STREAM MITIGATION PLAN

CAVINESS SITE
RANDOLPH COUNTY, NORTH CAROLINA

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Prepared for:

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
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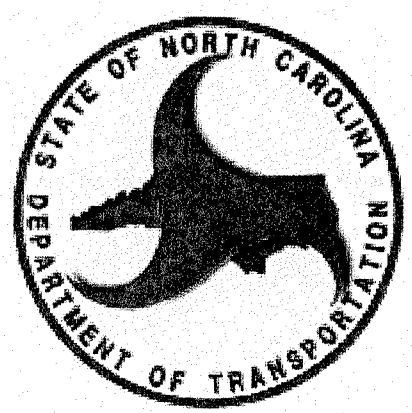

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1.0 INTRODUCTION

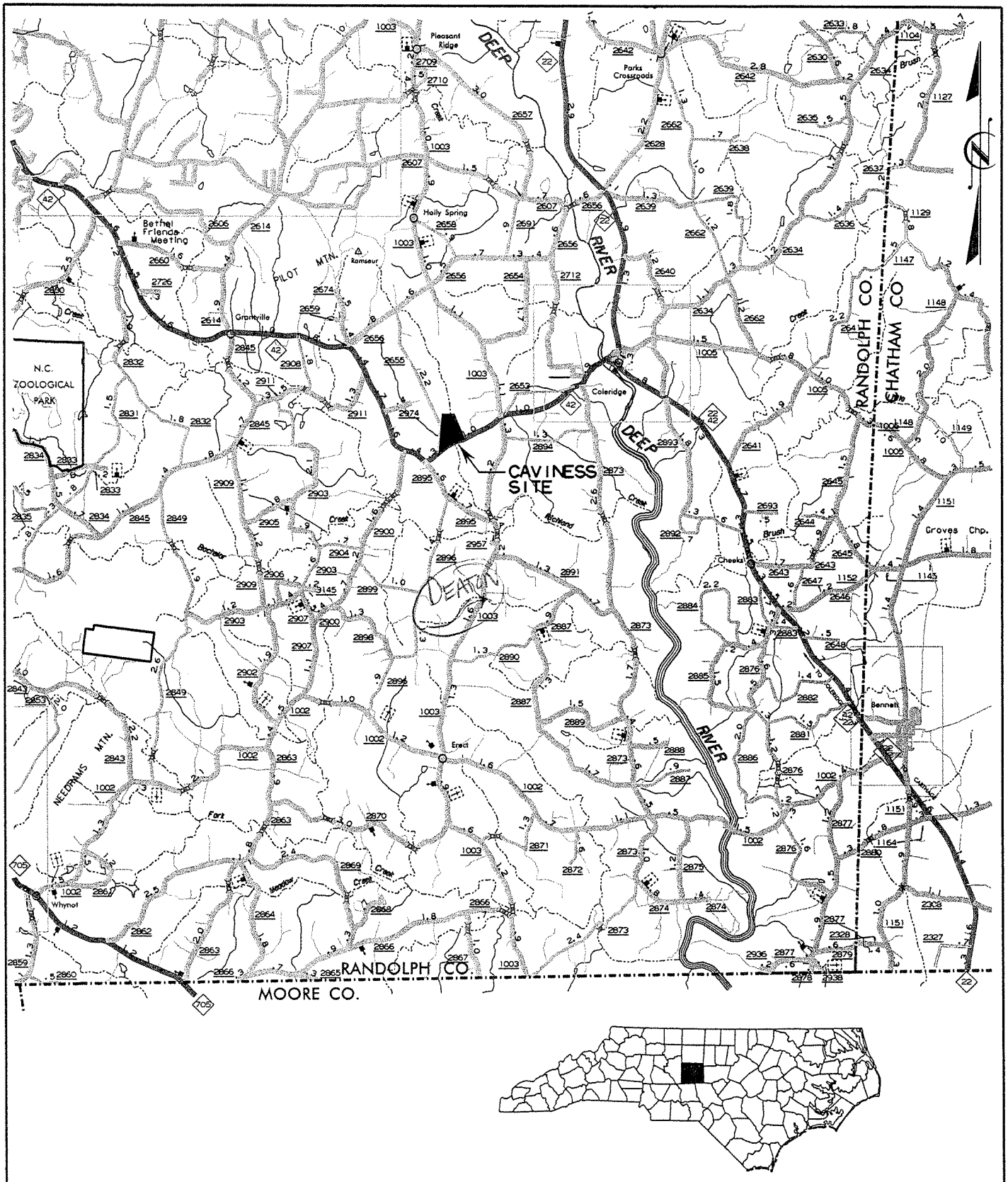
The North Carolina Department of Transportation (NCDOT) proposes to construct a 12.1-mile-long, four-lane, median-divided freeway on new location to serve as a US 421-NC 87 bypass of Sanford, North Carolina. The purpose of the proposed project is to improve capacity and safety for through-traffic using the US 421-NC 87 corridor in the vicinity of Sanford and to reduce traffic congestion within the City of Sanford along existing US 421-NC 87 (Horner Boulevard). The environmental impacts associated with construction of the project include an estimated 23,605 feet of jurisdictional streams.

The NCDOT has identified a reach of Tibbs Run and a tributary of Tibbs Run located on the property of William H. Caviness in Randolph County, North Carolina as potential stream restoration in order to mitigate a portion of these stream impacts. The property of William H. Caviness, hereafter referred to as "the Caviness site," is located on the north side of NC 42, approximately 2.6 miles west of the community of Coleridge in Randolph County (Figure 1). From the Caviness site, Tibbs Run flows southward to Richland Creek. Richland Creek then flows into Deep River approximately four miles downstream of NC 42. The Caviness site is located in the Hydrologic Unit 0303003.

The mitigation components planned for the Caviness site consist of restoring the natural pattern, dimension and profile of the streams and restoring the natural functions provided by the streams. Alteration of existing land use will consist of reforestation of the riparian buffer, eliminating access to the stream by domestic livestock and establishing a permanent conservation easement. The Caviness site will provide approximately 3,250 linear feet of stream mitigation credits and approximately 11 acres of riparian buffer credits.

2.0 METHODS

The preparation of the stream mitigation plan was initiated with an investigation into the existing features of the site. Subsequent to the initial site investigation, a reference reach analysis and an analysis of the existing site conditions were conducted. The reference reach search and analysis was performed in order to establish the necessary parameters for design of the stream restoration. The assessment of the existing site conditions consisted of an analysis of the geomorphology, hydrology and hydraulics of the streams and an assessment of the benthic macroinvertebrates, vegetation communities and wildlife. After completion of the assessment of the existing site conditions, the restoration plan for the subject streams was developed. The stream restoration plan includes the design of the proposed stream, analysis of sediment transport and channel hydraulics. Additionally, the plan includes provisions for re-vegetation of the riparian buffer, monitoring of the site and establishment of a permanent conservation easement.



SITE VICINITY MAP
CAVINESS SITE
STREAM MITIGATION PLAN
RANDOLPH COUNTY, N. C.

FIGURE 1

2.1 Analytical Methodology

2.1.1 Stream Classification

The Rosgen stream classification system was employed in the analysis of the streams that were studied as a part of this mitigation plan. The Rosgen system uses field measurements of stream features to describe a stream by morphologic type. An array of stream types is presented under the system that is delineated by slope, channel materials, width/depth ratio, sinuosity and entrenchment ratio. For the analysis of the reference reaches and the existing streams of the project site, the stream types are described at the morphological description level (Level II) of the hierarchical system of classification. At this level of inventory, the existing dimension, pattern, profile and materials are described (Rosgen, 1994, 1996, 1998).

Survey measurements taken as a part of this classification include the longitudinal profile of the thalweg, water surface and bankfull indicators. Also, cross sections of riffle and pool sections were surveyed to provide information such as bankfull cross sectional area, bankfull mean depth, width/depth ratio and entrenchment. Additionally, pebble counts were performed to provide a quantitative description of the channel bed material.

2.1.2 Hydraulic Analysis

Computer analysis of the hydraulic performance of the subject streams was accomplished by utilizing the United States Army Corp of Engineers' software, River Analysis System (HEC-RAS). This software allows for analysis of one-dimensional steady state flow by solving for the energy equation with an iterative standard step method. Energy losses are evaluated for friction losses by utilizing the Manning's equation and for contraction/expansion losses by utilizing the product of standard coefficients and changes in the velocity head. The hydraulic models of this study were constructed by inputting the cross sectional and profile data collected from the site along with roughness estimates. The HEC-RAS software was utilized in analyzing the hydraulic performance of the reference reach streams, the existing streams on the project site and the proposed stream restoration.

Discharges used in the hydraulic analysis consisted of the discharge associated with the bankfull, 10-year, 50-year and 100-year storm events. Discharges were computed at the upstream and downstream limits of the site and at locations of significant increases in drainage area, such as locations where tributaries enter the subject channel. The bankfull discharges were predicted by the methods described in Section 2.2.2, Reference Reach Analysis. The 10-year, 50-year and 100-year discharges were computed using the NCDOT methodology which stipulates that USGS regional regression equations be used for drainage areas greater than one square mile and that NCDOT curves be used for drainage areas less than one square mile (NCDOT, 1999).

2.2 Site Assessment Methodology

2.2.1 Site Investigation

The initial site investigation consisted of a review of available documents, visual observations of the existing conditions and interviews with local residents. The review of available documents included quadrangle maps, the county soil survey and aerial photography of the site taken in January of 2001. Visual observations were made of the channel characteristics, the valley form and on-site degrading factors influencing the stream. An investigation was conducted of the existing condition of the watershed, including current land use and activities within the watershed that could influence stream degradation. Interviews with local residents were conducted to gain insight into past land use practices, alterations made to the channel and possible historic channel characteristics.

2.2.2 Reference Reach Analysis

The reference reach analysis provides the foundation for developing the hydraulic geometry of the design channel. A reference reach is a stream segment that represents a stable channel within a particular valley morphology. A stable stream being defined as a stream, which over time in the present climate, transports the flows and sediment produced by its watershed in such a manner that the dimension, pattern and profile are maintained without either aggrading nor degrading (Rosgen, 1996, 1998).

The methodology used for the reference reach analysis consisted of the following tasks: (1) determine the appropriate properties of a reference reach based on information acquired during the site investigation, (2) conduct a search for the suitable reference reaches, (3) survey and classify the stream morphology, (4) perform a hydraulic analysis, and (5) develop dimensionless ratios for the reference reach.

The search for a suitable reference reach consisted of investigating the stream reaches upstream and downstream of the project site and investigating streams in neighboring watersheds. The advantage of having a reference reach located upstream or downstream of the project site is that it provides closer relationship between the channel properties and the discharges produced (flow and sediment) by the watershed.

Once identified, the reference reaches were surveyed and classified under the Rosgen stream classification system. A hydraulic analysis was performed on each reference reach to provide a prediction of bankfull discharge. The drainage area versus the bankfull discharge was plotted for each reference reach on a log-log graph. A regression analysis was used to develop an equation of the best-fit line. This best-fit line is referred to within this document as the "local curve." Likewise, a regression analysis of the plot of drainage area to bankfull cross sectional area was performed and a local curve of this relationship was generated. The values of bankfull discharge that are predicted by the local curve were subsequently used in the hydraulic analysis of existing and proposed site conditions.

Dimensionless ratios were developed from the survey data that was collected for the reference reaches. Dimensionless ratios provide a means of comparing channel features of streams with different drainage areas. These ratios were used in the restoration plan to establish a range of appropriate values for specific channel features. Using the surveyed features such as radius of curvature, meander length, pool spacing and maximum depth, the dimensionless ratios were computed by dividing by the appropriate channel dimension such as bankfull width or mean depth.

2.2.3 Site Geomorphology

The existing streams of the project site were surveyed to provide geomorphic classification under the Rosgen stream classification system. The longitudinal profile was surveyed for each stream and data collected included thalweg, water surface elevation, bankfull indicators, low-bank and bedrock control features. The profile provides insight into trends in the channel evolution along with the location of existing bed features, such as pools and bedrock controls, which can be incorporated into the design. Cross sections of the channel and valley were also surveyed throughout the stream reaches. These sections were used to evaluate the stream morphology along distinctive reaches of the site and to construct the computer model for the hydraulic analysis.

The methodology utilized to evaluate the existing stream classification required that a determination be made of the existing bankfull elevation for each of the surveyed sections. As is the case with many streams that are severely degraded, bankfull indicators were generally not present and unreliable. The existing bankfull elevations and bankfull cross sectional areas were predicted by performing a hydraulic analysis of the existing conditions using the bankfull discharges predicted by the local curves. The results of the hydraulic analysis provided for computation of the parameters necessary for the geomorphic classification.

In addition to the geomorphic classification, channel stability was assessed by evaluating bank stability. The bank height ratio, which is defined as the maximum bankfull depth divided by the height of the low bank, was computed for sections throughout the site. The methodology used for assessing bank stability consisted of interpreting bank height ratios which were greater than 1.2 as "moderately unstable" and ratios greater than 1.4 as "highly unstable". Physical evidence of bank stability or instability was noted during the site investigation. This evidence included features such as bank slopes, rooting depth and density, extent of surface protection from vegetation and soil stratification.

2.2.4 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrates inhabiting the subject streams were sampled and representative populations were analyzed in accordance with methods set forth in the EPA document titled *Volunteer Stream Monitoring: A Methods Manual* (U.S. Environmental Protection Agency, 1997) and North Carolina's standard biological monitoring procedures (NCDENR, 1997). Sampling and analysis was conducted (1) to provide a rapid bioassessment of relative stream conditions and stream health and (2) to assemble baseline data against which future stream conditions can be compared.

The methodology utilized consisted of using a kick net to sample stream segments having sandy-gravelly substrates. Within stream segments having muddy substrates, a D-frame net was used to sample the various types of habitat present such as the vegetated bank margin, snags, aquatic vegetation beds and silt/sand substrate.

Benthic macroinvertebrates were identified to the taxonomic level of Family. EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa richness was calculated and a water quality rating between "poor" to "excellent" was assigned according to North Carolina Department of Environment and Natural Resources, Division of Water Quality standard biological monitoring procedures (NCDENR, 1997). In this case taxa richness referred to the total number of families in the three EPT orders. A Hilsenhoff family-level biotic index was also calculated and assigned a water quality rating between "very poor" to "excellent" (Hilsenhoff, 1988). The EPT taxa richness value and Hilsenhoff biotic index values were both used to describe the relative water quality of the project site.

2.3 Restoration Design Methodology

The development of the proposed channel dimensions, pattern and profile was based on the fundamental concept that a channel should be designed to convey the flow and sediment loads of its watershed. Specifically, the cross section and slope of a channel should be configured such that (1) the channel conveys the bankfull discharge and (2) flows of greater magnitude are conveyed in part by the adjacent floodplains, as appropriate to the geomorphic classification of the stream. Additionally, the geometry of a channel and the profile combine to provide the dynamics necessary to transport the bedload. The many variables that affect these processes were combined in an iterative procedure to produce a channel design that is appropriate for geomorphic setting and that addresses the design constraints of flow and sediment transport.

Based on the assessment of the existing site conditions and the reference reach streams, the concept of the appropriate design channel was developed along with the corresponding hydraulic geometry. The design channel was evaluated for its capacity to transport the flow and sediment of the watershed.

Flow capacity was evaluated by modifying the existing sections of the hydraulic model to represent the proposed cross sections. The results of the hydraulic analysis were used to determine if bankfull elevations would be achieved or overtopped by the bankfull discharge. The hydraulic geometry was adjusted as necessary until the computed water surface elevation at bankfull discharge coincided with the bankfull elevation at each section.

Sediment transport capacity was evaluated on the basis of shear stress and stream power. Cross sections surveyed on the project site and in the reference reach located upstream of the site were evaluated for their ability to transport the sediment load of the watershed. This evaluation was based on field observation of depositional features and bed material. Based on this evaluation, shear stress and stream power were computed for those sections that effectively transport the sediment load. Shear stress and stream power were also calculated for the design cross sections and the values were compared to these reference sections. The hydraulic geometry of the design

sections was adjusted as necessary to result in values that were reasonably close to those computed for the reference sections.

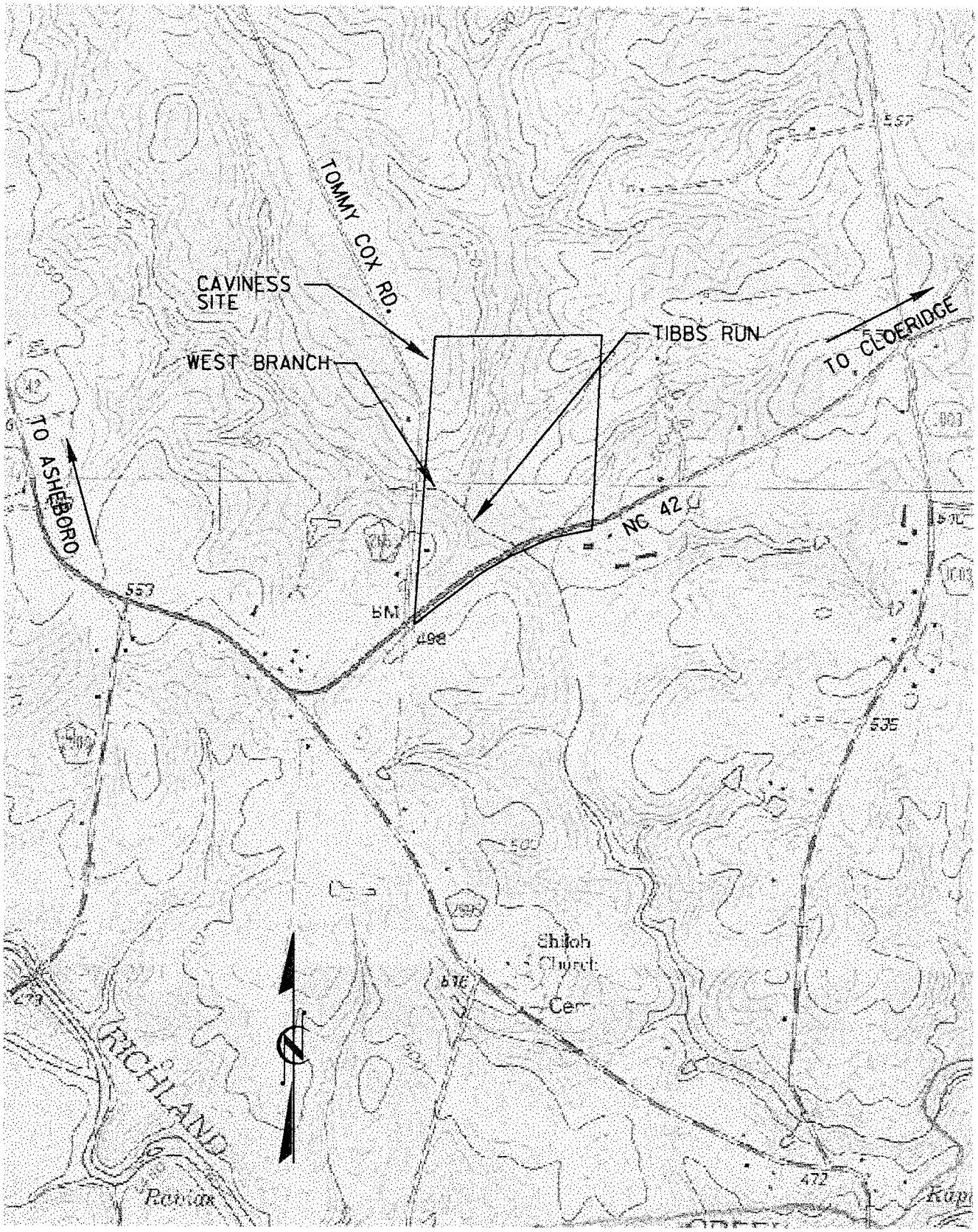
3.0 SITE ASSESSMENT

3.1 General Site Description

The stream reaches proposed for restoration in this mitigation plan consist of Tibbs Run and the tributary of Tibbs Run, hereafter referred to as "the West Branch," that are contained within the Caviness property (Figure 2). Tibbs Run has a drainage area of 2.0 square miles at the upstream end of the site and a drainage area of 3.3 square miles at NC 42. The West Branch has a drainage area of 1.08 square miles at Tommy Cox Road and a drainage area of 1.13 square miles at the confluence with Tibbs Run.

The streambed of the upper reach of Tibbs Run appears to be only slightly incised and has retained much of its natural pattern (Photographs 6 through 8, Appendix G). Although this stream segment and the adjacent floodplain are subject to unrestricted cattle grazing, a mature riparian overhanging tree canopy is present along much of the reach. This canopy provides for effective shading along most of the stream segment. Portions of the relic channel remain in a few locations on the floodplain and display the characteristic plan form of a type E stream with tortuous sinuosity. The bed material consists of sand, silt and gravel. At the time of investigation, evidence of stream incursions by cattle was less widespread than the lower reach. Further upstream, north of the Caviness Site, the stream emerges from a heavily wooded tract of land and it was initially anticipated that this reach would serve as a reference for portions of the restoration plan. However, recent logging has resulted in disturbance to the channel and the reach is no longer suitable for a reference reach survey.

The streambed of the lower reach of Tibbs Run appears to have degraded several feet below the historic stream grade (Photographs 1 through 5, Appendix G). As a result, the historic floodplain has been largely abandoned and the channel banks exhibit signs of excessive erosion. This reach of the stream is bounded along both sides by currently active pasturelands. No riparian overhanging tree canopy is present along the majority of this stream segment, thus stream shading is severely limited. In areas subject to direct cattle grazing, the riparian vegetation consists of opportunistic, first-successional, herbaceous vegetation. The natural channel pattern and dimensions have been significantly altered by a combination of manual regrading and stream incursions by cattle. There are many locations where the channel banks are bare and unstable. The features typically associated with normal stream processes, such as riffles and pools, are evident in a few locations. However, the natural process of meander development is occurring within the incised channel, thereby resulting in bank scour. The bed material along this reach of Tibbs Run consists primarily of sand, silt and gravel. Occasional outcrops of weathered bedrock and cobble form a few riffle sections. Additionally, the erosion along the ephemeral tributary that drains from the outlet of the pond on the southwest corner of the property is impacting water quality and channel stability by contributing an excessive sediment load to Tibbs Run.



USGS QUADRANGLE SITE MAP
CAVINESS SITE
STREAM MITIGATION PLAN
RANDOLPH COUNTY, N. C.

FIGURE 2

The streambed of the West Branch has degraded several feet below the historic stream grade (Photographs 9 through 13, Appendix G). As a result, the historic floodplain has been abandoned and the channel banks exhibit signs of excessive erosion. The West Branch is bounded along both sides by currently active pasturelands. No riparian overhanging tree canopy is present along the majority of this stream segment, thus stream shading is severely limited. In areas subject to direct cattle grazing, the riparian vegetation consists of opportunistic, first-successional, herbaceous vegetation. The natural channel pattern and dimensions have been significantly altered by a combination of manual regrading and stream incursions by cattle. There are many locations where the channel banks are bare and unstable. The features typically associated with normal stream processes, such as riffles and pools, are evident only at the downstream end of the West Branch. The bed material consists primarily of sand, silt and gravel. Occasional outcrops of weathered bedrock and cobble form a few riffle sections.

