UT BEAR CREEK MITIGATION PLAN
CHATHAM COUNTY, NORTH CAROLINA

T.I.P. No U-2524WM
O.N.E. # WM 019-001

NCDOT Consulting Project No. 02-ES-01

Prepared for:

The North Carolina Department of Transportation
Raleigh, North Carolina

June 2003

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1.0 INTRODUCTION

1.1 Project Description

The North Carolina Department of Transportation (NCDOT) recognizes in fulfilling its public service mission of roadway and other transportation construction projects, it has an important responsibility to protect the State's environment and to protect the State's wetland and stream resources in a prudent manner in compliance with applicable State and Federal laws. As part of this mission, NCDOT is developing a stream mitigation area identified as the Unnamed Tributary (UT) to Bear Creek Mitigation Site located in Chatham County, North Carolina.

The project study area associated with the UT Bear Creek Mitigation Site is located on SR 1141, north of its intersection with SR 1136 (Figure 1). The project study area is comprised of a single property which is approximately 93 acres in areal extent. The project study area is owned by Vicki and Lee Phillips. The project study area includes approximately 2,100 linear feet of an unnamed tributary to Bear Creek (UT Bear Creek) which is proposed for restoration. According to the landowners, an unnamed tributary (UT2) was present historically which flowed into UT Bear Creek, but the upper reach has been channelized and the lower reach has been destroyed by cattle incursions. Approximately 1,300 linear feet of an area which previously contained UT2 is proposed for restoration. Mitigation activities are expected to yield approximately 3,850 linear feet of restored stream channel and associated riparian buffer.

1.2 Project Purpose and Objectives

The project study area has been previously reviewed for mitigation feasibility (ESI 2002). At the time of the review, it was determined that the project study area offered the potential for up to 3,100 linear feet of stream channel restoration. The current report outlines a mitigation plan which would allow for the restoration of the stream channels within the project study area.

Existing conditions within the project study area are noted, as well as conditions of the supporting watershed. Reference reach stream segments were located and reviewed. Reference reach data were requested and received from NCDOT.

Project objectives include excluding cattle from the stream channels, increasing channel stability, and restoring dimension, pattern and profile to UT Bear Creek and UT2.

1.3 Project Personnel

Personnel involved in this study include ESI biologists Jan Gay, Ron Spears, Steve Jones, and Paul Petitgout as well as surveyors provided by Sungate Design Group. Mr. Gay, who

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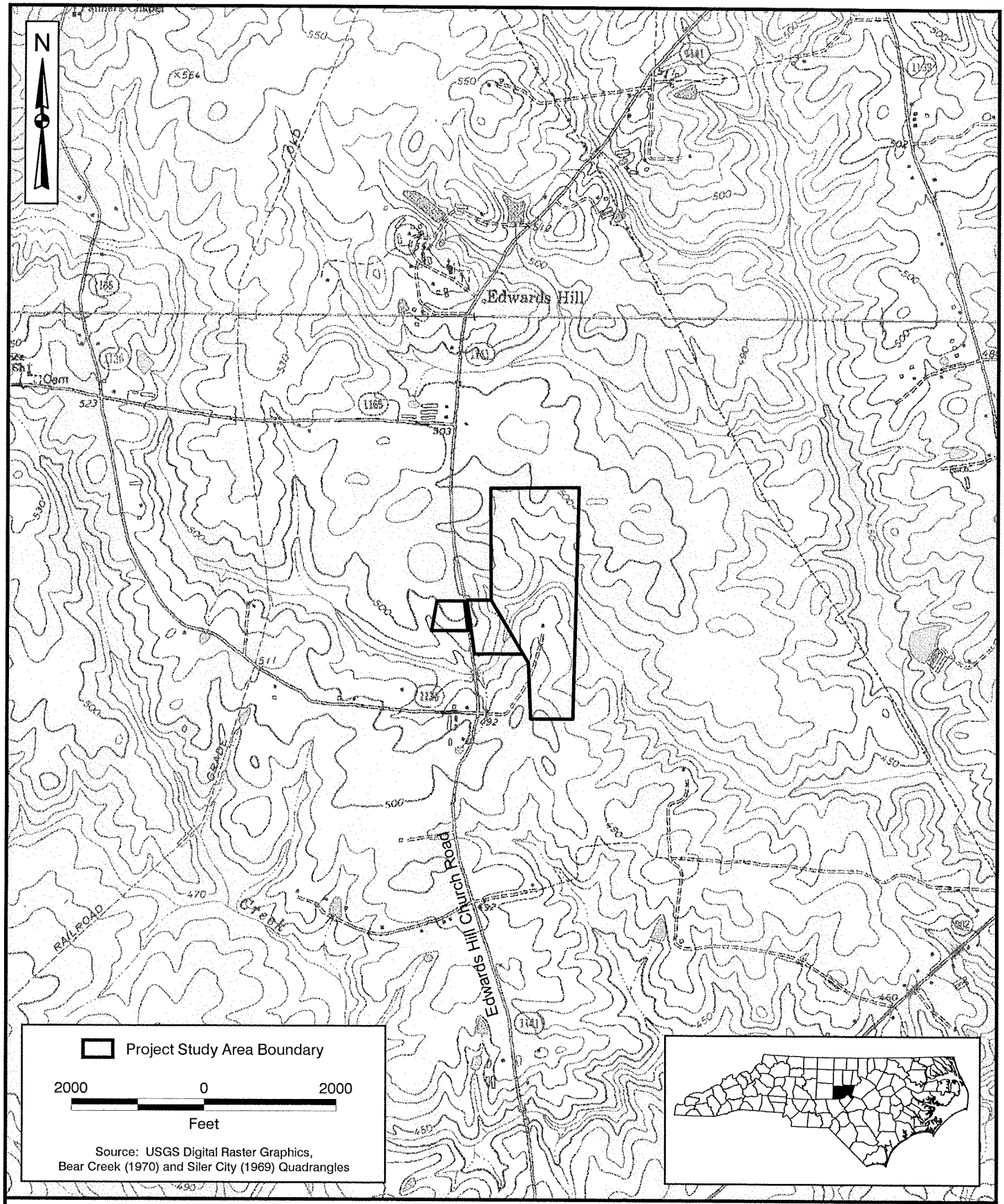

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Project Location Map
UT Bear Creek Mitigation Plan
Chatham County, North Carolina

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managed the development of the conceptual mitigation plan, is a Senior Scientist with a MS degree in Ecological Modeling and more than 11 years of professional experience. Mr. Spears, who assisted with developing the conceptual stream channel design, is a Senior Scientist with a MS degree in Biology and more than 7 years of professional experience. Dr. Jones, who assisted with the development of the conception stream channel design, is a Senior Scientist with a Ph.D. in Forestry with more than 28 years of professional experience. Mr. Petitgout, who assisted with data collection and review, is a Senior Scientist MS degree in Forested Wetland Ecology and Management and more than 10 years of professional experience. Each of the key personnel involved with this study have completed all four courses offered by Wildland Hydrology, as taught by Mr. Dave Rosgen. Additionally, Mr. Spears and Dr. Jones have developed and implemented stream channel designs across the Southeastern United States.

