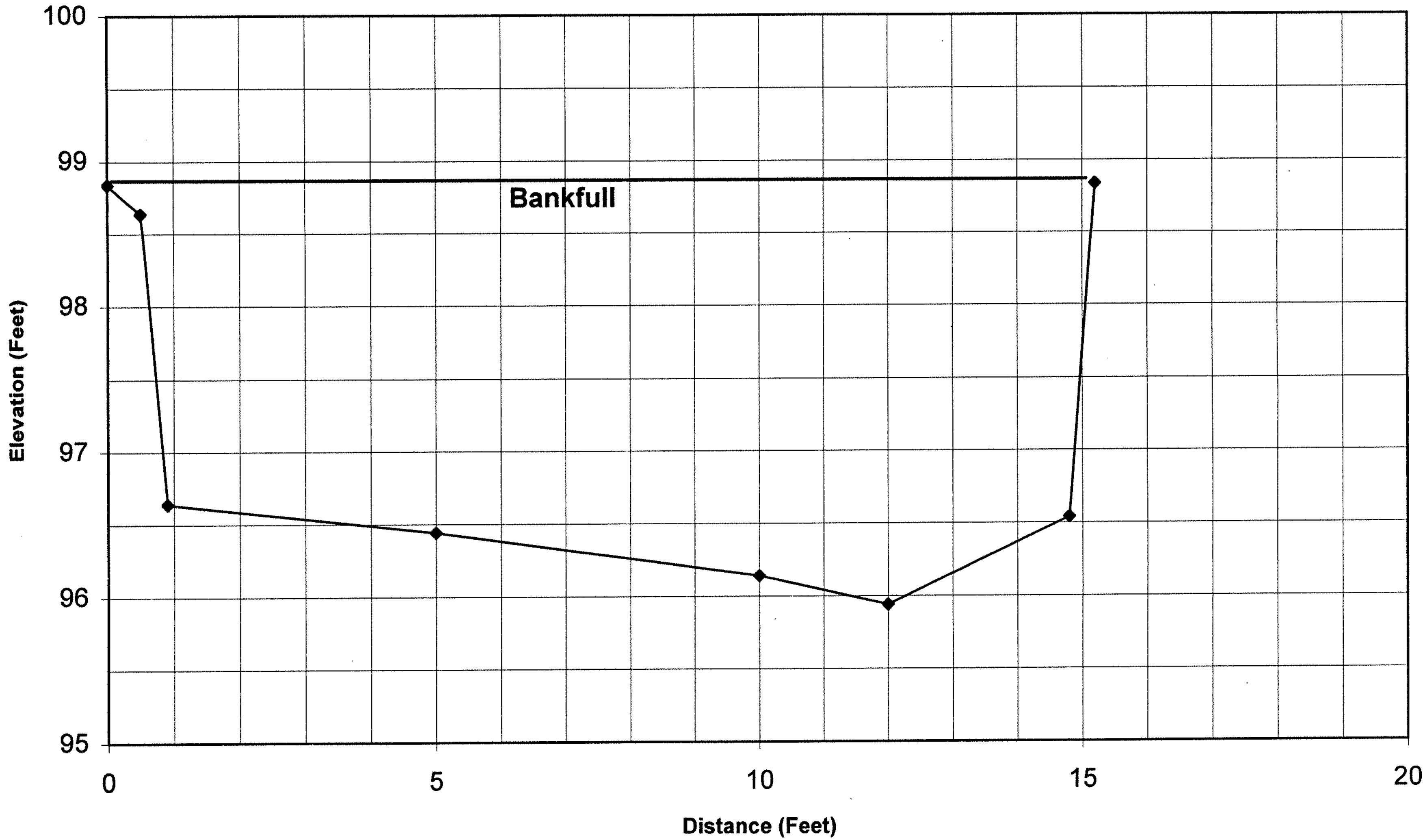
Summary Data

BKF A	36.1
BKF W	15.2
Max d	2.9
Mean d	2.4
W/D Ratio	6.4
FP W	86.0
ER	5.7
Str. Type	E5

Regional Curve (Rural)

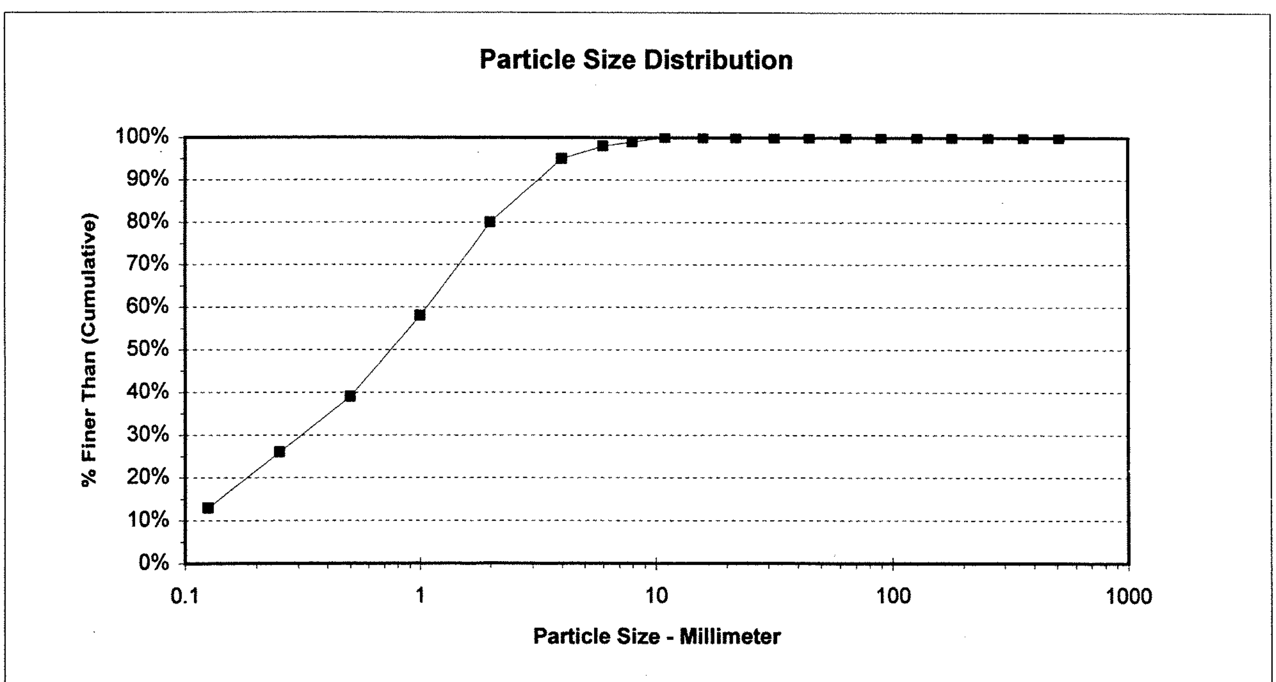
Watershed Size	4.0
Bkf A (Rural Curve)	52
Bkf W (Rural Curve)	27
Bkf D (Rural Curve)	2.0

