STREAM MITIGATION PLAN

DEATON SITE
RANDOLPH COUNTY, NORTH CAROLINA

STATE PROJECT NUMBER: 8.U492107
TIP NUMBER: U-2524WM

Prepared for:

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND ENVIRONMENTAL
ANALYSIS BRANCH
RALEIGH, NORTH CAROLINA

May 22,2001

TABLE OF CONTENTS

1.0 INTRODUCTION

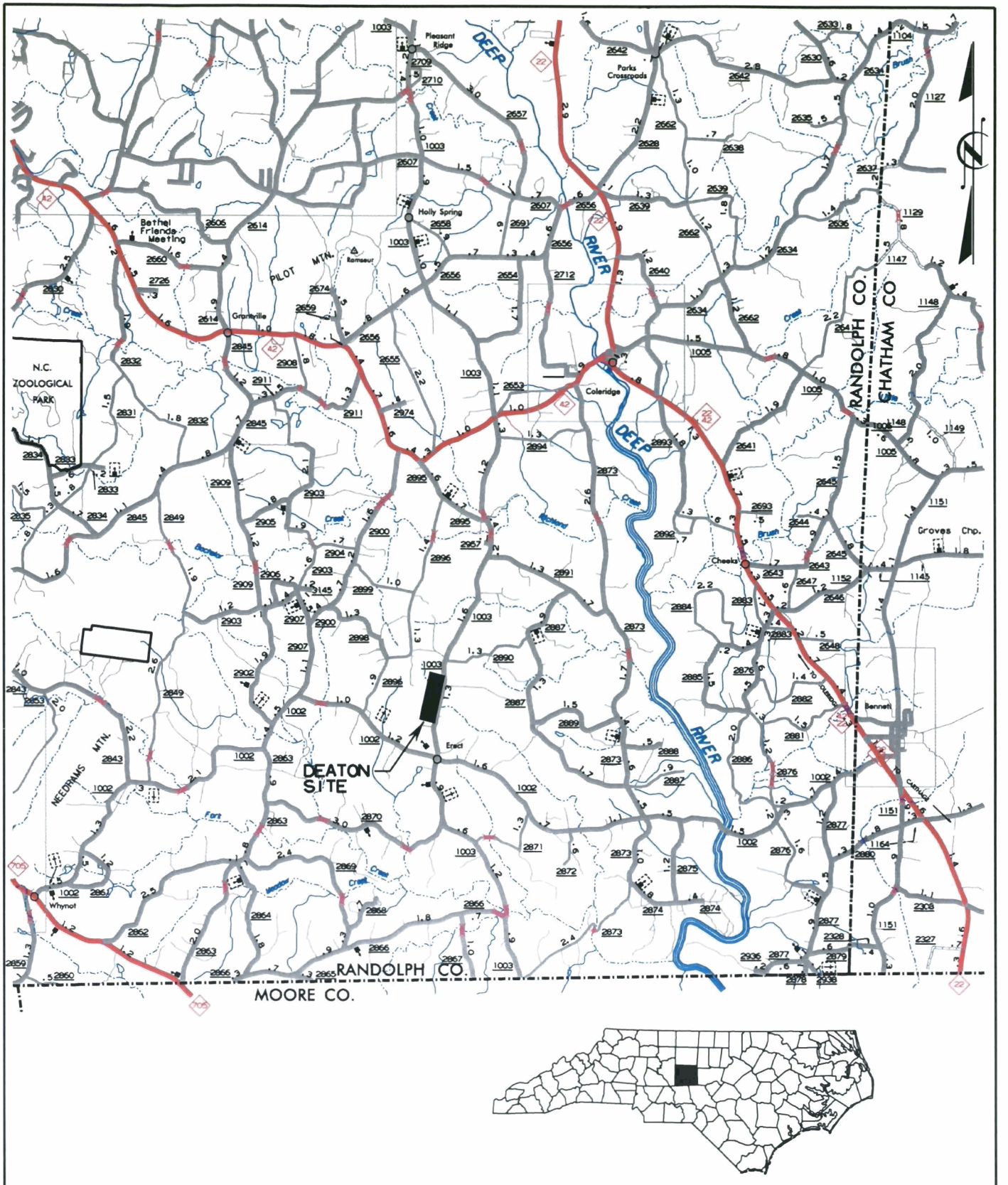
The North Carolina Department of Transportation (NCDOT) proposes to construct a 12.1-mile-long, four-lane, median-divided freeway on new location to serve as a US 421-NC 87 bypass of Sanford, North Carolina. The purpose of the proposed project is to improve capacity and safety for through-traffic using 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 23,640 feet of jurisdictional streams.

The NCDOT has identified two branches of an unnamed stream located on the property of Charles F. Deaton, Jr. in Randolph County, North Carolina as potential stream restoration in order to mitigate a portion of these stream impacts. The property of Charles F. Deaton, Jr., hereafter referred to as "the Deaton site," is located on SR 1003 (Erect Road) less than one mile north of the community of Erect in Randolph County (Figure 1). The studied streams drain to Fork Creek approximately four miles downstream, which is classified by the North Carolina Department of Environment and Natural Resources as a Class C surface waters (Index Number 17-25). Fork Creek subsequently flows into Deep River approximately six miles from the site. The Deaton site is located in the USGS Hydrologic Unit 03030003.

The mitigation components planned for the Deaton site consist of restoring the natural pattern, dimension and profile of the stream 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 Deaton site will provide approximately 4800 linear feet of stream mitigation credits and approximately 13 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
DEATON 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 subject streams. 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. Cross sections of riffle and pool sections were also 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 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 is defined as a stream, which over time and 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 neither 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 a 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 height of the low bank divided by the maximum bankfull depth, 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 consisted of using a kick net to sample stream segments having a sand/gravel substrate. Within stream segments having a muddy substrate, 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. Analysis of the bed material of the subject streams was conducted to determine the size of particles that would need to be mobilized by during the bankfull event. The critical shear stress was computed for the design sections and the particle size that would be mobilized was predicted by the Shield's curve. The hydraulic geometry of the design sections was adjusted as necessary to result in a prediction of the mobilized particle size that was comparable to the material supplied by the watershed.

3.0 SITE ASSESSMENT

3.1 General Site Description

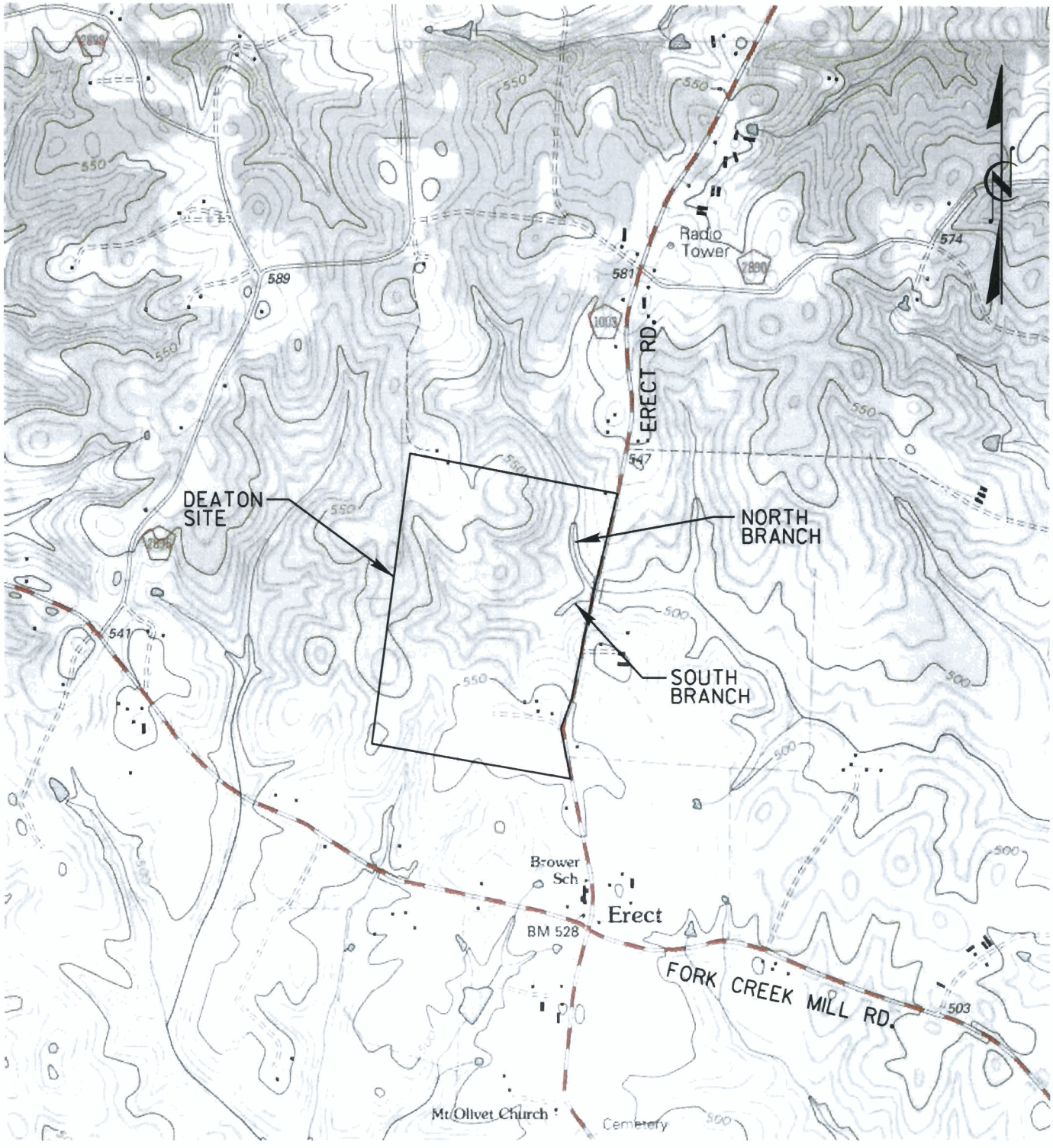
The stream reaches proposed for restoration in this mitigation plan consist of two branches on the Deaton site that join west of Erect Road. These streams are referred to in this plan as the "North Branch" and the "South Branch" (Figure 2). The North Branch has a drainage area of 228 acres (0.35 square miles) and the South Branch has a drainage area of 97 acres (0.15 square miles) at their confluence. At the upstream end of the Deaton site, the North Branch has a drainage area of 175 acres (0.27 square miles). The headwaters of the South Branch are contained entirely within the Deaton property.

The primary source of impact on these streams is the presence of unrestricted cattle grazing. Evidence of stream incursions by cattle is widespread and the grazing pressure on the riparian vegetation is extensive. The natural channel patterns and dimensions have been significantly altered by a combination of manual regrading, cattle traffic and changes in the flow regime. 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 largely nonexistent. The bed material consists of sand, silt and gravel. The streambed appears to have degraded several feet, in part from channelization work and from a headcut that precipitated from clearing of previously forested uplands. In some locations, excessive cattle access has resulted in over-widened sections of the stream that function as wading pools for the cattle.

The North Branch of the Deaton site stream emerges from a heavily wooded tract of land located north of the Deaton site. This reach of the stream has retained many of its natural functions and serves as reference for some of the key design parameters of the restoration plan. Additionally, the headwaters of the South Branch of the stream are contained entirely within the Deaton property. The western extent of the South Branch has a narrow riparian buffer, but has lost most of its natural functions due to recent cattle impacts.

3.2 Land Use and Geology

The Deaton site is located in the eastern portion of the Piedmont physiographic province of North Carolina. Elevations on the site range from 494 feet (msl) to 560 feet (msl). The valley slopes range from 0.004 to 0.015 ft./ft. on the North Branch and 0.011 to 0.021 ft./ft. on the South 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.



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

FIGURE 2

Soil survey information from Randolph County indicates that the predominant underlying soil layers of the Deaton site are Georgeville silt loam (8 to 15 percent slopes), Georgeville silty clay loam (2 to 8 percent slopes and 8 to 15 percent slopes) and Callison-Lignum complex (2 to 6 percent slopes). The Georgeville silt loam and Georgeville silty clay loam soils are gently to strongly sloping, well drained upland soils with a moderate permeability. These soils have a loamy surface layer and clayey subsoil with a seasonal high water table below six feet. The Callison-Lignum complex is moderately well drained with a slow permeability. The seasonal high water table for this soil complex is within one to three feet.

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 40 percent of the watershed, while woodlands account for 55 percent. Residential development accounts for the remaining 5 percent.

The present land use within the Deaton property consists of livestock and poultry production. There are approximately 160 head of cattle, which graze on 110 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 structures that house poultry, one residential dwelling and one abandoned dwelling.

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 exiting 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 North Branch of the Deaton site immediately upstream of the Deaton property line. Prior to entering the project site, the North Branch flows though a wooded riparian buffer that provides a stable environment to allow 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 section 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.)	Reference Reach (computed values)		Local Curve (predicted values)		Regional Curve (predicted values)	
		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
West Br. of 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 West Branch of 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	N. Br. of Deaton	Trib. To Sandy Cr.	Trib. of 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 the North Branch and the South 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 North Branch sections designated with the abbreviation "NB" and the South Branch sections designated with the abbreviation "SB." The longitudinal profile that was surveyed of the North Branch and the South Branch is represented in Attachment 2 and selected cross sections are represented in Attachment 3.

3.4.1 North Branch

The profile of North Branch 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 be livestock incursions. The headcutting of the profile has extended upstream, approximately 140 feet onto the adjacent property. Within the Deaton site the North Branch transitions through several stream types as illustrated below in Table 3. As the North Branch enters the property, the channel immediately widens from an E channel to a C channel (Section DN12). This is visually evident by the development of significant points bars along the first 50 feet of the stream. Approximately 120 feet from the property line, the stream enters a lightly wooded reach with minimal riparian vegetation. Through this reach, frequent access by cattle has resulted in the channel forming a wading pool that is approximately fifteen feet wide and three to four feet deep (Sections DN8 and DN9). The North Branch then enters the open pasture that characterizes the remainder of the stream. From this point, the channel pattern becomes relatively straight with minimal bed features. This reach of the North Branch is classified as a C4 and C5 channel. There is little evidence of fluvial processes acting to form the channel. The banks are highly dissected from cattle traffic and are generally sloping at a 35-degree angle with numerous local vertical bank features. Additionally, the relatively cohesive bank material and herbaceous vegetation act to hold these features in place even during significant runoff events.