2.0 EXISTING CONDITIONS

As part of this report review, the project vicinity and project study area were evaluated for significant features, including existing land use, existing plant community, jurisdictional wetland areas, stream channel features, potential habitat for any federally Threatened or Endangered species considered to have ranges extending into Chatham County, potential cultural resource issues, and potential environmental conditions (Phase I Environmental Site Assessment).

Material and research data in support of this investigation have been derived from a number of sources including a site prospectus provided by NCDOT, the applicable U.S. Geological Survey (USGS) 7.5-minute topographic quadrangle (Bear Creek, NC, 1970), the *Soil Survey of Chatham County, North Carolina* (USDA unpublished) (Figure 2), flood hazard boundary maps created under the Federal Emergency Management Act (FEMA) (FIRM 1991), and aerial photography furnished by NCDOT (scale 1:6000).

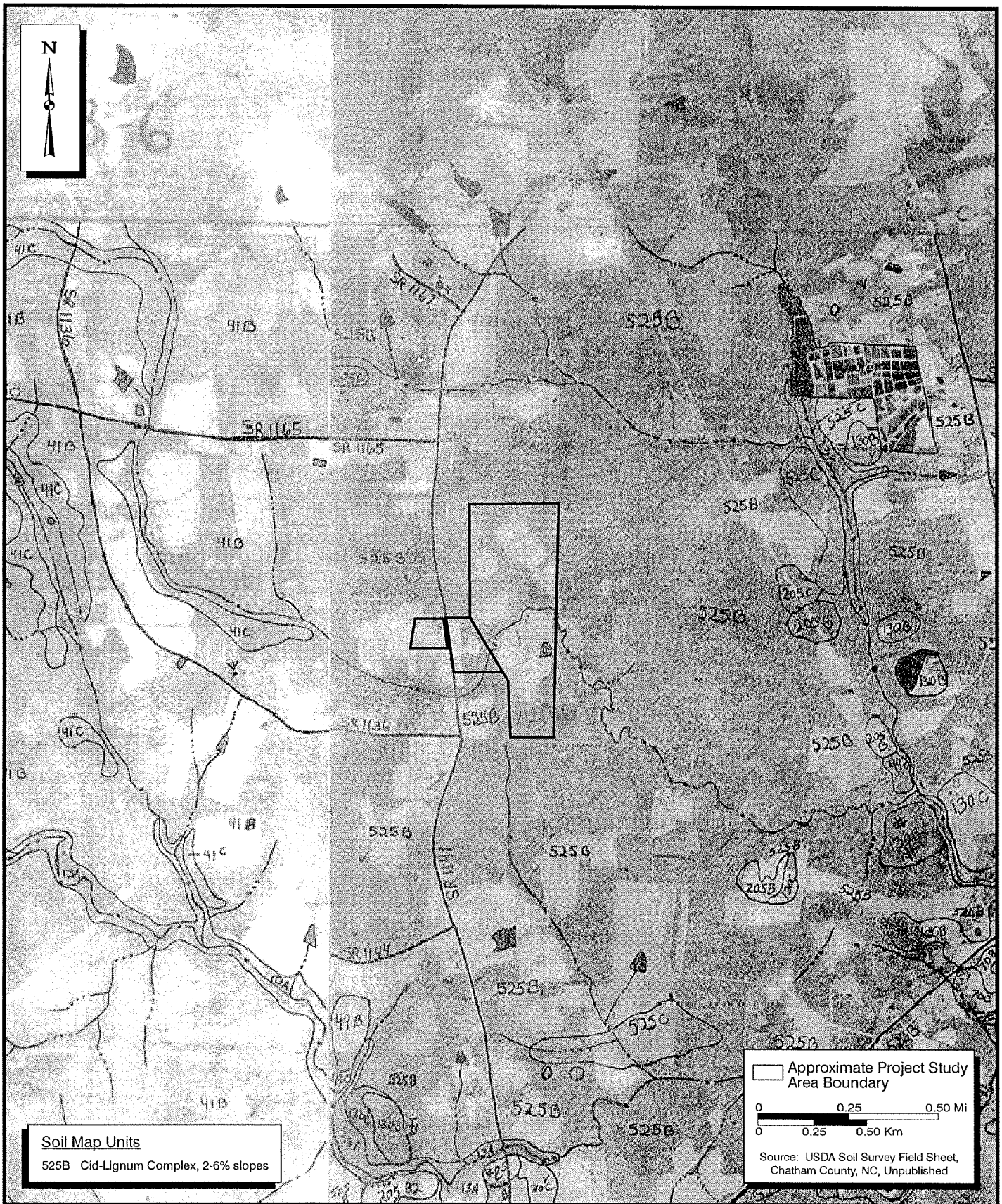
Plant community descriptions are based on a classification system utilized by the N.C. Natural Heritage Program (NHP) (Schafale and Weakley, 1990). When appropriate, community classifications were modified to better reflect field conditions. Vascular plant names generally follow nomenclature found in Radford *et al.* (1968). Jurisdictional areas were identified using the three parameter approach (hydrophytic vegetation, hydric soils, wetland hydrology) as outlined by the U.S. Army Corps of Engineers (COE) delineation guidelines (DOA 1987). Habitat used by terrestrial wildlife and aquatic organisms, as well as expected population distributions, were determined through field observations, evaluation of available habitat, and supportive documentation (Martof *et al.*, 1980, Webster *et al.*, 1985, Hamel 1992, Palmer and Braswell 1995, National Geographic Society 1999). Water quality information for project study area streams and tributaries was derived from available sources (DEM 1994, DENR 2000, DENR 2003). Quantitative sampling was not undertaken to support existing data.

The most current U.S. Fish and Wildlife Service (USFWS) listing of species offered federal protection with ranges considered to extend into Chatham County was obtained prior to initiation of field efforts (list date 29 January 2003). In addition, NHP records documenting the presence of federal or state listed species were consulted before commencing the field investigation and have been periodically updated (most recent review 15 May 2003).

2.1 Existing Watershed Conditions

2.1.1 Water Resources

The project study area is located within subbasin 03-06-12 of the Cape Fear River Basin (DENR 2000) and is part of USGS hydrologic unit 03030003 (USGS 1974). The two channels identified within the project study area have not been assigned separate Stream Index Numbers (SIN) or Best Usage Classifications. Their receiving water, Bear Creek, has been assigned SIN 17-43-16 (DEM 1994, DENR 2003) and a Best Usage Classification of **C** (DENR 2003). The classification **C** indicates freshwaters that support aquatic life propagation and survival, fishing,



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Soils Map
UT Bear Creek Mitigation Plan
Chatham County, North Carolina

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wildlife, secondary recreation and agriculture. Secondary recreation is any activity involving human body contact with water on an incidental or infrequent basis.

No High Quality Waters (**HQW**), Outstanding Resource Waters (**ORW**), **WS-I**, or **WS-II** waters occur within 3.0 miles upstream or downstream of the project study area (DEM 1994, DENR 2003). UT Bear Creek and UT2 have not been designated as a North Carolina Natural and Scenic River or as a national Wild and Scenic River. Bear Creek, UT Bear Creek and UT2 are not 303d Listed Waters (DENR 2000).

A measure of water quality being used by the N.C. Division of Water Quality (DWQ) is the North Carolina Index of Biotic Integrity (NCIBI), which assesses biological integrity using the structure and health of the fish community. Fish sampling was not conducted within UT Bear Creek. Fish sampling was conducted in Bear Creek in 1998, approximately 10 miles downstream of the project study area. At that time, Bear Creek received a Bioclassification of Good (DENR 2000). No macrobenthos sampling has been conducted within Bear Creek, UT Bear Creek or UT2 (DENR 2000).