Coss Section - Station 0+84
Mingo Creek Reference Reach



Pebble Count
Mingo Creek Reference Reach

PEBBLE COUNT								
Site: Abbott Property						Date: 10/1/98		
Party: Karen Hall, Gregg Jennings, Will Harman, Ron Johnson						Reach: Mingo Creek		
				Particle Counts				
Inches	Particle	Millimeter		Riffles	Pools	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	0	1	1	1%	1%
	Very Fine	.062 - .125	S	4	8	12	12%	13%
	Fine	.125 - .25	A	4	9	13	13%	26%
	Medium	.25 - .50	N	4	9	13	13%	39%
	Coarse	.50 - 1.0	D	10	9	19	19%	58%
.04 -.08	Very Coarse	1.0 - 2.0	S	12	10	22	22%	80%
.08 - .16	Very Fine	2.0 - 4.0		12	3	15	15%	95%
.16 - .22	Fine	4.0 - 5.7	G	3	0	3	3%	98%
.22 - .31	Fine	5.7 - 8.0	R	1	0	1	1%	99%
.31 - .44	Medium	8.0 - 11.3	A	0	1	1	1%	100%
.44 - .63	Medium	11.3 - 16.0	V	0	0	0	0%	100%
.63 - .89	Coarse	16.0 - 22.6	E	0	0	0	0%	100%
.89 - 1.26	Coarse	22.6 - 32.0	L	0	0	0	0%	100%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	0	0	0	0%	100%
1.77 - 2.5	Very Coarse	45.0 - 64.0		0	0	0	0%	100%
2.5 - 3.5	Small	64 - 90	C	0	0	0	0%	100%
3.5 - 5.0	Small	90 - 128	O	0	0	0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0	0	0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0	0	0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0	0	0	0%	100%
14.3 - 20	Small	362 - 512	L	0	0	0	0%	100%
20 - 40	Medium	512 - 1024	D	0	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0	0	0	0%	100%
	Bedrock		BDRK	0	0	0	0%	100%
			Totals	**50**	**50**	**100**	**100%**	**100%**



APPENDIX F

SAL'S BRANCH REFERENCE REACH

Longitudinal Profile
Sal's Branch Reference Reach

Basin: Neuse River
Reach: Sal's Branch
Date: 5/26/98
Crew: Will Harman, Dan Clinton, Jan Patterson, Neil Woerner, Jay Keller, Louise O'Hara, Jon Williams
Purpose: Site Characterization for Reference Reach

Longitudinal Profile

Station	Elevation-thalweg	Elevation-water surface
2.0	92.2	92.33
22.5	91.4	91.63
31.5	90.6	91.63
39.0	91.3	91.63
42.5	91.5	91.63
53.5	90.9	91.33
67.5	90.5	91.33
79.0	90.8	91.33
82.1	91.2	91.28
85.5	90.9	91.05
96.0	90.7	91.05
111.0	90.3	91.05
123.5	90.9	91.05
136.5	90.6	90.73
147.0	90.6	90.73
149.5	90.1	90.73
153.0	89.7	90.73
160.5	90.5	90.70
164.2	90.0	90.50
171.0	90.3	90.49
184.0	90.1	90.29
189.0	89.5	90.29