Table 3
Classification of Existing Stream Reaches
North Branch

Reach	Width/Depth Ratio	Entrenchment Ratio	Bed Material	Rosgen Classification
DN13 – DN14	5	10	Gravel	E4
DN12	12	3	Gravel	C4
DN10 – DN11	5	1.5	Gravel	G4
DN8 – DN9	14	1.6	Gravel	F4
DN3 – DN7	19	8	Sand – Gravel	C5 – C4
DN1 – DN2	6	5	Sand	E5

3.4.2 South Branch

The South Branch begins at the upstream end of the site as a series of seeps that combine to form the initial intermittent flow. Most evidence of a defined stream channel at the upstream end has been eliminated by cattle incursions. During the initial site visit, a small stream channel was identified within this reach, however, it too has since been eliminated. The South Branch then

enters a wooded reach, which is heavily grazed by cattle. There is only minimal vegetation along the banks throughout this reach. A headcut has resulted in incising of the streambed and the channel has evolved to form a G channel. The bank height ratio, which ranges from 1.4 to 2.0, confirms the apparent channel instability. A significant accumulation of woody debris (snags) and the presence of roots extending from woody vegetation along the banks have acted to limit the extent of the bed degradation by providing temporary grade control. From this wooded reach, the South Branch enters the open pasture that characterizes the remainder of the stream. According to the property owner's description of the South Branch prior to disturbance, it was a small meandering stream, which was appropriately positioned within the valley. Clear-cutting of a significant portion of the watershed resulted in rapid incision of the channel due to the increase in runoff and change in the sediment regime. Presently, the channel bed is approximately one to three feet below the historic channel grade. As illustrated in Table 4, the majority of the South Branch is classified as a G channel, although portions of stream retain an E channel classification. Approximately 70 percent of the South Branch has a bank height ratio greater than 1.4, which is indicative of high bank instability. The relatively high density of cattle on the property along with unrestricted cattle access to the stream have contributed to overgrazing and soil disturbance along the banks and buffer areas. These factors act to keep the stream in an unstable condition. Without intervention the evolutionary trend for the South Branch will likely result in the formation of a type G channel throughout the entire stream.

Table 4
Classification of Existing Stream Reaches
South Branch

Reach	Width/Depth Ratio	Entrenchment Ratio	Bed Material	Rosgen Classification
DS12.5 – DS14	8	2.5	Gravel – Sand	E4 – E5
DS10 – DS12	6	1.9	Gravel	G4
DS5 – DS9	6	1.9	Gravel	G4
DS1 – DS4	6	4	Gravel	E4

3.5 Bioassessment of Stream Quality

The Deaton site is classified as "poor" according to an EPT taxa richness value of 0. According to a Hilsenhoff family level biotic index value of 5.99, the water quality rating of the Deaton site is classified as "fairly poor", with a pollution potential factor of "substantial pollution likely." Hilsenhoff tolerance values range between 0 and 10, with 10 being the most tolerant to pollution. Pollution-tolerant families (Chironomidae-6 and Physidae-8) were the dominant groups of benthic macoinvertebrates sampled within this stream segment. Other families sampled include Hydrophilidae and Corduliidae (tolerance value 5). The total taxa for the Deaton site is four. Generally, a low taxa number is associated with poorer water quality (NCDENR, 1997) (Appendix F).

Lack of riparian shading, destabilization and erosion of stream banks, and the introduction of significant volumes of cattle fecal matter to the stream and adjacent areas are thought to be the primary factors contributing to poor stream habitat conditions observed at the time of investigation. The lack of snags and complete embeddedness of any gravel, cobble or boulder substrate within the sediment also contribute to poor habitat quality (Appendix F-Habitat Walk).

Excessive 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. Among these sedimentation-tolerant taxa are several chironomidae (NCDENR, 2000). This relationship was verified within stream reaches on the Deaton site, where indicators of rapid sedimentation rates and dominance by chironomidae were observed.

3.6 Vegetation Communities

The riparian vegetation consists of opportunistic, first-successional, herbaceous vegetation, which has been noticeably suppressed by grazing. Opportunistic species found along the stream banks of the Deaton site include cocklebur (*Xanthium sp.*) and dog-fennel (*Eupatorium capillifolium*). Tree canopy is present only along the north section of the North Branch and the west end of the South Branch adjacent to the headwaters. Therefore, stream shading is severely limited along the majority of the stream corridor. Forested communities in the vicinity and trees along the Deaton site banks include the following tree species: willow oak (*Quercus phellos*), white oak (*Quercus alba*), post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), turkey oak (*Quercus laevis*), sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), shortleaf pine (*Pinus echinata*), red cedar (*Juniperus virginiana*) and red maple (*Acer rubrum*). Shrub species include American holly (*Ilex opaca*) and privet (*Ligustrum sp.*). Herbaceous species found among the understory of wooded areas within the site boundaries include wild onion (*Allium sp.*), Christmas fern (*Polystichum acrostichoides*) and wild ginger (*Hexastylis sp.*).

3.7 Wildlife and Wildlife Habitat

The following amphibian and reptile species have been observed within the Deaton site boundaries: cricket frog (*Acris crepitans*), chorus frog (*Pseudacris triseriata*) and eastern fence lizard (*Sceloporus undulatus*). Mammal and bird species observed within the Deaton site include: whitetail deer (*Odocoileus virginianus*), turkey vulture (*Cathartes aura*), bluejay (*Cyanocitta cristata*), eastern towhee (*Pipilo erythrophthalmus*), American goldfinch (*Carduelis tristis*), eastern bluebird (*Sialia sialis*), northern mockingbird (*Mimus polyglottus*), slate-colored junco (*Junco hyemalis*), red-tailed hawk (*Buteo jamaicensis*) and mourning dove (*Zenaida macroura*). A population of the federally-endangered Cape Fear shiner (*Notropis mekistocholas*) has been located approximately four miles downstream of the Deaton site (North Carolina Natural Heritage Program, 2000).

4.0 STREAM RESTORATION PLAN

Stream restoration for the Deaton site will include reconstruction of the channel 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 II restoration (Rosgen 1997) in which the North Branch and the South Branch will be reconstructed to create the floodplain bench set slightly below the existing terrace and the channel invert set slightly above its existing grade. This reshaping is designed to balance cut-and-fill quantities as much as possible in order to minimize the need for offsite material. 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 to the South Branch in order to reduce sediment inputs into the stream.

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 also 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. Water quality improvements realized from the aforementioned stream restoration measures will cumulatively contribute to protection of the Cape Fear Shiner population located approximately four miles downstream.

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 Deaton site.

4.1 Channel Design

The proposed channel for the North Branch and the South Branch will have a stream classification of E4 under the Rosgen classification system. On the North Branch, the valley slope is 0.0075 ft./ft. and the channel slope will be 0.0058 ft./ft. with a sinuosity of 1.3. On the South Branch, the valley slope ranges from 0.011 ft./ft. to 0.021 ft./ft. and the channel slope will range from 0.0079 ft./ft. to 0.014 ft./ft. with sinuosity ranging from 1.3 to 1.5. The width/depth ratio for the reference streams range from 4.5 to 8.5. The design width/depth ratio within 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.

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 50-year or 100-yr floods upstream of the Deaton property. Additionally, there will be no rise in the flood stage on the North Branch. Increases in flood stage on the South Branch will be less than 0.5 feet and will not result in any adverse impacts.

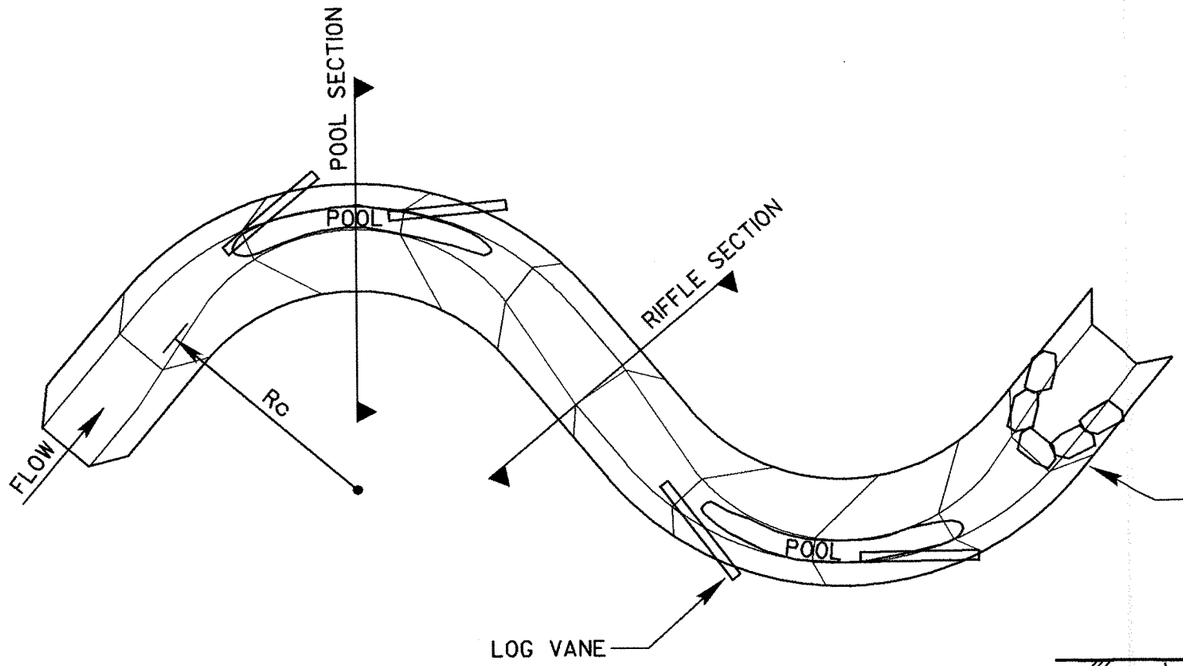
4.1.2 Sediment Transport

The design sections were evaluated for their competency to transport the sediment supplied by the watershed. The bed material of the North Branch reference was found to have a D_{84} (particle diameter of the 84 percentile) of 60 millimeters (mm) and a D_{50} of 21 mm. The largest particle measured was 100 mm. The critical shear stress was calculated for each of the design sections (See Appendix D) and the diameter of the particle that would be mobilized was determined from the Shield's diagram (modified by D. Rosgen). From these computations, it was determined that the design sections would move particles from 62mm to 69mm, which is consistent with the sediment that is anticipated to be supplied by the watershed.

4.2 Planting Plan

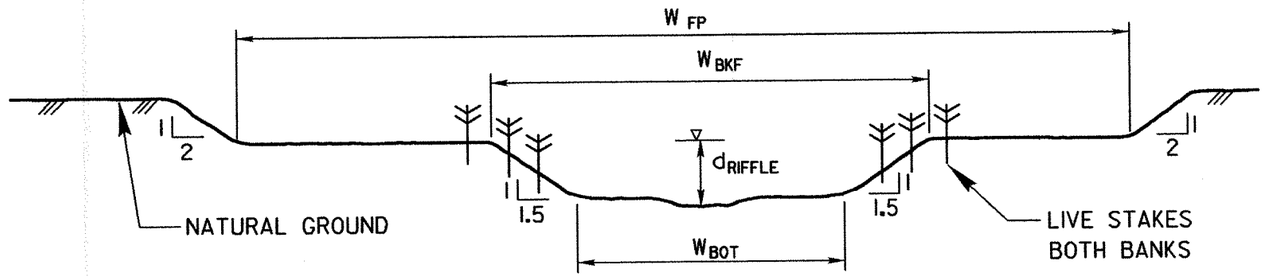
The planting plan for the riparian buffer of the Deaton site will provide post-construction erosion control and riparian habitat enhancement. The riparian buffer will include native species of the North Carolina Piedmont, which have been identified at the reference sites and at the Deaton site. Native species of the area will be locally adapted to conditions found at the Deaton 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 run, 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).

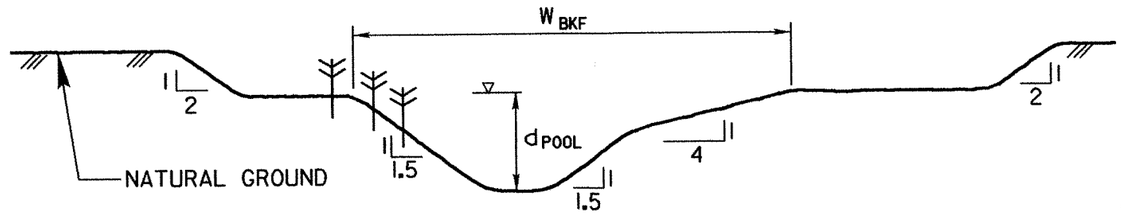


TYPICAL PLAN

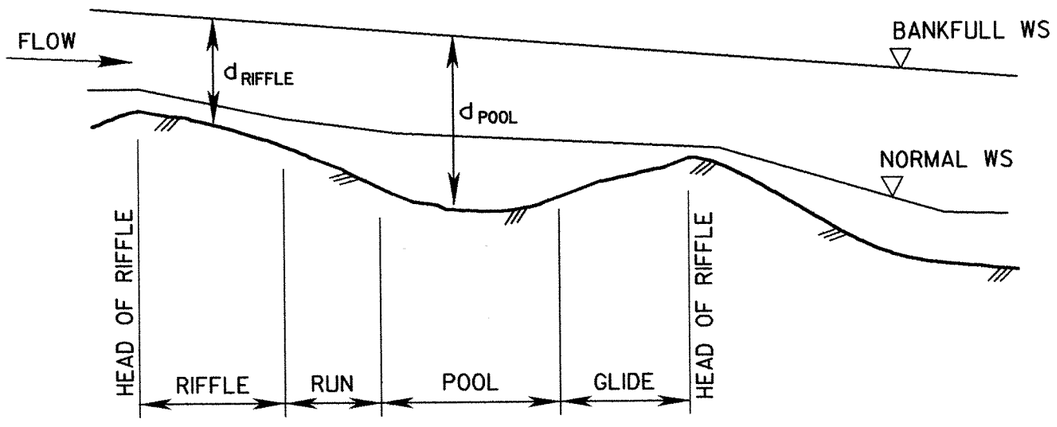
REACH	W_{BKF}	W_{BOT}	d_{RIFFLE}	d_{POOL}	R_c
DS-1 TO DS-5	8.6	5.5	1.1	1.8	17-26
DS-6 TO DS-8	7.3	4.6	0.9	1.5	14-21
DS-8 TO DS-11	5.4	3.4	0.7	1.2	10-15
DS-11 TO DS-14	4.8	3.0	0.6	1.0	9-13
DN-1 TO DN-5	11.2	7.1	1.4	2.3	23-35
DN-5 TO DN-12	10.7	6.7	1.3	2.2	21-32



RIFFLE SECTION
N.T.S.



POOL SECTION
N.T.S.



TYPICAL PROFILE

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

FIGURE 3

Tree and shrub species to be planted at the Deaton 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 Deaton 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 Deaton 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. One monitoring reach will be located on the North Branch and two monitoring reaches will be located on the South 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 14, 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 Deaton site stream mitigation plan provides for converting the unstable, altered and degraded stream segments on the Deaton 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 Deaton site will provide approximately 4800 linear feet of stream mitigation credits and approximately 13 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 Deaton 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, Deaton/Sugg Site. Inquiry Number: 5172282. 14 July 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.