3.2 Land Use and Geology

The Caviness site is located in the eastern portion of the Piedmont physiographic province of North Carolina. Elevations on the site range from 460 to 521 feet (msl). The valley slopes range from 0.0019 to 0.0059 ft./ft. on Tibbs Run and 0.0043 to 0.0105 ft./ft. on the West Branch. Based on interviews with the property owner and observations made of the site, the landform adjacent to the streams, prior to disturbance, was an alluvial floodplain, which was bounded by gentle slopes of upland soils.

Soil survey information from Randolph County indicates that the predominant underlying soil layers of the Caviness site are Georgeville silt loam (2 to 8 percent slopes), Georgeville silty loam (8 to 15 percent slopes), Cecil sandy clay loam (2 to 8 percent slopes), Appling sandy loam (2 to 6 percent slopes and 6 to 10 percent slopes) and Vance sandy loam (2 to 8 percent slopes and 8 to 15 percent slopes). The Georgeville silt loam, Georgeville silty loam, Appling sandy loam and Cecil sandy clay loam soils are gently sloping, very deep, well drained soils on uplands with a moderate permeability and low shrink-swell potential. These soils have a loamy surface layer and clayey subsoil with a seasonal high water table below six feet. Vance sandy loam soils are strongly sloping, very deep, well drained soils on uplands with a slow permeability and moderate shrink-swell potential (NRCS Soil Survey information for Randolph County, in press)

Land coverage within the watershed is rural, consisting primarily of pastureland and woodlands along with some low-density residential development. Open pasture and agriculture croplands comprise approximately 35 percent of the watershed, while woodlands account for 60 percent. Residential development accounts for the remaining 5 percent.

The present land use within the Caviness property consists of livestock production and single-family residence. There are approximately 40 head of cattle, which graze on 42 acres of pastureland. The streams provide the only source of water for the cattle. Portions of the property, which are not utilized as pasture, consist of two residential dwellings, two garages and one pond.

3.3 Reference Reach Analysis

Based on the initial site investigation, a search was conducted for reference reach streams which were formed in broad alluvial floodplains with low valley slopes (0.004 to 0.02 ft/ft). From observations of the channels and the relic channels it was determined that the suitable reference streams would be either type E channels or type C channels with low width/depth ratios and with bed material that consisted of either sand or gravel. Four streams in Chatham and Randolph County were identified as potential reference reach sites. These streams were surveyed and utilized for an analysis of bankfull discharge. Of these four streams, three were selected to provide an analysis of dimensionless ratios of stream features. A summary of the reference reach survey along with a site location map is provided for each of these streams in Appendix B.

3.3.1 Bankfull Discharge

Four streams were utilized to develop local relationships for watershed area to bankfull discharge and bankfull cross sectional area. Two of the streams were studied as part of nearby NCDOT stream restoration projects, one stream is in a heavily wooded reach north of Siler City and the fourth stream is the West Branch of Tibbs Run immediately upstream of the Caviness site. Prior to entering the project site, the West Branch flows though a wooded riparian buffer, which provides a stable environment, that allows for accurate measurement of bankfull indicators. Likewise, the other three streams included in this analysis have sufficiently stable forms to provide for accurate measurement of bankfull indicators and cross sectional dimensions.

The resulting hydraulic relationships and the equations that define the local curves are shown in Appendix C. Table 1 lists the values of bankfull discharges and cross sectional areas computed for the four reference reaches and the values predicted by the local curves and by the North Carolina Rural Piedmont Regional Curves.

Table 1
Bankfull Discharge

Stream Name	Drainage Area (sq.mi.)	Calibrated Values		Local Curve Values		Regional Curve Values (Rural Piedmont)	
		Q_{Bkf}	$Area_{Bkf}$	Q_{Bkf}	$Area_{Bkf}$	Q_{Bkf}	$Area_{Bkf}$
North Branch of Deaton	0.27	41	9.5	36	7.9	35	8.8
Tributary to Sandy Cr.	0.97	70	17.3	83	22.4	87	21.0
Tributary to Tibbs Run	1.08	79	20.7	89	24.4	94	22.6
Mud Lick Creek	2.75	190	66.2	162	52.0	185	42.6

3.3.2 Dimensionless Ratios

Three of the streams surveyed (North Branch of Deaton, Tributary to Sandy Creek and Tributary to Tibbs Run) proved to be the most appropriate for establishing dimensionless ratios of channel features. A summary of the key ratios is listed in Table 2 and a complete table of the morphological characteristics is located in Appendix A.

Table 2
Dimensionless Ratios

Dimensionless Ratio	North Branch of Deaton	Tributary to Sandy Cr.	West Branch to Tibbs Run
Radius of Curvature Ratio	3.0	2.1	4.2
Meander Length Ratio	5.8	6.4	7.6
Meander Width Ratio	1.3	3.3	7.3
Riffle Slope/Avg. W.S. Slope	1.38	1.33	3.03
Max. Riffle Depth Ratio	1.2	1.5	1.1
Pool Spacing Ratio	9.2	6.2	5.5
Max. Pool Depth Ratio	1.8	1.9	1.3
Pool Area Ratio	1.3	1.6	1.0
Sinuosity	1.03	1.35	1.2

3.4 Geomorphology

Based on the predictions made of the bankfull water surface elevations from the hydraulic analysis of Tibbs Run and the West Branch, calculations were made of the width/depth ratios and the entrenchment ratios. The results of the geomorphic classification from this analysis are listed in Tables 3 and 4. Attachments 1, 2 and 3, which are located at the end of this report, are referred to in the following discussion of the existing geomorphology of the site. The cross sections that were surveyed of the channel and valley are identified on Attachment 1 with the Tibbs Run sections designated with the abbreviation "TR" and the West Branch sections designated with the abbreviation "WB." The longitudinal profile that was surveyed of Tibbs Run and the West Branch is represented in Attachment 2 and selected cross sections are represented in Attachment 3.

3.4.1 Tibbs Run

Tibbs Run on the Caviness site is made up of three distinctive geomorphic reaches: (1) the upper reach from profile station 10+00 to station 21+00 which contains cross sections TR9 through TR6, (2) the middle reach from profile station 21+00 to station 25+00 which contains cross sections TR5 and TR4, and (3) the lower reach from profile station 25+00 to station 33+00 which contains cross sections TR3 through TR1.

The profile of the upper reach is only slightly incised and the channel transitions several times between a type E channel and a type C channel. Although this reach displays some of its historic pattern and the bank height ratio remains near 1.0, there are many deficiencies exhibited by the channel that are adversely affecting natural stream functions and aquatic habitat. Those sections of the stream that classify as a type C channel display width/depth ratios greater than twenty. This high ratio signifies a departure from desirable conditions. As a result of the high width, sediment is precipitating out and forming depositional features within the channel bed. Additionally, alterations in the pattern, from either manual regrading or channel evolutions, have resulted in portions of the reach that have little to no sinuosity. The effects of sediment deposition and changes in the pattern have combined to form a thalweg profile with shallow, poorly spaced pools and wide, fairly flat riffles. In locations where there are meanders, the radii of curvature are generally too small and in several cases the distance from bend-to-bend is not properly proportioned to the bankfull width. Those sections of the stream that classify as a type E channel, on the contrary, are in relatively stable condition. However, due to their location within this disturbed reach, natural stream functions have been compromised by increased sediment load and profile reversal.

The middle reach is characterized by a channel cross sectional area that is slightly less than what is required to convey the bankfull discharge. This is visually evident by the occurrence of significant deposition beyond the top of bank. Additionally, the results from the hydraulic analysis indicate that the physical bank feature is overtopped in the bankfull event. As a result, Section TR5 classifies as a type C channel with extremely high width/depth ratio of 31. Where cattle incursions are frequent the cross sectional area is larger and in some cases, large enough to contain the bankfull event. These locations, such as section TR4, classify as a type E channel, however, the affects of the cattle access has left the banks in a highly unstable condition.

The profile of lower reach of Tibbs Run is incised below the historic stream grade by approximately two feet. This bed degradation has resulted from changes in the flow regime, manual regrading and disturbances caused by livestock incursions. The headcutting of the profile has extended upstream from NC 42 approximately 800 feet to profile station 25+00. Despite this incision the channel has not become completely entrenched. The combination of the low width/depth ratio and the high entrenchment ratio results in this reach being classified as a type E channel. However, the low sinuosity and the bank height ratios of 1.1 to 1.3 are adversely affecting the stability and function of the stream. In many locations it is evident that the channel is attempting to establish a larger belt-width by meandering within the confines of the existing banks. This has resulted in significant bank retreat in numerous locations characterized by near vertical bank slopes and exposed soil surfaces. The lack of significant riparian vegetation throughout the majority of this reach means that poor rooting depth offers no protection from near bank shear stress once bank retreat has initiated. Only the cohesive nature of the alluvial bank material and areas where more modest bank angles allow for establishment of vegetation offer any resistance to erosive forces. Without intervention the evolutionary trend for Tibbs Run will consist of a headward extension of the channel incision, which will likely result in the formation of a type G channel. The lower reach and ultimately the entire length of Tibbs Run on the Caviness site will continue to widen and possibly form a type F channel before near bank shear stress is reduced to the point that natural stabilization processes can begin. This evolutionary trend will result in significant sediment loads being transported downstream.

Table 3
Classification of Existing Stream Reaches of Tibbs Run

Reach	Width/Depth Ratio	Entrenchment Ratio	Bed Material	Rosgen Classification
TR9	26	10	Sand	C5
TR8	8	11	Sand	E5
TR7	21	10	Sand	C5
TR6	4	17	Sand	E5
TR5	31	8	Sand	C5
TR1 – TR4	5	20	Sand	E5

3.4.2 West Branch

The profile of the West Branch begins only slightly incised at the upstream end of the project site and the incision gradually increases in the downstream direction. At the confluence with Tibbs Run, the existing profile is approximately two to three feet below the historic stream grade. The entire reach of the West Branch is classified as a type E channel, however, the stream is characterized by general instability. At the upstream end (cross section WB5 and WB4) the meanders display evidence of rapid bank retreat. The lack of riparian vegetation has resulted in poor rooting depth and exposed banks. The bank height ratio throughout the middle and lower portion of this reach ranges from 1.2 to 1.5. The bank angles range from 60 to 90 degrees. Factors that are acting to limit a rapid evolutionary change in the channel include the cohesive nature of the bank material and the presence of nick points in the bed which include several bedrock outcrops and a 42 inch concrete pipe. Despite these resistive factors the stream is evolving towards a type G channel.

Table 4
Classification of Existing Stream Reaches of the West Branch

Reach	Width/Depth Ratio	Entrenchment Ratio	Bed Material	Rosgen Classification
WB5	7	15	Sand	E5
WB4	5	19	Sand	E5
WB3	4	21	Sand	E5
WB2	3	28	Sand	E5
WB1	4	22	Sand	E5

3.5 Bioassessment of Stream Quality

The Caviness site is classified as "fair" according to an EPT taxa richness value of 7. Although the taxa richness from the orders Ephemeroptera, Plecoptera and Trichoptera is "fair", the Hilsenhoff family level biotic index value of 3.03, classifies the Caviness site as "excellent, organic pollution unlikely." The Hilsenhoff biotic index is a biometric that assigns tolerance values to all taxa, whereas the EPT taxa richness value only concentrates on the predominantly

intolerant orders of Ephemeroptera, Plecoptera and Trichoptera. Although the EPT taxa richness is "fair," the total taxa is 27 at the Caviness site. Generally, a higher taxa number is associated with good water quality, which is supported by the Hilsenhoff biotic index classification of "excellent" that is based on all taxa present. Hilsenhoff tolerance values range between 0 and 10, with 10 being the most tolerant to pollution. Benthic macroinvertebrates sampled within this stream segment include a wide range of tolerance values. Dominant intolerant taxa include Perlidae (tolerance value 1) and Corydalidae (tolerance value 0) and dominant tolerant taxa include Chironomidae (tolerance value 6). Other dominant taxa include Elmidae, Baetidae and Hydropsychidae (tolerance value 4) (NCDENR, 1997) (Hilsenhoff, 1988) (Appendix F).

In the upper reach of Tibbs Run the presence of riparian shading and the introduction of relatively smaller volumes of cattle fecal matter to the stream and adjacent areas are thought to be the primary factors contributing to good stream conditions observed at the time of investigation. Presence of riffles in the lower reaches of Tibbs Run and the West Branch may be contributing to oxygenation of stream waters, a factor that would also contribute to better water quality. The presence of Chironomidae and Baetidae confirms the effect of excessive sedimentation in the streams. Sedimentation reduces the substrate availability for colonization by macroinvertebrates and can lead to dominance within the benthic macroinvertebrate community of taxa that are tolerant to the effects of sedimentation.

3.6 Vegetation Communities

The riparian vegetation along Tibbs Run and the West Branch consists predominantly of trees and shrubs along the banks. Opportunistic shrub and herbaceous species along the banks include: privet (*Ligustrum sp.*), ironweed (*Veronia sp.*) and blackberry (*Rubus sp.*). Vegetation is sparse in many locations along the banks due to grazing. A hardwood forest community at the upper reach of Tibbs Run includes the following tree species: willow oak (*Quercus phellos*), white oak (*Quercus alba*), post oak (*Quercus stellata*), turkey oak (*Quercus laevis*), southern red oak (*Quercus rubra*), ironwood (*Carpinus caroliniana*), shagbark hickory (*Carya ovata*), American elm (*Ulmus americana*), tulip tree (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*),cottonwood (*Populus deltoides*), sweetgum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*) and red maple (*Acer rubrum*). Shrub species include pawpaw (*Asimina triloba*), sweetbay (*Magnolia virginiana*) and privet. Herbaceous species found among the understory of this wooded area include: greenbriar (*Smilax rotundifolia*), tickseed sunflower (*Bidens sp.*) and wild strawberry (*Fragaria virginiana*).

3.7 Wildlife and Wildlife Habitat

The following amphibian and reptile species have been observed within the Caviness site boundaries: chorus frog (*Pseudacris triseriata*), spring peeper (*Pseudacris crucifer*) and northern water snake (*Nerodia sipedon sipedon*). Bird species observed within the Caviness site include: golden-crowned kinglet (*Regulus satrapa*), great blue heron (*Ardea herodias*), northern flicker (*Colaptes auratus*), tufted titmouse (*Parus bicolor*) and turkey vulture (*Cathartes aura*).

4.0 STREAM RESTORATION PLAN

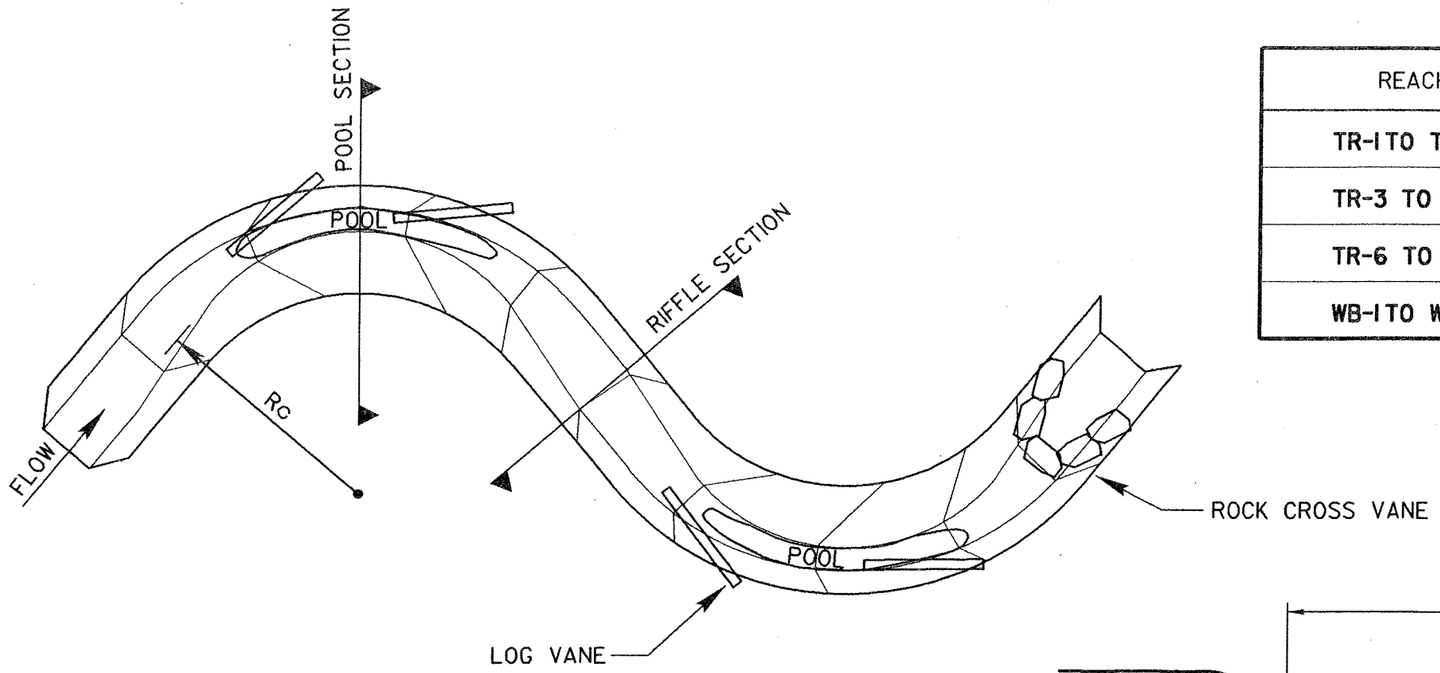
Stream restoration for the Caviness site will include reconstruction of the channels and management of the present land-use practices in order to address both the physical and biological degradation of the stream. The mitigation plan consists of a Priority I restoration (Rosgen 1997) of Tibbs Run and the West Branch. The stream restoration design provides for construction of the appropriate channel dimensions, meander pattern and bed features. In-stream structures such as root wads, rock cross vanes and log vanes will be utilized to provide stability for the newly constructed channel and to improve habitat diversity. Additionally, erosion control measures will be implemented along the ephemeral tributary that drains from the outlet of the pond on the southwest corner of the property in order to reduce sediment inputs into Tibbs Run.

Restoration of hydraulic geometry, removal of existing stressors (unrestricted stream incursions by cattle) and establishing a riparian buffer will contribute to water quality improvements within the watershed. The management of cattle access to the stream will significantly reduce bank destabilization, thereby reducing sediment loading. The management of cattle access to the stream will also significantly reduce pathways for the introduction of cattle fecal matter, thereby reducing nutrient and bacterial loading. Establishment and maintenance of a fifty-foot vegetated buffer along each bank of the stream will contribute to water quality improvements by providing (1) a mechanism for surface water infiltration, (2) the attenuation of pollutants normally associated with agricultural land uses (pesticides and herbicides), and (3) the attenuation of excessive nutrient levels resulting from fertilizer applications and livestock wastes. Changes in hydraulic geometry features, such as creation of riffles and runs, will enhance natural water column oxygenation processes, thereby contributing to an overall improvement in water quality, stream ecology, and habitat diversity.

The fifty-foot vegetated buffer will be fenced to restrict cattle access. Buffer and stream crossings will be limited to only a few locations, which have been negotiated with the property owner as a part of the conservation easement. An alternative water supply system will be provided for the cattle. This will include installation of a groundwater well, pump and distribution system to provide watering points at key locations on the Caviness site.

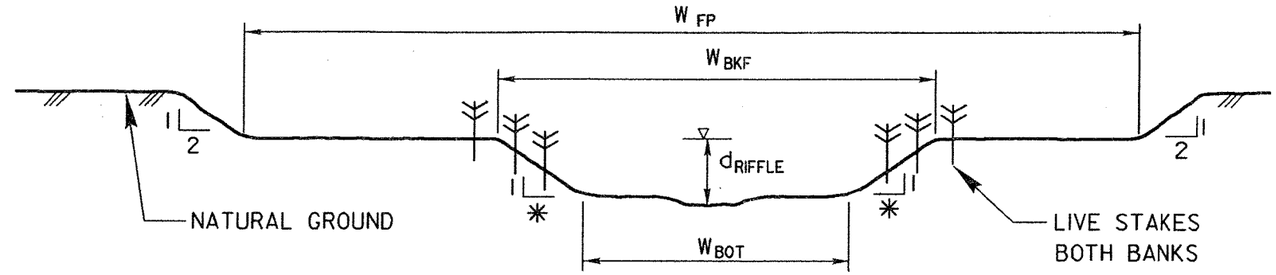
4.1 Channel Design

The proposed channel for Tibbs Run and the West Branch will have a stream classification of E5 under the Rosgen classification system. On Tibbs Run, the valley slope is approximately 0.004 ft./ft. and the channel slope will be 0.0033 ft./ft. with a sinuosity of 1.2. On the West Branch, the valley slope is 0.0043 ft./ft. and the channel slope will be 0.0036 ft./ft. with sinuosity of 1.2. The width/depth ratio for the reference streams range from 4.5 to 8.5. The design width/depth ratio for the stream restoration reaches will be 10. This slightly higher value is necessary to provide for construction of a new channel that is immediately stable. Over time, it is expected that the stream will narrow its banks through natural processes, thereby reducing the width/depth ratio.



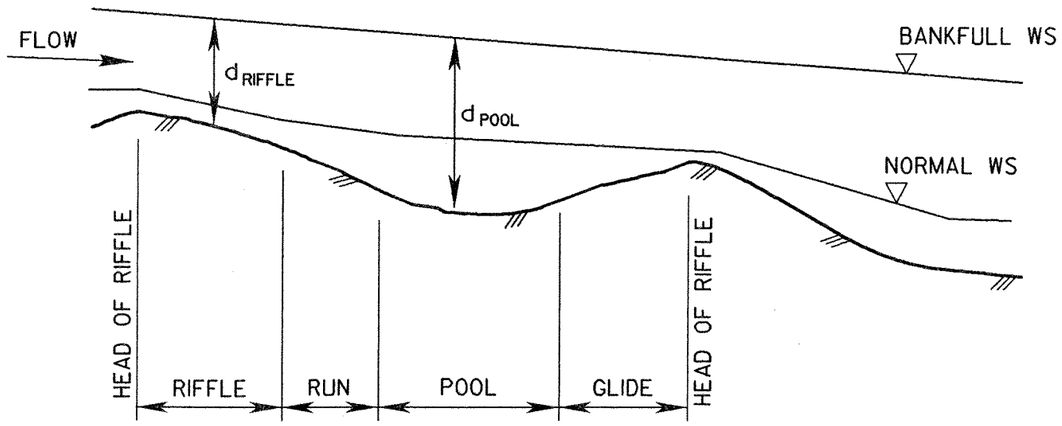
TYPICAL PLAN

REACH	W_{BKF}	W_{BOT}	d_{RIFFLE}	d_{POOL}	Rc	SIDE SLOPES
TR-1 TO TR-2	22.1	9.9	3.1	4.0	44-66	2
TR-3 TO TR-5	20.0	8.9	2.8	3.6	40-60	2
TR-6 TO TR-9	16.4	10.8	2.8	4.2	33-49	1
WB-1 TO WB-5	16.9	10.7	2.1	3.0	34-51	1.5

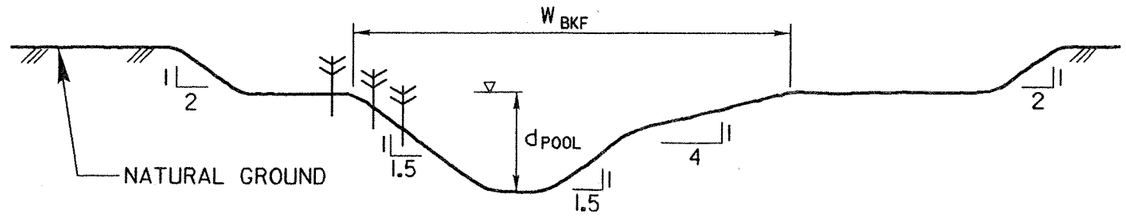


RIFFLE SECTION
N.T.S.