2.1.2 Existing Watershed

The existing watersheds contributing to UT Bear Creek and UT2 are rural in nature.

The watershed contributing to UT Bear Creek is approximately 1,075 acres (1.68 square miles) in areal extent. A cursory review of the watershed indicates the prevailing land use is pasture and forest, with small areas of rural development. Examples of rural development include single family homes, barns, sheds, and other structures associated with agricultural endeavors.

The watershed contributing to UT2 is approximately 100 acres (0.15 square mile) in areal extent. A cursory review of the watershed indicates the prevailing land use is pasture and forest, with small areas of rural development.

Impervious surfaces within both watersheds are limited to paved roads and small buildings.

2.2 Existing Project Study Area Conditions

The project study area was reviewed for significant features as part of this investigation.

2.2.1 Plant Communities

Terrestrial distribution and composition of plant communities throughout the project study area reflect landscape-level variations in topography, soils, hydrology, and past and present land use practices. Four (4) plant communities were identified within the project study area. When appropriate, the plant community names have been adopted and modified from the NHP classification system (Schafale and Weakley 1990) and the descriptions written to reflect local variations within the project study area. Approximate extent and location of each community is shown on Figure A-1 in Appendix A. A description of each community follows.

Pasture Lands are those areas which are maintained for use as grazing areas for cattle. The majority of the project study area is considered pasture land. Vegetation in these areas is generally limited to various pasture grasses. Portions of the areas in the northern portion of the project study area currently used as pasture land were recently converted from oak-hickory forest. Based on interviews with the landowners, the conversion of these areas was precipitated by clearing of hurricane damaged areas and clearing of pine beetle damaged areas.

Oak-Hickory Forest is the largest natural community remaining within the project study area and is located across the entire project study area, including the majority of the areas slated for mitigation activity. The largest contiguous area of this community is located at the southern end of the project study area; smaller, disjunct areas of this community are located at the northern end of the project study area. Overstory vegetation within this plant community includes laurel oak (*Quercus laurifolia*), willow oak (*Quercus phellos*), eastern red cedar (*Juniperus virginiana*), red maple (*Acer rubrum*), and shagbark hickory (*Carya ovata*), with occasional shortleaf pine (*Pinus echinata*) and white oak (*Quercus alba*). Midstory and understory vegetation within this plant community varies in density from completely absent in areas currently subjected to cattle grazing, to moderate in areas where cattle have been excluded. Midstory vegetation includes sapling sized material of overstory species, as well as American holly (*Ilex opaca*), ironwood (*Carpinus caroliniana*), and winged elm (*Ulmus alata*). Herbaceous vegetation includes poison ivy (*Toxicodendron radicans*), common ragweed (*Ambrosia artemisiifolia*), blackberry (*Rubus* sp.), wild rose (*Rosa* sp.), and trumpet creeper (*Campsis radicans*).

Maintained/Disturbed Land includes those areas subjected to regular maintenance. These areas include the residential yard and roadsides. Vegetation in these areas varies. Within the residential yard, vegetation is maintained for ornamental reasons, with black walnut (*Juglans nigra*) as the main tree species. Other tree species include eastern red cedar and laurel oak. Vegetation in the maintained roadside is limited to various grasses and seedlings of various tree species.

Successional Areas include those areas which have been subjected to disturbance and are regenerating naturally. Two portions of the project study area are considered successional. The first area is located at the northwestern corner of the project study area. Vegetation within this plant community includes seedlings and saplings of loblolly pine (*Pinus taeda*), eastern red cedar, and black willow (*Salix nigra*), with a dense herbaceous component including blackberry and common ragweed. The second area is located at the southern end of the project study area and consists of a powerline easement. Vegetation within this area consists mainly of herbaceous material, including various grasses, dog fennel (*Eupatorium capillifolium*) and bracken fern (*Pteridium aquilinum*). Seedlings of canopy species from the adjacent Oak-Hickory forest are also present.

2.2.3 Protected Species

2.2.3.1 Federally Protected Species

Species with the federal classification of Endangered (E) or Threatened (T), or officially proposed (P) for such listing, are protected under the Endangered Species Act (ESA) of 1973, as amended (16U.S.C. 1531 *et seq.*). Four species offered federal protection are considered by the USFWS to have ranges which extend into Chatham County (list date 29 January 2003). Table 1 lists these species.

Table 1. Federally Threatened and Endangered Species in Chatham County, North Carolina

Common Name	Scientific Name	Status	Potential Habitat	Biological Conclusion
Bald eagle	*Haliaeetus leucocephalus*	T[a]	N	No Effect
Cape Fear shiner	*Notropis mekistocholas*	E	N	No Effect
Red-cockaded woodpecker	*Picoides borealis*	E	N	No Effect
Harperella	*Ptilimnium nodosum*	E	N	No Effect

[a] Officially proposed for delisting

A review of the project study area and species habitat requirements indicates no potential, suitable habitat for any of the federally listed species is present within the project study area. Species descriptions and Biological Conclusions are located in Appendix D. A review of NHP records indicates no known occurrences of any federally listed species documented within 3.0 miles of the project study area (most recent review date 15 May 2003).

2.2.3.2 Federal Species of Concern

The 29 January 2003 USFWS list also includes a category of species designated as "Federal species of concern" (FSC). The FSC designation provides no federal protection under the ESA for the species listed. The presence of potential suitable habitat (Amoroso and Finnegan 2002, LeGrand *et al.* 2001) within the project study area has been evaluated for the following FSC species listed for Chatham County.

Table 2. Federal Species of Concern in Chatham County, North Carolina

Common Name	Species	State Status*	Potential Habitat Present
Bachman's sparrow	*Aimophila aestivalis*	SC	N
"Carolina" redhorse	*Moxostoma* sp. 2	SR	N
Brook floater	*Alasmidonta varicosa*	T(PE)	N
Atlantic pigtoe	*Fusconaia masoni*	T(PE)	N
Septima's clubtail dragonfly	*Gomphus septima*	SR	N
Yellow lampmussel	*Lampsilis cariosa*	T(PE)	N
Virginia quillwort	*Isoetes virginica*	SR-L	N
Buttercup phacelia	*Phacelia covillei*	SR-T	N

* - SC, Special Concern, SR, Significantly Rare; -L, Range is limited to North Carolina and adjacent states; -T, rare throughout range of species; T, Threatened; E, Endangered; P_, Proposed

A review of NHP records indicates that no occurrences of any of these species have been documented within 3.0 miles of the project study area (review date 15 May 2003).

2.3 Cultural Resources

Subsequent to the completion of the feasibility study in 2002, ESI conducted an intensive archaeological survey of the Archaeological Area of Potential Effect (A-APE) for proposed stream and wetland mitigation activities within the project study area during November and December 2002 and February 2003 to comply with Section 106 of the National Historic Preservation Act. The A-APE was defined by NCDOT and the North Carolina Office of State Archaeology (OSA) for this project as a 150-feet wide buffer on either side of 3,100 feet of stream channel and a 50-foot wide corridor for the placement of waterline, encompassing an area of approximately 28 acres.