STREAM MITIGATION PLAN

DEATON SITE
RANDOLPH COUNTY, NORTH CAROLINA

STATE PROJECT NUMBER: 8.U492107
TIP NUMBER: U-2524WM

Prepared for:

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND ENVIRONMENTAL
ANALYSIS BRANCH
RALEIGH, NORTH CAROLINA

May 22, 2001

APPENDIX A

MORPHOLOGIC CHARACTERISTICS TABLE

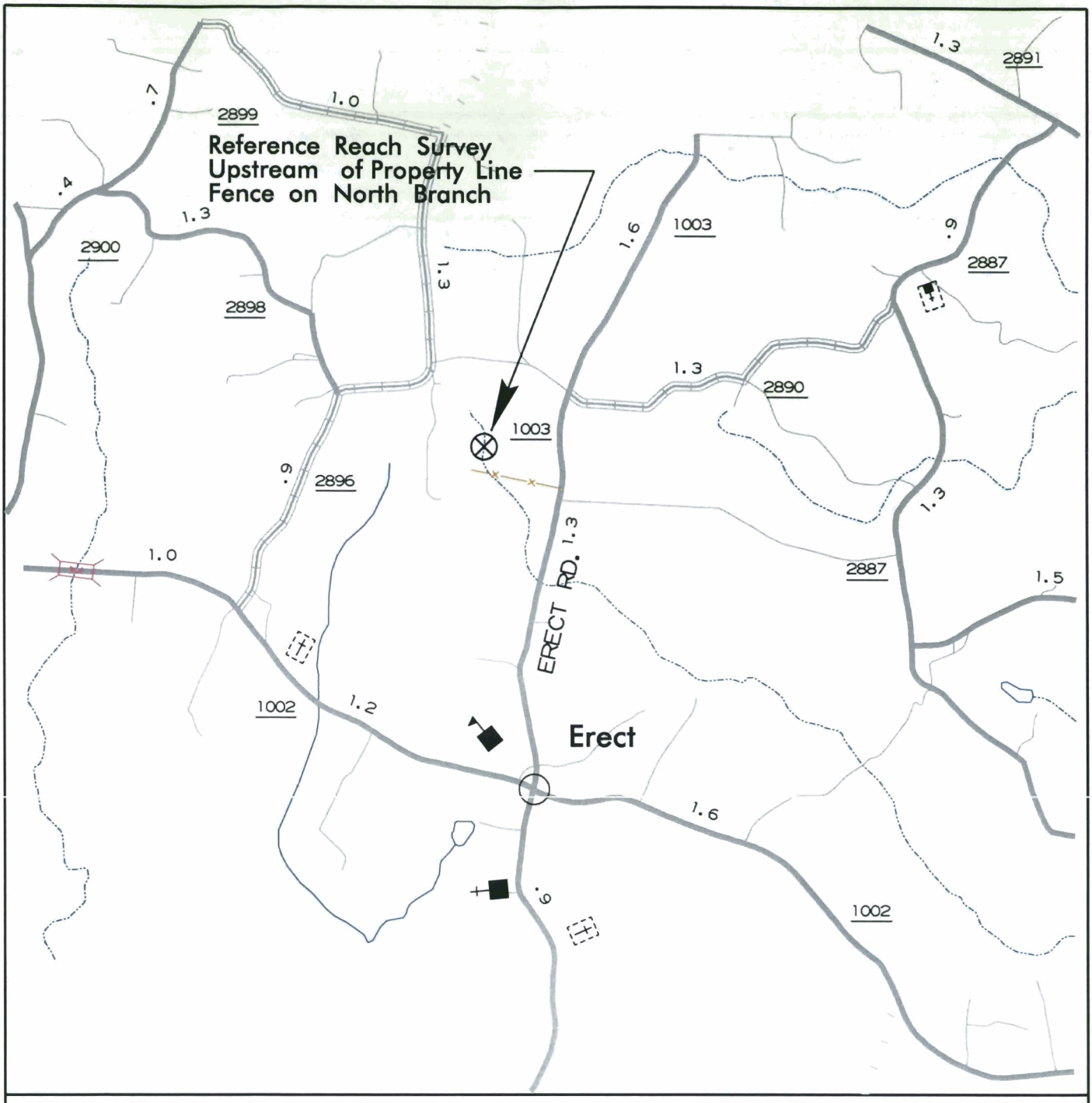
Morphological Characteristics of the Existing, Proposed and Reference Reach					
Variables	Existing Channel	Proposed Channel	Reference Reach		
			Deaton N. Br.	Amick Trib.	Caviness Trib.
1. Stream Type	G4 - E4	E4	E4	E4	E5
2. Drainage Area ($mi.^2$)	0.03 - 0.36	0.03 - 0.36	0.27	0.97	1.08
3. Bankfull Width (Wbkf)	3 - 20	4.8 - 11.6	7.25	12.14	9.65
4. Bankfull Mean Depth (Dbkf)	0.4 - 1.3	0.48 - 1.16	1.31	1.42	2.14
5. Width/Depth Ratio	4 - 20	10	5.52	8.52	4.5
6. Max Riffle Depth Ratio (Dmax/Dbkf)	*	1.4	1.2	1.5	1.1
7. Bankfull Cross-Sectional Area (Abkf)	2 - 18	2.3 - 13.4	9.53	17.29	20.7
8. Bankfull Mean Velocity (Vbkf)	2 - 5.5	3.5	4.5	4.0	3.8
9. Bankfull Discharge (Qbkf)	7 - 44	7 - 44	41	70	79
10. Bankfull Maximum Depth (Dmax)	0.8 - 2.7	0.7 - 1.6	1.6	2.14	2.3
11. Width of Floodprone Area (Wfpa)	8 - 160	30 - 40	71	80	270
12. Entrenchment Ratio (Wfpa/Wbkf)	1.5 - 10	6 - 4	9.8	6.6	28
13. Meander Length (Lm)	*	40 - 100	42	77	73
14. Meander Length Ratio (Lm/Wbkf)	*	8 - 10	5.8	6.4	7.6
15. Radius of Curvature (Rc)	*	10 - 35	22	26	41
16. Radius of Curvature Ratio (Rc/Wbkf)	*	2 - 3	3	2.1	4.2
17. Belt Width (Wblt)	*	20 - 50	12	40	70
18. Meander Width Ratio (Wblt/Wbkf)	*	3 - 5	1.6	3.3	7.3
19. Sinuosity (K)	1.0	1.3 - 1.5	1.1	1.35	1.2
20. Valley Slope	0.008 - 0.02	0.0075 - 0.021	0.01	0.0043	0.0232
21. Average Slope (Savg)	0.008 - 0.02	0.0063 - 0.014	0.011	0.0058	0.0037
22. Pool Slope (Spool)	0.001 - 0.01 *	0.001 - 0.003	0.0011	0.0026	0.0004
23. Pool Slope Ratio (Spool/Savg)	0.12 - 0.50 *	0.15 - 0.21	0.10	0.45	0.11
24. Max. Pool Depth (Dpool)	1.5 - 2.1 *	1.0 - 2.2	2.43	2.7	2.7
25. Pool Depth Ratio (Dpool/Dbkf)	1.6 - 3.8 *	1.9	1.9	1.9	1.3
26. Pool Area Ratio (Apool/Abkf)	1.0 - 1.6 *	1.3	1.3	1.6	1
27. Pool Length Ratio (Lpool/Wbkf)	1.0 - 2.6 *	1.5 - 2.5	2.88	1.65	2.07
28. Pool Width (Wpool)	4 - 22 *	4.8 - 11.6	9.2	9.6	11.3
29. Pool Width Ratio (Wpool/Wbkf)	1.0 - 2.0 *	1.0	1.3	0.8	1.2
30. Pool-Pool Spacing (p-p)	20 - 100 *	26 - 75	67	75	53
31. Pool Spacing Ratio (p-p/Wbkf)	4 - 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	1		12	0.46	0.2
d50	9		21	2.7	1
d84	29		60	23.3	13
d95	128		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

NORTH BRANCH OF DEATON



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**

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
Sheet: 3 of 6
TIP No.: U-2524WM
Comm. No.: 30036B

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**

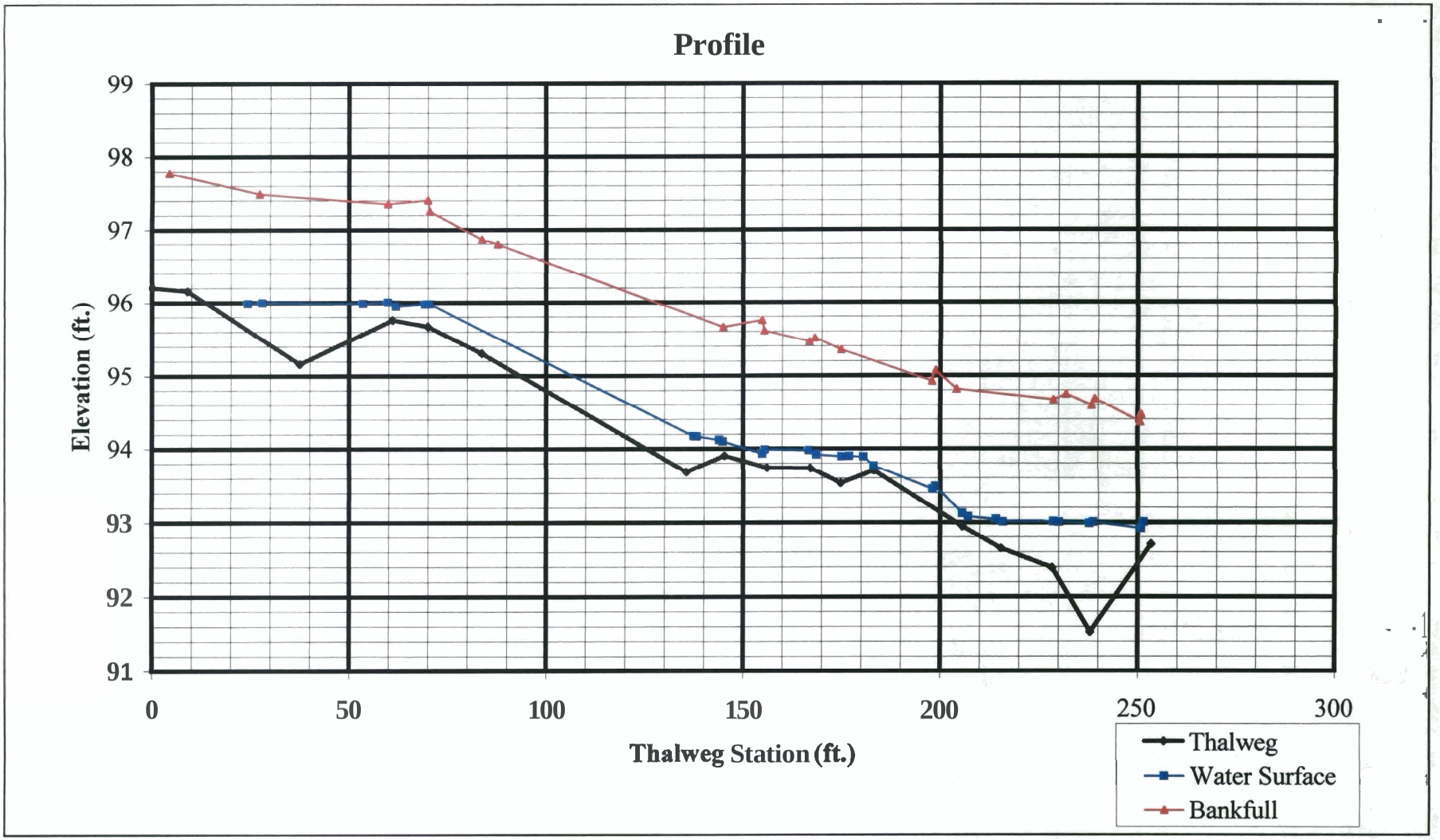
Cross Section Data

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
Sheet: 5 of 6
TIP No.: U-2524WM
Comm. No.: 30036B

Pebble Count

	Particle	mm	PARTICLE COUNT 1	2	3	Total #	Item Y_o	Y_o 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	%
8	60	mm	Boulder	0	%
D_{95}:	90	mm	Bedrock	0	%