Water Surface Slope **0.0108**

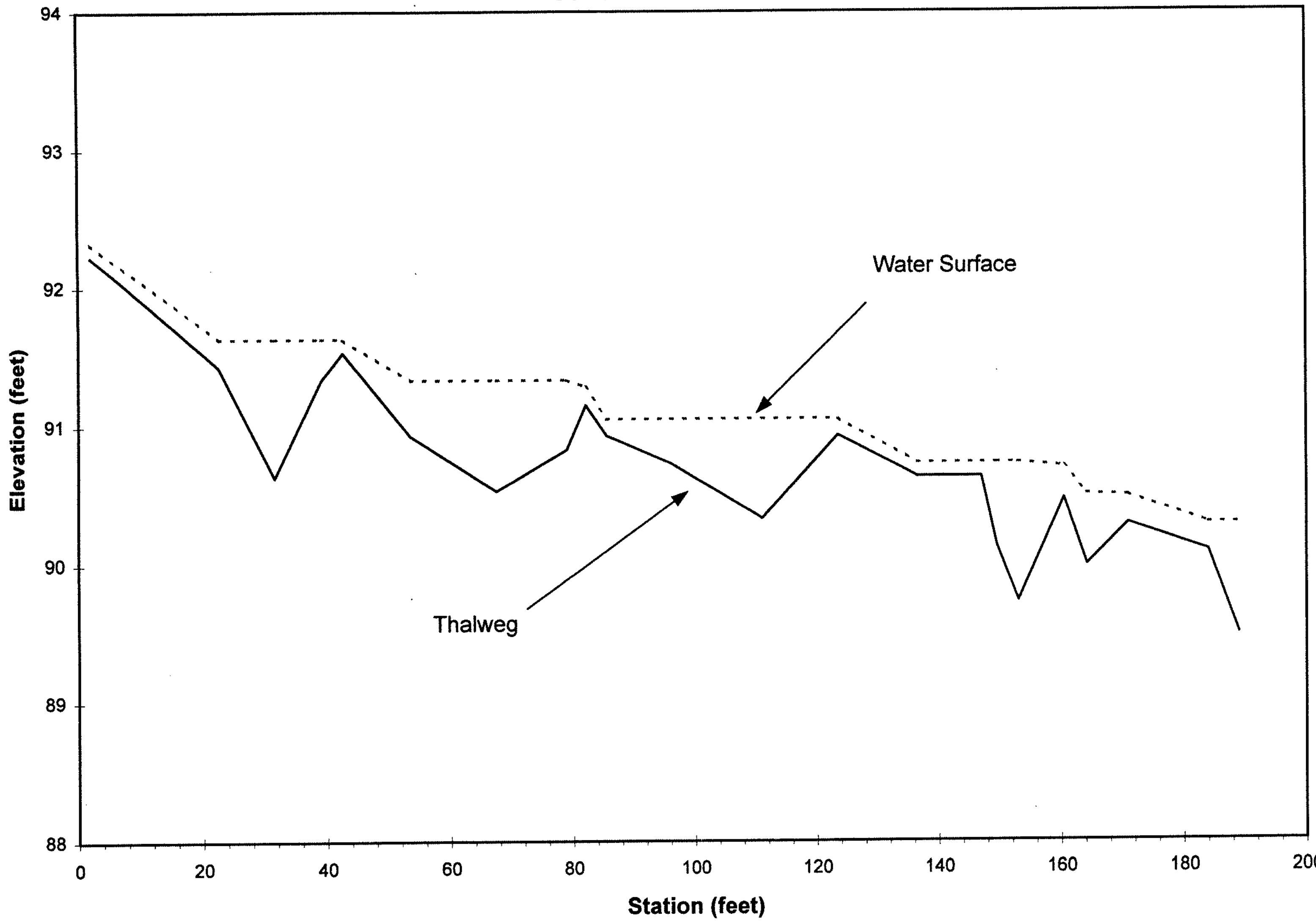
Stream Length (ft) 189
Valley Length (ft) 157

Sinuosity **1.20**

Channel Pattern:

Meander Length (ft) 38 - 45
Belt Width (ft) 10 - 16
Radius of Curvature (ft) 13 - 30

Longitudinal Profile
Sal's Branch Reference Reach



Cross Section - Station 0+85
Sal's Branch Reference Reach

Basin: Neuse River
Reach: Sal's Branch
Date: 5/26/98
Crew: Will Harman, Dan Clinton, Jan Patterson, Neil Woerner, Jay Keller, Louise O'Hara, Jon Williams
Purpose: Site Characterization for Reference Reach

Permanent Cross Section 0+85

Station	HI Feet	FS Feet	Elevation Feet	Notes
0	98.33	4.6	93.7	LTOB
2.0		4.5	93.8	
3.0		4.7	93.6	
4.0		**5.0**	93.3	**LBKF**
5.0		**5.4**	92.9	
6.0		**5.6**	92.7	
7.0		**6.1**	92.2	
7.9		**6.4**	91.9	
8.4		**7.0**	91.3	
9.6		**7.0**	91.3	**LEW**
10.7		**7.4**	90.9	**TW/REW**
11.5		**6.1**	92.2	
12.7		**5.0**	93.3	**RBKF**
14.0		4.8	93.5	
15.0		4.7	93.6	
16.8		4.6	93.7	RTOB

BKF Hydraulic Geometry

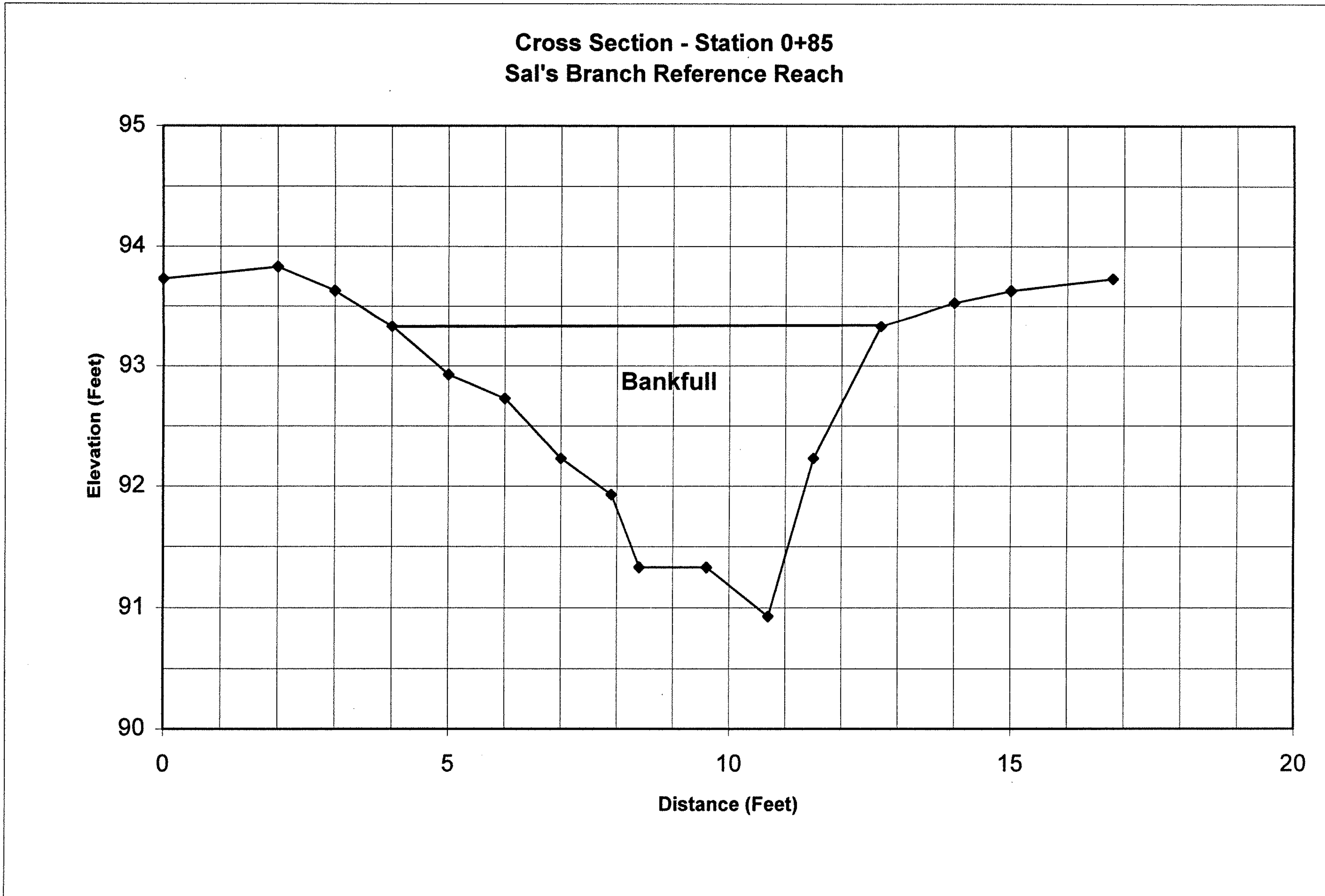
Width Feet	Depth Feet	Area Sq. Ft.
0	0	0.0
1.0	0.4	0.2
1.0	0.6	0.5
1.0	1.1	0.9
0.9	1.4	1.1
0.5	2.0	0.9
1.2	2.0	2.4
1.1	2.4	2.4
0.8	1.1	1.4
1.2	0.0	0.7
8.7		10.4