No cultural resources were recorded during this investigation, and it was recommended that the project be allowed to proceed as planned without concern for impacts to significant cultural resources.

2.4 Existing Project Study Area Stream Channels

Two stream channels are present within the project study area. Both channels were reviewed for mitigation feasibility in 2002 (ESI 2002). As part of the investigation, stream channels within the project study area were classified using the Natural Stream Channel Classification System (Rosgen 1996). The classification effort was a Level 1 classification, consisting of a general description of the channel type without detailed measurements.

The Natural Stream Channel Classification System uses several definitive criteria for classification: 1) number of channels associated with a stream; 2) slope; 3) width-to-depth ratio; 4) entrenchment ratio; 5) sinuosity; and 6) bed material. This classification system uses the first five criteria to assign one of eight channel types to a reach of a stream. Use of the Natural Stream Channel Classification System for a Level 1 classification requires the identification of several features in the field, including bankfull width and depth (the stage at which the controlling channel forming flow occurs), slope, sinuosity, and valley morphology.

UT Bear Creek

UT Bear Creek traverses the project study area west to east and has a drainage area of approximately 1,075 acres (1.68 square miles). The channel reach present within the project study area is approximately 2,100 linear feet in length and exhibited no flow, with scattered areas of standing water during the initial field effort. It should be noted that the field work was conducted during a severe drought, and that interviews with the landowners indicate UT Bear Creek has historically exhibited perennial flow. Substrate within the channel reach consisted of silt and clay, with areas of gravel, boulders and bedrock outcrops. Nine bedrock outcrops were noted within UT Bear Creek (Figure A-1 in Appendix A and Photographs 2, 4 and 6 in Appendix E).

A geomorphic characterization of this reach channel indicates the majority of this channel represents a "G" type stream. "G" type streams are generally entrenched systems with gentle to moderately steep channel gradients and are typically deeply incised channels. These stream types have relatively low bedload transport rates and are very sensitive to disturbance and tend to make significant adverse channel adjustments to changes in flow and sediment supply from the watershed. A typical riffle cross-section is located in Appendix A (Figure A-2). One reach surveyed initially appears to be an "E" type stream, with a low w/d ratio and entrenchment ratio. However, it appears that this channel is in transition to a "G" type channel with signs of bank failure noted.

Within the project study area, the channel ranged from 10 to 20 feet in width, with a bankfull mean depth of approximately 22 inches. Surveys of riffle sections indicate the channel has a bankfull width of approximately 13.2 to 16.7 feet and bankfull depth of approximately 18 to 22 inches, with a cross-sectional area of approximately 19.5 to 29.7 square feet. The channel is deeply entrenched, with an adjacent low bank height of approximately 3 to 4 feet. A typical cross-section is located in Appendix A (Figure A-3). Survey of the longitudinal profile indicates that the riffle-pool sequences are not well defined within the channel, and in some reaches the channel exhibits a negative slope, which is indicative of a reach currently out of equilibrium.

UT2

UT2 begins near the northern boundary of the project study area. The upper reach of this channel has been channelized while the lower reach has been completely destroyed by cattle incursions. A survey of this drainage feature indicates pattern and profile are absent. Dimension is absent within the lower reach due to continual cattle incursions; no discernable stream channel is present (Photographs 7 and 8 in Appendix E). Surveys of the upper channelized reach indicate the channel has a bankfull width of approximately 5.1 to 5.5 feet and a bankfull depth of approximately 13 inches, with a cross-sectional area of approximately 5.7 to 5.9 square feet and extremely low sinuosity. The channel is entrenched, with a low bank height of 3 to 4 feet. Surveys of the longitudinal profile that riffle-pool sequences are not well defined.

During an on-site review in 2002 for the Feasibility Study (ESI 2002), resource agencies questioned the use of UT2 for mitigation. The landowners stated that an intermittent channel had been present within the area historically. During the field review, the resource agencies agreed that UT2 would be considered ecologically significant. The resource agencies further agreed UT2 could be used for compensatory mitigation and should be included in the mitigation plan.

Restoration activities involving construction of a channel within the lower reach of UT2 would require limited tree removal to allow equipment passage. The resource agencies stated they would prefer that tree removal be kept to a minimum.

Surveyed channel information is depicted in Appendix A as Figures A-4 and A-5.

2.5 Channel Stability Evaluations

To better quantify restoration potential within UT Bear Creek, ESI undertook a channel stability assessment that included a Pfankuch Channel Stability Evaluation for the entire reach of UT Bear Creek a Bank Erosion Hazard Index (BEHI) evaluation for one reach of UT Bear Creek (Figure A-1 in Appendix A). Assessments were not conducted within UT2. Information collected during these assessments is included in Appendix A.

The Pfankuch Channel Stability Evaluation is a measure that roughly quantifies bank characteristics to determine overall stability. Upper bank factors evaluated include landform slope, mass wasting, debris jam potential, and vegetative bank protection. Lower bank factors evaluated include channel capacity, bank rock content, obstruction to flow, bank cutting, and deposition. Bottom factors evaluated include rock angularity, brightness, consolidation of particles, bottom size distribution, scouring and deposition, and aquatic vegetation. UT Bear Creek received a stability rating of Poor, indicating a high risk of erosion. Factors leading to the Poor rating include evidence of large scale mass wasting, lack of vegetation on the banks, and bank substrate consisting of fine particles as opposed to boulders and bedrock.

BEHI is a measure which quantifies characteristics to determine bank condition and susceptibility to erosion. Factors evaluated include the bank height to bankfull height ratio, root depth to bank height ratio, root density as a percentage of exposed bank, bank angle or slope in degrees, and surface protection as a percentage of the exposed bank covered in vegetation. UT Bear Creek received a BEHI rating of High, indicating the banks are in poor condition and highly susceptible to erosion.

3.0 REFERENCE REACH

A channel's ability to maintain a stable dimension, pattern and profile and to move sediment without aggrading or degrading are defining factors of a stable channel. Variability in stable channel dimension, pattern and profile over short channel reaches are to be expected due to changes in geology and tributary influence (Rosgen 1996). To ensure that all aspects of these potential changes are accounted for, stable reaches of channel are measured as reference.

Reference reaches are not necessarily pristine channels but are necessarily stable channels. By measuring stable reaches of channels formed in similar valley types, with similar contributing watersheds, a range of acceptable values defining stable channel characteristics can be generated. Stable channel characteristics include dimension, pattern, and profile.

Stream channel dimension is based on the ratio of width-to-depth. Channels which are too wide or too deep cannot efficiently transport sediment, leading to bank failure or down-cutting.

Stream channel pattern is based on sinuosity. Natural channels are rarely straight over long distances. Channel meanders contribute to energy dissipation and sediment transport. Channels which lack a stable pattern tend to be very straight and cannot efficiently dissipate energy or effectively transport sediment, which can lead to instability.

Stream channel profile is based on channel bed features. Natural channel bed features include riffles, glides, runs, and pools. Placement and spacing of these features regulate channel stability and are a function of the channels energy dissipation and sediment transport capability.

3.1 Reference Reach Search

A search was conducted within the project region to locate stream reaches which would be suitable as reference reaches. Additionally, ESI requested reference reach data from NCDOT. The information garnered was used to determine the stable form of the proposed channels.