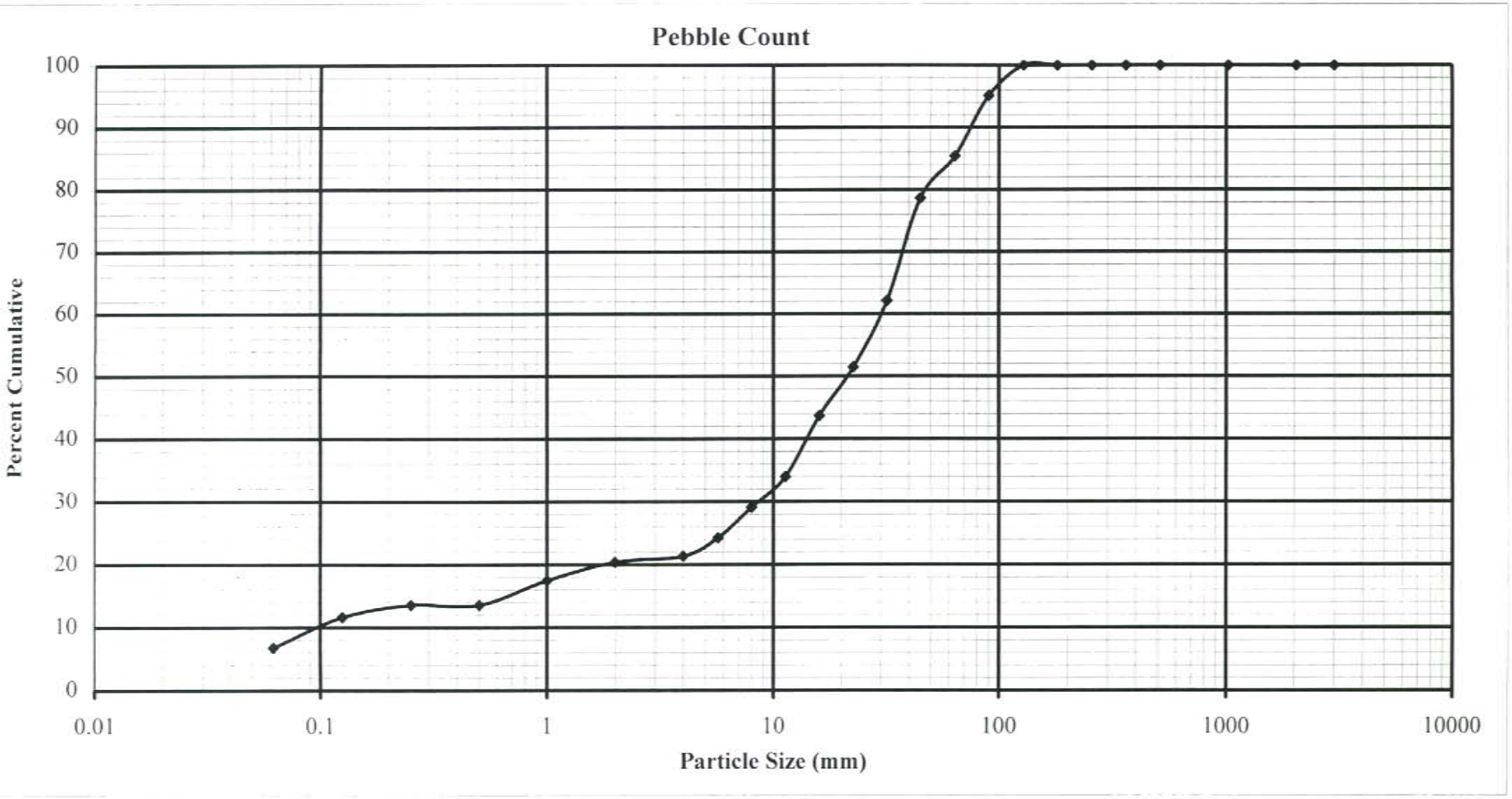
Reference Reach Survey

Project: Deaton Stream Mitigation Plan

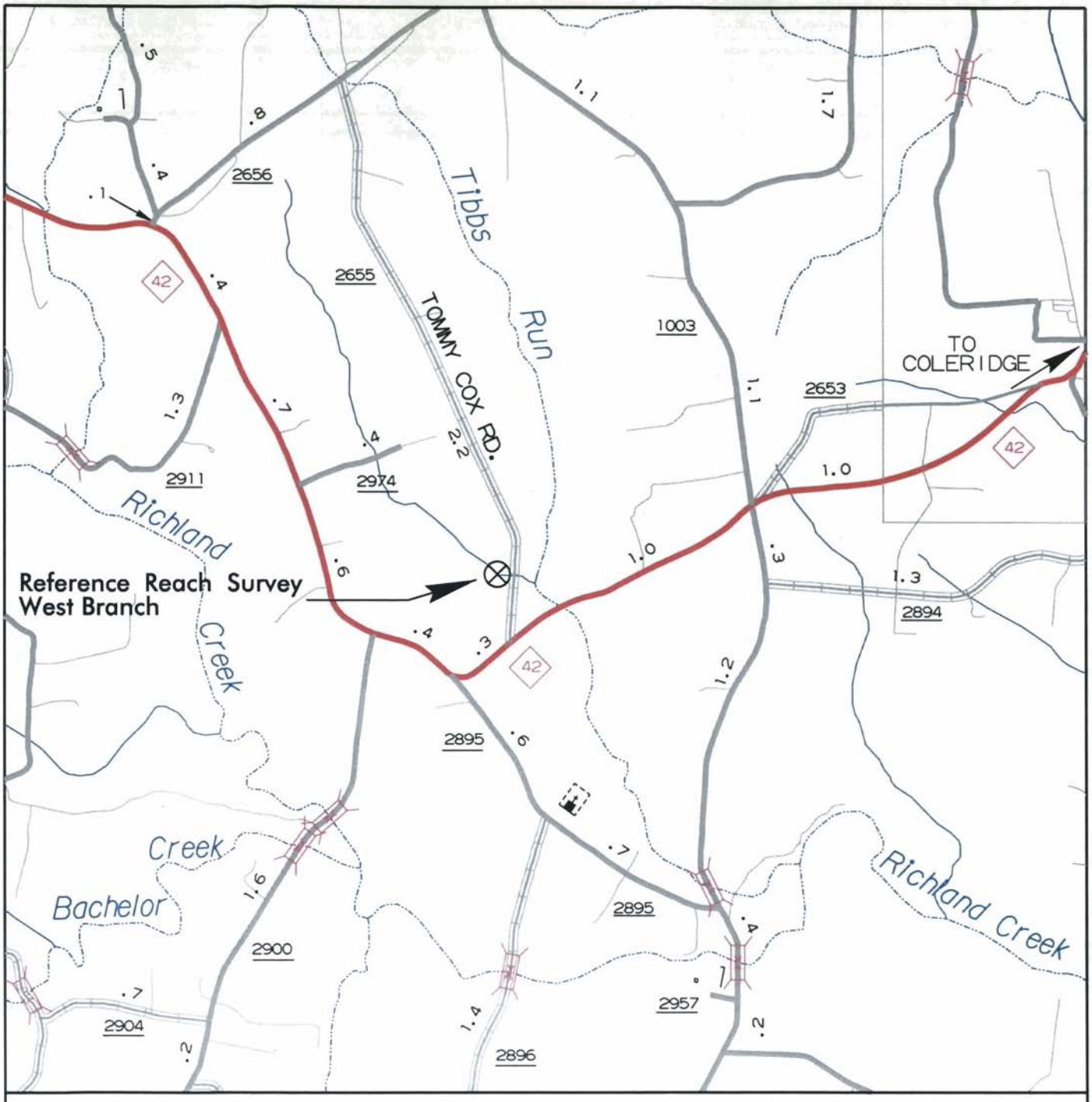
Sheet: 6 of 6

TIP No.: U-2524WM

Comm. No 30036B



WEST BRANCH OF TIBBS RUN



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
Sheet: 3 of 6
TIP No.: U-2524WM
Comm. No.: 30036C

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

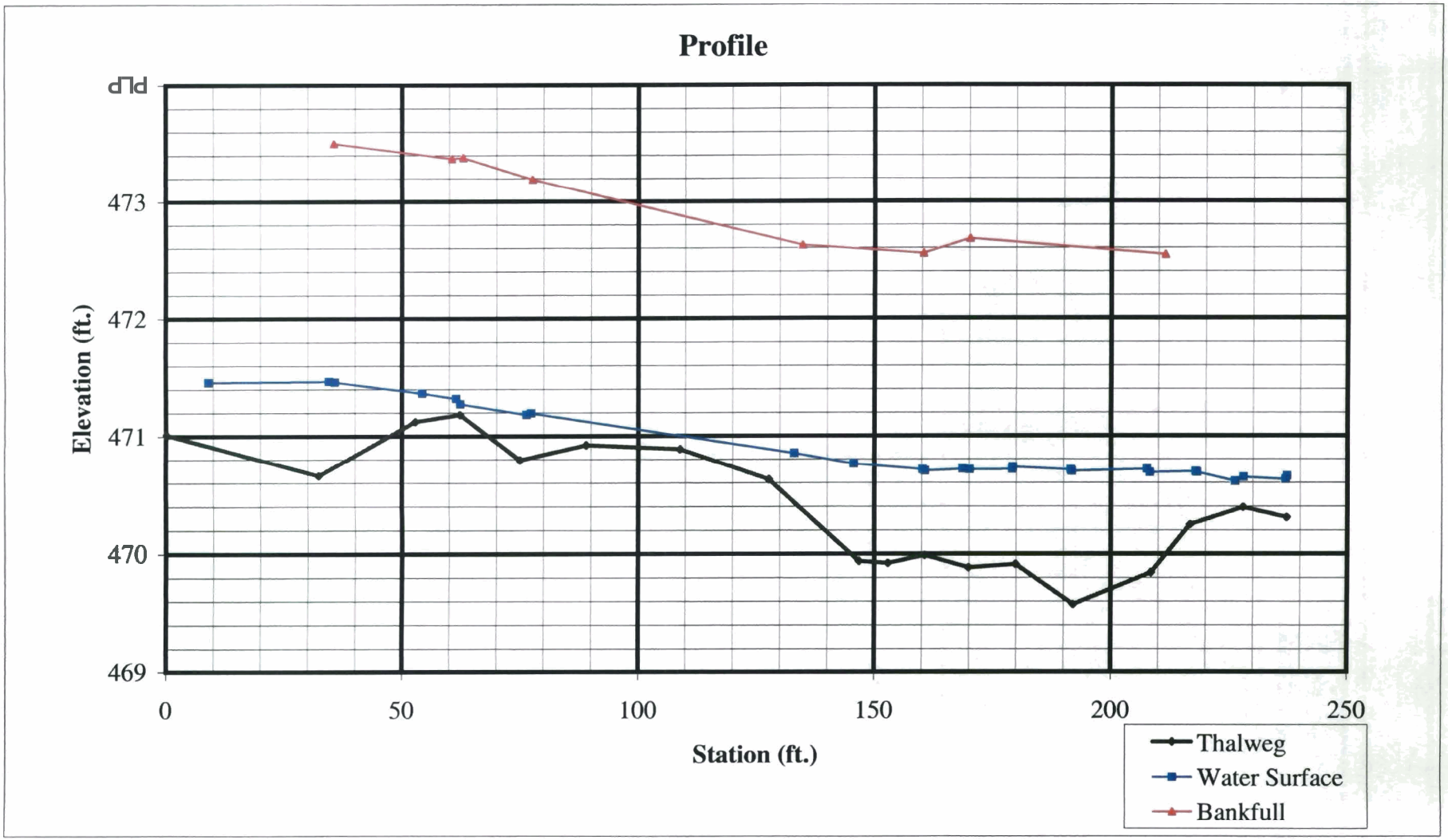
Section: CT-6
Bankfull Elev: 472.5
Bankfull Area: 20.85
Bankfull Width: 11.28
Mean Depth: 1.85
W/D Ratio: 6.10
Max Depth: 2.51

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

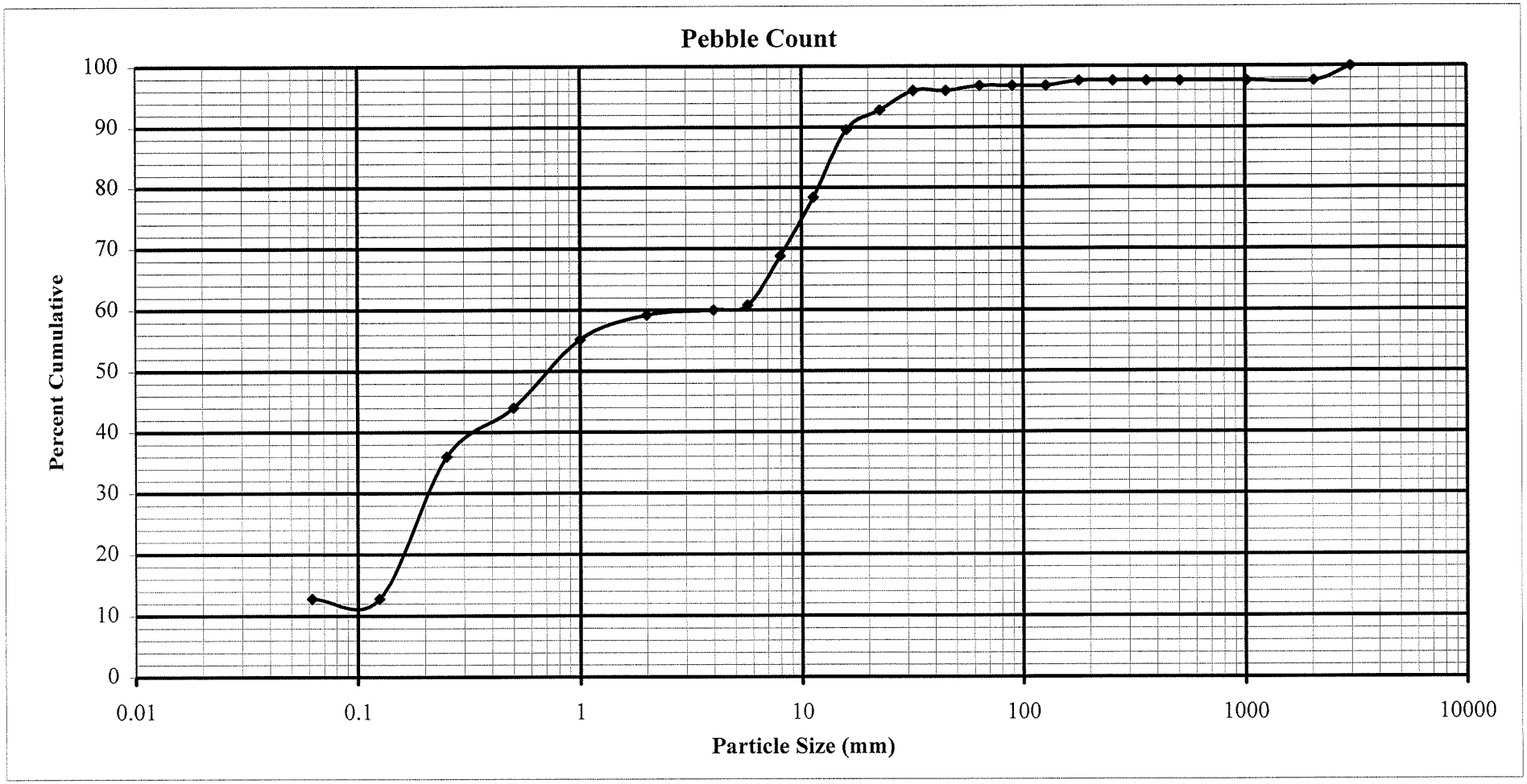
	Particle	mm	PARTICLE COUNT 1	2	3	Total #	Item %	% Cum.
	Silt/Clay	<.062	10	6		16	12.8	12.8
(Sand)	Very Fine	.062-.125				0	0.0	12.8
	Fine	.125-.25	12	17		29	23.2	36.0
	Medium	.25-.50	2	8		10	8.0	44.0
	Coarse	.50-1.0	1	13		14	11.2	55.2
	Very Coarse	1.0-2	2	3		5	4.0	59.2
(Gravel)	Very Fine	2.0-4.0		1		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	%