Summary Data

BKF A	10.4
BKF W	8.7
Max d	2.4
Mean d	1.2
W/D Ratio	7.3
FP W	163.0
ER	18.7
Str. Type	E4

Regional Curve (Rural)

This stream data was used for the regional curve.


Cross Section - Station 0+85
Sal's Branch Reference Reach
Elevation (Feet)
95
94
93
92
91
90
0
5
10
15
20
Distance (Feet)
Bankfull

Cross Section - Station 2+00
Sal's Branch Reference Reach

Basin: Neuse River
Reach: Sal's Branch
Date: 5/26/98
Crew: Will Harman, Dan Clinton, Jan Patterson, Neil Woerner, Jay Keller, Louise O'Hara, Jon Williams
Purpose: Site Characterization for Reference Reach
Permanent Cross Section 2+00

Station	HI Feet	FS Feet	Elevation Feet	Notes
1.9	98.33	4.3	94.0	LPIN
3.0		4.7	93.6	
3.6		**4.9**	**93.4**	**LBKF**
5.5		**6.4**	**91.9**	
5.7		**7.2**	**91.1**	**LEW**
6.1		**7.4**	**90.9**	
7.0		**7.8**	**90.5**	
7.4		**7.9**	**90.4**	
7.6		**8.0**	**90.3**	**TW**
8.2		**7.7**	**90.6**	**REW**
8.3		**7.8**	**90.5**	
9.2		**4.9**	**93.4**	**RBKF**
11.2		4.2	94.1	RTOB
12.0		4.2	94.1	RPIN

BKF Hydraulic Geometry

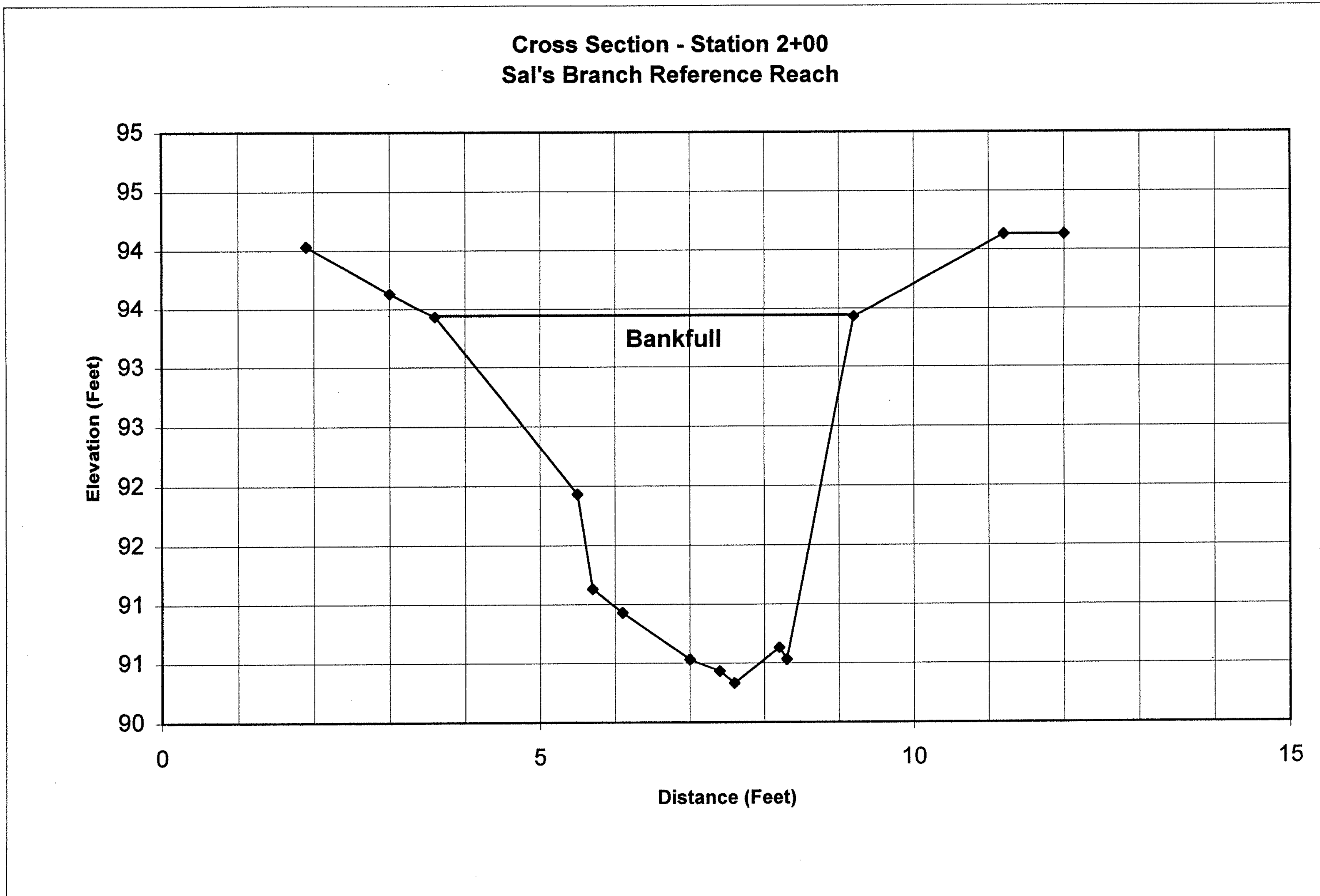
Width Feet	Depth Feet	Area Sq. Ft.
0	0	0.0
1.9	1.5	1.4
0.2	2.3	0.4
0.4	2.5	1.0
0.9	2.9	2.4
0.4	3.0	1.2
0.2	3.1	0.6
0.6	2.8	1.8
0.1	2.9	0.3
0.9	0.0	1.3
5.6		10.3