✳ SEE TABLE ABOVE FOR SIDE SLOPE



TYPICAL PROFILE



POOL SECTION
N.T.S.

CAVINESS SITE MAP
CAPE FEAR RIVER BASIN
STREAM MITIGATION PLAN
RANDOLPH COUNTY, NORTH CAROLINA

FIGURE 3

4.1.1 Hydraulic Analysis

The cross sectional area required to convey the bankfull discharge was calculated along with the corresponding channel dimensions. The proposed channel sections were evaluated for their ability to convey the bankfull flows and the flood flows of the watershed by performing a hydraulic analysis. The final design configuration, which provides for conveyance of the bankfull discharge at the bankfull stage, is illustrated in Figure 3. A comparison between existing and proposed flood elevations indicates that there will be no rise in the 100-yr flood on Tibbs Run or the West Branch. This result is due to the proposed removal of the undersized culverts on Tibbs Run, which currently cause a backwater effect during flooding events.

4.1.2 Sediment Transport

The design sections were evaluated for their competency to transport the sediment supplied by the watershed. Three existing sections were found to display the ability to effectively move the current sediment load. Two of these sections were located on Tibbs Run within the Caviness site (sections TR1 and TR6) and the third cross section was the riffle section of the West Branch reference reach. The critical shear stress and stream power were calculated for each of these sections. The critical shear stress was found to range from 0.34 to 0.40 lb/ft^2 and the stream power ranged from 1.3 to 1.8 lb/ft-s. The final design configuration resulted with a critical shear stress range of 0.37 to 0.43 lb/ft^2 and a stream power of 1.28 to 1.59 lb/ft-s on Tibbs Run. The results for the West Branch design indicate a critical shear stress of 0.35 lb/ft^2 and a stream power of 1.12 lb/ft-s (See Appendix D). From these computations, it was determined that the design sections would be able to transport the sediment supplied by the watershed.

4.2 Planting Plan

The planting plan for the riparian buffer of the Caviness site will provide post-construction erosion control and riparian habitat enhancement. The riparian buffer will include native species of the North Carolina Piedmont, which have been identified at the reference sites and at the Caviness site. Native species of the area will be locally adapted to conditions found at the Caviness site. Plants within the floodplain will be somewhat flood tolerant to accommodate for periodic flooding events throughout the year and in the long-term. A variety of shrubs and trees will be planted to provide cover and habitat variety for wildlife.

Trees with deep root systems will help stabilize the banks in the long term, while grasses and live stakes will be used at the site for stabilization (Allen and Leech, 1997). Vegetation will be planted in layers similar to layers found in a local reference site. Vegetative layers will include a shrubby edge layer adjacent to the stream and a forest canopy layer upslope of the shrub layer. Local colonization of herbaceous vegetation will also occur. Because of the shading effect of the associated forest layer, shrubs to be planted will be selected on the basis of their shade tolerance (FISRWG, 1998). and availability

Tree and shrub species to be planted at the Caviness site will be selected from the list of species found in the local reference and surrounding wooded areas. The following species will be planted depending on availability: oak species (willow oak, white oak, post oak, blackjack oak

and turkey oak), red cedar, alder (*Alnus serrulata*), serviceberry (*Amelanchier arborea*), silky dogwood (*Cornus amomum*) and spicebush (*Lindera benzoin*).

The Caviness site will be stabilized with a grass mix and erosion control matting along the stream banks. Willows (*Salix sp.*) will be live-staked on the channel banks on four-foot centers on the outside of the meander bends and on both banks of the riffle sections. Shrub species will be planted in staggered rows on the upslope on eight-foot centers. Trees will be planted as bare root stock on eight-foot centers (680 stems per acre). Planting of species using dormant plant stock will be performed between December 1st and March 15th.

5.0 MONITORING PLAN

Monitoring of the Caviness site following construction will include monitoring of geomorphology, macroinvertebrates and plants once each year for five years. Monitoring reports will be submitted annually to the United States Army Corps of Engineers and the 401-Wetlands Group of the North Carolina Division of Water Quality. In the event that success criteria is not met remedial measures will be installed to achieve success.

Monitoring of geomorphology will consist of establishing three reaches for measuring dimension, pattern and profile. Each reach will include a permanent riffle and permanent pool cross section along with a reference point for measuring the longitudinal profile. The profile will be measured for a length of at least twenty times the bankfull width. Pebble counts and bank stability assessments will be conducted at each monitoring reach. Permanent photography stations will be established adjacent to the cross sections. Two monitoring reaches will be located on Tibbs Run and one monitoring reach will be located on the West Branch. It is expected that some channel adjustment may take place, however, excessive channel adjustment and potential stream instability will be judged to be occurring if the width/depth ratio is measured to be greater than 12, the bank height ratio is greater than 1.2 or radius of curvature ratio is less than 2. Additionally the entire profile will be inspected for developing headcuts. If a headcut is discovered, remedial measures will be taken to arrest the headcut.

Macroinvertebrates will be sampled following the protocol prescribed in Standard operating Procedures Biological Monitoring (NCDENR, Division of Water Quality, 1997). Samples will be collected at each of the three monitoring reaches, upstream of the mitigation site, downstream of the mitigation site and at the regional reference yet to be determined. Samples will be collected during the summer months prior to construction, and five years following construction, excluding the year after construction. A comparison study will be conducted between the Caviness and Deaton mitigation sites as part of the monitoring plan to collect data on colonization of benthic macroinvertebrates and habitat quality factors. Sampling of macroinvertebrates will be for study purposes only. Colonization of macroinvertebrates will not considered as a criteria for evaluating the success of the stream restoration.

Vegetation monitoring plots adjacent to each monitoring reach will be established to assess compliance with a survival rate of 320 trees per acre after three years and 260 trees per acre after five years. Monitoring of the live stakes will consists of visual inspection to verify compliance with a seventy percent survival rate. In addition, stream bank stability will be assessed and a habitat assessment form will be prepared.

6.0 MITIGATION VALUE

The Caviness site stream mitigation plan provides for converting the unstable, altered and degraded stream segments on the Caviness property to stable natural conditions which will, in turn, provide enhanced aquatic habitat values. The mitigation plan includes restoring the geomorphic dimension, pattern and profile, the biological integrity, and the flow and sediment capacity of the streams. With a mitigation ratio of 1:1, the Caviness site will provide approximately 3250 linear feet of stream mitigation credits and approximately 11 acres of riparian buffer credits.

7.0 DISPENSATION OF PROPERTY

The NCDOT will negotiate the purchase of a conservation easement, which will encompass the restored stream reaches and the adjacent riparian buffer. The conservation easement will provide for the easement area to be (1) maintained in its natural, scenic and open condition and (2) restricted from any development that would impair or interfere with the conservation values. The NCDOT will retain ownership of the conservation easement throughout the construction and monitoring period established in the mitigation plan. No plan for final dispensation of the Caviness site conservation easement has been established, however, the NCDOT may seek to transfer the easement to a party which could provide responsible stewardship of the easement after the conclusion of the monitoring period.

8.0 REFERENCES

Allen, H.H. and J.R. Leech. 1997. Bioengineering for streambank erosion control. Technical Report EL-97-8. U.S. Army Corps of Engineers, Waterways Experiment Station. Vicksburg, Massachusetts.

Environmental Data Resources, Inc. Environmental Risk Management Report, Caviness Site. Inquiry Number: 531218.1s. 22 August 2000.

Hilsenhoff, W.L. 1988. Rapid field assessment of organic pollution with a family-level biotic index. Journal of the North American Benthological Society 7(1): 65-68.

North Carolina Natural Heritage Program. Element occurrence search for Randolph County, North Carolina. www.ncsparks.net/nhp/elements2.fm. 22 August 2000.

North Carolina Department of Environment, Health and Natural Resources. Division of Water Quality, Wetlands Unit. 2000. Benthic macroinvertebrate monitoring protocols for compensatory stream restoration projects.

North Carolina Department of Environment, Health and Natural Resources, Division of Water Quality, Water Quality Section. 1997. Standard operating procedures, biological monitoring. Environmental Sciences Branch, Ecosystems Analysis Unit, Biological Assessment Group.

North Carolina Department of Environment, Health and Natural Resources. 2000. Interim, internal DWQ policies on stream mitigation options and associated macrobenthos monitoring.

North Carolina Department of Transportation, Highway Design Branch, Hydraulics Unit. 1999. Guidelines for drainage Studies and hydraulic design.

Rosgen, D.L. 1994. A classification of natural rivers. Cantena, Volume 22, pp. 169-199

Rosgen, D., 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, CO.

Rosgen, D.L., P.H. A geomorphological approach to restoration of incised rivers. Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision. S.S.Y. Wang, E.J. Langendoen and F.D. Shields, Jr. (eds.). ISBN 0-937099-05-8

Rosgen, D.L., P.H. 1998. The reference reach, a blueprint for natural channel design. Proceedings ASCE Conference, Denver, CO.

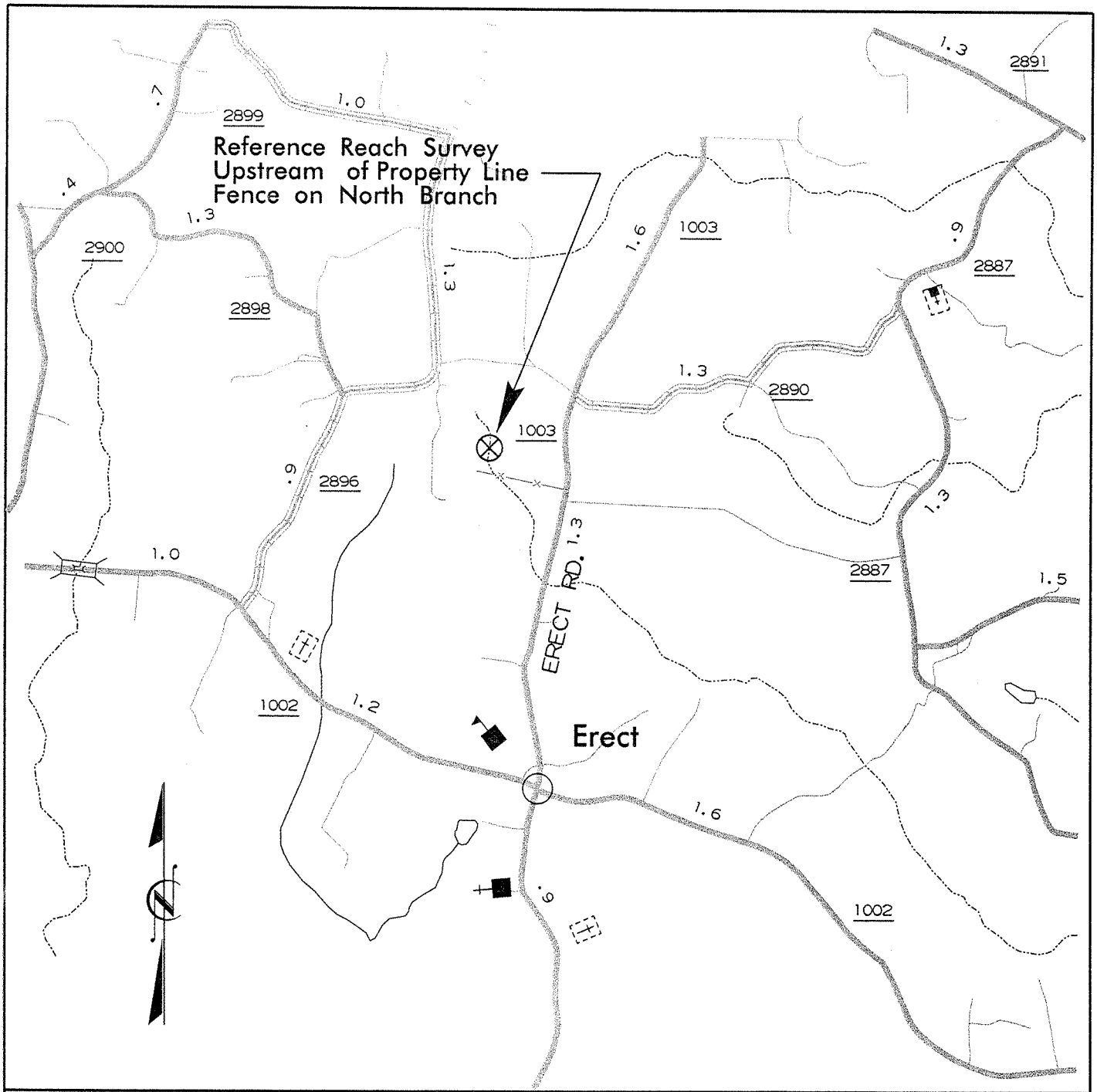
U.S. Environmental Protection Agency, Office of Water. Volunteer stream monitoring: a methods manual. EPA 841-B-97-003. November 1997.

U.S. Fish and Wildlife Service. Randolph County endangered species, threatened species, and federal species of concern. http://nc-es.fws.gov/es/cntylist/randolph.html. 22 August 2000.

APPENDIX A

MORPHOLOGIC CHARACTERISTICS TABLE

NORTH BRANCH OF DEATON



APPROXIMATE SCALE: 1" = 3000'

REFERENCE REACH LOCATION MAP
DEATON NORTH BRANCH
STREAM MITIGATION PLAN
RANDOLPH COUNTY, N. C.

Reference Reach Survey

Project: Deaton Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No.: 30036B

Sheet: 1 of 6

Summary Data

Basin Name:	Cape Fear
County:	Randolph
Stream Name:	North Branch
Location:	North of the Deaton Property, west of SR 1003
Land Use:	Rural
Drainage Area:	0.27 sq. mi.
Crew:	DMP, DGL, ALT, SGG
Date:	1/31/01

Bankfull Width:	7.25	ft.
Mean Bankfull Depth:	1.31	ft.
Cross Section Area:	9.53	sq. ft.
Width / Depth Ratio:	5.52	ft.
Max. Depth:	1.60	ft.
Flood-Prone Width:	71	ft.
Entrenchment Ratio:	9.8	
Bed Material (D_{50}):	21	mm
Water Surface Slope:	0.011	ft./ft.
Channel Sinuosity:	1.1	

Stream Type: **E4**

Morphological Characteristics of the Existing, Proposed and Reference Reach

Variables	Existing Channel	Proposed Channel	Reference Reach		
			Deaton N. Br.	Trib. to Sandy	West Br.of Tibbs
1. Stream Type	C5 - E5	E5	E4	E4	E5
2. Drainage Area ($mi.^2$)	1.1 - 3.3	1.1 - 3.3	0.27	0.97	1.08
3. Bankfull Width (Wbkf)	8 - 34	16.4 - 22.1	7.25	12.14	9.65
4. Bankfull Mean Depth (Dbkf)	1.1 - 3.1	1.7 - 2.2	1.31	1.42	2.14
5. Width/Depth Ratio	3 - 31	7 - 10	5.52	8.52	4.5
6. Max Riffle Depth Ratio (Dmax/Dbkf)	1.1 - 1.4	1.4	1.2	1.5	1.1
7. Bankfull Cross-Sectional Area (Abkf)	20 - 44	28.6 - 48.9	9.53	17.29	20.7
8. Bankfull Mean Velocity (Vbkf)	2.8 - 4.5	3.2 - 3.7	4.5	4.0	3.8
9. Bankfull Discharge (Qbkf)	89 - 182	89 - 182	41	70	79
10. Bankfull Maximum Depth (Dmax)	2.4 - 4.7	2.1 - 3.1	1.6	2.14	2.3
11. Width of Floodprone Area (Wfpa)	175 - 325	50 - 325	71	80	270
12. Entrenchment Ratio (Wfpa/Wbkf)	8 - 28	3 - 15	9.8	6.6	28
13. Meander Length (Lm)	90 - 150 *	140 - 180	42	77	73
14. Meander Length Ratio (Lm/Wbkf)	6 - 7 *	6 - 8	5.8	6.4	7.6
15. Radius of Curvature (Rc)	15 - 26 *	40 - 60	22	26	41
16. Radius of Curvature Ratio (Rc/Wbkf)	1.1 - 2.0 *	2.2 - 2.8	3	2.1	4.2
17. Belt Width (Wblt)	25 - 80 *	55 - 80	12	40	70
18. Meander Width Ratio (Wblt/Wbkf)	1 - 3.5 *	3 - 5	1.6	3.3	7.3
19. Sinuosity (K)	1.0 - 1.2	1.2	1.1	1.35	1.2
20. Valley Slope	0.0019 - 0.011	0.004	0.01	0.0043	0.0232
21. Average Slope (Savg)	0.0024 - 0.013	0.0033 - 0.0036	0.011	0.0058	0.0037
22. Pool Slope (Spool)	0.001 - 0.01 *	0.0005 - 0.0007	0.0011	0.0026	0.0004
23. Pool Slope Ratio (Spool/Savg)	0.42 - 0.77 *	0.1 - 0.2	0.10	0.45	0.11
24. Max. Pool Depth (Dpool)	3.1 - 5.7 *	3 - 4	2.43	2.7	2.7
25. Pool Depth Ratio (Dpool/Dbkf)	1.8 - 2.8 *	1.8	1.9	1.9	1.3
26. Pool Area Ratio (Apool/Abkf)	1.0 - 1.8 *	1.0 - 1.3	1.3	1.6	1
27. Pool Length Ratio (Lpool/Wbkf)	1.0 - 3.0 *	1.6 - 2.1	2.88	1.65	2.07
28. Pool Width (Wpool)	12 - 32 *	16.4 - 22.1	9.2	9.6	11.3
29. Pool Width Ratio (Wpool/Wbkf)	1.0 - 1.6 *	1.0	1.3	0.8	1.2
30. Pool-Pool Spacing (p-p)	30 - 180 *	90 - 140	67	75	53
31. Pool Spacing Ratio (p-p/Wbkf)	3 - 8 *	5.5 - 6.5	9.18	6.2	5.49
Materials:					
1. Particle Size Distribution					
d16	0.1		0.8	0.21	0.1
d35	0.2		12	0.46	0.2
d50	0.3		21	2.7	1
d84	11		60	23.3	13
d95	16		90	180	29

* Extensive disturbance of natural channel features limited the ability to provide accurate survey of these items. Where no values are presented in the table, these features were generally absent throughout the site. Where values are presented with an asterisk, channel features were measured where present. However, these values should not be considered as representative of the entire site since these features were absent elsewhere.

APPENDIX B

REFERENCE REACH DATA

Reference Reach Survey

Project: Deaton Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No.: 30036B

Channel Dimension

Pool Depth:	1.4	ft.	Pool D / Riffle D:	1.0	
Pool Width:	9.2	ft.	Pool W / Riffle W:	1.3	
Pool Section Area:	12.9	sq. ft.	Pool A / Riffle A:	1.3	
Riffle Depth:	1.35	ft.	Max Pool D / Mean D:	1.8	
Riffle Width:	7.3	ft.	Lowest Bank Ht. / Max. BF D:	1.1	
Riffle Section Area:	9.8	sq. ft.	Est. Mean Vel. at Bankfull:	4.5	f.p.s.
			Est. Discharge at Bankfull:	41	c.f.s.

Channel Pattern

Meander Length:	42	ft.	Meander Width Ratio:	1.6
Radius of Curvature:	22	ft.	Radius of Curvature / Bankfull Width:	3.0
Belt Width:	12	sq. ft.	Meander Length / Bankfull Width:	5.8

Channel Pattern

Valley Slope:	0.0100	ft./ft.	Riffle Slope / Avg. Wtr. Surf. Slope:	2.39
Avg. Wtr. Surf. Slope:	0.0110	ft./ft.	Pool Slope / Avg. Wtr. Surf. Slope:	0.10
Riffle Slope:	0.0263	ft./ft.	Run Slope / Avg. Wtr. Surf. Slope:	0.36
Pool Slope:	0.0011	ft./ft.	Glide Slope / Avg. Wtr. Surf. Slope:	0.23
Pool Spacing:	67.00	ft.	Run Depth / Mean Bankfull Depth:	1.52
Pool Length:	21.00	ft.	Glide Depth / Mean Bankfull Depth:	1.30
Run Slope:	0.004	ft./ft.	Pool Length / Bankfull Width:	2.88
Run Depth:	2.05	ft.	Pool Spacing / Bankfull Width:	9.18
Glide Slope:	0.0025	ft./ft.		
Glide Depth:	1.75	ft.		