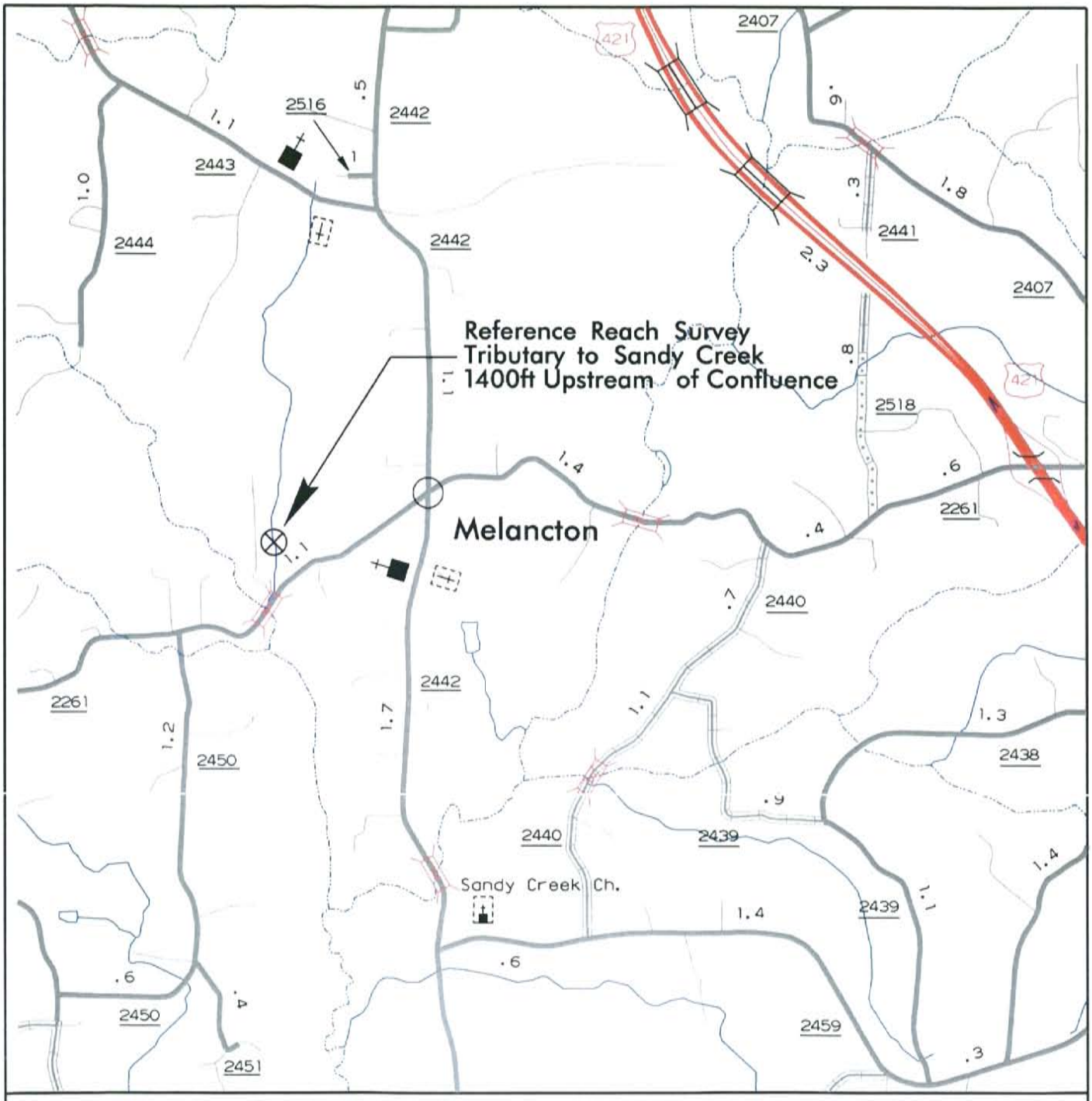
Reference Reach Survey

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

Sheet: 6 of 6



TRIBUTARY TO SANDY CREEK



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

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

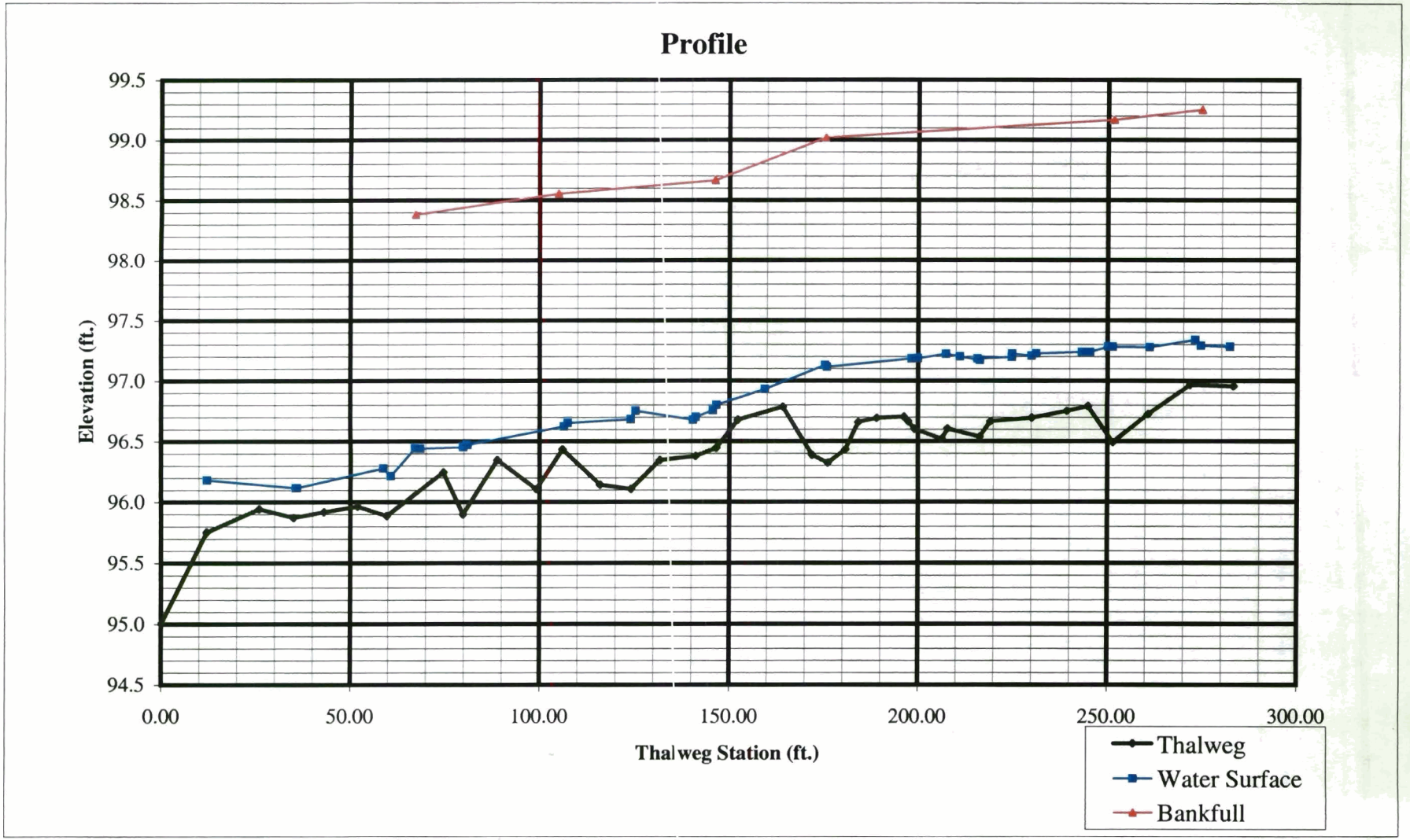
Section: A2
Bankfull Elev: 99.05
Bankfull Area: 28.25
Bankfull Width: 9.62
Mean Depth: 2.94
W/D Ratio: 3.28
Max Depth: 2.79

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



Reference Reach Survey

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

Sheet: 5 of 6

Pebble Count

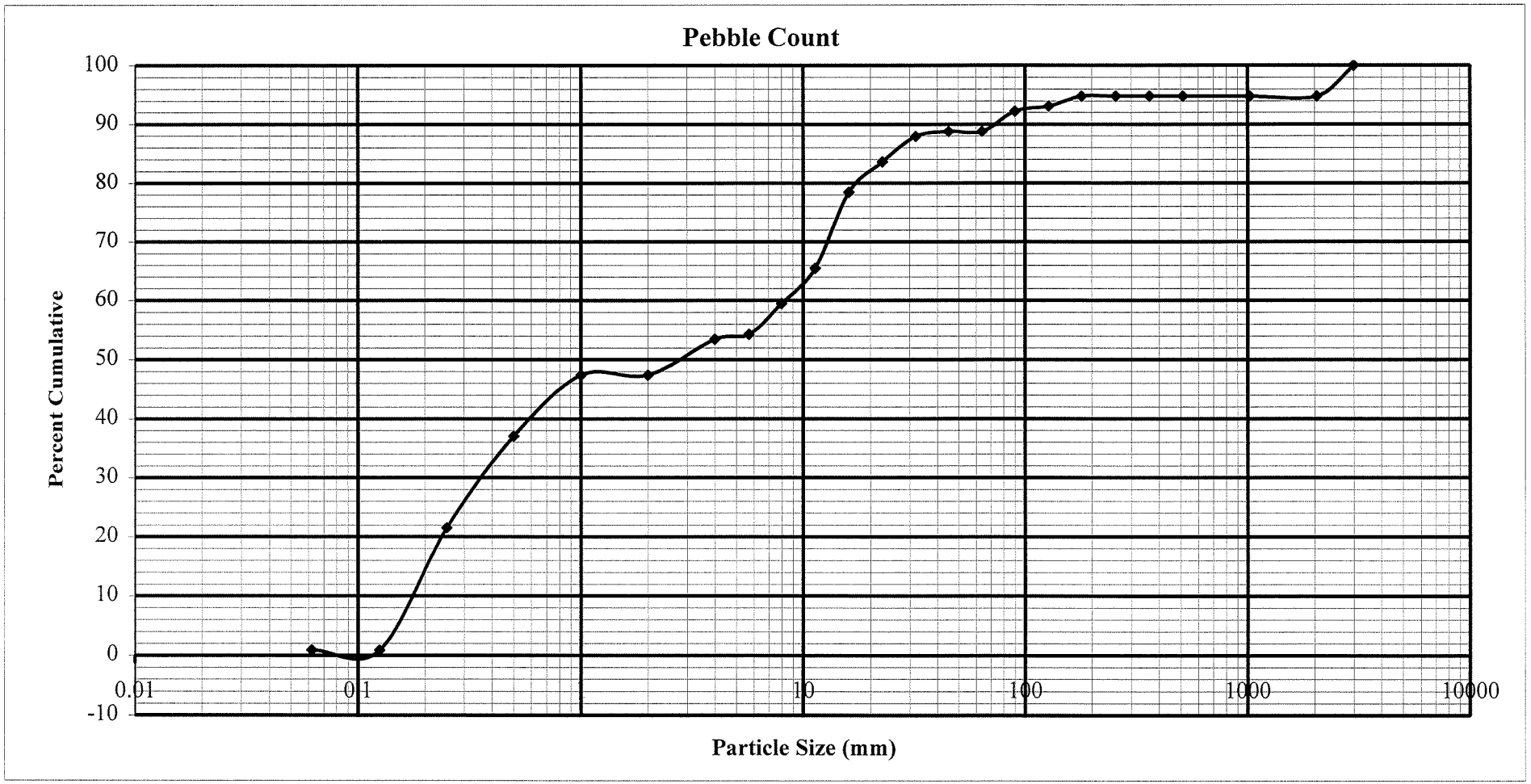
	Particle	mm	PARTICLE COUNT 1	2	3	Total #	Item %	% Cum.
	Silt/Clay	<.062		1		1	0.9	0.9
(Sand)	Very Fine	.062-.125				0	0.0	0.9
	Fine	.125-.25	8	16		24	20.7	21.6
	Medium	.25-.50	11	7		18	15.5	37.1
	Coarse	.50-1.0	2	10		12	10.3	47.4
	Very Coarse	1.0-2				0	0.0	47.4
(Gravel)	Very Fine	2.0-4.0	5	2		7	6.0	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: Deaton Stream Mitigation Plan
TIP No.: U-2524WM
Comm. No: 30036B

			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)
North Br. At Prop. Line	14	0.27	8.80	6.77	0.99	34.69
N. Br. at Erect Rd	5	0.36	10.70	7.66	1.08	42.67
South Br. U/s end	14	0.02	1.50	2.21	0.43	5.33
South Br. At Erect Rd.	5	0.15	5.90	5.26	0.82	22.72
North Br. At XS DN-11	11	0.29	9.24	6.98	1.01	36.52
South Br. At XS DS-11	11	0.03	1.97	2.63	0.49	7.13
South Br. At XS DS-8	8	0.08	3.85	4.01	0.67	14.45

			Reference Reach Curves			
Location	Hec-Ras Station	D.A. (mi^2)	$Area_{bkf}$ (ft^2)	$Width_{bkf}$ (ft)	$Depth_{bkf}$ (ft)	Q_{bkf} (cfs)
North Br. At Prop. Line	14	0.27	7.94	6.35	1.25	36.32
N. Br. at Erect Rd	5	0.36	10.03	7.38	1.38	43.70
South Br. U/s end	14	0.02	0.96	1.63	0.63	6.80
South Br. At Erect Rd.	5	0.15	4.93	4.67	1.09	24.88
North Br. At XS DN-11	11	0.29	8.42	6.59	1.30	38.03
South Br. At XS DS-11	11	0.03	1.34	2.02	0.70	8.83
South Br. At XS DS-8	8	0.08	2.97	3.37	0.92	16.60

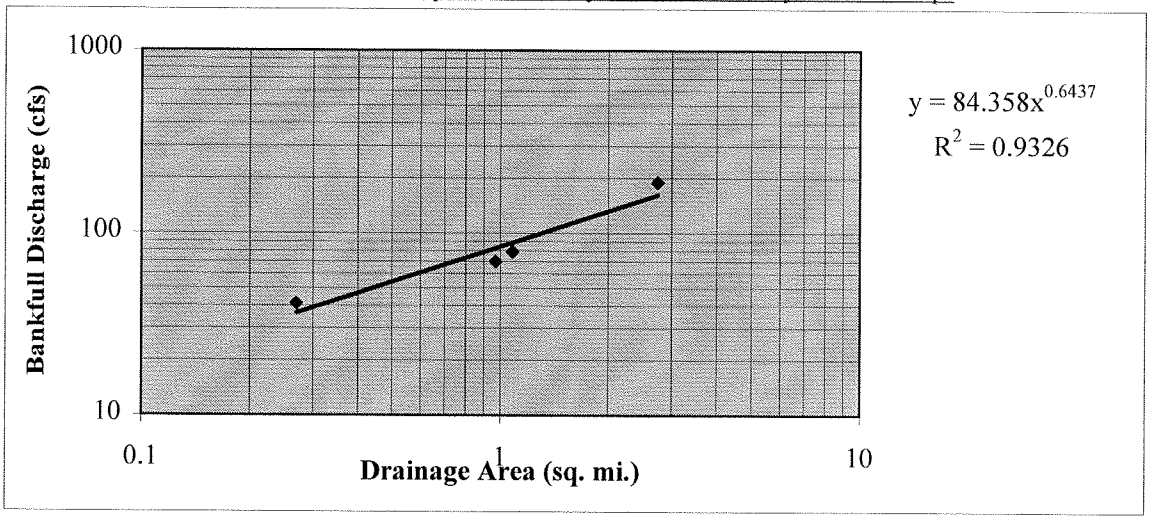
			USGS Regression Equations (Piedmont)			
Location	Hec-Ras Station	D.A. (mi^2)	Q_5 (cfs)	Q_{10} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)
North Br. At Prop. Line	14	0.27	102.88	144.69	272.97	344.61
N. Br. at Erect Rd	5	0.36	124.82	174.79	327.12	411.66
South Br. U/s end	14	0.02	17.90	26.17	53.11	68.99
South Br. At Erect Rd.	5	0.15	69.31	98.34	188.60	239.64

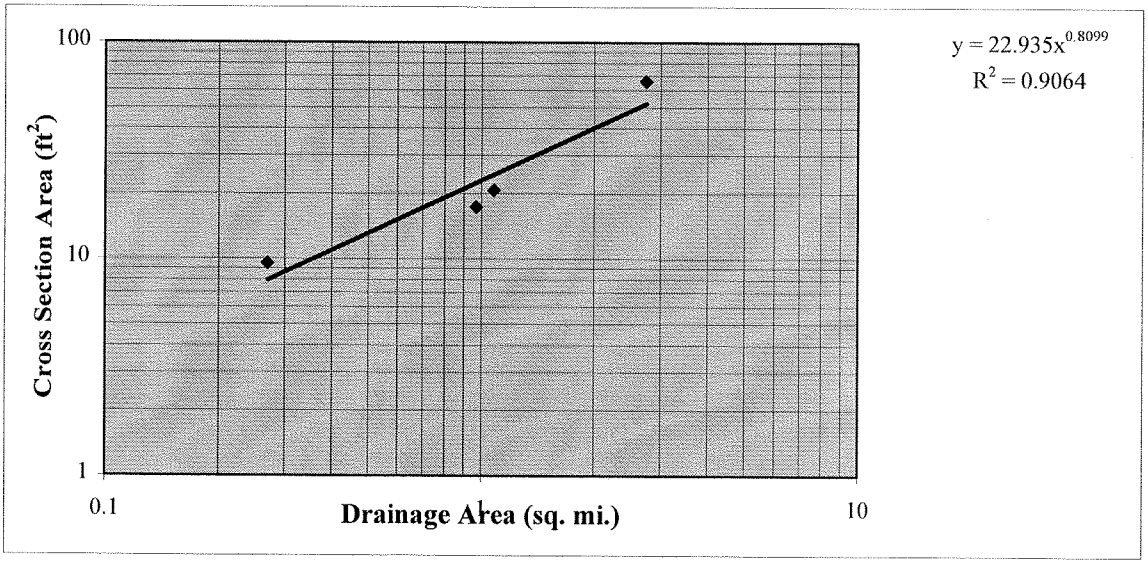
Reference Reach Analysis
Local Curves

Reference Reach Computed Values

Stream Name	Drainage Area	$Discharge_{Bkf}$	X-Sect. $Area_{Bkf}$	$Width_{Bkf}$	Mean $Depth_{Bkf}$
	(mi^2)	(cfs)	(ft^2)	(ft)	(ft)
North Branch of Deaton	0.27	41	9.53	7.25	1.31
West 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

Local Curves and Equations for Hydraulic Geometry Relationships





APPENDIX D

SEDIMENT TRANSPORT CALCULATIONS

Sediment Transport Validation

Project:	Deaton Mitigation Site
Stream:	South Branch
Date:	04/24/2001
Reach:	DS-1 to DS-5

Q_{Bkf} :	25 cfs
W/D_{Design} :	10
Side Slopes :	1.5
Mannings n :	0.035
S_{Valley} =	0.011 ft./ft.
Sinuosity =	1.3

$S_{WS} = S_{valley}/Sin.$ =	0.0085 ft./ft.
V =	3.4 fps
$A_{X\text{-}Sect} = Q/V$ =	7.4 sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	8.6 ft.
$D_{Mean} = A/W$ =	0.86 ft.
$D_{Avg.\ Bot.}$ =	1.05 ft.
P =	9.24 ft.
R = A/P =	0.801 ft.