Summary Data

BKF A	10.3
BKF W	5.6
Max d	3.1
Mean d	1.8
W/D Ratio	3.0
FP W	163.0
ER	29.1
Str Type	E4

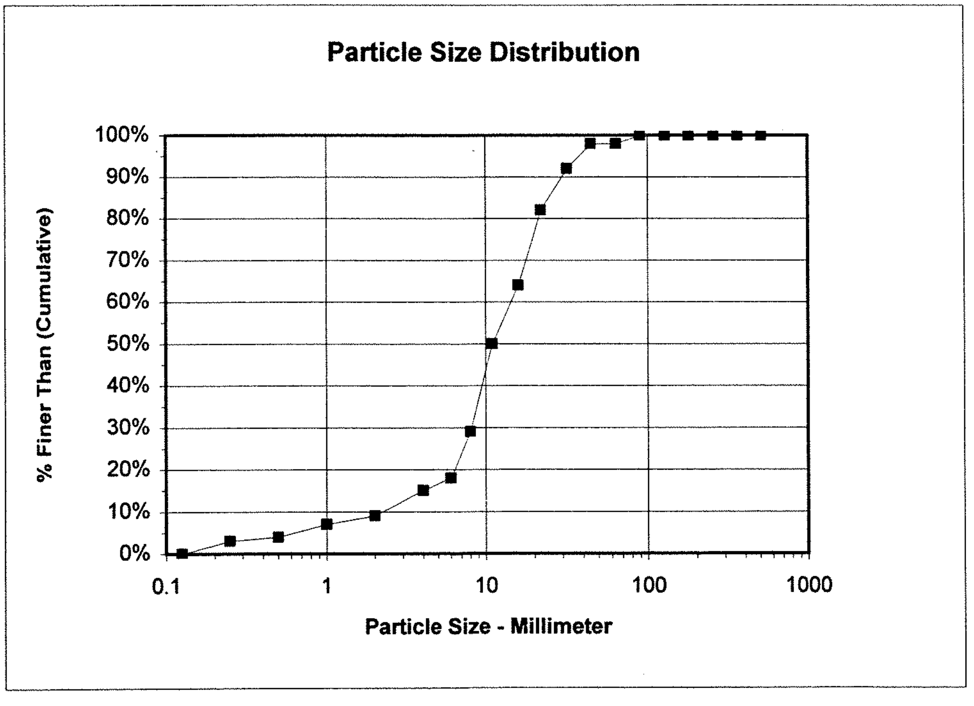
Regional Curve (Rural)

This stream data was used for the regional curve.


Cross Section - Station 2+00
Sal's Branch Reference Reach
Bankfull
Elevation (Feet)
95
95
94
94
93
93
92
92
91
91
90
Distance (Feet)
0
5
10
15

Pebble Count
Sal's Branch Reference Reach

PEBBLE COUNT						
Project: Speight Branch			Date: 5-26-98			
Party: John Williams, Jay Keller			Reach: Sal's Branch			
Inches	Particle	Millimeter		Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	0	0%	0%
	Very Fine	.062 - .125	S	0	0%	0%
	Fine	.125 - .25	A	3	3%	3%
	Medium	.25 - .50	N	1	1%	4%
	Coarse	.50 - 1.0	D	3	3%	7%
.04 -.08	Very Coarse	1.0 - 2.0	S	2	2%	9%
.08 - .16	Very Fine	2.0 - 4.0		6	6%	15%
.16 - .22	Fine	4.0 - 5.7	G	3	3%	18%
.22 - .31	Fine	5.7 - 8.0	R	11	11%	29%
.31 - .44	Medium	8.0 - 11.3	A	21	21%	50%
.44 - .63	Medium	11.3 - 16.0	V	14	14%	64%
.63 - .89	Coarse	16.0 - 22.6	E	18	18%	82%
.89 - 1.26	Coarse	22.6 - 32.0	L	10	10%	92%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	6	6%	98%
1.77 - 2.5	Very Coarse	45.0 - 64.0		0	0%	98%
2.5 - 3.5	Small	64 - 90	C	2	2%	100%
3.5 - 5.0	Small	90 - 128	O	0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0	0%	100%
14.3 - 20	Small	362 - 512	L	0	0%	100%
20 - 40	Medium	512 - 1024	D	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0	0%	100%
	Bedrock		BDRK	0	0%	100%
			Totals	**100**	**100%**	**100%**



APPENDIX G

NATURAL CHANNEL DESIGN METHODOLOGY

NATURAL CHANNEL DESIGN METHODOLOGY

The following 40-step design procedure developed by Dave Rosgen was used for this natural channel design. Variations or omission of certain steps are noted in italics. Appendices listed below are found in Section F of the course manual for Fluvial Geomorphology for Engineers by Richard Hey and David Rosgen and also in Dave Rosegn's River Restoration and Natural Channel Design Manual.