Channel Materials

Sand & <	20	%	D_{16}:	0.8	mm
Gravel	65	%	D_{35}:	12	mm
Cobble	15	%	D_{50}:	21	mm
Boulder	0	%	D_{84}:	60	mm
Bedrock	0	%	D_{95}:	90	mm

Reference Reach Survey

Project: Deaton Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No.: 30036B
Sheet: 3 of 6

Cross Section Data

Section: DN14
Bankfull Elev: 97.36
Bankfull Area: 9.53
Bankfull Width: 7.25
Mean Depth: 1.31
W/D Ratio: 5.52
Max Depth: 1.60

Point	Station	Elevation	Notes	Depth	Avg. Depth	Width	Area
1005	97.85	97.16	Bankfull	0.20			
1006	96.97	95.95	Edge of Water	1.41	0.81	0.88	0.71
1007	96.07	95.85	Bed	1.51	1.46	0.89	1.31
1008	94.04	95.76	Thalweg	1.60	1.56	2.04	3.17
1009	92.78	95.79	Bed	1.57	1.59	1.26	1.99
1010	91.68	96.00	Edge of Water	1.36	1.46	1.10	1.62
1012	90.60	97.36	Bankfull	0.00	0.68	1.08	0.73
						Total Area:	**9.53**

Cross Section Data

Section: DN13
Bankfull Elev: 94.93
Bankfull Area: 10.00
Bankfull Width: 7.26
Mean Depth: 1.38
W/D Ratio: 5.27
Max Depth: 1.60

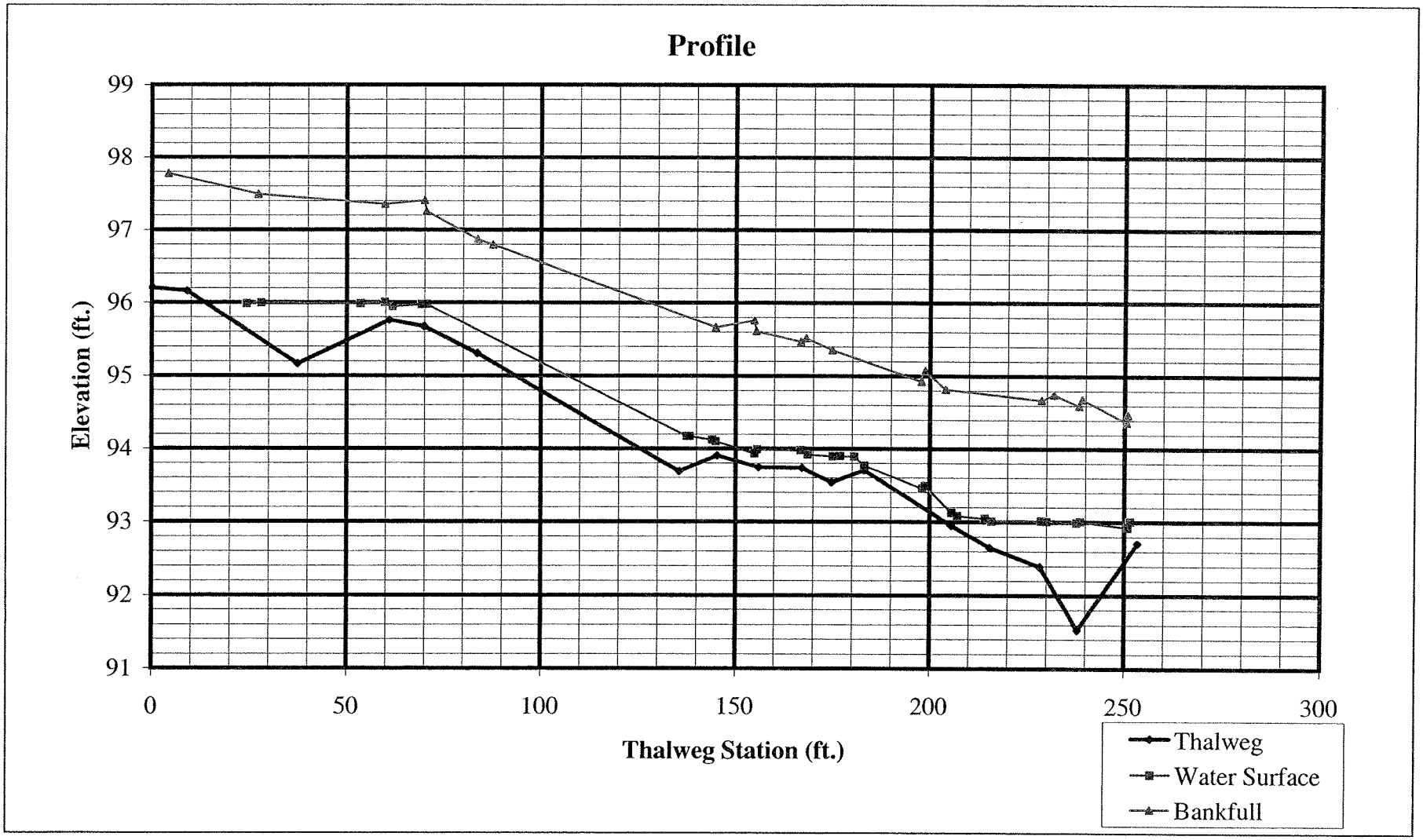
Point	Station	Elevation	Notes	Depth	Avg. Depth	Width	Area
1056	122.00	95.07	Bankfull	0.00			
1057	121.80	94.49	Ground	0.44	0.22	0.20	0.04
1059	120.54	93.49	Edge of Water	1.44	0.94	1.26	1.18
1060	120.47	93.33	Bed	1.60	1.52	0.08	0.12
1061	119.77	93.33	Bed	1.60	1.60	0.70	1.11
1062	118.76	93.39	Bed	1.54	1.57	1.01	1.58
1063	117.30	93.47	Bed	1.46	1.50	1.46	2.20
1064	115.60	93.38	Bed	1.55	1.51	1.70	2.57
1065	115.05	93.45	Edge of Water	1.48	1.51	0.54	0.82
1066	114.54	94.93	Bankfull	0.00	0.74	0.51	0.38
						Total Area:	**10.00**

Project: Deaton Stream Mitigation Plan

TIP No.: U-2524WM

Comm. No.: 30036B

Sheet: 4 of 6



Reference Reach Survey

Project: Deaton Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No.: 30036B

Sheet: 5 of 6

Pebble Count

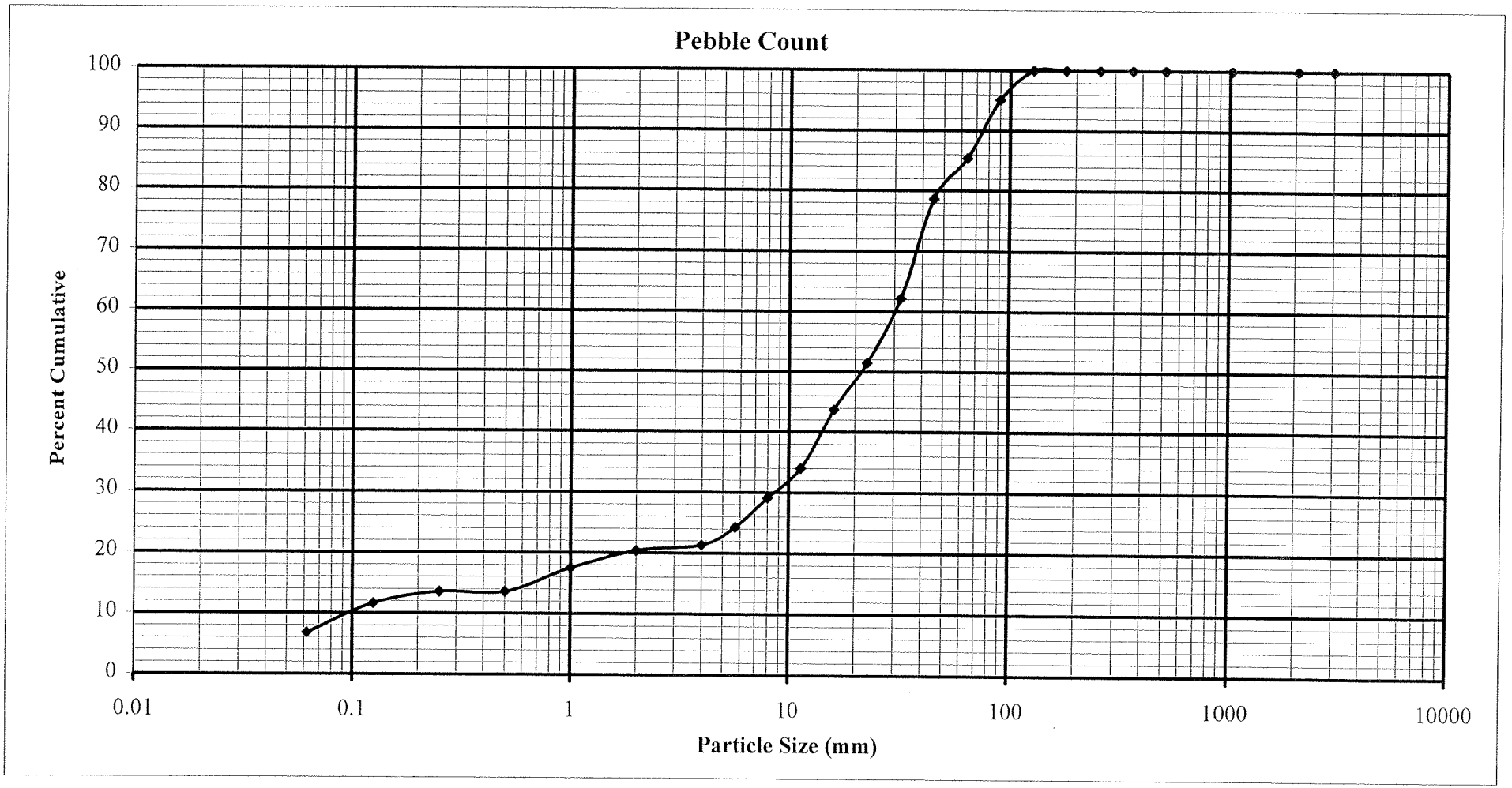
	Particle	mm	PARTICLE COUNT 1	2	3	Total #	Item %	% Cum.
	Silt/Clay	<.062			7	7	6.8	6.8
(Sand)	Very Fine	.062-.125	1		4	5	4.9	11.7
	Fine	.125-.25	2			2	1.9	13.6
	Medium	.25-.50				0	0.0	13.6
	Coarse	.50-1.0	1	1	2	4	3.9	17.5
	Very Coarse	1.0-2		1	2	3	2.9	20.4
(Gravel)	Very Fine	2.0-4.0			1	1	1.0	21.4
	Fine	4.0-5.7	2		1	3	2.9	24.3
	Fine	5.7-8.0	1	2	2	5	4.9	29.1
	Medium	8.0-11.3	1	1	3	5	4.9	34.0
	Medium	11.3-16.0	3	2	5	10	9.7	43.7
	Coarse	16.0-22.6	4	3	1	8	7.8	51.5
	Coarse	22.6-32.0	6	4	1	11	10.7	62.1
	Very Coarse	32-45	6	6	5	17	16.5	78.6
	Very Coarse	45-64	3	3	1	7	6.8	85.4
(Cobble)	Small	64-90	3	3	4	10	9.7	95.1
	Small	90-128	1	1	3	5	4.9	100.0
	Large	128-180				0	0.0	100.0
	Large	180-256				0	0.0	100.0
(Boulder)	Small	256-362				0	0.0	100.0
	Small	362-512				0	0.0	100.0
	Medium	512-1024				0	0.0	100.0
	Lg-Very Lg	1024-2048				0	0.0	100.0
(Bedrock)						0	0.0	100.0
TOTALS			**34**	**27**	**42**	**103**		**100.0**

D_{16}:	0.8	mm	Sand &<	20	%
D_{35}:	12	mm	Gravel	65	%
D_{50}:	21	mm	Cobble	15	%
D_{84}:	60	mm	Boulder	0	%
D_{95}:	90	mm	Bedrock	0	%

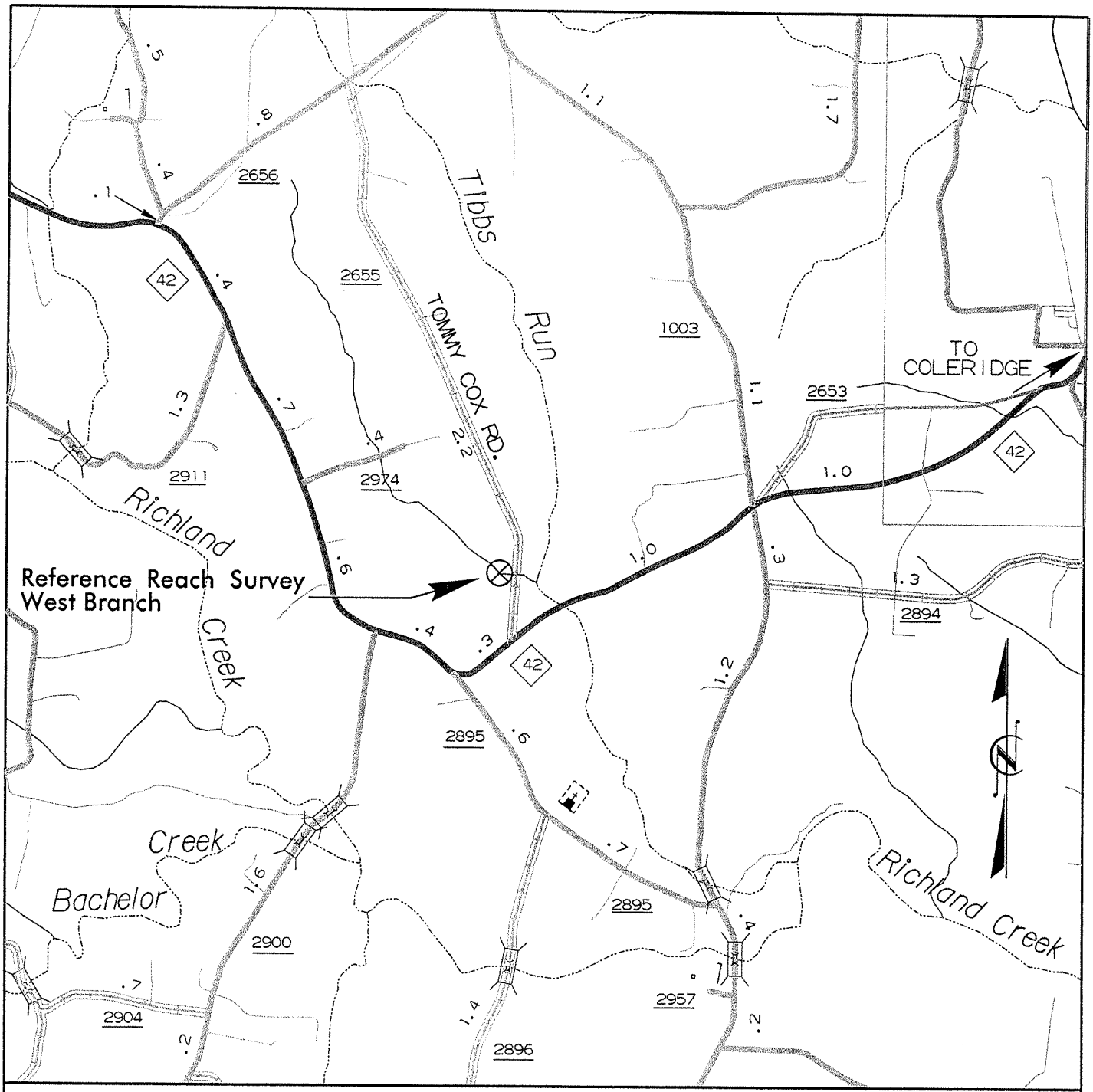
Reference Reach Survey

Project: Deaton Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No 30036B

Sheet: 6 of 6



WEST BRANCH OF TIBBS RUN



APPROXIMATE SCALE: 1" = 3000'

REFERENCE REACH LOCATION MAP
WEST BRANCH OF TIBBS RUN
STREAM MITIGATION PLAN
RANDOLPH COUNTY, N. C.

Reference Reach Survey

Project: Caviness Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No.: 30336C

Sheet: 1 of 6

Summary Data

Basin Name:	Cape Fear
County:	Randolph
Stream Name:	West Branch of Tibbs Run
Location:	West of Caviness Property
Land Use:	Rural
Drainage Area:	1.08 sq. mi.
Crew:	DMP, DGL, ALT, SGG
Date:	2/13/01

Bankfull Width:	9.65	ft.
Mean Bankfull Depth:	2.14	ft.
Cross Section Area:	20.70	sq. ft.
Width / Depth Ratio:	4.50	ft.
Max. Depth:	2.30	ft.
Flood-Prone Width:	270	ft.
Entrenchment Ratio:	28	
Bed Material (D_{50}):	1	mm
Water Surface Slope:	0.0037	ft./ft.
Channel Sinuosity:	1.17	

Stream Type: **E5**

Reference Reach Survey

Project: Caviness Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No.: 30036C
Sheet: 2 of 6

Channel Dimension

Pool Depth:	1.9	ft.	Pool D / Riffle D:	0.9	
Pool Width:	11.3	ft.	Pool W / Riffle W:	1.2	
Pool Section Area:	20.9	sq. ft.	Pool A / Riffle A:	1.0	
Riffle Depth:	2.1	ft.	Max Pool D / Mean D:	1.3	
Riffle Width:	9.7	ft.	Lowest Bank Ht. / Max. BF D:	1.5	
Riffle Section Area:	20.7	sq. ft.	Est. Mean Vel. at Bankfull:	3.8	f.p.s.
			Est. Discharge at Bankfull:	79	c.f.s.

Channel Pattern

Meander Length:	73	ft.	Meander Width Ratio:	7.3
Radius of Curvature:	41	ft.	Radius of Curvature / Bankfull Width:	4.2
Belt Width:	70	ft.	Meander Length / Bankfull Width:	7.6

Channel Pattern

Valley Slope:	0.0232	ft./ft.	Riffle Slope / Avg. Wtr. Surf. Slope:	2.03
Avg. Wtr. Surf. Slope:	0.0037	ft./ft.	Pool Slope / Avg. Wtr. Surf. Slope:	0.11
Riffle Slope:	0.0075	ft./ft.	Run Slope / Avg. Wtr. Surf. Slope:	1.92
Pool Slope:	0.0004	ft./ft.	Glide Slope / Avg. Wtr. Surf. Slope:	1.11
Pool Spacing:	53	ft.	Run Depth / Mean Bankfull Depth:	1.12
Pool Length:	20	ft.	Glide Depth / Mean Bankfull Depth:	1.03
Run Slope:	0.0071	ft./ft.	Pool Length / Bankfull Width:	2.07
Run Depth:	2.4	ft.	Pool Spacing / Bankfull Width:	5.49
Glide Slope:	0.0041	ft./ft.		
Glide Depth:	2.2	ft.		

Channel Materials

Sand & <	59	%	D_{16}:	0.1	mm
Gravel	38	%	D_{35}:	0.2	mm
Cobble	1	%	D_{50}:	1	mm
Boulder	0	%	D_{84}:	13	mm
Bedrock	2	%	D_{95}:	29	mm

Reference Reach Survey

Project: Caviness Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No.: 30036C
Sheet: 3 of 6

Cross Section Data

Section: CT-7
Bankfull Elev: 473.38
Bankfull Area: 20.70
Bankfull Width: 9.65
Mean Depth: 2.14
W/D Ratio: 4.50
Max Depth: 2.30

Point	Station	Elevation	Notes	Depth	Avg. Depth	Width	Area
1032	101.21	473.37	Bankfull	0.01			
1016	100.75	471.32	Edge of Water	2.06	1.04	0.46	0.47
1015	99.02	471.10	Bed	2.28	2.17	1.74	3.77
1014	98.06	471.13	Bed	2.25	2.26	0.95	2.16
1013	96.01	471.18	Thalweg	2.20	2.22	2.05	4.56
1012	94.08	471.14	Bed	2.24	2.22	1.93	4.27
1011	92.37	471.08	Bed	2.30	2.27	1.71	3.89
1010	91.74	471.27	Edge of Water	2.11	2.20	0.63	1.38
1033	91.56	473.38	Bankfull	0.00	1.05	0.18	0.19
						Total Area:	**20.70**

Cross Section Data

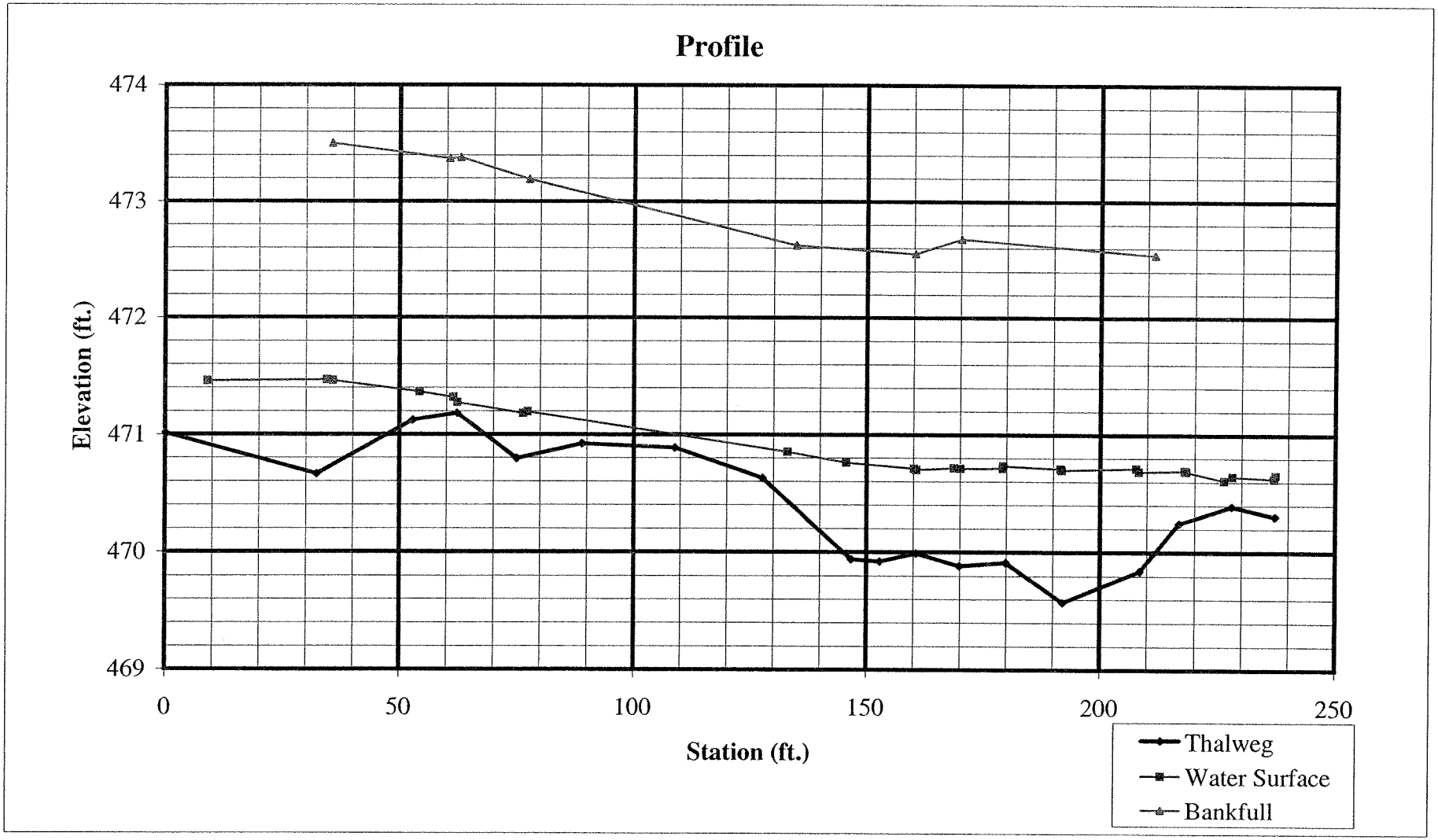
Section: CT-6
Bankfull Elev: 472.5
Bankfull Area: 20.85
Bankfull Width: 11.28
Mean Depth: 1.85
W/D Ratio: 6.10
Max Depth: 2.51

Point	Station	Elevation	Notes	Depth	Avg. Depth	Width	Area
1069	98.61	472.55	Bankfull	0.00			
1071	97.13	470.70	Edge of Water	1.80	0.90	1.48	1.33
1072	96.83	470.00	Bed	2.50	2.15	0.30	0.64
1073	95.32	469.99	Thalweg	2.51	2.50	1.51	3.79
1074	93.24	470.36	Bed	2.14	2.32	2.08	4.84
1075	90.94	470.17	Bed	2.33	2.23	2.30	5.13
1076	90.13	470.71	Edge of Water	1.79	2.06	0.82	1.68
1077	87.59	471.66	Ground	0.84	1.31	2.54	3.33
1078	87.33	472.46	Bankfull	0.04	0.44	0.26	0.11
						Total Area:	**20.85**

Reference Reach Survey

Project: Caviness Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No.: 30036C

Sheet: 4 of 6



Reference Reach Survey

Project: Caviness Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No.: 30036C