$\tau_c = \gamma S_{WS} R$ =	0.42 lb/ft^2
Particle Moved =	69 mm

Sediment Transport Validation

Project:	Deaton Mitigation Site
Stream:	South Branch
Date:	04/24/2001
Reach:	DS-6 to DS-8

Q_{Bkf} :	17	cfs
W/D_{Design} :	10	
Side Slopes :	1.5	
Mannings n :	0.035	
S_{Valley} =	0.012	ft./ft.
Sinuosity =	1.3	

$S_{WS} = S_{valley}/Sin.$ =	0.0092	ft./ft.
V =	3.2	fps
$A_{X\text{-}Sect} = Q/V$ =	5.4	sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	7.3	ft.
$D_{Mean} = A/W$ =	0.73	ft.
$D_{Avg.\ Bot.}$ =	0.90	ft.
P =	7.87	ft.
R = A/P =	0.682	ft.

$\tau_c = \gamma S_{WS} R$ =	0.39	lb/ft^2
Particle Moved =	63	mm

Sediment Transport Validation

Project:	Deaton Mitigation Site
Stream:	South Branch
Date:	04/24/2001
Reach:	DS-8 to DS-11

Q_{Bkf} :	8.8	cfs
W/D_{Design} :	10	
Side Slopes :	1.5	
Mannings n :	0.035	
S_{Valley} =	0.0162	ft./ft.
Sinuosity =	1.3	

$S_{WS} = S_{valley}/Sin.$ =	0.0125	ft./ft.
V =	3.0	fps
$A_{X\text{-}Sect} = Q/V$ =	2.9	sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	5.4	ft.
$D_{Mean} = A/W$ =	0.54	ft.
$D_{Avg.\ Bot.}$ =	0.66	ft.
P =	5.81	ft.
R = A/P =	0.504	ft.

$\tau_c = \gamma S_{WS} R$ =	0.39	lb/ft^2
Particle Moved =	63	mm

Sediment Transport Validation

Project:	Deaton Mitigation Site
Stream:	South Branch
Date:	04/24/2001
Reach:	DS-11 to DS-14

Q_{Bkf} :	6.8 cfs
W/D_{Design} :	10
Side Slopes :	1.5
Mannings n :	0.035
S_{Valley} =	0.021 ft./ft.
Sinuosity =	1.5

$S_{WS} = S_{valley}/Sin.$ =	0.0140 ft./ft.
V =	2.9 fps
$A_{X\text{-}Sect} = Q/V$ =	2.3 sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	4.8 ft.
$D_{Mean} = A/W$ =	0.48 ft.
$D_{Avg.\ Bot.}$ =	0.59 ft.
P =	5.16 ft.
R = A/P =	0.447 ft.

$\tau_c = \gamma S_{WS} R$ =	0.39 lb/ft^2
Particle Moved =	63 mm

Sediment Transport Validation

Project:	Deaton Mitigation Site
Stream:	North Branch
Date:	04/24/2001
Reach:	DN-1

Q_{Bkf} :	43.7	cfs
W/D_{Design} :	10	
Side Slopes :	1.5	
Mannings n :	0.035	
S_{Valley} =	0.0075	ft./ft.
Sinuosity =	1.2	

$S_{WS} = S_{valley}/Sin.$ =	0.0063	ft./ft.
V =	3.5	fps
$A_{X\text{-}Sect} = Q/V$ =	12.6	sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	11.2	ft.
$D_{Mean} = A/W$ =	1.12	ft.
$D_{Avg.\ Bot.}$ =	1.38	ft.
P =	12.06	ft.
R = A/P =	1.045	ft.

$\tau_c = \gamma S_{WS} R$ =	0.41	lb/ft^2
Particle Moved =	66	mm

Sediment Transport Validation

Project:	Deaton Mitigation Site
Stream:	North Branch
Date:	04/24/2001
Reach:	DS-11

Q_{Bkf} :	38	cfs
W/D_{Design} :	10	
Side Slopes :	1.5	
Mannings n :	0.035	
S_{Valley} =	0.0075	ft./ft.
Sinuosity =	1.2	

$S_{WS} = S_{valley}/Sin.$ =	0.0063	ft./ft.
V =	3.3	fps
$A_{X\text{-}Sect} = Q/V$ =	11.4	sq. ft.
$W_{Bkf} = (A*W/D)^{1/2}$ =	10.7	ft.
$D_{Mean} = A/W$ =	1.07	ft.
$D_{Avg.\ Bot.}$ =	1.31	ft.
P =	11.45	ft.
R = A/P =	0.992	ft.

$\tau_c = \gamma S_{WS} R$ =	0.39	lb/ft^2
Particle Moved =	62	mm

APPENDIX E

HEC-RAS ANALYSIS

EXISTING

EXIST

HEC-RAS Plan: deatonnorthp River: DEATON Reach: NORTH

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
NORTH	14	Bankfull	40.00	508.07	509.58	509.31	509.92	0.019453	4.71	8.76	10.57	0.72
NORTH	14	10-yr	110.00	508.07	510.57	510.45	510.84	0.010464	5.03	54.09	71.16	0.58
NORTH	14	50-yr	207.00	508.07	511.25	510.88	511.47	0.008248	5.30	107.82	87.25	0.54
NORTH	14	100-yr	250.00	508.07	511.42	511.02	511.67	0.008745	5.66	123.39	91.39	0.56
NORTH	13	Bankfull	40.00	505.64	507.28		507.52	0.015059	3.95	10.13	7.76	0.61
NORTH	13	10-yr	110.00	505.64	508.14	507.82	508.80	0.021196	6.51	17.44	14.91	0.78
NORTH	13	50-yr	207.00	505.64	509.16	509.16	509.88	0.015851	7.29	50.98	57.02	0.72
NORTH	13	100-yr	250.00	505.64	509.49	509.49	510.13	0.013597	7.21	72.12	76.08	0.68
NORTH	12	Bankfull	40.00	504.70	506.35		506.51	0.009054	3.20	12.89	13.46	0.50
NORTH	12	10-yr	110.00	504.70	507.98		508.10	0.002913	3.13	60.65	50.14	0.32
NORTH	12	50-yr	207.00	504.70	508.43		508.67	0.005132	4.57	85.30	57.66	0.44
NORTH	12	100-yr	250.00	504.70	508.66		508.93	0.005476	4.94	98.82	61.76	0.46
NORTH	11	Bankfull	42.00	503.31	505.36	504.85	505.70	0.017362	4.67	9.00	11.19	0.62
NORTH	11	10-yr	121.00	503.31	506.84	506.21	507.61	0.022703	7.04	17.83	21.63	0.71
NORTH	11	50-yr	228.00	503.31	508.08	507.66	508.28	0.006811	4.84	120.15	117.38	0.41
NORTH	11	100-yr	276.00	503.31	508.35	507.84	508.53	0.006068	4.76	154.06	128.40	0.39
NORTH	10	Bankfull	42.00	502.78	504.44		504.74	0.016671	4.39	9.57	6.89	0.66
NORTH	10	10-yr	121.00	502.78	505.47		506.25	0.026583	7.09	17.07	8.06	0.84
NORTH	10	50-yr	228.00	502.78	506.89	506.89	507.68	0.015174	7.42	47.07	51.22	0.69
NORTH	10	100-yr	276.00	502.78	507.20	507.20	507.97	0.014438	7.64	63.42	55.30	0.68
NORTH	9	Bankfull	42.00	502.31	504.15		504.21	0.002618	1.96	21.43	15.37	0.29
NORTH	9	10-yr	121.00	502.31	505.24		505.39	0.003596	3.10	38.97	16.66	0.36
NORTH	9	50-yr	228.00	502.31	506.11		506.39	0.004890	4.23	53.92	18.22	0.43
NORTH	9	100-yr	276.00	502.31	506.32		506.67	0.005772	4.80	57.90	20.48	0.47
NORTH	8	Bankfull	42.00	502.14	503.88		503.95	0.003045	2.07	20.49	17.23	0.32
NORTH	8	10-yr	121.00	502.14	504.92		505.07	0.003356	3.17	41.65	25.98	0.37
NORTH	8	50-yr	228.00	502.14	505.69		505.97	0.004258	4.34	68.32	70.53	0.44
NORTH	8	100-yr	276.00	502.14	505.78		506.15	0.005519	5.04	75.53	87.73	0.50
NORTH	7	Bankfull	42.00	501.01	503.25		503.41	0.005804	3.29	16.26	19.35	0.43
NORTH	7	10-yr	121.00	501.01	504.16		504.44	0.007440	4.90	43.34	46.15	0.53
NORTH	7	50-yr	228.00	501.01	504.74		505.15	0.010071	6.49	89.96	131.12	0.63
NORTH	7	100-yr	276.00	501.01	505.00		505.29	0.007691	5.98	127.55	150.47	0.56
NORTH	6	Bankfull	42.00	499.56	501.62		501.80	0.012262	4.79	18.23	22.53	0.61
NORTH	6	10-yr	121.00	499.56	502.86		502.99	0.006879	5.01	63.56	59.70	0.50
NORTH	6	50-yr	228.00	499.56	503.80		503.88	0.003929	4.51	155.55	148.44	0.39
NORTH	6	100-yr	276.00	499.56	503.77		503.89	0.006177	5.62	150.51	144.44	0.49
NORTH	5	Bankfull	47.00	497.47	499.49		499.68	0.007561	3.48	13.73	11.22	0.50
NORTH	5	10-yr	134.00	497.47	500.34		500.87	0.012274	5.99	27.17	21.11	0.69
NORTH	5	50-yr	253.00	497.47	500.78	500.78	501.92	0.022310	9.05	37.71	28.14	0.96
NORTH	5	100-yr	306.00	497.47	501.55	501.55	502.11	0.009588	6.98	92.34	100.78	0.65
NORTH	4	Bankfull	47.00	495.83	498.09		498.24	0.005622	3.39	19.56	21.27	0.43
NORTH	4	10-yr	134.00	495.83	499.27		499.40	0.003641	3.74	88.46	125.30	0.37
NORTH	4	50-yr	253.00	495.83	499.99		500.07	0.002592	3.61	207.96	201.71	0.32
NORTH	4	100-yr	306.00	495.83	500.22		500.28	0.002222	3.47	254.37	207.76	0.30
NORTH	3	Bankfull	47.00	495.13	497.54		497.69	0.005164	3.45	21.49	22.30	0.43
NORTH	3	10-yr	134.00	495.13	498.82		498.99	0.004196	4.30	64.11	60.28	0.42
NORTH	3	50-yr	253.00	495.13	499.53		499.71	0.004469	5.05	136.27	123.35	0.44
NORTH	3	100-yr	306.00	495.13	499.82		499.98	0.003868	4.92	173.49	132.14	0.42
NORTH	2	Bankfull	47.00	494.62	496.43	496.43	497.11	0.038570	6.64	7.12	5.62	1.00
NORTH	2	10-yr	134.00	494.62	497.85	497.85	498.57	0.019462	7.52	28.04	27.14	0.79
NORTH	2	50-yr	253.00	494.62	498.87	498.87	499.36	0.012111	7.30	79.06	74.86	0.66
NORTH	2	100-yr	306.00	494.62	498.87		499.59	0.017535	8.79	79.45	74.95	0.80
NORTH	1	Bankfull	47.00	493.87	496.15	495.53	496.34	0.008203	3.52	13.73	11.45	0.50
NORTH	1	10-yr	134.00	493.87	497.42	496.63	497.77	0.008207	4.93	33.13	20.82	0.53
NORTH	1	50-yr	253.00	493.87	498.43	497.60	498.91	0.008212	6.11	62.82	42.31	0.56
NORTH	1	100-yr	306.00	493.87	498.72	498.01	499.22	0.008200	6.43	75.55	44.62	0.57