Prior to initiation of the reference reach search, available data concerning the target channels was reviewed, including watershed size and valley type. GIS modeling was conducted to determine the location of potential reference reach areas within the project vicinity. Additional potential reference reaches were found and investigated. Review of the potential reference reach areas indicated the majority of reaches were unstable and not suitable for use as reference. A single potential reference reach identified by the GIS model was also a reference reach provided by NCDOT. Provided information for this reference reach was used for this study. Other reference reaches proposed for use were submitted to DWQ for approval prior to use as reference. DWQ indicated the additional reference reaches under consideration would not be useable as they were located in different hydrologic units than the project study area.

Information concerning the useable reference reaches was obtained from NCDOT. These reference reaches were from "C" stream types and are located within the same hydro-physiographic region to provide stable form morphological data providing a model for the conceptual design of UT Bear Creek. Stream variables collected from an unnamed tributary (UT) to South Fork Cane Creek and Richland Creek, which are stable C4 type streams (NCDOT 2002a), and an unnamed tributary to Bear Creek (UT Bear Creek reference), which is a stable C5 stream (NCDOT 2002b) are summarized in Table B-1 in Appendix B.

3.1.1 Methodology for Developing a Reference Model for Stream Design and Restoration

The data collected from stream assessments studies are maintained in a database for quick reference for stream design and restoration projects. The reference reach is used to develop natural channel design criteria based upon measured morphological relationships associated with the bankfull stage for specific stable stream types. Specific data on stream channel dimension, pattern and profile are collected and presented by dimensionless ratios by stream type. The reference reach is a portion of a river segment that represents a stable channel within particular valley type morphology. The morphological data collected are used as a model for disturbed or unstable reaches of similar types for the purposes of restoration, stream enhancement, and stabilization. Bankfull discharge and dimensions from stream gage stations for particular hydro-physiographic provinces are correlated with drainage area to develop regional curves for extrapolation to non-gauged reaches.

Establishment of regime equations can often be used for river restoration design by representing data observed and collected from a range of stream types. If the restoration stream, where the data are being used as a model, is not similar to the streams from which the equations were developed, resultant designs can be incompatible with natural channel morphology. Reference reach data can be used to validate and sort appropriate regime equations by stream type prior to implementation.

The targeted channel dimension, pattern and profile will be determined from dimension, pattern and profile data collected on a reference reach.

The two reaches proposed for restoration have significantly deviated from stable conditions, which is evidenced by several channel parameters. The following pattern, dimension, and profile variables will be specifically addressed in the detail design:

Channel Pattern	**Channel Profile**	**Channel Dimension**
Sinuosity	Channel Slope	BKF width of pool and Riffle
Belt Width	Riffle Slope	BKF depth of pool and riffle
Radius of Curvature	Run Slope	BKF cross-sectional area of pools and riffles
	Pool Slope	Point bar cross-sectional slope
	Glide Slope	Size distribution of channel material (d50)
	Pool to Pool Spacing	

3.2 Reference Reach Data

Three reference reaches for "C" type streams were selected from data provided by NCDOT to provide reference dimensions for the channels proposes for restoration within the project study area: Richland Creek, UT South Fork Cane Creek, and UT Bear Creek reference.

3.3 Reference Reach Findings

3.3.1 Richland Creek

The Richland Creek reference reach is located in Moore County, North Carolina, and has a watershed size of 1.04 square miles (665 acres) (Figure B-1). For the cross-sections sampled on Richland Creek, the existing riffle width/depth (w/d) ratio was 17.8 (Table 3). The predicted w/d ratio is greater than 12 and within an acceptable range for a C4 stream type (Rosgen 1996). According to the regional curves, the predicted mean bankfull depth (riffle) for streams with a 1.0 square mile watershed size is 1.5 feet in comparison to the actual riffle bankfull mean depth of 0.9 foot for Richland Creek.

Table 3. Reference Variables for Richland Creek (C4-type) Stream Channel from Riffle Cross-sections.

Dimension Variables			
X-Section area (ft^2)	15.3.	**Hydraulic Variables**	
D mean (ft)	0.9	Velocity (ft/sec)	*
D max (ft)	1.5	Discharge rate, Q (cfs)	*
Width (ft)	16.5	Shear Stress (lbs/ft sq)	*
		Shear velocity (ft/sec)	*
Hydraulic Variables		Unit stream power (lbs/ft/sec)	*
Wet P	*	Froude number	*
Hydraulic radius	*	Friction Factor (u/u*)	*
Bank ht	*	Threshold grain size (mm)	*
w/d ratio	17.8	W Flood Prone Area (ft)	*
Entrenchment Ratio	3.2	Channel Slope (%)	1% to 3%
		Manning's "n"	*

* Data not provided for this study.

3.3.2 UT South Fork Cane Creek

The UT South Fork Cane Creek reference reach, located in Chatham County, North Carolina, has a watershed size of approximately 0.41 square mile (260 acres) (Figure B-2). The channel has been classified as a "C4" type stream. From cross-sections sampled at this reach, the existing w/d ratio is 14.0. According to the regional curves, the predicted mean bankfull depth (riffle) for streams with a 0.41-square mile watershed size is 1.1 feet in comparison to the actual riffle bankfull mean depth of 0.9 foot for UT South Fork Cane Creek.

Table 4. Reference Variables for UT South Fork Cane Creek (C4-type) Stream Channel from Riffle Cross-sections.

Dimension Variables			
X-Section area (ft^2)	11.9.	**Hydraulic Variables**	
D mean (ft)	0.9	Velocity (ft/sec)	*
D max (ft)	1.4	Discharge rate, Q (cfs)	*
Width (ft)	13.1	Shear Stress (lbs/ft sq)	*
		Shear velocity (ft/sec)	*
Hydraulic Variables		Unit stream power (lbs/ft/sec)	*
Wet P	*	Froude number	*
Hydraulic radius	*	Friction Factor (u/u*)	*
Bank height	*	Threshold grain size (mm)	*
w/d ratio	14.3	W Flood Prone Area (ft)	26-36
Entrenchment Ratio	2.4	Channel Slope (%)	0.2%
		Manning's "n"	*

* Data not provided for this study.

3.3.3 UT Bear Creek Reference

The UT Bear Creek reference reach is located approximately 1.8 miles downstream of the project study area, below the confluence of another unnamed tributary to Bear Creek. This reference reach has a watershed of approximately 6.6 square miles (4,200 acres) (Figure B-3). This channel has been classified as a "C5" type stream. From cross-sections sampled at this reach, the existing w/d ratio is 12.7. According to the regional curves, the predicted mean bankfull depth (riffle) for streams with a 6.6 square mile watershed is 2.7 feet in comparison to the measured riffle bankfull depth of 1.8 feet.

Table 5. Reference Variables for UT Bear Creek Reference (C5-type) Stream Channel from Riffle Cross-sections.

Dimension Variables			
X-Section area (ft^2)	41.7	**Hydraulic Variables**	
D mean (ft)	1.8	Velocity (ft/sec)	*
D max (ft)	2.6	Discharge rate, Q (cfs)	*
Width (ft)	22.8	Shear Stress (lbs/ft sq)	*
		Shear velocity (ft/sec)	*
Hydraulic Variables		Unit stream power (lbs/ft/sec)	*
Wet P	*	Froude number	*
Hydraulic radius	*	Friction Factor (u/u*)	*
Bank height	*	Threshold grain size (mm)	*
w/d ratio	12.7	W Flood Prone Area (ft)	>70
Entrenchment Ratio	>3.1	Channel Slope (%)	*
		Manning's "n"	*

* Data not provided for this study.