Sheet: 5 of 6

Pebble Count

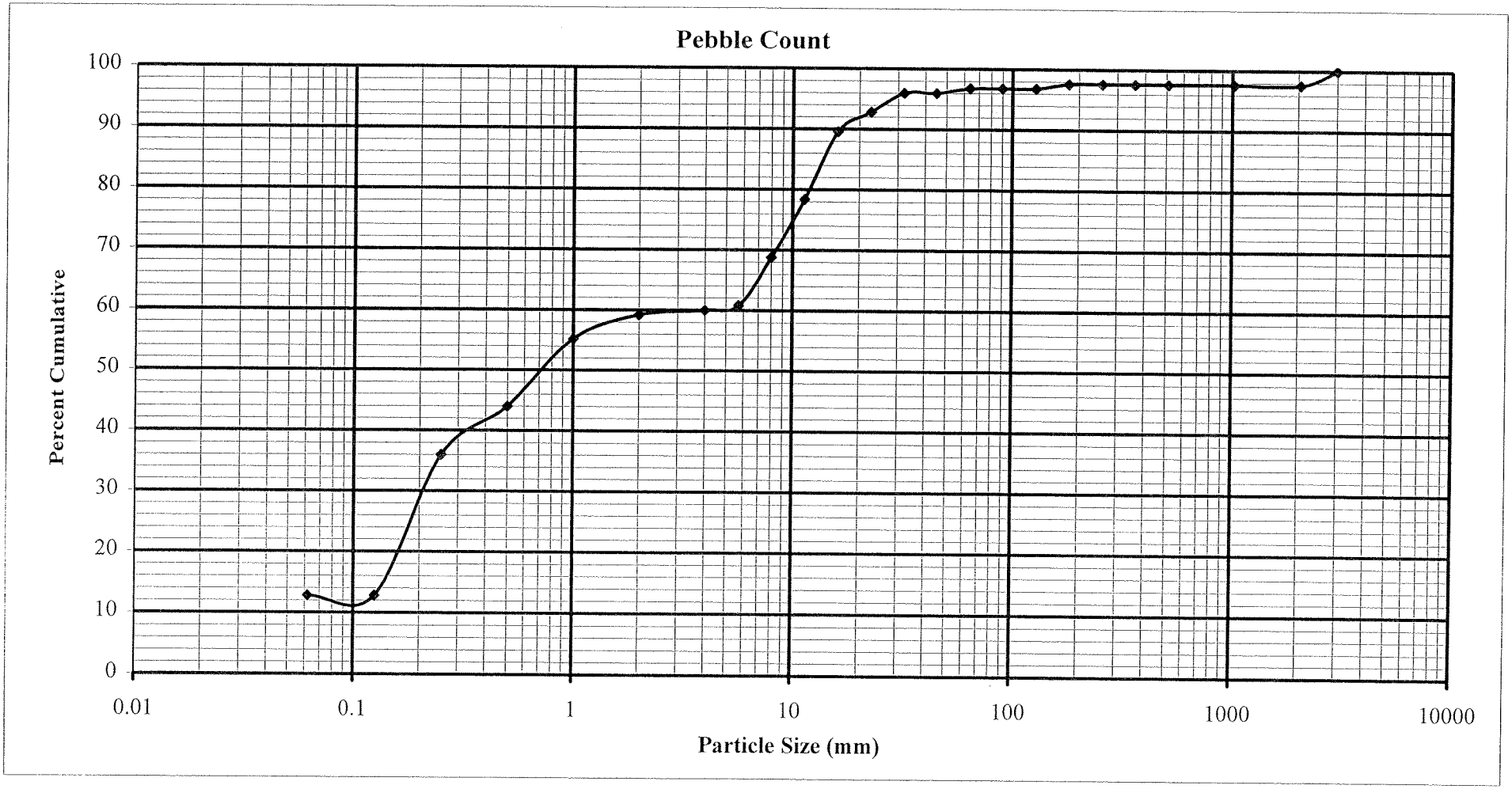
	Particle	mm	PARTICLE COUNT 1	2	3	Total #	Item %	% Cum.
	Silt/Clay	<.062	10	6		16	12.8	12.8
(Sand)	Very Fine	.062-.125				0	0.0	12.8
	Fine	.125-.25	12	17		29	23.2	36.0
	Medium	.25-.50	2	8		10	8.0	44.0
	Coarse	.50-1.0	1	13		14	11.2	55.2
	Very Coarse	1.0-2	2	3		5	4.0	59.2
(Gravel)	Very Fine	2.0-4.0		1		1	0.8	60.0
	Fine	4.0-5.7		1		1	0.8	60.8
	Fine	5.7-8.0	9	1		10	8.0	68.8
	Medium	8.0-11.3	9	3		12	9.6	78.4
	Medium	11.3-16.0	10	4		14	11.2	89.6
	Coarse	16.0-22.6	4			4	3.2	92.8
	Coarse	22.6-32.0	4			4	3.2	96.0
	Very Coarse	32-45				0	0.0	96.0
	Very Coarse	45-64		1		1	0.8	96.8
(Cobble)	Small	64-90				0	0.0	96.8
	Small	90-128				0	0.0	96.8
	Large	128-180		1		1	0.8	97.6
	Large	180-256				0	0.0	97.6
(Boulder)	Small	256-362				0	0.0	97.6
	Small	362-512				0	0.0	97.6
	Medium	512-1024				0	0.0	97.6
	Lg-Very Lg	1024-2048				0	0.0	97.6
(Bedrock)				3		3	2.4	100.0
TOTALS			**63**	**62**		**125**		**100.0**

D_{16}:	0.1	mm	Sand &<	59	%
D_{35}:	0.2	mm	Gravel	38	%
D_{50}:	1	mm	Cobble	1	%
D_{84}:	13	mm	Boulder	0	%
D_{95}:	29	mm	Bedrock	2	%

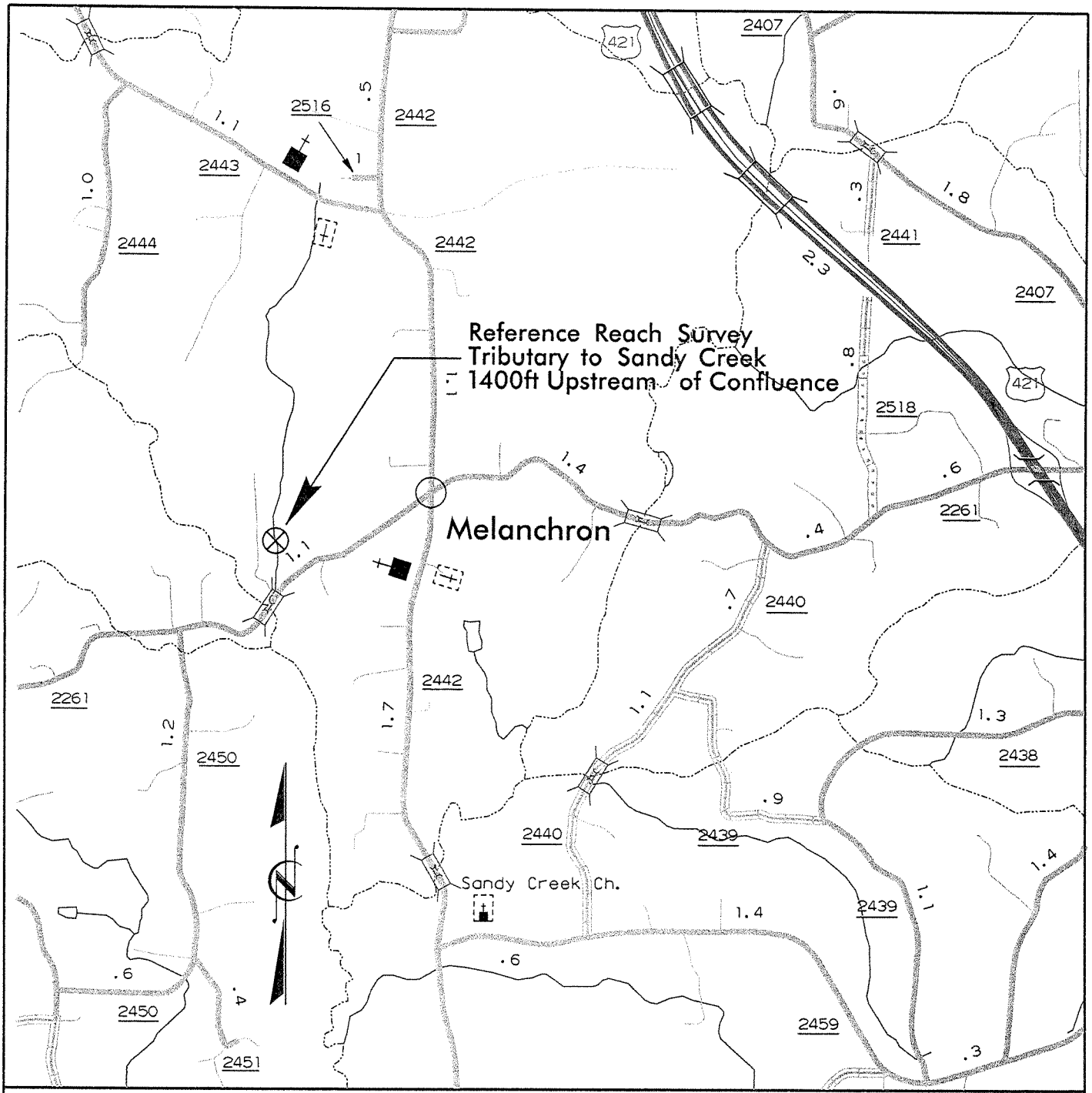
Reference Reach Survey

Project: Caviness Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No 30036C

Sheet: 6 of 6



TRIBUTARY TO SANDY CREEK



APPROXIMATE SCALE: 1" = 3000'

REFERENCE STREAM LOCATION MAP
TRIBUTARY TO SANDY CREEK
STREAM MITIGATION PLAN
RANDOLPH COUNTY, N. C.

Reference Reach Survey

Project: Amick Reference
TIP No.: U-2524WM
Comm. No.: 30036D

Sheet: 1 of 6

Summary Data

Basin Name:	Cape Fear
County:	Randolph
Stream Name:	Tributary to Sandy Creek
Location:	Old Liberty Rd., 5 miles west of Liberty
Land Use:	Rural
Drainage Area:	0.97 sq. mi.
Crew:	DGL, ALT, SGG
Date:	3/2/01

Bankfull Width:	12.14	ft.
Mean Bankfull Depth:	1.42	ft.
Cross Section Area:	17.29	sq. ft.
Width / Depth Ratio:	8.52	ft.
Max. Depth:	2.14	ft.
Flood-Prone Width:	80	ft.
Entrenchment Ratio:	6.6	
Bed Material (D_{50}):	3	mm
Water Surface Slope:	0.0058	ft./ft.
Channel Sinuosity:	1.35	

Stream Type: **E4**

Reference Reach Survey

Project: Amick Reference
TIP No.: U-2524WM
Comm. No.: 30036D

Sheet: 2 of 6

Channel Dimension

Pool Depth:	2.94	ft.	Pool D / Riffle D:	2.1	
Pool Width:	9.6	ft.	Pool W / Riffle W:	0.8	
Pool Section Area:	28.2	sq. ft.	Pool A / Riffle A:	1.6	
Riffle Depth:	1.42	ft.	Max Pool D / Mean D:	1.9	
Riffle Width:	12.1	ft.	Lowest Bank Ht. / Max. BF D:	1.0	
Riffle Section Area:	17.3	sq. ft.	Est. Mean Vel. at Bankfull:	4.0	f.p.s.
			Est. Discharge at Bankfull:	70	c.f.s.

Channel Pattern

Meander Length:	77	ft.	Meander Width Ratio:	3.3
Radius of Curvature:	26	ft.	Radius of Curvature / Bankfull Width:	2.1
Belt Width:	40	sq. ft.	Meander Length / Bankfull Width:	6.4

Channel Pattern

Valley Slope:	0.0043	ft./ft.	Riffle Slope / Avg. Wtr. Surf. Slope:	1.33
Avg. Wtr. Surf. Slope:	0.0058	ft./ft.	Pool Slope / Avg. Wtr. Surf. Slope:	0.45
Riffle Slope:	0.0077	ft./ft.	Run Slope / Avg. Wtr. Surf. Slope:	0.57
Pool Slope:	0.0026	ft./ft.	Glide Slope / Avg. Wtr. Surf. Slope:	0.29
Pool Spacing:	75	ft.	Run Depth / Mean Bankfull Depth:	1.62
Pool Length:	20	ft.	Glide Depth / Mean Bankfull Depth:	1.69
Run Slope:	0.0033	ft./ft.	Pool Length / Bankfull Width:	1.65
Run Depth:	2.30	ft.	Pool Spacing / Bankfull Width:	6.20
Glide Slope:	0.0017	ft./ft.		
Glide Depth:	2.40	ft.		

Channel Materials

Sand & <	47	%	D_{16}:	0.21	mm
Gravel	41	%	D_{35}:	0.46	mm
Cobble	6	%	D_{50}:	2.70	mm
Boulder	0	%	D_{84}:	23	mm
Bedrock	5	%	D_{95}:	180	mm

Reference Reach Survey

Project: Amick Reference
TIP No.: U-2524WM
Comm. No.: 30036D
Sheet: 3 of 6

Cross Section Data

Section: A1
Bankfull Elev: 98.59
Bankfull Area: 17.29
Bankfull Width: 12.14
Mean Depth: 1.42
W/D Ratio: 8.52
Max Depth: 2.14

Point	Station	Elevation	Notes	Depth	Avg. Depth	Width	Area
1049	113.86	98.46	Bankfull	0.13			
1050	114.55	96.80	Edge of Water	1.79	0.96	0.69	0.66
1051	115.64	96.45	Thalweg	2.14	1.97	1.09	2.14
1052	117.02	96.53	Bed	2.06	2.10	1.38	2.90
1053	118.83	96.76	Edge of Water	1.83	1.95	1.81	3.52
1054	120.05	97.41	Ground	1.18	1.51	1.22	1.83
1055	120.89	97.35	Ground	1.24	1.21	0.85	1.03
1056	121.58	97.03	Ground	1.56	1.40	0.68	0.96
1057	123.01	97.17	Ground	1.42	1.49	1.43	2.14
1058	124.31	97.80	Ground	0.79	1.11	1.30	1.44
1059	126.00	98.66	Bankfull	0.00	0.40	1.69	0.67
						Total Area:	**17.29**

Cross Section Data

Section: A2
Bankfull Elev: 99.05
Bankfull Area: 28.25
Bankfull Width: 9.62
Mean Depth: 2.94
W/D Ratio: 3.28
Max Depth: 2.79

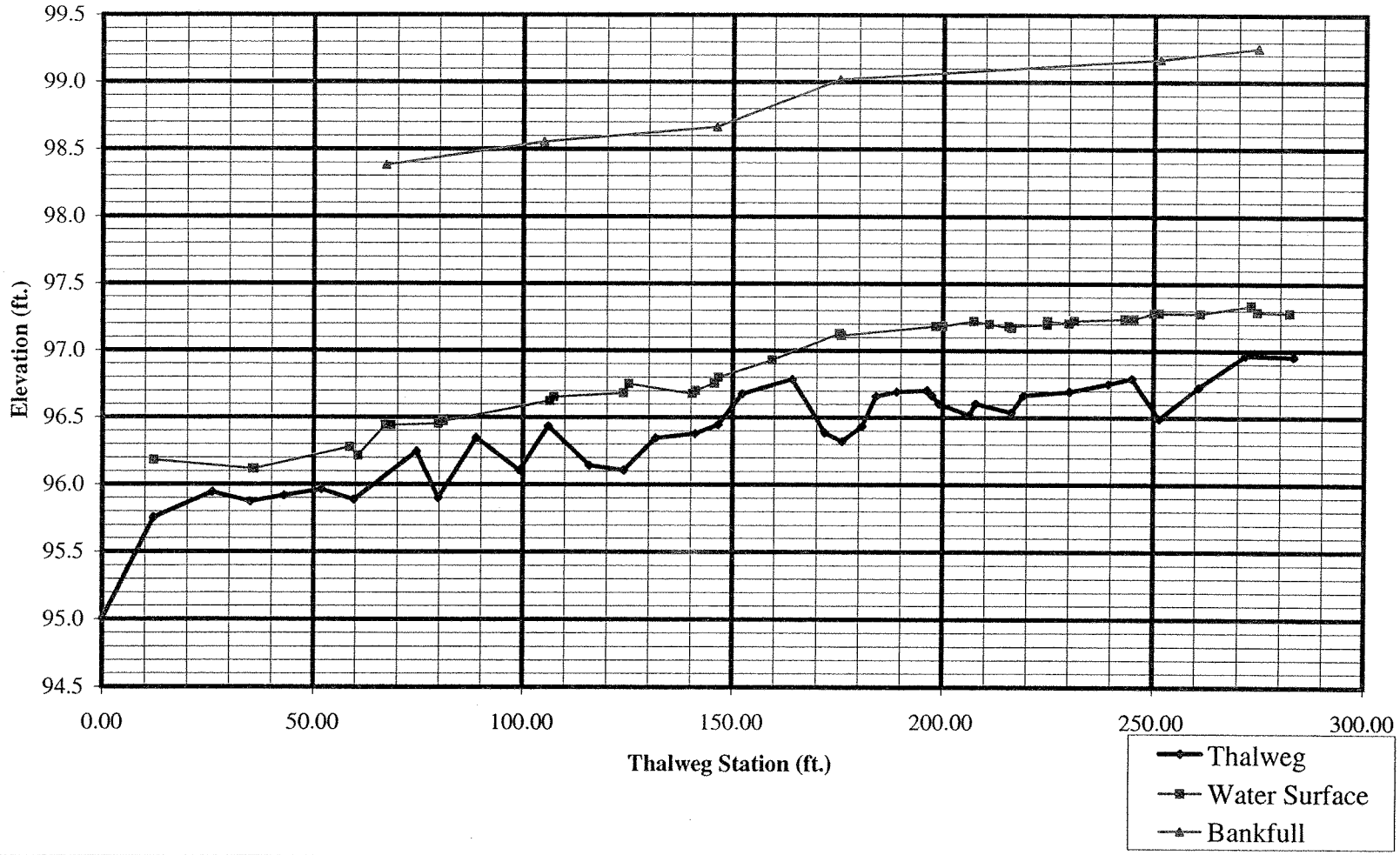
Point	Station	Elevation	Notes	Depth	Avg. Depth	Width	Area
1084	75.22	98.90	Bankfull	0.15			
1085	76.63	98.47	Ground	0.58	0.37	1.41	0.52
1086	77.82	98.21	Ground	0.84	0.71	1.19	0.85
1087	78.15	97.24	TOE	1.81	1.33	0.33	0.44
1088	78.87	97.11	Edge of Water	1.94	1.88	0.72	1.35
1089	80.10	96.86	Bed	2.19	2.07	1.23	2.54
1090	80.88	96.65	Bed	2.40	2.30	0.78	1.79
1091	82.34	96.32	Thalweg	2.73	2.56	5.71	14.64
1092	83.67	96.26	Bed	2.79	2.76	1.33	3.67
1093	84.39	96.48	TOE	2.57	2.68	0.72	1.93
1094	84.46	97.13	Edge of Water	1.92	2.24	0.07	0.16
1095	84.84	99.02	Bankfull	0.03	0.98	0.38	0.37
						Total Area:	**28.25**

Reference Reach Survey

Project: Amick Reference
TIP No.: U-2524WM
Comm. No.: 30036D

Sheet: 4 of 6

Profile



Reference Reach Survey

Project: Amick Reference
TIP No.: U-2524WM
Comm. No.: 30036D

Sheet: 5 of 6

Pebble Count

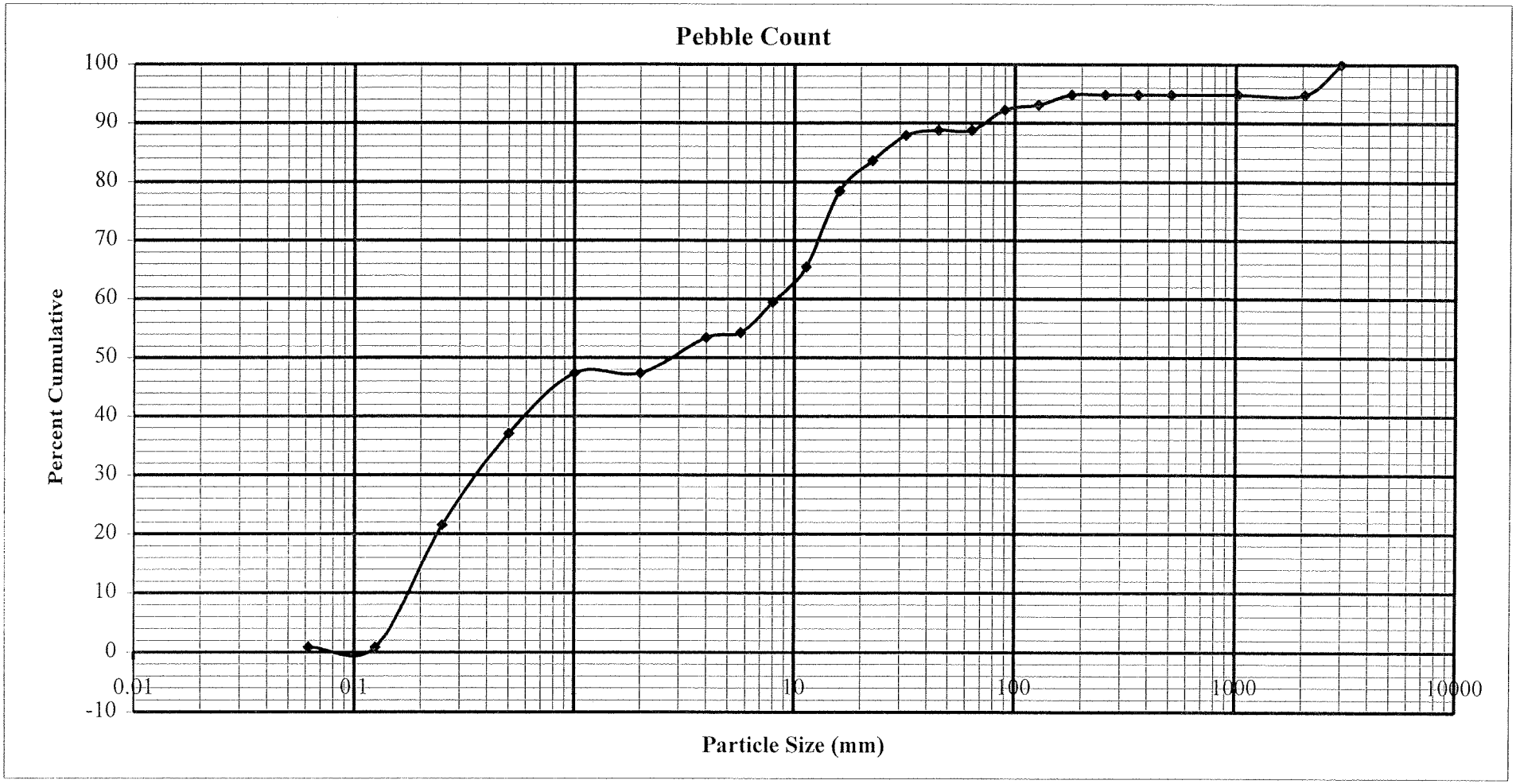
	Particle	mm	PARTICLE COUNT 1	2	3	Total #	Item %	% Cum.
	Silt/Clay	<.062		1		1	0.9	0.9
(Sand)	Very Fine	.062-.125				0	0.0	0.9
	Fine	.125-.25	8	16		24	20.7	21.6
	Medium	.25-.50	11	7		18	15.5	37.1
	Coarse	.50-1.0	2	10		12	10.3	47.4
	Very Coarse	1.0-2				0	0.0	47.4
(Gravel)	Very Fine	2.0-4.0	5	2		7	6.0	53.4
	Fine	4.0-5.7	1			1	0.9	54.3
	Fine	5.7-8.0	6			6	5.2	59.5
	Medium	8.0-11.3	5	2		7	6.0	65.5
	Medium	11.3-16.0	11	4		15	12.9	78.4
	Coarse	16.0-22.6	3	3		6	5.2	83.6
	Coarse	22.6-32.0	2	3		5	4.3	87.9
	Very Coarse	32-45		1		1	0.9	88.8
	Very Coarse	45-64				0	0.0	88.8
(Cobble)	Small	64-90		4		4	3.4	92.2
	Small	90-128		1		1	0.9	93.1
	Large	128-180		2		2	1.7	94.8
	Large	180-256				0	0.0	94.8
(Boulder)	Small	256-362				0	0.0	94.8
	Small	362-512				0	0.0	94.8
	Medium	512-1024				0	0.0	94.8
	Lg-Very Lg	1024-2048				0	0.0	94.8
(Bedrock)				6		6	5.2	100.0
TOTALS						**116**		**100.0**