HEC-RAS Plan: deatonsouthp River: deaton Reach: south

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)	
south	14	Bankfull	9.00	537.94	538.84	538.84	539.12	0.050612	4.29	2.18	4.45	0.99
south	14	10-yr	12.00	537.94	538.96	538.96	539.30	0.046081	4.67	2.78	5.10	0.98
south	14	50-yr	22.00	537.94	539.39	539.39	539.72	0.026108	4.83	7.69	21.31	0.80
south	14	100-yr	27.00	537.94	539.56	539.56	539.85	0.021261	4.77	11.86	31.08	0.74
south	13	Bankfull	9.00	534.62	535.65	535.38	535.74	0.015064	2.51	3.58	5.54	0.55
south	13	10-yr	12.00	534.62	535.70	535.50	535.85	0.021275	3.08	3.90	5.76	0.66
south	13	50-yr	22.00	534.62	536.04	535.80	536.24	0.021203	3.62	6.09	7.51	0.68
south	13	100-yr	27.00	534.62	536.15	535.93	536.39	0.022418	3.96	6.93	8.78	0.71
south	12.5	Bankfull	9.00	530.11	530.58	530.52	530.65	0.029050	2.15	4.52	18.54	0.71
south	12.5	10-yr	12.00	530.11	530.67	530.57	530.74	0.019806	2.09	6.48	21.47	0.61
south	12.5	50-yr	22.00	530.11	530.83	530.71	530.93	0.021208	2.60	10.11	26.04	0.66
south	12.5	100-yr	27.00	530.11	530.90	530.77	531.01	0.020566	2.74	12.04	28.17	0.66
south	12	Bankfull	9.00	525.27	526.36	526.15	526.51	0.022116	3.14	2.91	4.45	0.65
south	12	10-yr	12.00	525.27	526.42	526.28	526.65	0.030392	3.82	3.21	4.73	0.77
south	12	50-yr	22.00	525.27	526.82	526.64	527.11	0.024946	4.44	5.79	10.20	0.75
south	12	100-yr	27.00	525.27	526.96	526.81	527.29	0.023888	4.71	7.47	13.38	0.74
south	11	Bankfull	11.00	521.05	522.63		522.81	0.015905	3.42	3.48	4.37	0.55
south	11	10-yr	14.00	521.05	522.90	522.38	523.08	0.012373	3.45	4.85	5.79	0.50
south	11	50-yr	27.00	521.05	523.40	522.91	523.65	0.013211	4.33	10.63	15.84	0.54
south	11	100-yr	33.00	521.05	523.55	523.32	523.81	0.013557	4.60	13.15	17.76	0.55
south	10	Bankfull	11.00	516.95	517.99		518.22	0.028638	3.85	2.85	3.98	0.80
south	10	10-yr	14.00	516.95	517.99	517.99	518.36	0.045221	4.86	2.88	3.99	1.01
south	10	50-yr	27.00	516.95	518.43	518.43	518.91	0.042162	5.58	4.84	5.05	1.01
south	10	100-yr	33.00	516.95	518.58	518.58	519.11	0.041420	5.83	5.66	5.43	1.01
south	9	Bankfull	11.00	512.89	514.28		514.40	0.009666	2.76	4.07	4.57	0.46
south	9	10-yr	14.00	512.89	514.80		514.88	0.003960	2.27	7.32	7.95	0.31
south	9	50-yr	27.00	512.89	515.36		515.48	0.004655	3.00	13.16	17.42	0.36
south	9	100-yr	33.00	512.89	515.51		515.64	0.005081	3.27	16.00	21.43	0.37
south	8	Bankfull	19.00	510.36	511.82		512.03	0.018809	3.66	5.19	5.90	0.69
south	8	10-yr	47.00	510.36	512.52		512.87	0.019476	4.78	9.82	7.43	0.73
south	8	50-yr	89.00	510.36	513.40		513.82	0.013362	5.21	17.97	13.61	0.64
south	8	100-yr	108.00	510.36	513.70		514.11	0.011393	5.28	27.35	48.14	0.61
south	7	Bankfull	19.00	507.26	508.80		508.95	0.009425	3.12	6.72	9.32	0.49
south	7	10-yr	47.00	507.26	509.54		509.78	0.009242	4.20	14.57	11.60	0.52
south	7	50-yr	89.00	507.26	509.97		510.45	0.015245	6.14	19.78	12.76	0.69
south	7	100-yr	108.00	507.26	510.07		510.70	0.019225	7.07	21.01	13.02	0.78
south	6	Bankfull	19.00	503.23	504.21	504.21	504.61	0.041352	5.12	3.71	4.61	1.01
south	6	10-yr	47.00	503.23	504.90	504.90	505.55	0.039170	6.51	7.22	5.57	1.01
south	6	50-yr	89.00	503.23	505.95		506.49	0.016735	6.13	18.74	15.57	0.72
south	6	100-yr	108.00	503.23	506.35		506.84	0.012738	5.96	25.58	18.34	0.64
south	5	Bankfull	28.00	500.55	502.48		502.58	0.004612	2.52	11.12	6.56	0.34
south	5	10-yr	65.00	500.55	503.54		503.72	0.006114	3.49	18.65	7.68	0.39
south	5	50-yr	122.00	500.55	504.29		504.68	0.009195	4.97	25.02	9.42	0.49
south	5	100-yr	148.00	500.55	504.37		504.90	0.012484	5.88	25.75	9.69	0.57
south	4	Bankfull	28.00	499.06	500.53		500.82	0.019632	4.33	6.53	7.21	0.73
south	4	10-yr	65.00	499.06	501.28		501.71	0.016885	5.47	14.54	15.02	0.72
south	4	50-yr	122.00	499.06	502.01		502.43	0.012644	5.95	40.40	64.37	0.66
south	4	100-yr	148.00	499.06	502.26		502.57	0.009605	5.53	57.10	69.48	0.59
south	3	Bankfull	28.00	496.59	498.38		498.52	0.008353	3.07	9.13	7.24	0.48
south	3	10-yr	65.00	496.59	499.29		499.54	0.008316	3.97	16.72	10.32	0.50
south	3	50-yr	122.00	496.59	500.06		500.45	0.009040	5.16	27.83	22.32	0.55
south	3	100-yr	148.00	496.59	500.22		500.71	0.010488	5.77	33.56	42.86	0.60
south	2	Bankfull	28.00	495.51	497.59		497.72	0.006699	2.90	9.65	6.82	0.43
south	2	10-yr	65.00	495.51	498.42		498.67	0.007802	4.06	17.41	12.92	0.49
south	2	50-yr	122.00	495.51	499.18		499.52	0.007980	5.04	37.77	69.22	0.52
south	2	100-yr	148.00	495.51	499.41		499.72	0.007228	5.05	55.34	80.96	0.50
south	1	Bankfull	28.00	494.66	496.90	496.42	497.10	0.014804	3.59	7.79	7.22	0.61
south	1	10-yr	65.00	494.66	497.69	497.21	498.00	0.014801	4.43	14.66	10.14	0.65
south	1	50-yr	122.00	494.66	498.43	497.93	498.85	0.014814	5.23	25.33	30.19	0.68
south	1	100-yr	148.00	494.66	498.61	498.23	499.08	0.014810	5.58	32.36	41.09	0.69

HEC-RAS Plan: deatonculver River: Main Reach: Culvert

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)	
Culvert	3	Bankfull	54.83	493.70	497.63	494.62	497.64	0.000189	0.92	69.92	42.03	0.09
Culvert	3	10-yr	201.00	493.70	501.17	495.68	501.18	0.000077	0.93	495.00	216.07	0.06
Culvert	3	50-yr	378.00	493.70	504.94	496.66	504.94	0.000017	0.57	1668.96	405.86	0.03
Culvert	3	100-yr	458.00	493.70	505.15	497.09	505.15	0.000022	0.66	1755.44	414.51	0.03
Culvert	2		Culvert									
Culvert	1	Bankfull	54.83	493.67	494.92	494.45	495.07	0.007801	3.08	17.82	14.64	0.49
Culvert	1	10-yr	201.00	493.67	496.49	495.51	496.85	0.007812	4.83	41.85	18.09	0.52
Culvert	1	50-yr	378.00	493.67	497.67	496.47	498.21	0.007808	6.02	74.00	43.29	0.54
Culvert	1	100-yr	458.00	493.67	498.04	496.91	498.63	0.007805	6.41	92.63	56.61	0.55

PROPOSED

PROPOSED

HEC-RAS Plan: deatonnorthp River: DEATON Reach: NORTH

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S Elev (ft)	Crit W.S (ft)	E.G Elev (ft)	E.G Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
NORTH	14	Bankfull	40.00	508.07	509.80	509.31	510.05	0.011332	4.00	10.74	17.76	0.57
NORTH	14	10-yr	110.00	508.07	510.67	510.45	510.88	0.008193	4.57	61.09	73.45	0.52
NORTH	14	50-yr	207.00	508.07	511.25	510.88	511.47	0.008248	5.30	107.82	87.25	0.54
NORTH	14	100-yr	250.00	508.07	511.42	511.02	511.67	0.008745	5.66	123.39	91.39	0.56
NORTH	13	Bankfull	40.00	505.64	506.91	506.87	507.37	0.039333	5.47	7.31	7.26	0.96
NORTH	13	10-yr	110.00	505.64	507.82	507.82	508.73	0.036742	7.69	14.48	8.49	1.00
NORTH	13	50-yr	207.00	505.64	509.16	509.16	509.88	0.015851	7.29	50.98	57.02	0.72
NORTH	13	100-yr	250.00	505.64	509.49	509.49	510.13	0.013597	7.21	72.12	76.08	0.68
NORTH	12	Bankfull	40.00	504.69	506.15		506.28	0.005367	2.95	15.57	29.01	0.47
NORTH	12	10-yr	110.00	504.69	506.98		507.20	0.005199	4.12	41.17	32.35	0.51
NORTH	12	50-yr	207.00	504.69	507.73		508.09	0.005763	5.35	67.80	45.71	0.56
NORTH	12	100-yr	250.00	504.69	508.01		508.40	0.005711	5.67	81.43	51.31	0.57
NORTH	11	Bankfull	42.00	504.18	505.65		505.79	0.005654	3.05	16.30	31.55	0.49
NORTH	11	10-yr	121.00	504.18	506.47		506.73	0.006013	4.43	43.59	34.81	0.55
NORTH	11	50-yr	228.00	504.18	507.24		507.60	0.006072	5.51	71.39	37.84	0.58
NORTH	11	100-yr	276.00	504.18	507.47		507.89	0.006525	6.01	82.75	81.61	0.61
NORTH	10	Bankfull	42.00	503.81	505.34		505.46	0.004727	2.88	18.14	31.79	0.45
NORTH	10	10-yr	121.00	503.81	506.09		506.35	0.006155	4.47	43.19	34.80	0.55
NORTH	10	50-yr	228.00	503.81	506.77		507.18	0.007215	5.86	74.32	60.27	0.63
NORTH	10	100-yr	276.00	503.81	507.07		507.48	0.006550	6.00	93.28	64.09	0.61
NORTH	9	Bankfull	42.00	503.18	504.69		504.84	0.007077	3.18	16.31	32.62	0.54
NORTH	9	10-yr	121.00	503.18	505.44		505.67	0.006517	4.35	41.87	35.62	0.57
NORTH	9	50-yr	228.00	503.18	506.14		506.46	0.006307	5.32	67.63	38.40	0.59
NORTH	9	100-yr	276.00	503.18	506.57		506.87	0.004973	5.25	85.03	50.50	0.54
NORTH	8	Bankfull	42.00	502.49	503.95		504.09	0.005777	3.07	15.98	31.50	0.49
NORTH	8	10-yr	121.00	502.49	504.73		504.97	0.005998	4.36	41.85	34.57	0.54
NORTH	8	50-yr	228.00	502.49	505.45		505.78	0.006011	5.35	67.74	37.40	0.57
NORTH	8	100-yr	276.00	502.49	505.84		506.25	0.006146	5.92	91.32	90.71	0.59
NORTH	7	Bankfull	42.00	501.52	502.98		503.12	0.005737	3.06	16.05	31.52	0.49
NORTH	7	10-yr	121.00	501.52	503.75		503.99	0.006126	4.39	41.53	34.60	0.55
NORTH	7	50-yr	228.00	501.52	504.42		504.77	0.006677	5.56	71.57	63.06	0.60
NORTH	7	100-yr	276.00	501.52	504.62		505.11	0.008238	6.49	90.29	114.05	0.68
NORTH	6	Bankfull	42.00	500.05	501.50		501.65	0.005906	3.09	15.77	31.51	0.50
NORTH	6	10-yr	121.00	500.05	502.33		502.56	0.005704	4.30	43.96	40.13	0.53
NORTH	6	50-yr	228.00	500.05	503.26		503.51	0.004155	4.72	98.78	86.20	0.48
NORTH	6	100-yr	276.00	500.05	503.63		503.84	0.003385	4.61	138.58	129.08	0.44
NORTH	5	Bankfull	47.00	498.25	499.80		499.95	0.005635	3.13	16.70	31.98	0.49
NORTH	5	10-yr	134.00	498.25	500.59		500.86	0.006300	4.56	43.29	35.29	0.56
NORTH	5	50-yr	253.00	498.25	500.94		501.56	0.012399	7.08	56.72	55.57	0.80
NORTH	5	100-yr	306.00	498.25	500.91	500.88	501.85	0.018950	8.69	55.27	50.00	0.99
NORTH	4	Bankfull	47.00	496.59	498.09		498.25	0.006275	3.24	16.03	31.96	0.51
NORTH	4	10-yr	134.00	496.59	498.90		499.15	0.006102	4.46	51.37	89.47	0.55
NORTH	4	50-yr	253.00	496.59	499.68		499.84	0.003492	4.19	159.69	179.02	0.44
NORTH	4	100-yr	306.00	496.59	499.94		500.06	0.002807	3.98	209.19	200.07	0.40
NORTH	3	Bankfull	47.00	495.79	497.35		497.49	0.005224	3.05	17.97	32.27	0.47
NORTH	3	10-yr	134.00	495.79	498.18		498.42	0.005542	4.36	46.17	36.59	0.53
NORTH	3	50-yr	253.00	495.79	499.04		499.33	0.004818	5.10	91.37	94.34	0.52
NORTH	3	100-yr	306.00	495.79	499.26		499.60	0.005191	5.56	114.30	110.76	0.55
NORTH	2	Bankfull	47.00	495.48	497.00		497.16	0.005894	3.17	16.69	32.00	0.50
NORTH	2	10-yr	134.00	495.48	497.83		498.08	0.005989	4.47	44.40	35.24	0.55
NORTH	2	50-yr	253.00	495.48	498.61		499.00	0.006492	5.76	78.85	67.42	0.60
NORTH	2	100-yr	306.00	495.48	498.87		499.27	0.006202	5.97	98.15	74.97	0.59
NORTH	1	Bankfull	47.00	495.27	496.80	496.28	496.95	0.005809	3.16	16.84	32.01	0.49
NORTH	1	10-yr	134.00	495.27	497.63	497.20	497.88	0.005806	4.43	44.92	35.23	0.54
NORTH	1	50-yr	253.00	495.27	498.44	497.75	498.79	0.005804	5.49	77.56	51.27	0.57
NORTH	1	100-yr	306.00	495.27	498.69	497.99	499.07	0.005803	5.81	91.10	53.23	0.58