4.0 PROPOSED CHANNEL RESTORATION

The proposed channel for both UT Bear Creek and UT2 will have a stream classification of C4/C5 under the Natural Stream Channel classification system. This classification is based on particle size analysis of materials currently present in the banks. Reaches may alternate between gravel and sand dominance. The purpose of the proposed stream restoration is to restore and stabilize approximately 2,100 feet of degraded stream channel from a G6 to a C4/C5 stream type with a stable dimension, pattern, and profile and conduct a restoration on approximately 1,300 feet of UT2 where dimension pattern, and profile have been destroyed by historic channelizing and livestock incursions (ESI 2002).

The proposed restoration activities for UT Bear Creek would take place generally within the current channel location. The proposed restoration activities for UT2 would generally take place around the current channel location in the upper reaches; final location of the restored channel for the lower reach of UT2 has not been determined. Figure C-1 in Appendix C indicates the approximate post-restoration location of each channel.

Within UT Bear Creek, the natural channel pattern, profile, and dimension have been destroyed, and the stable riffle/pool complex is non-existent in certain sections and poorly formed in other sections due to livestock incursions. The channel banks are vertical and have become highly erosive in sections of this reach. The restoration reach has a low gradient (0.003), an extremely low w/d ratio (8.9), few pools, and low sinuosity (mean: 1.2, range: 1.15-1.34). The low w/d ratio and low entrenchment ratio indicates an unstable channel dimension. The existing channel dimensions are not within an acceptable range in comparison to the regional curves for the stream to maintain a stable channel.

Table 6. Existing Mean Variables for UT Bear Creek Stream Channel from Riffle Cross-sections.

Dimension Variables			
X-Section area (ft^2)	19.5-29.7	**Hydraulic Variables**	
D mean (ft)	1.5-1.8	Velocity (ft/sec)	7.9
D max (ft)	2.0-2.2	Discharge rate, Q (cfs)	153.6
Width (ft)	13.2-16.7	Shear Stress (lbs/ft sq)	0.46
		Shear velocity (ft/sec)	0.49
Hydraulic Variables		Unit stream power (lbs/ft/sec)	4
Wet P (ft)	14.6-18.4	Froude number	1.3
Hydraulic radius	1.3-1.6	Friction Factor (u/u*)	16.2
Bank ht (ft)	3.8-4.4	Threshold grain size (mm)	27.9
w/d ratio	8.9-9.3	W Flood Prone Area (ft)	16-30
Entrenchment Ratio	1.2-2.4	Channel Slope (%)	0.33
		Manning's "n"	0.017

In UT2, features resembling stream channel were noted; however, cattle incursions have effectively destroyed the channel in the lower portions of this reach; the upper portions of this reach have been channelized and retain some stream features. The landowners have indicated

that a stream channel was historically present. Inclusion of this feature as mitigation would increase available channel by up to 1,700 linear feet. The uppermost reach of this feature is not being considered for stream restoration, but is included in the conservation area.

Table 7. Existing Mean Variables for UT2 Stream Channel from Riffle Cross-sections.

Dimension Variables			
X-Section area (ft^2)	5.7-5.9	**Hydraulic Variables**	
D mean (ft)	1.1	Velocity (ft/sec)	*
D max (ft)	1.3	Discharge rate, Q (cfs)	*
Width (ft)	5.1-5.5	Shear Stress (lbs/ft sq)	*
		Shear velocity (ft/sec)	*
Hydraulic Variables		Unit stream power (lbs/ft/sec)	*
Wet P (ft)	6.6-6.9	Froude number	*
Hydraulic radius	0.9	Friction Factor (u/u*)	*
Bank ht (ft)	3.3-3.7	Threshold grain size (mm)	*
w/d ratio	4.5-5.1	W Flood Prone Area (ft)	*
Entrenchment Ratio	1.1-1.6	Channel Slope (%)	*
		Manning's "n"	*

4.1 Dimension

4.1.1 UT Bear Creek

Typical riffle and pool cross-sections for UT Bear Creek show the target conditions for the restoration being proposed (Table 8). For the cross-sections sampled, the existing riffle w/d ratio ranged from 8.9 to 9.3 in comparison to the NC rural regional curve prediction of 8.39. According to Rosgen (1996), stable form "C" type streams have a w/d ratio that is greater than 12 but can vary by +/- 2.0 units. According to the regional curves, the predicted mean bankfull depth (riffle) is 1.77 feet in comparison to the actual riffle bankfull mean depth of 1.5 to 1.8 feet. The predicted riffle bankfull width was 14.86 feet while the actual riffle bankfull width ranges from 13.2 to 16.7 feet.

Table 8. Existing channel dimension of UT Bear Creek and comparison to NC regional curves.

Channel Dimension Variable	NC Regional Curves	Existing Dimensions
Bankfull Depth (ft)	1.77	1.5-1.8
Bankfull Width (ft)	14.86	13.2-16.7
Bankfull XS Area (ft^2)	30.5	19.5-29.7
Width / Depth Ratio	8.39	8.9-9.3

Typical riffle and pool cross-sections are provided showing target conditions for the UT Bear Creek with an appropriate w/d ratio (Appendix C). Proposed conditions are summarized in tabular form in Appendix B (Table B-1). This slightly higher value proposed for w/d ratio (12.2) is necessary to provide for construction of a new channel that is immediately stable. Over time, minor adjustments can be expected in the width and depth of the restored stream.

4.1.2 UT2

Predicted dimensions for the UT2 according to the NC regional curves indicate (Table 9) an average bankfull depth of 0.82 foot with a bankfull width of 5.26 feet. Typical riffle and pool cross-sections are provided for UT2 showing target conditions with an appropriate w/d ratio (Appendix C). Proposed conditions are summarized in tabular form in Appendix B (Table B-1). This slightly higher value proposed for w/d ratio (10.8) is necessary to provide for construction of a new channel that is immediately stable. Over time, minor adjustments can be expected in the width and depth of the restored stream.

Table 9. Existing channel dimension of UT2 and comparison to NC regional curves.

Channel Dimension Variable	NC Regional Curves	Existing Dimensions
Bankfull Depth (ft)	0.82	1.1
Bankfull Width (ft)	5.26	5.1-5.5
Bankfull XS Area (ft^2)	5.9	5.7-5.9
Width / Depth Ratio	6.41	4.5-5.1

* Dimension, pattern, and profile have been destroyed in portions of the channel. No data collected from that reach.

4.2 Pattern

On UT Bear Creek, the slope proposed for the design is 1% to 3% (0.01 to 0.03 ft/ft) with a sinuosity of 1.2. Based on reference data for C4 stream types the design radius of curvature for the restored channel will be approximately 19 with a R_C/W_{BKF} ratio of 1.2 to 2.0. Additional design pattern dimensions are provided in Appendix C. Typical pattern and profile drawings are provided in Figure C-4.