D_{16}:	0.21	mm	Sand &<	47	%
D_{35}:	0.46	mm	Gravel	41	%
D_{50}:	2.70	mm	Cobble	6	%
D_{84}:	23.34	mm	Boulder	0	%
D_{95}:	180.0	mm	Bedrock	5	%

Reference Reach Survey

Project: Amick Reference
TIP No.: U-2524WM
Comm. No 30036D

Sheet: 6 of 6



APPENDIX C

DISCHARGE ANALYSIS

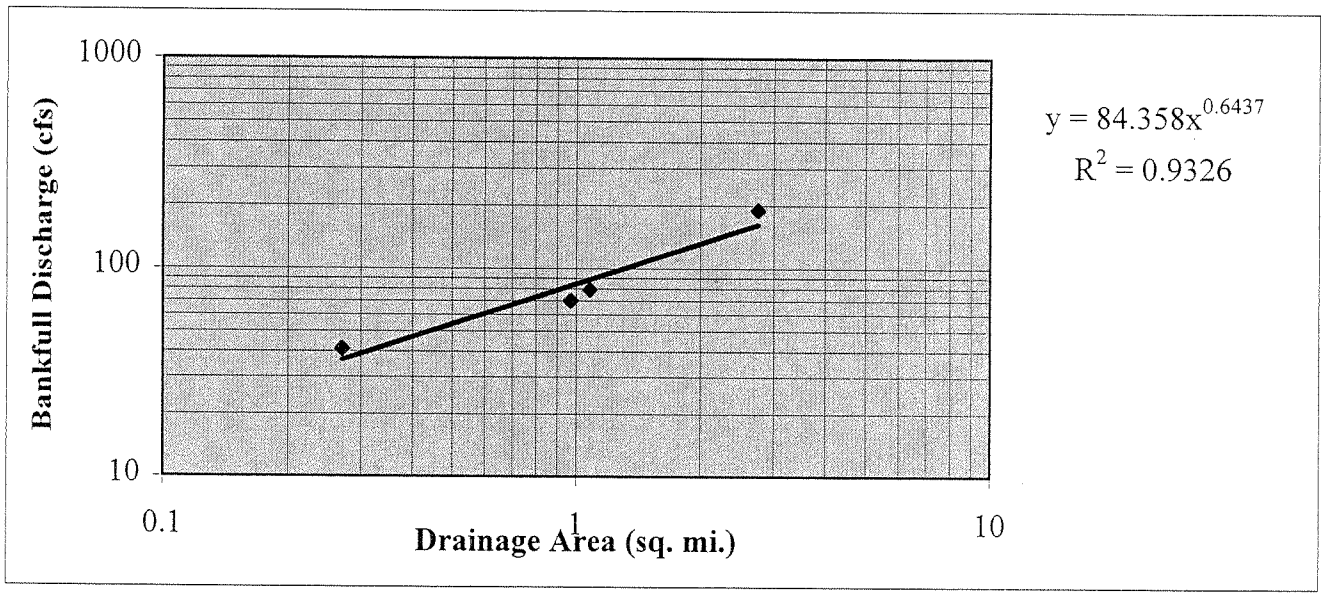
Project:	Caviness Stream Mitigation Plan
TIP No.:	U-2524WM
Comm. No:	30036C

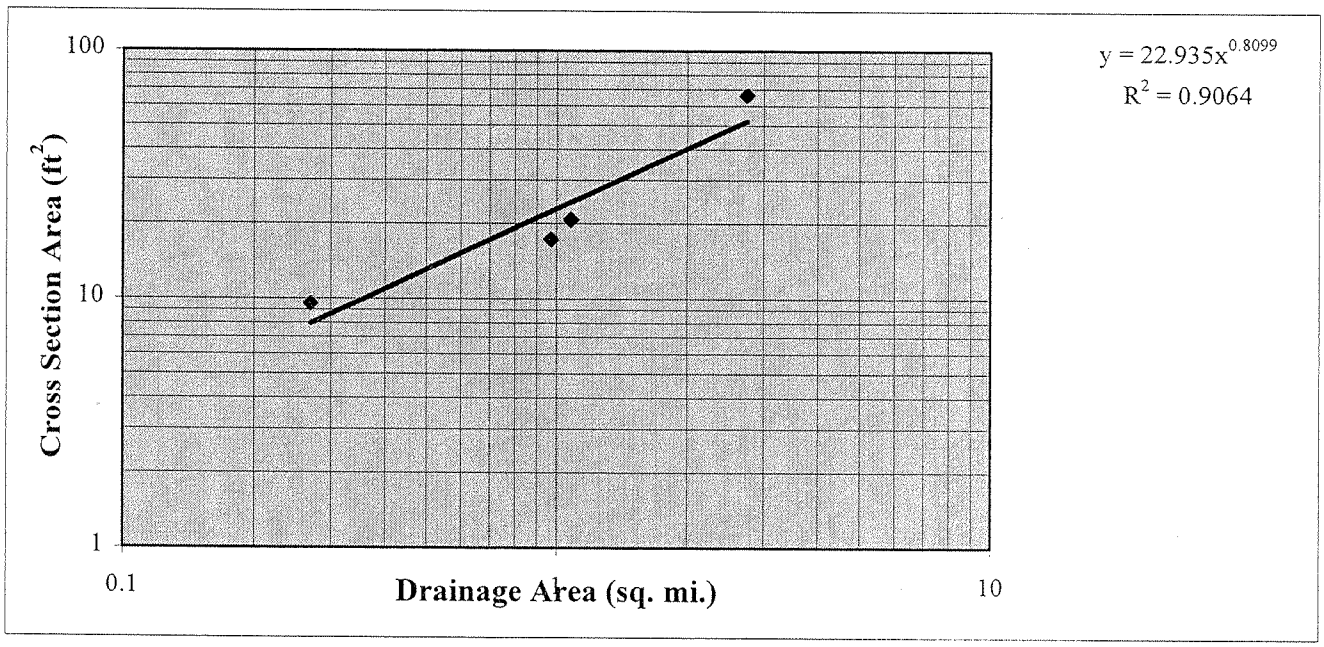
			NC Regional Curves (Rural Piedmont)			
Location	Hec-Ras Station	D.A. (mi^2)	$Area_{bkf}$ (ft^2)	$Width_{bkf}$ (ft)	$Depth_{bkf}$ (ft)	Q_{bkf} (cfs)
West Branch at Tommy Rd.	5	1.08	22.58	12.29	1.54	94.11
West Branch at Tibbs Run	2	1.13	23.29	12.53	1.56	97.23
Tibbs Run @ N. Prop Line	9	2	34.33	16.02	1.87	146.67
Tibbs Run at NC 42	1	3.31	48.36	19.89	2.20	210.80
Tibbs Run & West Branch	2	3.25	47.76	19.74	2.19	208.04
Tibbs Run At XS C-5	5	2.12	35.72	16.43	1.91	152.95

			Local Reach Curves			
Location	Hec-Ras Station	D.A. (mi^2)	$Area_{bkf}$ (ft^2)	$Width_{bkf}$ (ft)	$Depth_{bkf}$ (ft)	Q_{bkf} (cfs)
West Branch at Tommy Rd.	5	1.08	24.41	13.10	1.86	88.64
West Branch at Tibbs Run	2	1.13	25.32	13.41	1.89	91.26
Tibbs Run @ N. Prop Line	9	2	40.21	18.07	2.22	131.80
Tibbs Run at NC 42	1	3.31	60.47	23.51	2.57	182.28
Tibbs Run & West Branch	2	3.25	59.58	23.29	2.56	180.15
Tibbs Run At XS C-5	5	2.12	42.15	18.63	2.26	136.83

			USGS Regression Equations (Piedmont)			
Location	Hec-Ras Station	D.A. (mi^2)	Q_5 (cfs)	Q_{10} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)
West Branch at Tommy Rd.	5	1.08	261.16	359.74	652.85	811.70
West Branch at Tibbs Run	2	1.13	269.23	370.59	671.70	834.73
Tibbs Run @ N. Prop Line	9	2	395.13	539.27	961.92	1187.89
Tibbs Run at NC 42	1	3.31	554.34	750.85	1320.57	1621.79

Site	DA (mi^2)	Q (cfs)	A (ft^2)	W (ft)	D (ft)
N. Branch of Deaton	0.27	41	9.53	7.25	1.31
W. Branch of Tibbs Run	1.08	79	20.7	9.65	2.15
Mud Lick Creek	2.75	190	66.19	25.9	2.55
Tributary to Sandy Creek	0.97	70	17.29	12.14	1.42





APPENDIX D

SEDIMENT TRANSPORT CALCULATIONS

Sediment Transport: Reference Section Calculations

Project:	Caviness Mitigation Site
Stream:	Tibbs Run
Date:	05/14/2001
Reach:	TR-1
$A_{X\text{-}Sect}$ =	40.7 sq. ft.
W_{Bkf} =	13.0 ft.
D_{Mean} = A/W =	3.12 ft.
W/D :	4.2
S_{WS} =	0.0030 ft./ft.
V =	4.5 fps
P =	19.23 ft.
R = A/P =	2.116 ft.
$\tau_c = \gamma S_{WS} R$ =	0.40 lb/ft^2
Particle Range =	18 - 86 mm
Stream Power =	1.78 lb/ft-s

Stream:	Tibbs Run
Reach:	TR-6
$A_{X\text{-}Sect}$ =	39.2 sq. ft.
W_{Bkf} =	13.0 ft.
D_{Mean} = A/W =	3.02 ft.
W/D :	4.3
S_{WS} =	0.0030 ft./ft.
V =	3.4 fps
P =	19.0 ft.
R = A/P =	2.063 ft.
$\tau_c = \gamma S_{WS} R$ =	0.39 lb/ft^2
Particle Range =	18 - 83 mm
Stream Power =	1.30 lb/ft-s

Stream:	West Branch of Tibbs Run
Reach:	WB-7
$A_{X\text{-}Sect}$ =	20.7 sq. ft.
W_{Bkf} =	9.7 ft.
D_{Mean} = A/W =	2.15 ft.
W/D :	9
S_{WS} =	0.0037 ft./ft.
V =	3.8 fps
P =	13.93 ft.
R = A/P =	1.486 ft.
$\tau_c = \gamma S_{WS} R$ =	0.34 lb/ft^2
Particle Range =	16 - 73 mm
Stream Power =	1.30 lb/ft-s

Sediment Transport Validation

Project:	Caviness Mitigation Site
Stream:	Tibbs Run
Date:	05/11/2001
Reach:	TR1 to TR2

Q_{Bkf} :	180 cfs
W/D_{Design} :	10
Side Slopes :	2
Manning's n :	0.038
S_{Valley} =	0.004 ft./ft.
Sinuosity =	1.2

$S_{WS} = S_{valley}/Sin.$ =	0.0033 ft./ft.
V =	3.7 fps
$A_{X\text{-}Sect} = Q/V$ =	48.9 sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	22.1 ft.
$D_{Mean} = A/W$ =	2.21 ft.
$D_{Avg.\ Bot.}$ =	3.06 ft.
P =	23.55 ft.
R = A/P =	2.075 ft.

$\tau_c = \gamma S_{WS} R$ =	0.43 lb/ft^2
Particle Range =	20 - 94 mm
Stream Power =	1.59 lb/ft-s

Sediment Transport Validation

Project:	Caviness Mitigation Site
Stream:	Tibbs Run
Date:	05/11/2001
Reach:	TR3 to TR5

Q_{Bkf} :	137	cfs
W/D_{Design} :	10	
Side Slopes :	2	
Manning's n :	0.038	
S_{Valley} =	0.004	ft./ft.
Sinuosity =	1.2	

$S_{WS} = S_{valley}/Sin.$ =	0.0033	ft./ft.
V =	3.4	fps
$A_{X\text{-}Sect} = Q/V$ =	39.8	sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	20.0	ft.
$D_{Mean} = A/W$ =	2.00	ft.
$D_{Avg.\ Bot.}$ =	2.76	ft.
P =	21.26	ft.
R = A/P =	1.873	ft.

$\tau_c = \gamma S_{WS} R$ =	0.39	lb/ft^2
Particle Range =	18 - 84	mm
Stream Power =	1.34	lb/ft-s

Sediment Transport Validation

Project:	Caviness Mitigation Site
Stream:	Tibbs Run
Date:	05/11/2001
Reach:	TR6 to TR9

Q_{Bkf} :	132	cfs
W/D_{Design} :	7	
Side Slopes :	1	
Manning's n :	0.038	
S_{Valley} =	0.0035	ft./ft.
Sinuosity =	1.2	

$S_{WS} = S_{valley}/Sin.$ =	0.0029	ft./ft.
V =	3.4	fps
$A_{X\text{-}Sect} = Q/V$ =	38.6	sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	16.4	ft.
$D_{Mean} = A/W$ =	2.35	ft.
$D_{Avg.\ Bot.}$ =	2.84	ft.
P =	18.78	ft.
R = A/P =	2.054	ft.

$\tau_c = \gamma S_{WS} R$ =	0.37	lb/ft^2
Particle Range =	17 - 80	mm
Stream Power =	1.28	lb/ft-s

Sediment Transport Validation

Project:	Caviness Mitigation Site
Stream:	West Branch
Date:	05/11/2001
Reach:	WB1 to WB5

Q_{Bkf} :	91	cfs
W/D_{Design} :	10	
Side Slopes :	1.5	
Manning's n :	0.038	
S_{Valley} =	0.0043	ft./ft.
Sinuosity =	1.2	

$S_{WS} = S_{valley}/Sin.$ =	0.0036	ft./ft.
V =	3.2	fps
$A_{X\text{-}Sect} = Q/V$ =	28.6	sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	16.9	ft.
$D_{Mean} = A/W$ =	1.69	ft.
$D_{Avg.\ Bot.}$ =	2.07	ft.
P =	18.18	ft.
R = A/P =	1.575	ft.

$\tau_c = \gamma S_{WS} R$ =	0.35	lb/ft^2
Particle Range =	16 - 75	mm
Stream Power =	1.12	lb/ft-s

APPENDIX E

HEC-RAS ANALYSIS

EXISTING

Existing Tibbs Run

HEC-RAS Plan: caviness spi River: caviness Reach: main

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
main	9	Bankfull	131.80	468.87	472.67	471.41	472.92	0.003908	4.04	40.24	142.19	0.42
main	9	10-yr	539.00	468.87	474.17	473.52	474.31	0.002802	4.55	404.31	265.30	0.39
main	9	50-yr	962.00	468.87	475.06	474.03	475.19	0.002609	4.97	652.20	294.15	0.38
main	9	100-yr	1188.00	468.87	475.53	474.22	475.65	0.002316	4.96	795.25	306.22	0.37
main	8	Bankfull	131.80	468.93	472.34		472.44	0.001603	2.73	84.10	146.98	0.29
main	8	10-yr	539.00	468.93	473.65		473.83	0.002618	4.53	357.31	239.15	0.40
main	8	50-yr	962.00	468.93	474.57		474.74	0.002441	5.01	584.36	251.59	0.40
main	8	100-yr	1188.00	468.93	475.11		475.27	0.002087	4.96	721.85	256.12	0.37
main	7	Bankfull	131.80	468.04	471.90	470.19	472.01	0.001696	2.64	52.43	242.01	0.29
main	7	10-yr	539.00	468.04	473.37	472.20	473.43	0.001007	2.75	568.00	277.01	0.24
main	7	50-yr	962.00	468.04	474.26	472.53	474.33	0.001157	3.37	821.74	293.60	0.27
main	7	100-yr	1188.00	468.04	474.84	472.71	474.91	0.001028	3.43	995.32	304.43	0.26
main	6	Bankfull	131.80	467.47	471.43	469.56	471.59	0.002428	3.22	41.51	91.78	0.32
main	6	10-yr	539.00	467.47	472.74	472.18	473.05	0.004729	5.66	248.12	159.59	0.47
main	6	50-yr	962.00	467.47	473.48	472.91	473.89	0.006066	7.10	374.81	181.59	0.55
main	6	100-yr	1188.00	467.47	474.27	473.18	474.56	0.004153	6.45	526.20	205.10	0.46
main	5	Bankfull	136.83	466.09	470.21	468.86	470.46	0.003647	3.99	38.46	187.23	0.42
main	5	10-yr	560.00	466.09	471.07	470.66	471.29	0.004947	5.54	324.29	227.92	0.51
main	5	50-yr	998.00	466.09	472.31	471.13	472.44	0.002736	4.99	619.70	247.58	0.40
main	5	100-yr	1231.00	466.09	473.79	471.35	473.85	0.001045	3.67	1000.97	267.01	0.26
main	4	Bankfull	136.83	465.70	468.82	468.42	469.51	0.016360	6.66	20.78	37.71	0.77
main	4	10-yr	560.00	465.70	470.62	469.96	470.73	0.003392	4.43	331.61	220.68	0.39
main	4	50-yr	998.00	465.70	472.12	470.42	472.17	0.001366	3.46	694.38	262.08	0.26
main	4	100-yr	1231.00	465.70	473.73	470.59	473.75	0.000479	2.42	1133.28	283.31	0.16
main	3	Bankfull	136.83	462.38	468.02	464.98	468.09	0.001050	2.27	98.89	134.09	0.19
main	3	10-yr	560.00	462.38	469.31	468.27	469.44	0.002336	4.04	313.66	152.75	0.30
main	3	50-yr	998.00	462.38	471.62	468.83	471.68	0.000854	3.08	695.26	172.59	0.19
main	3	100-yr	1231.00	462.38	473.51	469.13	473.55	0.000410	2.47	1032.05	183.95	0.14
main	2	Bankfull	180.15	461.91	467.83	464.86	467.94	0.001713	2.73	68.12	190.82	0.26
main	2	10-yr	742.00	461.91	469.03	468.29	469.17	0.002702	4.17	399.81	243.10	0.34
main	2	50-yr	1305.00	461.91	471.57	468.80	471.61	0.000553	2.51	1102.82	299.21	0.16
main	2	100-yr	1604.00	461.91	473.49	468.98	473.51	0.000236	1.92	1705.41	327.66	0.11
main	1.6	Bankfull	180.15	461.49	467.70	464.45	467.81	0.001516	2.61	71.10	189.43	0.24
main	1.6	10-yr	742.00	461.49	468.74	468.16	468.93	0.003369	4.59	359.20	236.91	0.37
main	1.6	50-yr	1305.00	461.49	471.53	468.66	471.56	0.000517	2.46	1126.34	300.21	0.16
main	1.6	100-yr	1604.00	461.49	473.47	468.88	473.49	0.000223	1.88	1738.81	329.02	0.11
main	1.5		Culvert									
main	1.4	Bankfull	180.15	461.60	466.16		466.46	0.006167	4.45	40.49	13.73	0.46
main	1.4	10-yr	742.00	461.60	468.68		468.93	0.004377	5.11	319.83	231.21	0.42
main	1.4	50-yr	1305.00	461.60	471.53		471.56	0.000563	2.54	1093.44	298.59	0.16
main	1.4	100-yr	1604.00	461.60	473.47		473.49	0.000237	1.92	1703.17	327.42	0.11
main	1	Bankfull	182.28	461.32	464.52		465.17	0.015094	6.45	28.25	11.37	0.72
main	1	10-yr	751.00	461.32	468.33		468.46	0.002359	4.27	436.22	259.68	0.32
main	1	50-yr	1321.00	461.32	471.48		471.50	0.000316	2.10	1430.06	351.88	0.13
main	1	100-yr	1622.00	461.32	473.45		473.47	0.000144	1.63	2157.28	385.04	0.09
main	0.7	Bankfull	182.28	460.08	463.83	462.46	464.13	0.005518	4.42	41.28	14.75	0.47
main	0.7	10-yr	751.00	460.08	468.17	465.48	468.28	0.001171	3.63	510.25	269.02	0.25
main	0.7	50-yr	1321.00	460.08	471.45	467.62	471.47	0.000216	2.03	1516.29	325.25	0.11
main	0.7	100-yr	1622.00	460.08	473.44	467.87	473.45	0.000111	1.65	2173.01	335.59	0.08
main	0.5		Culvert									
main	0.1	Bankfull	182.28	459.20	463.55	461.65	463.80	0.004286	4.03	45.22	14.18	0.40
main	0.1	10-yr	751.00	459.20	467.03	464.93	467.53	0.004287	6.19	235.78	225.60	0.44
main	0.1	50-yr	1321.00	459.20	467.95	467.54	468.40	0.004283	6.80	461.80	262.54	0.45
main	0.1	100-yr	1622.00	459.20	468.32	467.81	468.75	0.004281	7.03	559.74	273.29	0.46