HEC-RAS Plan: deatonsouthp River: deaton Reach: south

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
south	14	Bankfull	9.00	538.01	539.04	539.04	539.40	0.032873	4.83	2.05	4.08	0.97
south	14	10-yr	12.00	538.01	539.31	539.31	539.59	0.018465	4.44	4.62	17.24	0.77
south	14	50-yr	22.00	538.01	539.67	539.67	539.91	0.014050	4.70	13.76	34.02	0.70
south	14	100-yr	27.00	538.01	539.76	539.76	540.01	0.013988	4.91	17.17	35.41	0.71
south	13	Bankfull	9.00	535.30	535.98		536.13	0.016945	3.16	4.33	25.09	0.74
south	13	10-yr	12.00	535.30	536.01		536.23	0.024190	3.90	5.07	25.20	0.89
south	13	50-yr	22.00	535.30	536.23		536.47	0.020144	4.39	10.72	26.01	0.86
south	13	100-yr	27.00	535.30	536.32		536.57	0.018913	4.57	13.16	26.35	0.84
south	12.5	Bankfull	9.00	529.99	530.62	530.62	530.78	0.021170	3.33	4.37	26.60	0.81
south	12.5	10-yr	12.00	529.99	530.74		530.88	0.015856	3.29	7.54	29.20	0.73
south	12.5	50-yr	22.00	529.99	530.90		531.10	0.018728	4.18	12.72	33.02	0.82
south	12.5	100-yr	27.00	529.99	530.96		531.19	0.020371	4.57	14.75	34.41	0.87
south	12	Bankfull	9.00	526.37	527.10		527.19	0.010404	2.61	6.81	27.39	0.59
south	12	10-yr	12.00	526.37	527.09	527.09	527.26	0.019453	3.54	6.62	27.36	0.80
south	12	50-yr	22.00	526.37	527.30		527.49	0.016796	4.02	12.63	28.51	0.78
south	12	100-yr	27.00	526.37	527.40		527.59	0.015490	4.17	15.45	29.03	0.77
south	11	Bankfull	11.00	522.00	522.65	522.61	522.87	0.026592	3.80	2.90	5.44	0.92
south	11	10-yr	14.00	522.00	522.82		522.98	0.015312	3.40	6.20	26.07	0.72
south	11	50-yr	27.00	522.00	523.01		523.26	0.018097	4.38	11.44	26.87	0.82
south	11	100-yr	33.00	522.00	523.08		523.36	0.019304	4.76	13.29	27.14	0.86
south	10	Bankfull	11.00	518.40	519.26		519.34	0.007150	2.42	7.36	26.25	0.50
south	10	10-yr	14.00	518.40	519.27		519.40	0.010916	3.02	7.61	26.29	0.62
south	10	50-yr	27.00	518.40	519.52		519.68	0.010980	3.68	14.34	28.30	0.65
south	10	100-yr	33.00	518.40	519.63		519.80	0.010307	3.83	17.59	30.05	0.64
south	9	Bankfull	11.00	514.40	515.05	515.05	515.30	0.031574	4.02	2.73	5.41	1.00
south	9	10-yr	14.00	514.40	515.22	515.22	515.38	0.016031	3.42	6.14	26.10	0.74
south	9	50-yr	27.00	514.40	515.41	515.41	515.62	0.017237	4.20	11.19	26.90	0.80
south	9	100-yr	33.00	514.40	515.46	515.46	515.71	0.019679	4.66	12.56	27.68	0.87
south	8	Bankfull	19.00	511.50	512.55	512.24	512.66	0.007188	2.76	9.40	27.90	0.52
south	8	10-yr	47.00	511.50	512.99		513.13	0.006842	3.53	22.16	29.71	0.54
south	8	50-yr	89.00	511.50	513.41		513.61	0.007230	4.37	35.17	31.45	0.58
south	8	100-yr	108.00	511.50	513.65		513.89	0.007147	4.73	45.03	53.97	0.59
south	7	Bankfull	19.00	508.64	509.57	509.38	509.75	0.013114	3.39	6.17	27.42	0.68
south	7	10-yr	47.00	508.64	509.90	509.90	510.20	0.016431	4.81	15.39	28.77	0.81
south	7	50-yr	89.00	508.64	510.23		510.63	0.017477	5.93	25.29	30.16	0.88
south	7	100-yr	108.00	508.64	510.33		510.79	0.019365	6.52	28.18	30.55	0.93
south	6	Bankfull	19.00	505.61	506.68		506.78	0.006611	2.69	10.09	28.53	0.50
south	6	10-yr	47.00	505.61	507.21		507.34	0.005351	3.29	26.26	32.42	0.48
south	6	50-yr	89.00	505.61	507.69		507.86	0.005680	4.11	46.37	76.73	0.52
south	6	100-yr	108.00	505.61	507.90		508.07	0.005258	4.24	69.29	126.54	0.51
south	5	Bankfull	28.00	503.65	504.72		504.93	0.012388	3.62	7.74	8.82	0.68
south	5	10-yr	65.00	503.65	505.10	505.10	505.49	0.016522	5.27	18.30	30.30	0.83
south	5	50-yr	122.00	503.65	505.56	505.56	506.04	0.015360	6.26	34.01	44.79	0.85
south	5	100-yr	148.00	503.65	505.67	505.67	506.24	0.017242	6.91	39.26	51.78	0.90
south	4	Bankfull	28.00	501.34	502.63	502.19	502.75	0.005586	2.80	11.65	77.36	0.47
south	4	10-yr	65.00	501.34	502.70	502.70	502.72	0.002070	1.77	69.72	81.27	0.29
south	4	50-yr	122.00	501.34	504.95	502.70	504.95	0.000097	0.79	337.79	146.71	0.08
south	4	100-yr	148.00	501.34	505.16	502.70	505.16	0.000110	0.87	369.14	149.94	0.08
south	3	Bankfull	28.00	499.30	500.26		500.53	0.018242	4.13	6.78	8.49	0.81
south	3	10-yr	65.00	499.30	501.19		501.22	0.001559	1.98	79.83	110.07	0.27
south	3	50-yr	122.00	499.30	504.94		504.94	0.000012	0.39	763.52	225.64	0.03
south	3	100-yr	148.00	499.30	505.15		505.15	0.000015	0.44	811.07	225.65	0.03
south	2	Bankfull	28.00	498.10	499.30		499.36	0.004581	2.38	23.64	80.10	0.42
south	2	10-yr	65.00	498.10	501.18		501.18	0.000090	0.68	215.25	128.96	0.07
south	2	50-yr	122.00	498.10	504.94		504.94	0.000007	0.34	815.58	178.46	0.02
south	2	100-yr	148.00	498.10	505.15		505.15	0.000009	0.39	853.21	179.20	0.03
south	1	Bankfull	28.00	497.40	498.25	498.25	498.61	0.027783	4.77	5.87	12.71	0.99
south	1	10-yr	65.00	497.40	501.17	498.77	501.17	0.000092	0.79	174.36	79.68	0.07
south	1	50-yr	122.00	497.40	504.94	499.06	504.94	0.000013	0.49	586.86	129.30	0.03
south	1	100-yr	148.00	497.40	505.15	499.14	505.15	0.000017	0.56	614.04	129.48	0.04

HEC-RAS Plan: deatonculver River: Main Reach: Culvert

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)	
Culvert	3	Bankfull	54.83	494.38	497.61	495.65	497.64	0.000656	1.56	48.53	41.26	0.17
Culvert	3	10-yr	201.00	494.38	501.17	497.09	501.18	0.000108	1.10	474.33	216.03	0.08
Culvert	3	50-yr	378.00	494.38	504.94	498.17	504.94	0.000019	0.63	1648.48	405.87	0.03
Culvert	3	100-yr	458.00	494.38	505.15	498.46	505.15	0.000024	0.72	1734.98	414.51	0.04
Culvert	2		Culvert									
Culvert	1	Bankfull	54.83	493.67	494.92	494.45	495.07	0.007801	3.08	17.82	14.64	0.49
Culvert	1	10-yr	201.00	493.67	496.49	495.51	496.85	0.007812	4.83	41.85	18.09	0.52
Culvert	1	50-yr	378.00	493.67	497.67	496.46	498.21	0.007808	6.02	74.00	43.29	0.54
Culvert	1	100-yr	458.00	493.67	498.04	496.91	498.63	0.007805	6.41	92.63	56.61	0.55

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)

Deaton Mitigation Site Macroinvertebrate Analysis

Hilsenhoff Biotic Index

Order	Family	# Individuals (xi)	Tolerance Value (ti)	xi*ti	xi*ti / N
Coleoptera	Hydrophilidae	2	5	10	0.05
Diptera	Chironomidae	195	6	1170	5.85
Gastropoda	Physidae	1	8	8	0.04
Odonata	Corduliidae	2	5	10	0.05
Total (N)		200			5.99

Summary

Total #:	**200**	
Total Taxa:	**4**	
EPT #:	**0**	
EPT Taxa:	**0**	**Rating: Poor**
HBI:	**5.99**	**Rating: Fairly poor, substantial pollution likely**

Benthic Macroinvertebrate Laboratory Sheet

Project Number: 30036B	Stream Name/Location: Deaton, Randolph County
Client: NCDOT	River Basin: Cape Fear
Collected By: Martin Mitchell HSMM, Inc.	Date: 6/20/00
	Number Sampled: 437

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

Organisms					
Order	**Family**	**Number**	**Tolerance**	**Abundance***	**Notes**
Coleoptera	Hydrophilidae	2	5	Rare	PR (larva)
Diptera	Chironomidae	432	6	Abundant	GC
Gastropoda	Physidae	1	8	Rare	SC
Odonata	Corduliidae	2	5	Rare	PR

Total #: 437
Total Taxa: 4

EPT #: 0
EPT Taxa: 0

STREAMSIDE BIOSURVEY: HABITAT WALK

Stream Name: Tributary to Fork Creek

County: Randolph **State:** NC

Investigators: Martin Mitchell, Grant Ginn, Daren Pait

Site (description): 300 ft of stream west of road and south of perennial tributary. Surrounding land use is pasture for cattle.

Latitude: _____ **Longitude:** _____

Site or Map Number: Deaton Site

Date: 6/20/00 **Time:** 2:00 PM

Weather in past 24 hours:

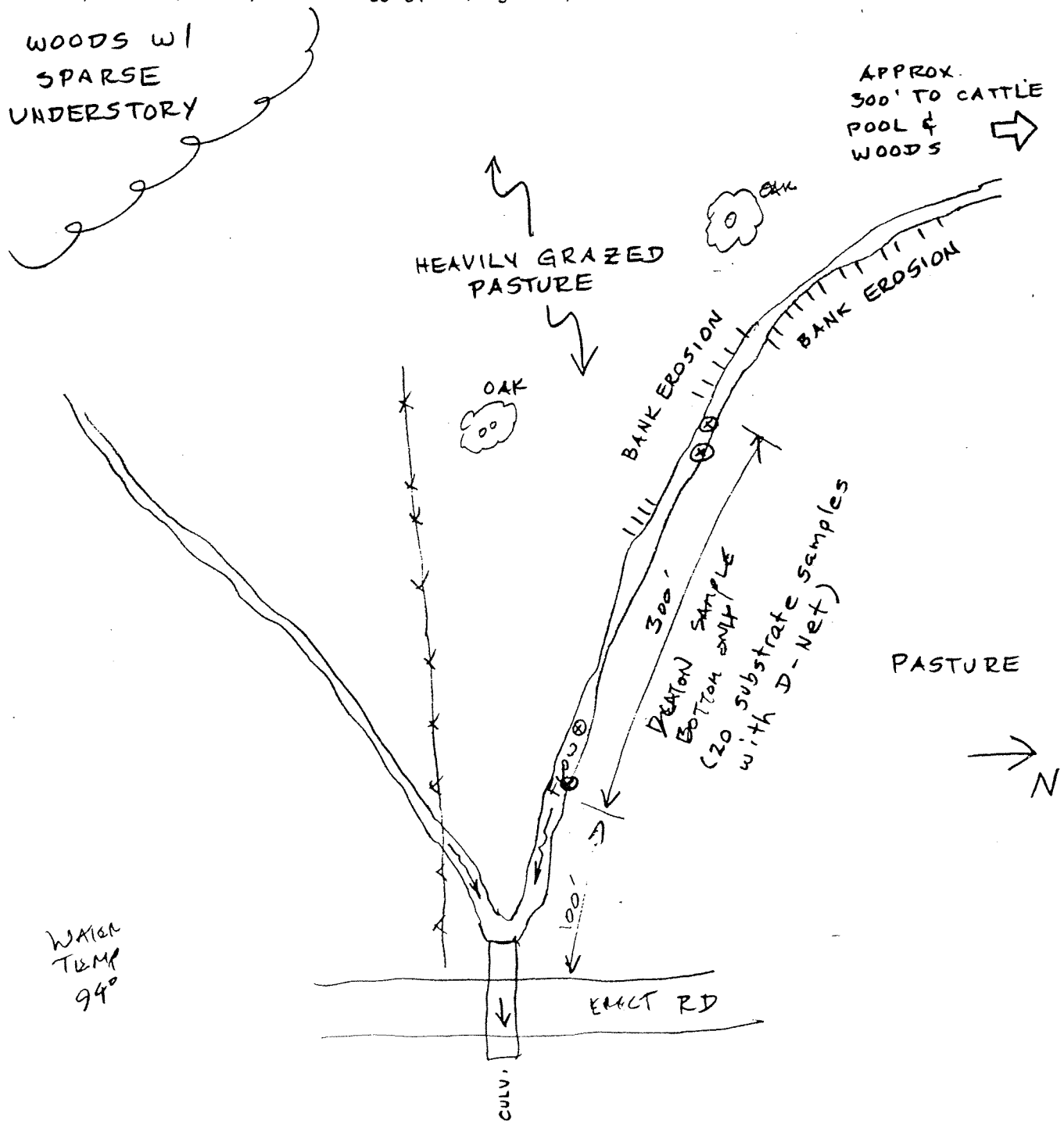
- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☒ Overcast
- ☐ Clear/Sunny

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	85
Sand (up to 0.1" in diam.)	10
Gravel (0.1 - 2" in diam.)	5
Cobbles (2 - 10" in diam.)	
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 CATTLE WASTE

9. **Water temperature:** Page 74
   _____ °C *or* 94 °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): N/A
    ☐ < 1 ft ☐ 1-2 ft ☐ > 2 ft

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

12. **Stream velocity:** 1/2 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)*
	Trees	
	Bushes, shrubs	
	Tall grasses, ferns, etc.	
80	Lawn (CUT-AREA FARM)	80
	Boulders/rocks	
	Gravel/sand	
20	Bare soil	20
	Pavement, structures	
TOTALS *100%*		*100%*

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

Left *(Percent)*		Right *(Percent)*
____	Trees	____
____	Bushes, shrubs	____
____	Tall grasses, ferns, etc.	____
100	Lawn (GRAZED PASTURE)	100
____	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 N/A
☐	☐	Power boating
☐	☐	Golfing
☐	☐	Camping
☐	☐	Swimming/fishing/canoeing
☐	☐	Hiking/paths
		Other N/K
☐	☐	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)*

APPENDIX G

PHOTOGRAPHS

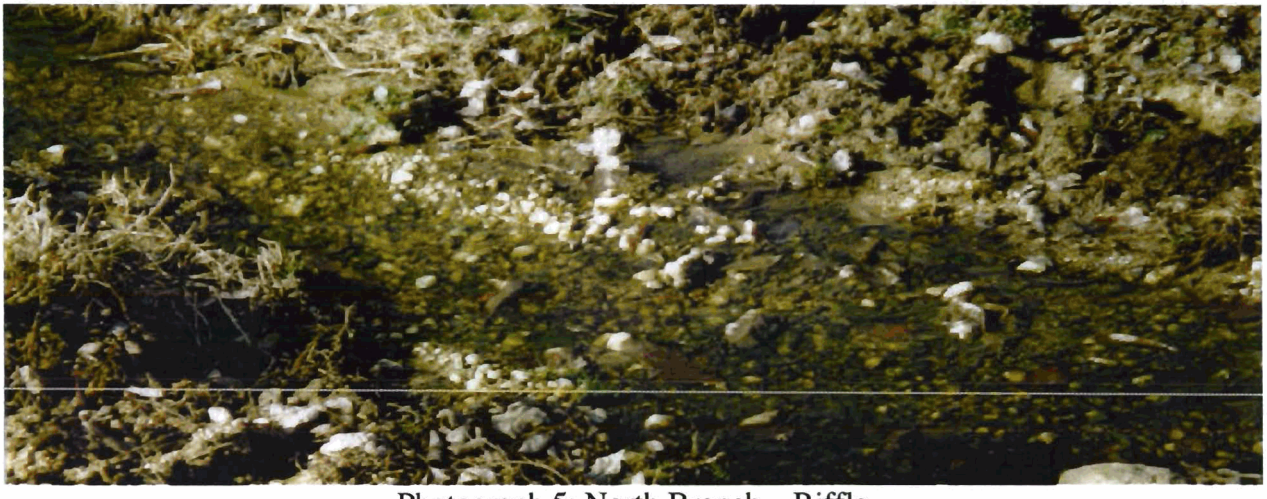
DEATON MITIGATION SITE PHOTOGRAPHS

Photograph 1: North Branch – Section DN 11

Photograph 2: North Branch – Section DN 9

Photograph 3: North Branch – Section DN 8

Photograph 4: North Branch – Section DN 7



Photograph 5: North Branch – Riffle

Photograph 6: South Branch – Bedrock Channel Feature

Photograph 7: South Branch – Section DS 4

Photograph 8: South Branch – Section DS 5

Photograph 9: South Branch – Section DS 7

Photograph 10: South Branch – Section DS 10

Photograph 11: South Branch – Section DS 12