Step 1. Perform a watershed analysis to determine the past history and search for the reasons of altered channel state/dis-equilibrium. This includes changes in the vegetation, location, development, and other landscape and vegetative changes that reflect on peak flows, duration of high flows and precipitation/runoff response. Sediment sources for introduced sediment from landslides, roads, and surface runoff from exposed surfaces (agriculture) are also identified. Procedures in WRENSS, 1980 may help you quantify these cumulatively. If TR 20 or TR 55 is used to simulate a peak flow, verify the model by back calculating the corresponding storm intensity/duration that generates the 1.5 year return period discharge (or the return period associated with field calibrated bankfull discharge from your local USGS gage station data). Any excess flows predicted beyond the bankfull value should be considered as flood flows and treated accordingly (see rest of steps). *Watershed analysis is in Section 2.1.*

Step 2. If the river is regulated by a storage reservoir and/or diversion, obtain the operational hydrology of the installation. Compare the hydrograph with the field evidence of bankfull discharge. Back calculate the streamflow from the cross-sectional area of the bankfull channel using morphological evidence. Determine change in timing of the tributaries. *Speight Branch is not controlled by any reservoirs or diversions.*

Step 3. Travel to the nearest stream gaging stations in a similar hydro-physiographic province. Follow the steps in Appendix I for field calibration of the bankfull stage and development of regional curves of drainage area vs bankfull discharge and drainage area vs bankfull dimensions. This procedure is used to not only develop regional curves, but to establish the return period of the flows that shape and maintain the channel. This information is critical when designing a stream where streamflow records are not available. *The regional curve developed by NCSU's Water Quality Group was used*.

Step 4. Plot the hydraulic geometry for the gage station. *Step 4 was not done.*

Step 5. Classify the stream type at the streamgage location and morphological characterization using the procedures outlined in Appendix II (Use the stream classification form for use at streamgage locations for this purpose. *Step 5 was not done.*

Step 6. Plot Manning's "n" for bankfull stage by stream type on the relation in Figure 5. *This step was performed for both the Mingo Creek and Sal's Branch reference reaches, E5 - n=0.035; E4 – n=0.035.*

Step 7. Obtain the following information for stream classification at the gage site:

A. Bankfull discharge return period (years), operational hydrology, and altered flows.
B. Valley type, landform/landtype.
C. Valley slope.
D. Dimensions, Pattern and Profile
   1. Stream type (level II)
   2. Drainage area (square miles)
   3. Bankfull width (W_{bkf})(taken at riffle)
   4. Bankfull mean depth (d_{bkf})
   5. Width/depth ratio (W_{bkf}/d_{bkf})
   6. Bankfull cross-sectional area (A_{bkf})
   7. Bankfull velocity (U_{bkf})
   8. Bankfull discharge (Q_{bkf})
   9. Bankfull maximum depth (d_{max})(taken at riffle)
   10. Ratio of bankfull max depth to bankfull mean depth (d_{max}/d_{bkf})
   11. Width of flood prone area (W_{fpa})
   12. Entrenchment ratio (W_{fpa}/W_{bkf})
   13. Meander length (L_m)
   14. Ratio of meander length to bankfull width (L_m/W_{bkf})
   15. Radius of Curvature (R_c)
   16. Ratio of Radius of Curvature to bankfull width (R_c/W_{bkf})
   17. Belt width (W_{blt})
   18. Meander width ration (W_{blt}/W_{bkf})
   19. Sinuosity (stream length/valley distance)
   20. Average slope (S_{ave})
   21. Riffle slope (S_{riff})
   22. Ratio of riffle slope to mean
   23. Pool slope (S_{pool})
   24. Ratio of pool slope to average slope (S_{pool}/S_{ave})
   25. Maximum pool depth (d_{pool})
   26. Ratio of pool depth to average bankfull depth (d_{pool}/d_{bkf})
   27. Pool width (W_{pool})
   28. Ratio pool width to bankfull width (W_{pool}/W_{bkf})
   29. Pool/pool spacing
   30. P/P spacing/W_{bkf}

   See Table 2, Morphological Characteristics for existing channel and reference reaches.

E. Materials
   1. Particle size of channel material (riffles and pools) (Wolman pebble count – frequency distribution) D15, D35, D50, D84, D95:
   2. Particle size of channel material (riffle) (Wolman pebble count – frequency distribution) D15, D35, D50, D84, D95:
   3. Particle size analysis of bar material (weight/size from field sieves) D15, D35, D50, D84, D95:
   4. Largest size particle at toe of bar (mm)

See Table 2 and Appendices for pebble count data. Note: lack of point bars prevented an analysis of the point bar materials.

Step 8. Calculate the bankfull critical shear stress = (62.4 #'s/cu.ft.) x (hydraulic radius) x (slope), then compare size of sediment potentially entrained (obtained from Figure 7) to largest size as measured in bar sample. If values are not similar, plot the largest size found in bar and the corresponding bankfull shear stress on the relationship presented in Figure 7 (note the stream type and width/depth ratio and gradation ratio {D84/D35}). This computation is applied to the riffle reach. *Shear stress is discussed in Section 6.1, Sediment Transport.*

Evaluation of impacted reach. The next steps are designed to determine existing condition, potential condition (reference reach) and the proposed dimension, pattern and profile for the natural channel design.

Step 9. Determine the valley type, land type and corresponding stream type commensurate with the landform for the study reach.

Step 10. Locate a reference reach in the immediate area or in an adjacent watershed for a similar hydro-physiographic province.

Step 11. Obtain and analyze aerial photographs for a reference reach to observe time trends in stability (before vs after major floods, above vs below impacts, etc.)

Step 12. Complete the morphological characterization information (Table 2). This data from the reference reach is extremely important, as it will provide the appropriate ratios for the dimension, pattern and profile of the stable stream type, to be used for the natural channel design.

Step 13. Complete a level III analysis for the reference reach to determine the relationships associated with the natural stable channel, including bank erodibility, stress in the near-bank-region, and estimates of lateral erosion rates. Use form summary (Table 3), and summary of rating procedures in Appendix III. *A Level III analysis was not done.*

Step 14. Repeat **Step 11** through **Step 13** for the *impacted study reach* to determine existing morphology and condition, using Table 2 to document morphological relations for *existing* and *proposed* conditions.

Step 15. Once the stable reference reach stream type is selected, obtain the drainage area for the area immediately upstream of the impacted reach.