Existing West Branch

HEC-RAS Plan: Caviness River: Cav. Tribb Reach: Tribb

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Tribb	7	Bankfull	88.64	471.08	473.56	472.57	473.78	0.005469	3.81	23.27	11.92	0.45
Tribb	7	10-yr	360.00	471.08	475.86	474.91	475.93	0.001538	3.19	391.94	263.06	0.26
Tribb	7	50-yr	653.00	471.08	477.94	475.39	477.96	0.000423	2.15	1038.14	341.86	0.15
Tribb	7	100-yr	812.00	471.08	478.31	475.59	478.33	0.000472	2.35	1165.63	348.87	0.16
Tribb	6	Bankfull	88.64	469.99	473.23		473.38	0.002847	3.13	29.65	14.23	0.34
Tribb	6	10-yr	360.00	469.99	475.60		475.75	0.002159	4.01	268.44	168.90	0.32
Tribb	6	50-yr	653.00	469.99	477.85		477.91	0.000692	2.92	733.88	224.82	0.19
Tribb	6	100-yr	812.00	469.99	478.21		478.27	0.000800	3.25	814.06	226.03	0.21
Tribb	5.6	Bankfull	88.64	469.91	472.10	471.40	472.40	0.008179	4.36	20.32	10.19	0.54
Tribb	5.6	10-yr	360.00	469.91	475.50	473.72	475.52	0.000508	2.04	620.11	306.09	0.16
Tribb	5.6	50-yr	653.00	469.91	477.82	474.21	477.83	0.000179	1.54	1407.19	361.79	0.10
Tribb	5.6	100-yr	812.00	469.91	478.17	474.42	478.18	0.000216	1.75	1534.29	368.40	0.11
Tribb	5.5		Culvert									
Tribb	5.4	Bankfull	88.64	469.28	472.00		472.18	0.004312	3.42	27.57	24.78	0.38
Tribb	5.4	10-yr	360.00	469.28	472.93		473.40	0.011055	6.73	129.81	186.28	0.64
Tribb	5.4	50-yr	653.00	469.28	473.54		473.86	0.008684	6.66	261.69	234.98	0.59
Tribb	5.4	100-yr	812.00	469.28	474.10		474.27	0.004618	5.30	402.35	265.17	0.44
Tribb	5	Bankfull	88.64	468.81	471.47	470.65	471.68	0.006026	3.67	24.14	99.51	0.48
Tribb	5	10-yr	360.00	468.81	472.38	472.10	472.55	0.005782	4.60	177.16	166.01	0.50
Tribb	5	50-yr	653.00	468.81	472.91	472.46	473.11	0.006275	5.42	267.99	176.40	0.54
Tribb	5	100-yr	812.00	468.81	473.83	472.62	473.93	0.002402	3.98	438.81	192.27	0.35
Tribb	4	Bankfull	88.64	467.17	469.52		470.02	0.017697	5.66	15.67	9.09	0.76
Tribb	4	10-yr	360.00	467.17	471.37		471.61	0.007148	5.33	155.96	165.90	0.51
Tribb	4	50-yr	653.00	467.17	472.18		472.35	0.004807	5.06	298.32	184.09	0.44
Tribb	4	100-yr	812.00	467.17	473.65		473.70	0.001158	3.04	596.70	223.16	0.23
Tribb	3	Bankfull	88.64	465.35	468.69		468.87	0.004028	3.32	26.72	10.87	0.37
Tribb	3	10-yr	360.00	465.35	470.75		470.91	0.003322	4.21	204.93	194.50	0.36
Tribb	3	50-yr	653.00	465.35	471.84		471.93	0.001782	3.59	431.64	217.32	0.27
Tribb	3	100-yr	812.00	465.35	473.58		473.60	0.000430	2.12	826.22	235.24	0.14
Tribb	2	Bankfull	91.26	464.27	467.49		467.79	0.008693	4.42	20.64	7.79	0.48
Tribb	2	10-yr	371.00	464.27	469.35		469.85	0.012291	6.92	135.66	188.57	0.58
Tribb	2	50-yr	672.00	464.27	471.66		471.69	0.000966	2.57	613.57	221.14	0.18
Tribb	2	100-yr	835.00	464.27	473.52		473.54	0.000299	1.68	1025.41	221.17	0.10
Tribb	1	Bankfull	91.26	463.08	466.75	465.30	466.94	0.004600	3.50	26.09	9.98	0.38
Tribb	1	10-yr	371.00	463.08	469.17	467.71	469.24	0.001695	3.00	294.94	185.47	0.24
Tribb	1	50-yr	672.00	463.08	471.60	468.68	471.62	0.000349	1.80	808.51	226.92	0.12
Tribb	1	100-yr	835.00	463.08	473.50	468.88	473.51	0.000146	1.36	1258.81	247.08	0.08

PROPOSED

Proposed Tibbs Run

HEC-RAS Plan: caviness spi River: caviness Reach: main

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
main	9	Bankfull	131.80	468.87	472.71	470.75	472.82	0.001475	2.70	55.49	150.16	0.27
main	9	10-yr	539.00	468.87	474.14	473.34	474.28	0.002038	4.08	408.59	264.12	0.34
main	9	50-yr	962.00	468.87	475.00	473.91	475.15	0.002154	4.71	648.54	292.58	0.36
main	9	100-yr	1188.00	468.87	475.45	474.13	475.59	0.002024	4.82	782.44	304.12	0.35
main	8	Bankfull	131.80	468.93	472.21	470.99	472.42	0.003394	3.71	37.21	127.50	0.41
main	8	10-yr	539.00	468.93	473.60	473.15	473.81	0.003489	5.04	338.01	237.98	0.45
main	8	50-yr	962.00	468.93	474.52	473.65	474.70	0.002977	5.36	565.58	251.28	0.43
main	8	100-yr	1188.00	468.93	475.03	473.86	475.19	0.002558	5.31	693.88	255.04	0.40
main	7	Bankfull	131.80	468.04	471.32	470.08	471.51	0.003464	3.52	37.49	113.32	0.40
main	7	10-yr	539.00	468.04	473.22	472.20	473.29	0.001314	3.11	523.47	274.19	0.27
main	7	50-yr	962.00	468.04	474.14	472.58	474.22	0.001389	3.65	783.82	291.36	0.28
main	7	100-yr	1188.00	468.04	474.70	472.72	474.77	0.001242	3.70	947.87	301.68	0.27
main	6	Bankfull	131.80	467.47	470.52		470.73	0.004090	3.71	35.52	15.36	0.43
main	6	10-yr	539.00	467.47	472.33		472.79	0.005898	6.23	194.07	147.87	0.55
main	6	50-yr	962.00	467.47	473.01		473.66	0.007923	8.02	300.57	167.35	0.66
main	6	100-yr	1188.00	467.47	473.97		474.36	0.004378	6.76	475.37	196.23	0.50
main	5	Bankfull	136.83	466.40	469.19	468.09	469.37	0.003132	3.37	41.40	67.25	0.42
main	5	10-yr	560.00	466.40	470.64	470.21	470.96	0.004099	5.51	268.74	211.10	0.52
main	5	50-yr	998.00	466.40	472.07	470.88	472.25	0.002014	4.86	601.07	244.43	0.39
main	5	100-yr	1231.00	466.40	473.65	471.13	473.73	0.000768	3.61	1003.74	265.15	0.25
main	4	Bankfull	136.83	465.90	468.69	467.59	468.86	0.003167	3.38	41.03	55.80	0.42
main	4	10-yr	560.00	465.90	470.21	469.67	470.42	0.002922	4.71	279.68	206.22	0.44
main	4	50-yr	998.00	465.90	471.94	470.21	472.03	0.001007	3.61	684.89	258.93	0.28
main	4	100-yr	1231.00	465.90	473.61	470.47	473.65	0.000367	2.62	1137.55	281.84	0.17
main	3	Bankfull	136.83	464.10	466.82		467.01	0.003523	3.50	39.09	19.82	0.44
main	3	10-yr	560.00	464.10	468.95		469.15	0.002077	4.37	280.08	147.66	0.38
main	3	50-yr	998.00	464.10	471.56		471.64	0.000596	3.25	704.24	172.23	0.22
main	3	100-yr	1231.00	464.10	473.43		473.48	0.000302	2.73	1036.48	183.47	0.16
main	2	Bankfull	180.15	463.30	466.37		466.58	0.003297	3.67	49.34	42.72	0.43
main	2	10-yr	742.00	463.30	468.61		468.87	0.002445	5.02	340.95	228.79	0.42
main	2	50-yr	1305.00	463.30	471.53		471.58	0.000408	2.87	1131.63	298.62	0.19
main	2	100-yr	1604.00	463.30	473.42		473.45	0.000191	2.29	1723.24	326.63	0.13
main	1	Bankfull	182.28	461.97	464.07		464.66	0.013944	6.15	29.66	18.32	0.85
main	1	10-yr	751.00	461.97	468.22		468.37	0.001116	3.86	473.01	255.59	0.29
main	1	50-yr	1321.00	461.97	471.46		471.50	0.000215	2.32	1486.43	351.57	0.14
main	1	100-yr	1622.00	461.97	473.39		473.41	0.000110	1.89	2194.94	383.93	0.10
main	.7	Bankfull	182.28	460.61	464.02	462.21	464.13	0.001246	2.67	78.97	45.25	0.28
main	.7	10-yr	751.00	460.61	468.24	464.46	468.28	0.000258	2.21	878.88	311.02	0.15
main	.7	50-yr	1321.00	460.61	471.46	466.20	471.47	0.000093	1.70	1993.78	374.34	0.09
main	.7	100-yr	1622.00	460.61	473.39	466.52	473.40	0.000058	1.50	2746.48	406.72	0.08
main	0.5		Culvert									
main	0.1	Bankfull	182.28	459.20	463.55	461.65	463.80	0.004286	4.03	45.22	14.18	0.40
main	0.1	10-yr	751.00	459.20	467.03	464.93	467.53	0.004287	6.19	235.78	225.60	0.44
main	0.1	50-yr	1321.00	459.20	467.95	467.54	468.40	0.004283	6.80	461.80	262.54	0.45
main	0.1	100-yr	1622.00	459.20	468.32	467.81	468.75	0.004281	7.03	559.74	273.29	0.46

Proposed West Branch

HEC-RAS Plan: Caviness River: Cav. Tribb Reach: Tribb

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Tribb	7	Bankfull	88.64	471.08	473.60	472.57	473.82	0.005134	3.74	23.77	13.95	0.43
Tribb	7	10-yr	360.00	471.08	475.92	474.91	475.98	0.001415	3.08	406.22	265.95	0.25
Tribb	7	50-yr	653.00	471.08	477.93	475.39	477.95	0.000427	2.16	1034.24	341.64	0.15
Tribb	7	100-yr	812.00	471.08	478.30	475.60	478.33	0.000474	2.36	1163.80	348.77	0.16
Tribb	6	Bankfull	88.64	469.99	473.31	471.84	473.45	0.002604	3.03	30.80	17.37	0.33
Tribb	6	10-yr	360.00	469.99	475.68		475.82	0.001960	3.86	281.75	171.95	0.31
Tribb	6	50-yr	653.00	469.99	477.84		477.89	0.000699	2.93	731.10	224.78	0.19
Tribb	6	100-yr	812.00	469.99	478.20		478.26	0.000804	3.25	812.78	226.01	0.21
Tribb	5.6	Bankfull	88.64	469.91	471.42	471.40	472.09	0.027268	6.55	13.54	9.81	0.98
Tribb	5.6	10-yr	360.00	469.91	475.59	473.72	475.61	0.000457	1.96	647.53	310.86	0.15
Tribb	5.6	50-yr	653.00	469.91	477.81	474.21	477.82	0.000181	1.55	1402.63	361.55	0.10
Tribb	5.6	100-yr	812.00	469.91	478.16	474.42	478.17	0.000217	1.75	1532.13	368.29	0.11
Tribb	5.5		Culvert									
Tribb	5.4	Bankfull	88.64	469.28	471.44		471.74	0.009435	4.43	20.00	10.17	0.56
Tribb	5.4	10-yr	360.00	469.28	473.33	472.99	473.49	0.004230	4.48	213.32	223.66	0.40
Tribb	5.4	50-yr	653.00	469.28	473.42	473.42	473.85	0.011422	7.48	232.75	228.28	0.67
Tribb	5.4	100-yr	812.00	469.28	473.96		474.17	0.005925	5.88	364.89	257.48	0.49
Tribb	5	Bankfull	88.64	469.00	470.70	470.21	470.94	0.006811	3.93	22.58	15.80	0.58
Tribb	5	10-yr	360.00	469.00	471.88	471.88	472.75	0.012897	7.80	59.80	154.78	0.87
Tribb	5	50-yr	653.00	469.00	472.57	472.32	472.90	0.006047	6.28	243.77	170.58	0.62
Tribb	5	100-yr	812.00	469.00	473.73	472.50	473.85	0.001777	4.19	454.31	190.54	0.35
Tribb	4	Bankfull	88.64	467.90	469.97	469.11	470.12	0.003434	3.10	28.61	66.60	0.42
Tribb	4	10-yr	360.00	467.90	471.17	470.80	471.42	0.004216	4.91	156.60	150.57	0.51
Tribb	4	50-yr	653.00	467.90	472.04	471.37	472.25	0.003134	5.04	304.04	180.80	0.46
Tribb	4	100-yr	812.00	467.90	473.61	471.59	473.68	0.000789	3.20	620.04	222.00	0.24
Tribb	3	Bankfull	88.64	467.30	469.40	468.51	469.55	0.003215	3.04	29.83	55.00	0.41
Tribb	3	10-yr	360.00	467.30	470.61	470.26	470.80	0.003370	4.43	196.29	191.46	0.46
Tribb	3	50-yr	653.00	467.30	471.79	470.72	471.89	0.001484	3.69	438.39	216.44	0.32
Tribb	3	100-yr	812.00	467.30	473.56	470.90	473.59	0.000356	2.29	840.54	235.12	0.17
Tribb	2	Bankfull	91.26	466.50	467.95		468.32	0.012598	4.88	18.69	15.05	0.77
Tribb	2	10-yr	371.00	466.50	469.40	469.40	469.81	0.007839	6.11	146.73	189.46	0.68
Tribb	2	50-yr	672.00	466.50	471.64		471.69	0.000753	2.89	609.00	221.14	0.23
Tribb	2	100-yr	835.00	466.50	473.52		473.54	0.000237	2.03	1024.69	221.17	0.14
Tribb	1	Bankfull	91.26	464.80	467.93	466.03	467.97	0.000583	1.77	69.86	143.13	0.19
Tribb	1	10-yr	371.00	464.80	469.17	467.70	469.23	0.000883	2.79	333.24	185.47	0.25
Tribb	1	50-yr	672.00	464.80	471.60	468.44	471.62	0.000240	2.00	846.81	226.92	0.14
Tribb	1	100-yr	835.00	464.80	473.50	468.65	473.51	0.000109	1.60	1297.10	247.08	0.10

APPENDIX F

MACROINVERTEBRATE SURVEY DATA

Benthic Macroinvertebrates Rating Tables

DWQ Rating Scale for EPT Taxa Richness in the Piedmont Region

EPT Taxa Richness	Water Quality Rating
>27	Excellent
21-27	Good
14-20	Good-Fair
7-13	Fair
0-6	Poor

(NCDENR, 1997)

Hilsenhoff Family-Level Biotic Index Rating Scale

Family Biotic Index	Water Quality Rating	Degree of Organic Pollution
0.00-3.75	Excellent	Organic pollution unlikely
3.76-4.25	Very Good	Possible slight organic pollution
4.26-5.00	Good	Some organic pollution probable
5.01-5.75	Fair	Fairly substantial pollution likely
5.76-6.50	Fairly poor	Substantial pollution likely
6.51-7.25	Poor	Very substantial pollution likely
7.26-10.00	Very poor	Severe organic pollution likely

(Hilsenhoff, 1988)

Caviness Mitigation Site Macroinvertebrate Biotic Index

Order	Family	# Individuals (xi)	Tolerance Value (ti)	xi*ti	xi*ti / N
Coleoptera	Dytiscidae	3	5	15	0.04573
	Elmidae	13	4	52	0.15854
	Hydrophilidae	9	5	45	0.1372
Decapoda	Cambaridae	1	6	6	0.01829
Diptera	Ceratopogonidae	1	6	6	0.01829
	Chironomidae	46	6	276	0.84146
	Culicidae	3	8	24	0.07317
	Tabanidae	1	8	8	0.02439
	Tipulidae	14	3	42	0.12805
Ephemeroptera	Baetidae	23	4	92	0.28049
	Ephemeridae	1	4	4	0.0122
	Heptageniidae	10	4	40	0.12195
Gastropoda	Physidae	1	8	8	0.02439
	Planorbidae	1	7	7	0.02134
Hemiptera	Gerridae	2	5	10	0.03049
Megaloptera	Corydalidae	107	0	0	0
	Sialidae	3	7.4	22.2	0.06768
Odonata	Aeshnidae	2	3	6	0.01829
	Coenagrionidae	5	9	45	0.1372
	Gomphidae	4	1	4	0.0122
Oligochaeta	Lumbriculidae	6	7.3	43.8	0.13354
Pelecypoda	Corbicula	1	6.3	6.3	0.01921
Plecoptera	Perlidae	17	1	17	0.05183
Trichoptera	Limniphilidae	1	4	4	0.0122
	Hydropsychidae	53	4	212	0.64634
		328			3.03

Total #:	**328**	
Total Taxa:	**25**	
EPT #:	**105**	
EPT Taxa:	**6**	**Rating: Poor**
HBI:	**3.03**	**Rating: Excellent, organic pollution unlikely**

Benthic Macroinvertebrate Laboratory Sheet

Project Number: 30036C	Stream Name/Location: Tibbs Run, Randolph County
Client: NCDOT	River Basin: Cape Fear
Collected By: Martin Mitchell HSMM, Inc.	Date: 6/20/00
	Number Sampled: 338

* Rare: 1 to 2
Common: 3 to 9
Abundant: ≥ 10

Organisms					
Order	**Family**	**Number**	**Tolerance**	**Abundance***	**Notes**
Coleoptera	Dytiscidae	3	5	Common	larva PR
	Elmidae	8	4	Abundant	adult GC
		5			larva
	Hydrophilidae	9	5	Common	adult PR
Diptera	Ceratopogonidae	1	6	Rare	PR
	Chironomidae	46	6	Abundant	GC
	Culicidae	3	8	Common	GC
	Tabanidae	1	8	Rare	PR
	Tipulidae	14	3	Abundant	SH two species
Ephemeroptera	Baetidae	23	4	Abundant	GC
	Ephemeridae	1	4	Rare	GC
	Heptageniidae	10	4	Abundant	SC
	Oligoneuridae	2	—	Rare	—
Gastropoda	Planorbidae	1	7	Rare	SC
	Physidae	1	8	Rare	SC
Hemiptera	Gerridae	2	5	Rare	PR
Megaloptera	Corydalidae	107	0	Abundant	PR
	Sialidae	3	7.4 (Sialis)	Common	PR
Odonata	Aeshnidae	2	3	Rare	PR
	Coenagrionidae	5	9	Common	PR
	Cordulegastridae	8	—	Common	PR
	Gomphidae	4	1	Common	PR
Class: Oligochaeta	Lumbriculidae	6	8	Common	GC
Pelecypoda	Corbicula	1	6.3 (fluminea)	Rare	FC
Plecoptera	Perlidae	17	1	Abundant	PR
Trichoptera	Hydropsychidae	53	4	Abundant	FC
	Limnephilidae	1	4	Rare	SH
Decapoda	Cambaridae	1	6	Rare	SH

Total #: 338 EPT #: 107
Total Taxa: 27 EPT Taxa: 7

STREAMSIDE BIOSURVEY: HABITAT WALK

Stream Name: Tibbs Run

County: Randolph **State:** NC

Investigators: Martin Mitchell, Grant Ginn, Daren Pait

Site (description): 300 ft of stream between NC 42 culvert and old culvert under dirt farm road. This part of the stream is muddy bottom and is referred to as Mainly Muddy (MM).

Latitude: _____ **Longitude:** _____

Site or Map Number: Caviness Site (lower)

Date: 6/20/00 **Time:** 3:00

Weather in past 24 hours:

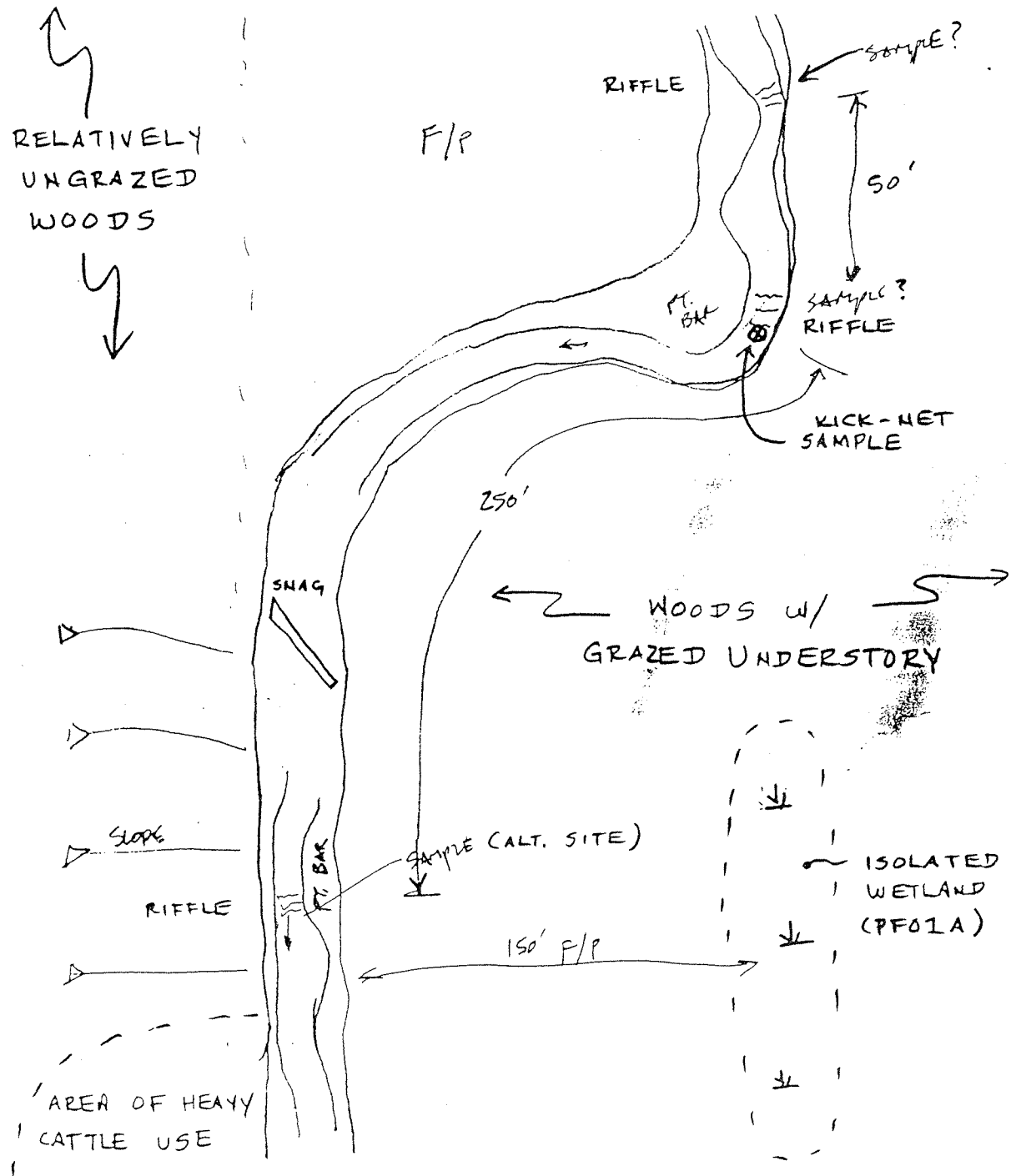
- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☒ Overcast
- ☐ Clear/Sunny

Weather now:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☒ Overcast
- ☐ Clear/Sunny

Sketch of site

On your sketch, note features that affect stream habitat, such as: riffles, runs, pools, ditches, wetlands, dams, riprap, outfalls, tributaries, landscape features, logging paths, vegetation, and roads.