On UT2, the proposed water surface slope is < 2 % (0.01 to 0.02 ft/ft) with a sinuosity of 1.2. Based on reference data for C4 stream types the design radius of curvature for the restored channel will be approximately 19 with a R_C/W_{BKF} ratio of 1.2 to 2.0. Additional design pattern dimensions are provided in Appendix C. Typical pattern and profile drawings are provided in Figure C-4.

4.3 Profile

Pool spacing is based on the relationship of bankfull width to average water slope (0.01 ft/ft to 0.03 ft/ft). Pool spacing is highly variable and using a reference reach as a model for the proposed restoration is essential in the design of a stable stream. Based on reference data provided by NCDOT on similar C4 stream types, the ratio of pool/pool spacing has a range of 2.3 to 6.2. The proposed pool-to-pool spacing for UT Bear Creek will be 28 to 55 feet (mean 41.5 feet) for the entire restoration reach. Pool to pool spacing for UT2 will range from 14 to 27 feet (mean 20.5 feet) for the entire restoration reach with a bankfull width of 9 feet.

4.4 General Channel View

The rock cross-vane and J-hook vane structures will be utilized to minimize pressure at the near bank region. The rock cross-vane structures can be used to create stable transition into pools or as grade control for glides, if needed. In addition, the cross-vane structures will be used to

adjust the channel slope in combination with in-channel meanders. The J-hook vane will be used on the outer bank of meanders to direct the thalweg away from the bank toe. The J-hook vane will also function to maintain velocities and sediment transport through the pools. Typical cross-vane and J-hook designs and descriptions are Figures C-4 and C-5, respectively, in Appendix C (NCDOT 2003).

4.5 Sediment Transport

Detailed sediment transport calculations have not been made at this point in the study. These calculations need to carefully consider final stream grades which have not been fully determined at this time. Drought conditions during the data collection phase of this study limited the ability to collect reliable streambed sediment data. Sediment transport relationships will be submitted as an addendum to this report.

5.0 RIPARIAN BUFFER

The project study area was reviewed for the potential for stream buffer mitigation. Vegetated buffers adjacent to stream channels enhance stream function in a variety of ways. Deep rooted tree species help stabilize channel bank slopes and help intercept nutrient inputs to the channel through groundwater interception. Shallow rooted herbaceous species help stabilize channel banks and intercept nutrient inputs and sediment inputs through interception of surface water and shallow groundwater. For purposes of this study, vegetated buffers were reviewed within a generally 50-foot wide area adjacent to each bank of both channels; however, the buffer has been expanded in some areas and encompasses approximately 12.1 acres.

Vegetation adjacent to UT Bear Creek consists primarily of oak-hickory forest. Because of cattle incursions, very little herbaceous vegetation remains adjacent to the channel. One reach of UT Bear Creek contains no forest vegetation. This area contains various grasses, but is devoid of any tree species. One reach of UT Bear Creek has forest vegetation directly adjacent to the southern channel edge; however, this vegetation disappears further away from the channel.

The area which historically contained UT2 is currently under intact forest vegetation. The reach of UT2 which is currently channelized has forest vegetation directly adjacent to the banks, but none further from the bank. Restoration activities will impact this vegetation.

Removal of existing tree stems within the riparian buffer area will be minimized as to the greatest extent practicable during construction activities. If necessary, specific tree stems determined to be a high value based on best professional judgment will be located using GPS technology and slated for avoidance.

Vegetation within the proposed conservation area should be consistent with forest vegetation currently present adjacent to parts of the channels, depending on availability. Tree species found within the forested system present within the project study area available to NCDOT for planting include laurel oak, willow oak, and white oak. The landowners have requested that an evergreen component be included in the buffer area to act as a visual barrier and wind break. The evergreen component currently in place is eastern red cedar. Approximately 3.2 acres of riparian buffer would be restored adjacent to UT Bear Creek and UT2. Upon completion of a final planting plan, the number of planted stems, species mix, and species percentages will be calculated.

6.0 MONITORING OF SUCCESS CRITERIA

To demonstrate mitigative success, baseline conditions will be established prior to any mitigation activities for each of the criteria outlined below.

Proposed success criteria for stream mitigation will be based on the stream stability. To exhibit success, permanent cross-section stations will be established within each restored reach. Within these areas, cross-sections will be surveyed in years 1, 3, and 5 following construction. Permanent cross-sections will be established at an interval of approximately 1 every 20 bankfull widths. The cross-section sites will be selected such that approximately 50% are placed in riffles and approximately 50% are placed in pools. As proposed, a total of four (4) permanent cross-sections will be established within the restored UT Bear Creek, targeting two (2) riffle cross-sections and two (2) pool cross-sections. As proposed, a total of eight (8) cross-sections will be established within the restored UT2, targeting four (4) riffle cross-sections and four (4) pool cross-sections.

In addition to the cross-section areas, NCDOT will establish photo-reference points. These points will be used to document visual evidence of increased channel stability. The NCDOT will photograph the site for five years after completion of construction.

Vegetative sampling will be undertaken on a yearly basis within the riparian buffer. A 0.05-acre permanent plot will be established within the planted areas of the conservation easement along each restored reach.

7.0 DISPENSATION OF PROPERTY

NCDOT will hold a conservation easement on the 12.1 acres until all mitigation activities are completed and the site is determined to be successful. The conservation easement will be signed at the completion of the design plans for the stream mitigation project. Although no plan for dispensation of the mitigation site has been developed, the NCDOT will likely transfer the easement to a resource agency or land conservancy organization whose mission is consistent with the purposes of the conservation easement. The NCDOT will notify the COE about any potential intentions to transfer the conservation easement to a resource agency or land conservancy organization. The conservation easement will be attached to the deed to insure adequate management and protection of the site in perpetuity.

8.0 POTENTIAL MITIGATION CREDITS

Mitigation credits generated will be based on the total linear footage of stream channel restoration. Current guidelines accepted by DWQ and COE allow for a mitigation ratio of 1:1 for stream channel restoration. With this ratio, the proposed stream restoration could offset approximately 3,850 linear feet of stream channel impact; actual mitigation credits potentially available will be determined by resource agencies following final design.

Table 10. Proposed Mitigation Credit

Restoration Reach	Existing Length (linear feet)	Proposed Length (linear feet)	Treatment Administered
UT Bear Creek	2,100	2,150	Restore dimension, pattern and profile
UT2	1,200	1,700	Restore dimension, pattern and profile

Potential benefits incurred from restoration of the two reaches include increases in water quality. Restoring a stable dimension, pattern and profile to each channel will reduce sediment inputs from bank failures and down-cutting. Restoring a riparian buffer should reduce sediment and nutrient input from the surrounding landscape. Excluding cattle from the restored channels and riparian buffer will allow the stability of the restored systems to continue.