Step 16. Obtain the bankfull discharge from the drainage area/discharge relationships from the regional curves as verified in **Step 3.**

Step 17. Obtain the cross-sectional area associated with the bankfull discharge. This can be obtained from regional curves, hydraulic geometry by stream type from gage stations, (**Step 4**), or from obtaining bankfull velocity (**Step 4, 6,** or other methods) and calculating

$$A_{bkf} = Q_{bkf}/U_{bkf}.$$

Step 18. Calculate proposed bankfull width

$$W_{bkf} = ((A_{bkf}) \text{ x } (W/D))^{1/2}$$

or from hydraulic geometry for same stream type and same relative size (**Step 4**).

Step 19. Calculate proposed bankfull mean depth, $D_{bkf} = W/D$, or A_{bkf}/W_{bkf}.

Step 20. Calculate mean bankfull velocity, $U_{bkf} = Q_{bkf}/A_{bkf}$.

Step 21. Calculate bankfull max depth (obtained at the riffle). Obtain from refernce reach by obtaining the ratio of

$$D_{max}/D_{bkf}/D_{max} = (D_{max}/D_{bkf}) \text{ x } D_{bkf}$$

Step 22. Calculate flood prone area width (from cross-section of stream and valley),

$$W_{fpa} = @ \text{ an elevation } 2 \text{ x } D_{max}.$$

Step 23. Computation of flood stage levels are often used with HEC 2 or HEC-RAS procedures when more detail is required due to FEMA requirements. This procedure only provides an approximate flood stage level and does not intend to substitute for the FEMA procedures. At gage stations, however, it is necessary to plot various return period floods and their corresponding depths on the flood prone area on the relationship in Figure 8. *A HEC-RAS analysis was not completed because Speight Branch is within the 100-year floodplain of Swift Creek as discussed in Section 6.2.*

Step 24. Calculate meander wavelength ($L_m = L_m$ ratio x W_{bkf}). L_m ratio is obtained from the reference reach data, as L_m ratio = L_m/W_{bkf}.

Step 25. Calculate radius of curvature ($R_c = R_c$ ratio x W_{bkf}). R_c ratio is obtained from the reference reach information.

Step 26. Calculate Belt width. Obtain stable meander width ratio, (MWR), from reference reach or from Figure 9, (W_{blt} = MWR x W_{bkf}). If the river is confined, use actual belt width and backcalculate meander width ration (MWR = W_{blt}/W_{bkf}). Make sure MWR is within acceptable lower limits for that stream type.

Step 27. Calculate sinuosity. Layout proposed pattern on aerial photograph or map. Obtain stream length. Sinuosity = stream length / valley distance. (Be certain that valley distance is obtained along the fall line of the valley).

Step 28. Calculate average slope (S_{ave} = valley slope / sinuosity).

Step 29. Calculate riffle slope ($S_{riff} = S_{riff}$ ratio x S_{ave})(S_{riff} ratio from reference reach).

Step 30. Calculate the bankfull shear stress of proposed channel at the riffle (repeat Step 8). If the corresponding size as obtained from Figure 9 is larger than the largest size on the bar, repeat Step 18 to calculate a new bankfull width using a lower width/depth ratio. This will result in a larger hydraulic radius (mean depth) and may result in a shear stress that will potentially move the sizes of sediment made available to the channel. A sub-pavement sample may also be obtained to go along with the bar sample that indicates the size distribution and largest size of bedload that moves at bankfull discharge. If the reduction in width/depth ratio and the corresponding increase in shear stress does not meet the entrainment size of the largest particle in the bar, then the next priority is to decrease sinuosity and meander width ratio, increase meander length and radius of curvature. This will result in an increase in slope, hopefully balancing the sediment transport competency of the river. (Note: This does require a validation).

Step 31. Calculate Pool slope ($S_{pool} = S_{pool}$ ratio x S_{ave})(S_{pool} ratio from reference reach).

Step 32. Calculate Max pool depth ($d_{pool} = d_{pool}$ ratio x d_{bkf})(d_{pool} ratio from reference reach).

Step 33. Calculate W_{pool} ($W_{pool} = W_{pool}$ ratio x W_{bkf})(W_{pool} ratio from reference reach).

Step 34. Calculate sequence of pool/pool spacing for step/pool stream types (from reference reach based on relationship of bankfull width and inverse proportion to average water surface slope). Obtain from reference reach.

Step 35. Layout proposed plan view over existing channel with the appropriate bankfull width, pool width, meander wavelength, radius, and belt width. Adjust dimensions to take into account existing vegetation, landform changes, avoidance of high banks such as conditions where a stream would extend laterally against a terrace or alluvial fan. Adjust alignment to match natural variability – avoid a totally symmetrical layout for visual/natural appearance objectives.

Step 36. Plot longitudinal profiles for both existing and proposed condition. Overlay the profiles for comparison purposes. Use stationing from longitudinal profile to identify (name) cross-section locations and for implementation for implementation layout. On the profile show proposed depths and slopes of bed features (riffles, steps, and pools) and as previously computed. Locate position of pools from plan view layout (i.e. for C stream types, pools are located on the outside of meander bends).

Step 37. Plot cross sections for existing and proposed condition using an overlay. Plot typical cross sections for riffles, pools, steps, glides or other features. Calculate earthwork (cut/fill) volumes from the cross-sections and use stream length appropriate for the persistence of a particular cross-section. Make sure dimensions are properly scaled, and that point bar slopes, entrenchment ratio, and side slope gradients are shown. E*arthwork calculations will be done in final design.*

Step 38. Select specific stabilization structures such as grade control structures, streambank revetment, riparian vegetation, and other design features. Locate these features on the plan, profile and section views. *This step will be performed in final design.*

Step 39. Develop detailed design drawings for the specific stabilizing features such as cross-vane for grade control and bank stabilization. These drawings, used for inserts into the design package, need to show all dimensions, and installation details. Each stabilization feature needs to have a plan, profile and section view. *This step will be performed in final design.*

Step 40. Each design should have a monitoring plan layout (See Section 10) which will insure that the design implementation will be evaluated to:

a. Insure stabilization structures are functioning properly
b. Monitor channel response in dimension, pattern and profile, channel stability (aggradation/degradation), particle size distribution of channel materials, sediment transport and streambank erosion rates.
c. Determine biological response (food chains, standing crop, species diversity, etc.)
d. Determine if all of the specific objectives as part of the restoration have been met.