PHYSICAL CHARACTERIZATION

In-Stream Characteristics

1. **Check which stream habitats are present:** Page 73
   (You can check more than 1 habitat)
   ☐ Pool(s) ☒ Riffle(s) ☒ Run(s)

2. Nature of particles in the stream bottom at site Page 73

	Percent
Silt/Clay/Mud	
Sand (up to 0.1" in diam.)	70
Gravel (0.1 - 2" in diam.)	20
Cobbles (2 - 10" in diam.)	10
Boulders (over 10" in diam.)	
Bedrock (solid)	
TOTAL	*100%*

3. **Pick the category that best describes the extent to which gravel, cobbles, and boulders on the stream bottom are embedded (sunk) in silt, sand, or mud.** Page 74
   ☒ Somewhat/not embedded (0-25%) ☐ Mostly embedded (75%)
   ☐ Halfway embedded (50%) ☐ Completely embedded (100%)

4. **Streambank sinks beneath your feet in:** Page 74
   ☒ No spots ☐ A few spots ☐ Many spots

5. **Presence of logs or large woody debris in stream:** Page 74
   ☐ None ☒ Occasional ☐ Plentiful

6. **Presence of naturally-occurring organic material (i.e., leaves and twigs, etc.) in stream:** Page 74
   ☐ None ☒ Occasional ☐ Plentiful

7. Water appearance: Page 74
   ☒ Clear ☐ Turbid ☐ Orange
   ☐ Milky ☐ Dark brown ☐ Greenish
   ☐ Foamy ☐ Oily sheen ☐ Other _____

8. Water odor: Page 74
   ☐ Sewage ☐ Fishy ☒ None
   ☐ Chlorine ☐ Rotten eggs ☐ Other _____

9. Water temperature: Page 74
   _____ °C *or* 73 °F

Streambank and Channel Characteristics

10. **(a) Approximate depth of run(s):** Page 75
    ☒ < 1 ft ☐ 1-2 ft ☐ > 2 ft
    (b) Approximate depth of pool(s):
    ☐ < 1 ft ☐ 1-2 ft ☐ > 2 ft

11. **Approximate width of stream channel:** Page 75
    6 feet ☐ measured ☒ estimated

12. **Stream velocity:** 1 ft/sec. Page 75

13. **Looking upstream (100 yds.), pick the description that best fits the shape of the stream bank and the channel.** Page 75
    (a) Stream bank:

Left		Right
☒	Vertical/undercut	☒
☐	Steeply sloping (> 30°)	☐
☐	Gradual/no slope (< 30°)	☐

    (b) Extent of artificial bank modifications:

Left		Right
☒	Bank 0-25% covered	☒
☐	Bank 25-50% covered	☐
☐	Bank 50-75% covered	☐
☐	Bank 75-100% covered	☐

    (c) Shape of the channel:
    ☐ Narrow, deep ☐ Wide, deep
    ☐ Narrow, shallow ☒ Wide, shallow

14. **Looking upstream (100 yds.), describe the streamside cover** Page 76
    (a) Along water's edge and stream bank only:

Left *(Percent)*		Right *(Percent)*
20	Trees	20
20	Bushes, shrubs	20
25	Tall grasses, ferns, etc.	25
	Lawn	
	Boulders/rocks	
35	Gravel/sand	35
	Bare soil	
	Pavement, structures	
TALS 100%		*100%*

(b) From the top of the **streambank out to 25 yards.**

Left *(Percent)*		Right *(Percent)*
30	Trees	30
20	Bushes, shrubs	20
10	Tall grasses, ferns, etc.	10
	Lawn	
	Boulders/rocks	
	Gravel/sand	
40	Bare soil	40
	Pavement, structures	
TOTALS 100%		100%

15. Pick the category that **best describes the extent to which vegetation shades the stream at your site.** Page 77

☐ 0% ☐ 25% ☐ 50% ☒ 75% ☐ 100%

16. Looking upstream, **note general conditions.** Page 77
Check "1" if present, "2" if severe problem is clearly evident.

Left 1	2		Right 1	2
		Stream Banks		
☐	☒	Natural streamside plant cover degraded	☐	☐
☒	☐	Banks collapsed/eroded	☐	☐
☐	☐	Garbage/junk adjacent to the stream	☐	☐
☐	☐	Foam or sheen on bank	☐	☐
1	2	**Stream Channel**	1	2
☐	☐	Mud, silt, or sand in or entering the stream	☐	☐
☐	☐	Garbage/junk in the stream	☐	☐
1	2	**Other**	1	2
☐	☐	Yard waste on bank (grass, clippings, etc.)	☐	☐
☒	☐	Livestock in or with unrestricted access to stream	☒	☐
☐	☐	Actively discharging pipe(s)	☐	☐
☐	☐	Other pipe(s) entering the stream	☐	☐
☐	☐	Ditches entering the stream	☐	☐

Local Watershed Characteristics

(within about 1/4 mile of the site; adjacent and upstream)

17. **Land uses in the local watershed can potentially have an impact on a stream.** Check "1" if present, "2" if clearly having an impact on the stream. Page 78

1	2		
		Residential	
☐	☐	Single-family housing	✓
☐	☐	Multifamily housing	✓
☐	☐	Lawns	✓
☐	☐	Commercial/institutional	✓
1	2	**Roads, etc.**	
☐	☐	Paved roads or bridges	✓
☐	☐	Unpaved roads	✓
1	2	**Construction underway on:**	
☐	☐	Housing development	✓
☐	☐	Commercial development	✓
☐	☐	Road bridge construction/repair	✓
1	2	**Agricultural**	
☒	☐	Grazing land	✓
☐	☐	Feeding lots or animal holding areas	✓
☐	☐	Cropland	✓
☐	☐	Inactive agricultural land/fields	✓
1	2	**Recreation**	
☐	☐	Power boating	✓
☐	☐	Golfing	✓
☐	☐	Camping	✓
☐	☐	Swimming/fishing/canoeing	✓
☐	☐	Hiking/paths	✓
1	2	**Other**	
☐	☐	Mining or gravel pits	✓
☐	☐	Logging	✓
☐	☐	Industry	✓
☐	☐	Oil and gas drilling	✓
☐	☐	Trash dump	✓
☐	☐	Landfills	✓

BIOLOGICAL CHARACTERIZATION

VISUAL BIOLOGICAL SURVEY

18. **Fish in the stream?** *(Mark all that apply)* Page 78

- ☐ No
- ☒ Yes, but rare
- ☐ Yes, abundant
- ☒ Small (1-2 in.)
- ☐ Medium (3-6 in.)
- ☐ Large (7 in. and above)

19. **Are there any barriers to fish movement?** Page 78

- ☐ Beaver dams
- ☐ Waterfalls (>1')
- ☒ None
- ☐ Dams
- ☐ Road barriers
- ☐ Other _____

20. **Aquatic plants in the stream.** *(Mark all that apply)* Page 78

- ☒ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Attached
- ☐ Free-floating
- ☐ Stream margin
- ☐ Pools
- ☐ Near riffle

21. **Extent of algae in the stream.** *(Mark all that apply)* Page 78

(a) **Are the submerged stones, twigs, or other material in the stream coated with a layer of algal "slime"?**

- ☒ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Light coating
- ☐ Heavy coating
- ☐ Brownish
- ☐ Greenish
- ☐ Other _____

(b) **Are there any filamentous (string-like) algae?**

- ☒ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Brownish
- ☐ Greenish
- ☐ Other _____

(c) **Are any detached "clumps" or "mats" of algae floating on the water's surface?**

- ☒ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Brownish
- ☐ Greenish
- ☐ Other _____

COMMENTS: *(Note changes or potential problems such as spills, new construction, type of discharging pipes)*

STREAMSIDE BIOSURVEY: MACROINVERTEBRATES

Stream Name: Tibbs Run

County: Randolph **State:** NC

Investigators: Martin Mitchell, Grant Ginn, Daren Pait

Site (description): 300 ft of stream between tree line and north property boundary. Surrounding land use is cattle grazing. This northern part of the stream is sandy bottom.

Latitude: _____ **Longitude:** _____

Site or Map Number: Caviness Site (upper)

Date: 6/20/00 **Time:** 4:00 P.M.

Samples taken in this section of the stream are labled Main Sandy (MS).

Weather in past 24 hours:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☒ Overcast
- ☐ Clear/Sunny

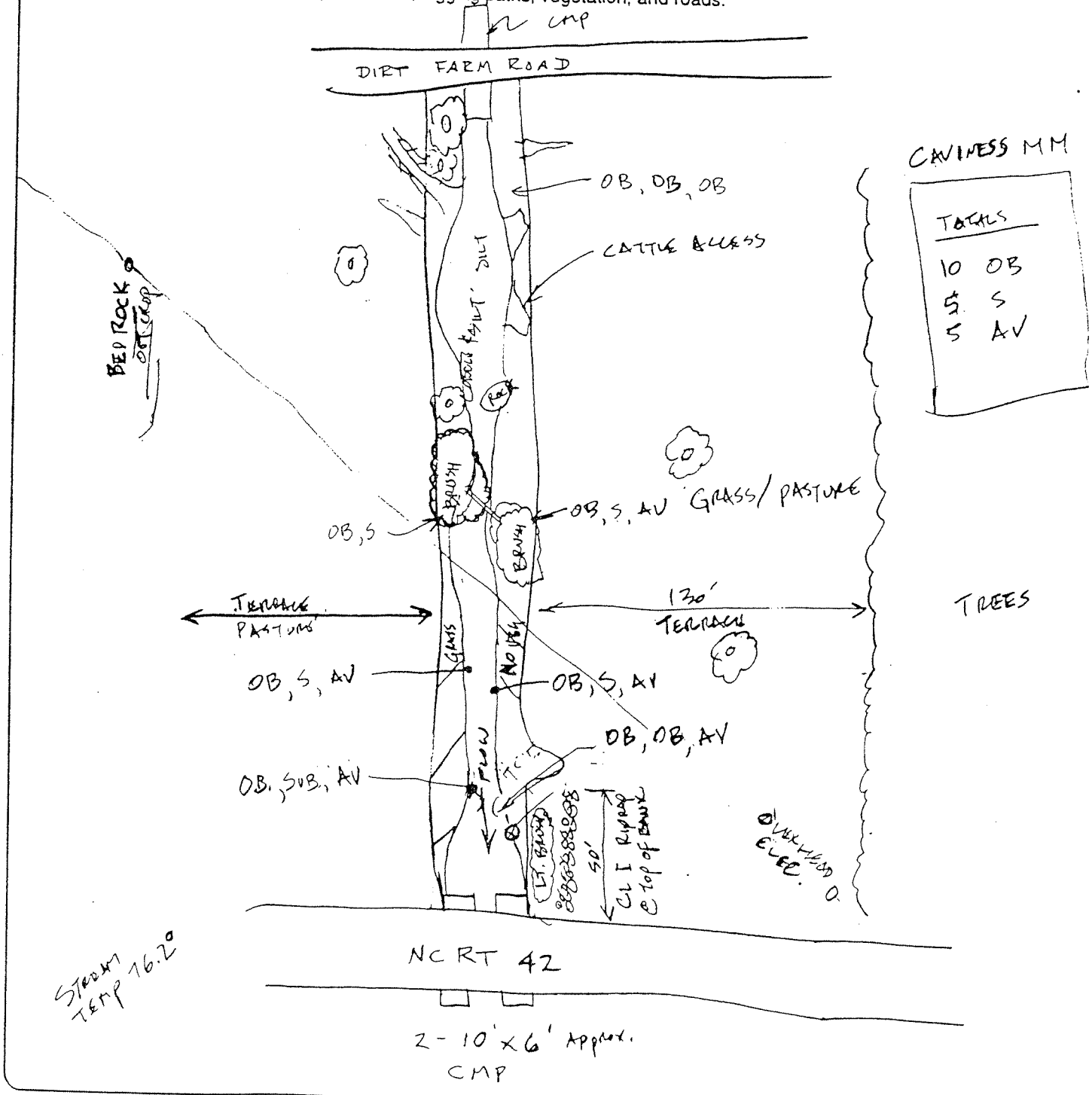
Weather now:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☒ Overcast
- ☐ Clear/Sunny

OB = OVERHEAD P
AV = AQUATIC V
SUB = BED

Sketch of site

On your sketch, note features that affect stream habitat, such as: riffles, runs, pools, ditches, wetlands, dams, riprap, outfalls, tributaries, landscape features, logging paths, vegetation, and roads.



PHYSICAL CHARACTERIZATION

In-Stream Characteristics

1. **Check which stream habitats are present:** Page 73
   (You can check more than 1 habitat)
   ☐ Pool(s) ☐ Riffle(s) ☒ Run(s)

2. **Nature of particles in the stream bottom at site** Page 73

	Percent
Silt/Clay/Mud	80
Sand (up to 0.1" in diam.)	
Gravel (0.1 - 2" in diam.)	
Cobbles (2 - 10" in diam.)	20
Boulders (over 10" in diam.)	
Bedrock (solid)	
TOTAL	*100%*

3. **Pick the category that best describes the extent to which gravel, cobbles, and boulders on the stream bottom are embedded (sunk) in silt, sand, or mud.** Page 74
   ☐ Somewhat/not embedded (0-25%) ☑ Mostly embedded (75%)
   ☐ Halfway embedded (50%) ☐ Completely embedded (100%)

4. **Streambank sinks beneath your feet in:** Page 74
   ☑ No spots ☐ A few spots ☐ Many spots

5. **Presence of logs or large woody debris in stream:** Page 74
   ☐ None ☒ Occasional ☐ Plentiful

6. **Presence of naturally-occurring organic material (i.e., leaves and twigs, etc.) in stream:** Page 74
   ☐ None ☒ Occasional ☐ Plentiful

7. **Water appearance:** Page 74
   ☐ Clear ☒ Turbid ☐ Orange
   ☐ Milky ☐ Dark brown ☐ Greenish
   ☐ Foamy ☐ Oily sheen ☐ Other _____

8. **Water odor:** Page 74
   ☐ Sewage ☐ Fishy ☒ None
   ☐ Chlorine ☐ Rotten eggs ☐ Other _____

9. **Water temperature:** Page 74
   _____ °C *or* 76.2 °F

Streambank and Channel Characteristics

10. **(a) Approximate depth of run(s):** Page 75
    ☒ < 1 ft ☐ 1-2 ft ☐ > 2 ft
    (b) Approximate depth of pool(s):
    ☒ < 1 ft ☐ 1-2 ft ☐ > 2 ft

11. **Approximate width of stream channel:** Page 75
    6 feet ☐ measured ☒ estimated

12. **Stream velocity:** 1 ft/sec. Page 75

13. **Looking upstream (100 yds.), pick the description that best fits the shape of the stream bank and the channel.** Page 75
    (a) Stream bank:

Left		Right
☒	Vertical/undercut	☒
☐	Steeply sloping (> 30°)	☐
☐	Gradual/no slope (< 30°)	☐

    (b) Extent of artificial bank modifications:

Left		Right
☒	Bank 0-25% covered	☒
☐	Bank 25-50% covered	☐
☐	Bank 50-75% covered	☐
☐	Bank 75-100% covered	☐

    (c) Shape of the channel:
    ☒ Narrow, deep ☐ Wide, deep
    ☐ Narrow, shallow ☐ Wide, shallow

14. **Looking upstream (100 yds.), describe the streamside cover** Page 76
    (a) Along water's edge and stream bank only:

Left *(Percent)*		Right *(Percent)*
20	Trees	20
40	Bushes, shrubs	40
20	Tall grasses, ferns, etc.	20
20	Lawn	20
	Boulders/rocks	
	Gravel/sand	
	Bare soil	
	Pavement, structures	
TOTALS 100%		100%

(b) From the top of the **streambank out to 25 yards.**

Left *(Percent)*		Right *(Percent)*
25	Trees	10
20	Bushes, shrubs	10
20	Tall grasses, ferns, etc.	10
35	Lawn / PASTURE	70
	Boulders/rocks	
	Gravel/sand	
	Bare soil	
	Pavement, structures	
TOTALS 100%		100%

15. Pick the category that **best describes the extent to which vegetation shades the stream at your site.** Page 77

☐ 0% ☒ 25% ☐ 50% ☐ 75% ☐ 100%

16. **Looking upstream, note general conditions.** Page 77
Check "1" if present, "2" if severe problem is clearly evident.

Left 1	Left 2		Right 1	Right 2
		Stream Banks		
☒	☐	Natural streamside plant cover degraded	☒	☐
☒	☐	Banks collapsed/eroded	☒	☐
☐	☐	Garbage/junk adjacent to the stream ✓	☐	☐
☐	☐	Foam or sheen on bank ✓	☐	☐
		Stream Channel		
☐	☒	Mud, silt, or sand in or entering the stream	☐	☒
☐	☐	Garbage/junk in the stream ✓	☐	☐
		Other		
☐	☐	Yard waste on bank (grass, clippings, etc.) ✓	☐	☐
☐	☒	Livestock in or with unrestricted access to stream	☐	☒
☐	☐	Actively discharging pipe(s) ✓	☐	☐
☐	☐	Other pipe(s) entering the stream ✓	☐	☐
☒	☐	Ditches entering the stream	☐	☐

Local Watershed Characteristics

(within about 1/4 mile of the site; adjacent and upstream)

17. **Land uses in the local watershed can potentially have an impact on a stream.** Check "1" if present, "2" if clearly having an impact on the stream. Page 78

1	2	
		Residential
☐	☐	Single-family housing ✓
☐	☐	Multifamily housing ✓
☐	☐	Lawns ✓
☐	☐	Commercial/institutional ✓
		Roads, etc.
☒	☐	Paved roads or bridges
☒	☐	Unpaved roads
		Construction underway on:
☐	☐	Housing development ✓
☐	☐	Commercial development
☐	☐	Road bridge construction/repair
		Agricultural
☐	☒	Grazing land
☒	☐	Feeding lots or animal holding areas
☐	☐	Cropland ✓
☐	☐	Inactive agricultural land/fields ✓
		Recreation
☐	☐	Power boating ✓
☐	☐	Golfing ✓
☐	☐	Camping ✓
☐	☐	Swimming/fishing/canoeing ✓
☐	☐	Hiking/paths ✓
		Other
☐	☐	Mining or gravel pits ✓
☐	☐	Logging ✓
☐	☐	Industry ✓
☐	☐	Oil and gas drilling ✓
☐	☐	Trash dump ✓
☐	☐	Landfills ✓

BIOLOGICAL CHARACTERIZATION

VISUAL BIOLOGICAL SURVEY

18. **Fish in the stream?** *(Mark all that apply)* Page 78

☒ No ☐ Yes, but rare ☐ Yes, abundant

☐ Small (1-2 in.) ☐ Medium (3-6 in.) ☐ Large (7 in. and above)

19. **Are there any barriers to fish movement?** N/A Page 78

☐ Beaver dams ☐ Waterfalls (>1') ☒ None

☐ Dams ☐ Road barriers ☐ Other _____

20. **Aquatic plants in the stream.** *(Mark all that apply)* Page 78

☐ None ☒ Occasional ☐ Plentiful

☐ Attached ☐ Free-floating

☐ Stream margin ☐ Pools ☐ Near riffle

21. Extent of algae in the **stream.** *(Mark all that apply)* Page 78

(a) **Are the submerged stones, twigs, or other material in the stream coated with a layer of algal "slime"?**

☐ None ☐ Occasional ☐ Plentiful

☒ Light coating ☐ Heavy coating

☐ Brownish ☐ Greenish ☐ Other _____

(b) **Are there any filamentous (string-like) algae?**

☐ None ☒ Occasional ☐ Plentiful

☐ Brownish ☐ Greenish ☐ Other _____

(c) **Are any detached "clumps" or "mats" of algae floating on the water's surface?**

☐ None ☒ Occasional ☐ Plentiful

☐ Brownish ☐ Greenish ☐ Other _____

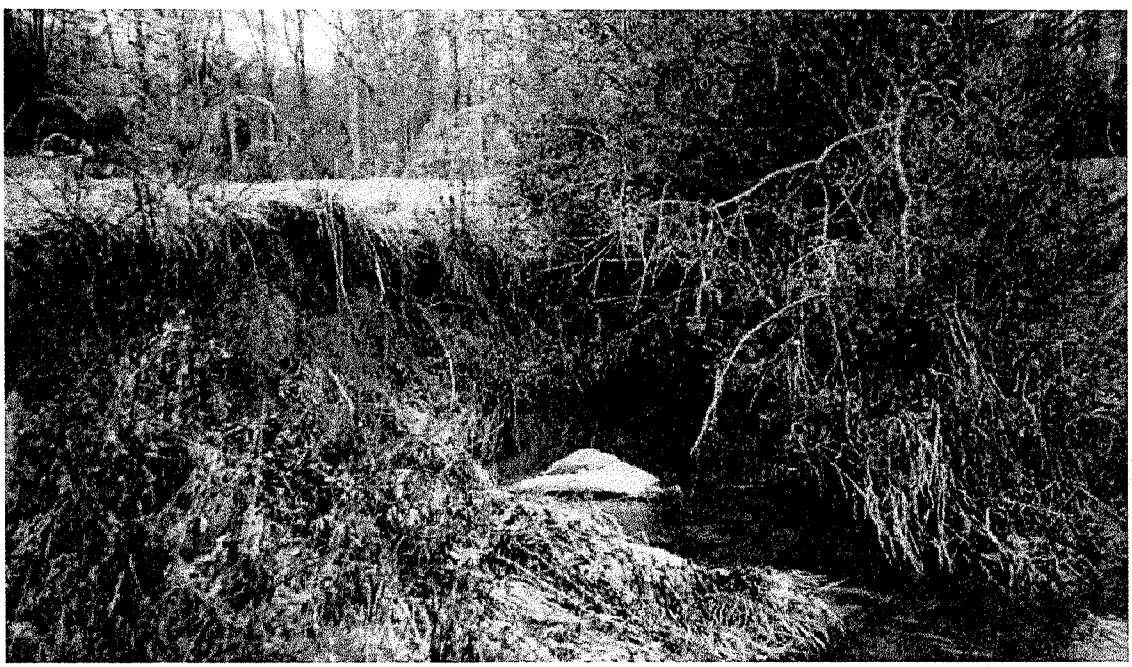
COMMENTS: *(Note changes or potential problems such as spills, new construction, type of discharging pipes)*

APPENDIX G

PHOTOGRAPHS

Caviness Mitigation Site Photographs

Photograph 1. Tibbs Run – Downstream of Section TR1



Photograph 2. Tibbs Run – Downstream of Section TR1

Photograph 3. Tibbs Run – Section TR2

Photograph 4. Tibbs Run – Section TR3

Photograph 5. Tibbs Run – Section TR4

Photograph 6. Tibbs Run – Section TR6

Photograph 7. Tibbs Run – Section TR7

Photograph 8. Tibbs Run – Section TR8

Photograph 9. West Branch of Tibbs Run – Section WB5

Photograph 10. West Branch of Tibbs Run – WB4

Photograph 11. West Branch of Tibbs Run – Section WB3

Photograph 12. West Branch of Tibbs Run – Section WB2

Photograph 13. Confluence of Tibbs Run and West Branch