APPENDIX H

USACE MITIGATION CHECK LIST

COMPENSATORY MITIGATION PLANNING
CHECKLIST
9/19/94

ACTION ID: ____________________

SITE NAME: Speight Branch Mitigation site

LOCATION/WATERBODY/COUNTY: Speight Branch at Swift Creek, Holly Springs Road, Wake County, NC

USGS QUAD(S): Lake Wheeler, NC

SOIL SURVEY SHEET NOS.: 67

PREPARED BY: Ron Johnson, Earth Tech DATE: 3/9/99

I. INTRODUCTION

A. Type of Mitigation (Circle / A separate checklist may be prepared if more than one type)

1. Restoration Creation Enhancement Preservation

a. In-kind Out-of-kind Both

b. On-site Off-site Both

2. Up-front Concurrent After-the-fact Bank

B. Wetland types and acreage Impacted / Attach or Describe:

R-2541 will impact 3.17 acres bottomland hardwood forest 0.94 ac, headwater forest 1.80 ac, and disturbed emergent wetlands 0.42 ac

C. Wetland types and acreage Mitigated / Attach or Describe:

8.3 acres enhancement of bottomland hardwood

1 acre creation of bottomland hardwood

D. Describe mitigation Ratios : 2:1 - Creation, 3:1 for enhancement Provides only partial mitigation for impacts

		YES	NO
E.	Will any Endangered Species, Archeological Resources, or Haz/Tox sites be impacted by this effort?		x
F.	Has a wetland determination been undertaken and verified?	X	

II. TARGET GOALS AND FUNCTIONS

		YES	NO
A.	Are there stated GOALS?	X	

Describe: Restoration of bottomland hardwood forest

Wildlife habitiat, flood storage

B. Describe Success Criteria: See wetland mitigation plan

Are they:		YES	NO
	1. Specific	x	
	2. Measurable	x	
	3. Attainable	x	

		YES	NO
C.	Target FUNCTIONS chosen and indicated?		X

Describe:

		YES	NO
D.	Was a Reference Ecosystem (RE) report prepared? (Attach)		X

1. Describe comparison between the RE and the Mitigation Plan: NA

III. STRUCTURAL COMPONENT

A. VEGETATION:

		YES	NO
1.	Are plantings listed to species?	X	
2.	Are "local" (200 Miles North/South) propagules to be planted and verified by nursery certificate?		
3.	Have diversity and densities of species within the RE been considered in the plan?	X	
4.	Has consideration been given to planting the interface between the mitigation site and upland habitats with suitable transition zone species?		X

5. Describe Quality Control during planting: ____________

B. SOILS:

		YES	NO
1.	Have the soils been mapped?	X	

2. Soils Series/Phases ______ Chewacla and Wehadkee ______

		YES	NO
3.	Fertility Sampling undertaken in RE? (Attach Report)		x
4.	Fertility Sampling undertaken on mitigation site? (Attach Report)		x

		YES	NO
5.	Are fertility results within the standards for the proposed plantings?	______	______

Describe Results / Amendments Required: ______________

Fertility sampling to be conducted during construction.

____

		YES	NO
6.	Are the soil types appropriate for the target wetland?	x	______

Describe: ____

____

____

		YES	NO
7.	If PC Farmland, has site been evaluated for:		
	a. Plow pans	______	______
	b. Field crowns	______	______
	c. Herbicide carry-over	______	______
	d. Drainage system	______	______

Describe: ____

____

____

C. <u>HYDROLOGY</u>:

		YES	NO
1.	Were the principles of HGM or other classification system considered?	______	x

Describe: ____

____

____

2. Describe the primary hydrologic input(s): ____________

Groundwater and surface water from drainage feature

____

	YES	NO
3. Was a Hydrology Model/Water Budget developed?	____	X
a. Were low, average, and high precipitation/water table/ flood conditions considered?	____	____

Describe the water budget: ______________________

____

____

____

4. Will the hydrologic regime predicted by the Water Budget be appropriate for the target wetland?	____	____

Describe: ______________________________________

____

____

5. Have Monitoring Wells/tide/ flood gauges been installed?	X	____

Describe: 2 wells installed in wetlands

____

____

NOTES: ____

____

____

IV. MONITORING

A. Name and number of person responsible for the success of this project: NCDOT ( )

	YES	NO
B. Is there a Monitoring Plan?	X	

Describe: 5 years - See report

	YES	NO
C. As Built Report provided?		
D. Procedure to account for beneficial natural regeneration?		

Describe:

V. CONSIDERATION OF CAUSES OF FAILURE

A. How does project rate regarding the following:

1. Elevation:

	YES	NO	N/A
a. Have biological Benchmarks been established?			
b. Is there a grading plan?			
c. Is grading plan specific?			
d. Is discing proposed after grading and/or prior to planting?			

2. Describe provisions for Drainage:

3. Describe Erosion Control Measures: ______________

4. Describe management of Human Impacts: ______________

5. Describe management of Herbivory/Noxious Plants:

	YES	NO
B. Are there Contingency Plans built into the proposal to address these factors?	____	____

Describe when and how will these contingencies be implemented: ______________

NOTES: ______________

VI. SITE MANAGEMENT

A. Describe Final Disposition of the property ______________

Not yet determined ____

____

____

B. Who will manage the site after the mitigation effort is deemed a success? ______________________ (   ) ______

	YES	NO
C. Will wetland functions be impacted by current or future land use patterns?	____	X

Describe: ____

T ____

____

	YES	NO
D. Will this site have the opportunity to function as planned?	X	____

Describe: ____

____

____

E. Describe how this project rates ecologically: ____________

____

____

____

HIGHLIGHT AND ADDRESS ALL PROBLEMS AND/OR INADEQUACIES WITH THE MITIGATION PLAN/SITE AS INDICATED BY THIS CHECKLIST.