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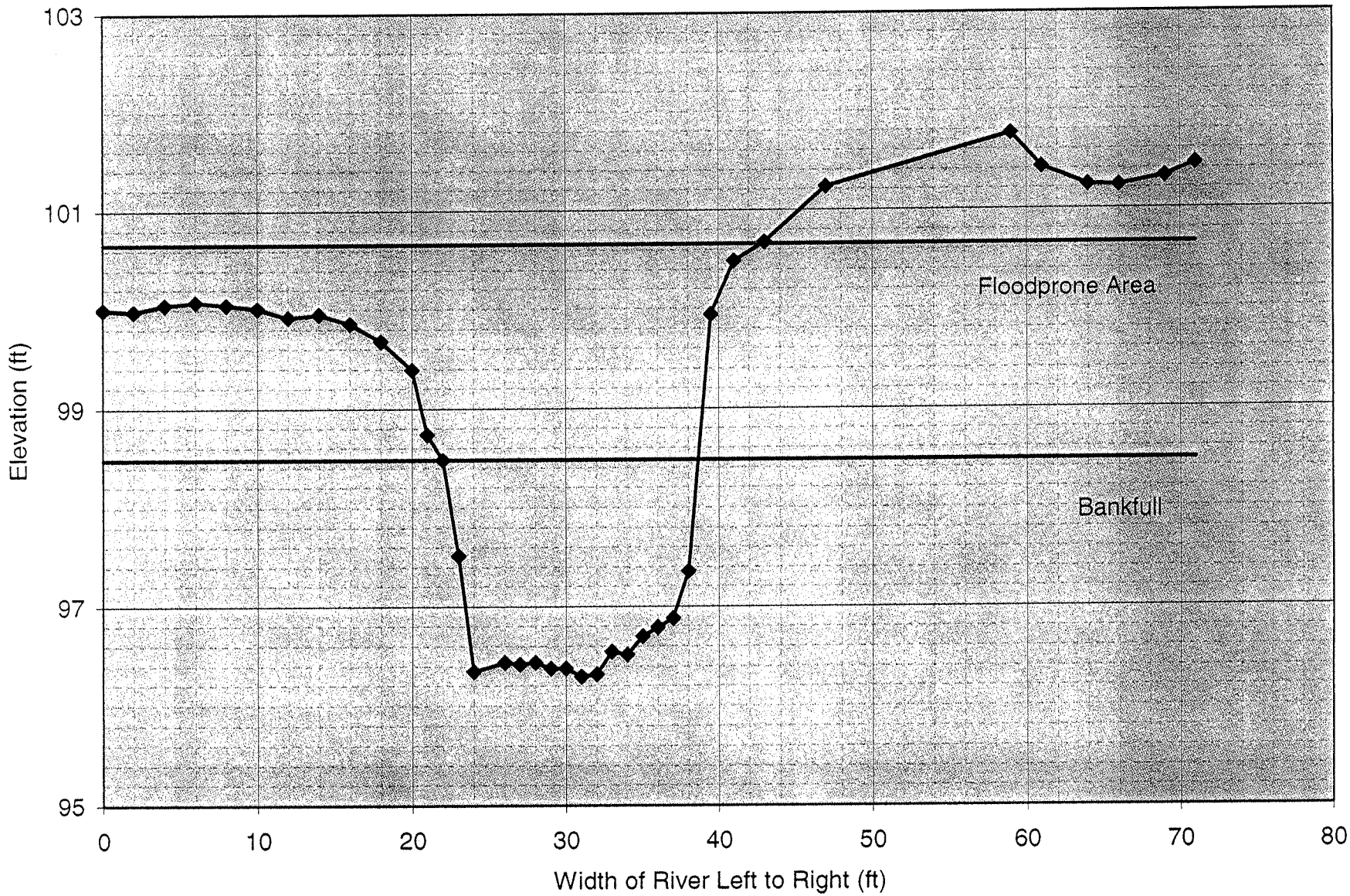
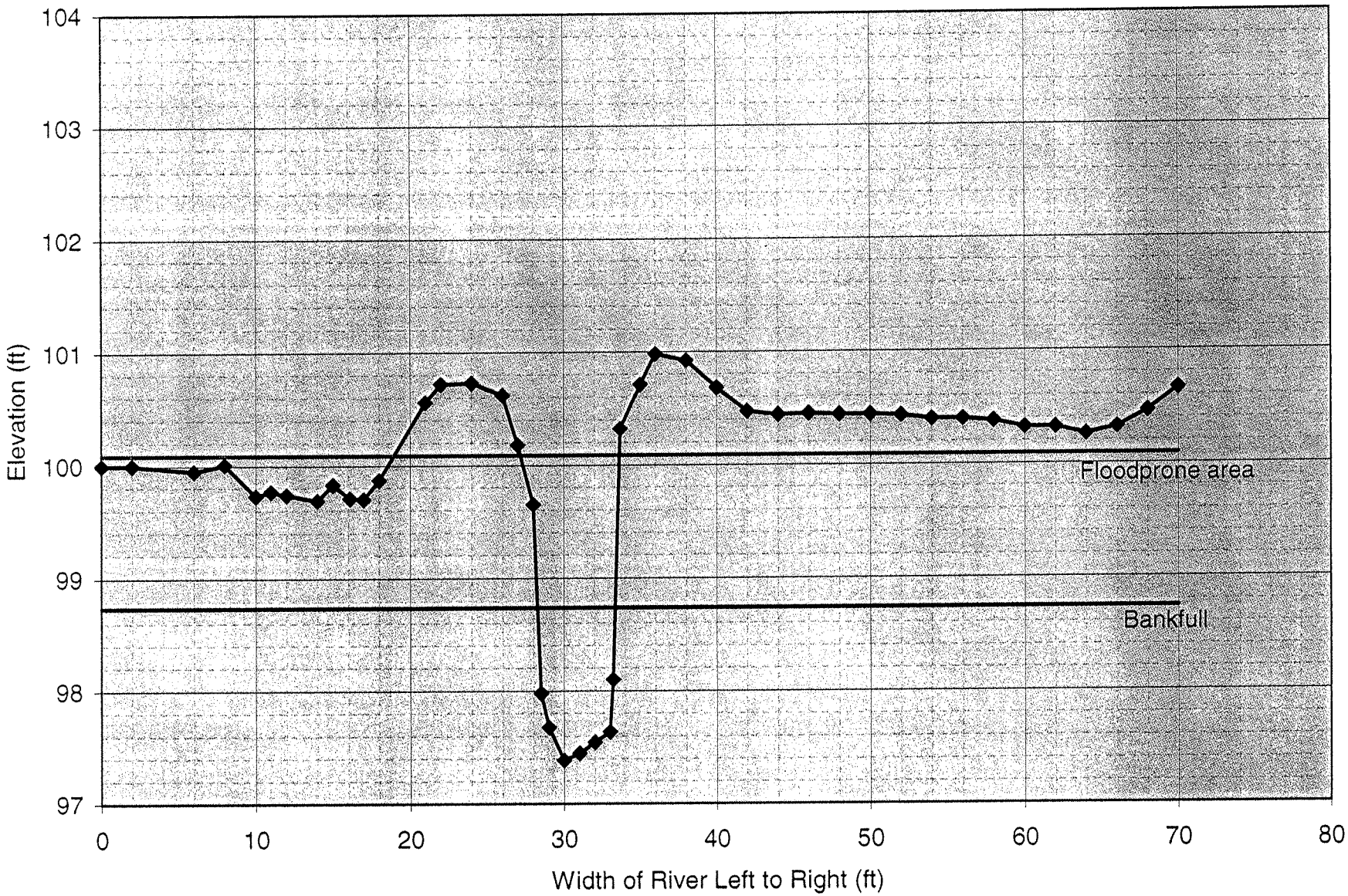
APPENDIX A
EXISTING CONDITIONS



UT Bear Creek Riffle Cross-section

UT Bear Creek Mitigation Plan
Chatham County, North Carolina

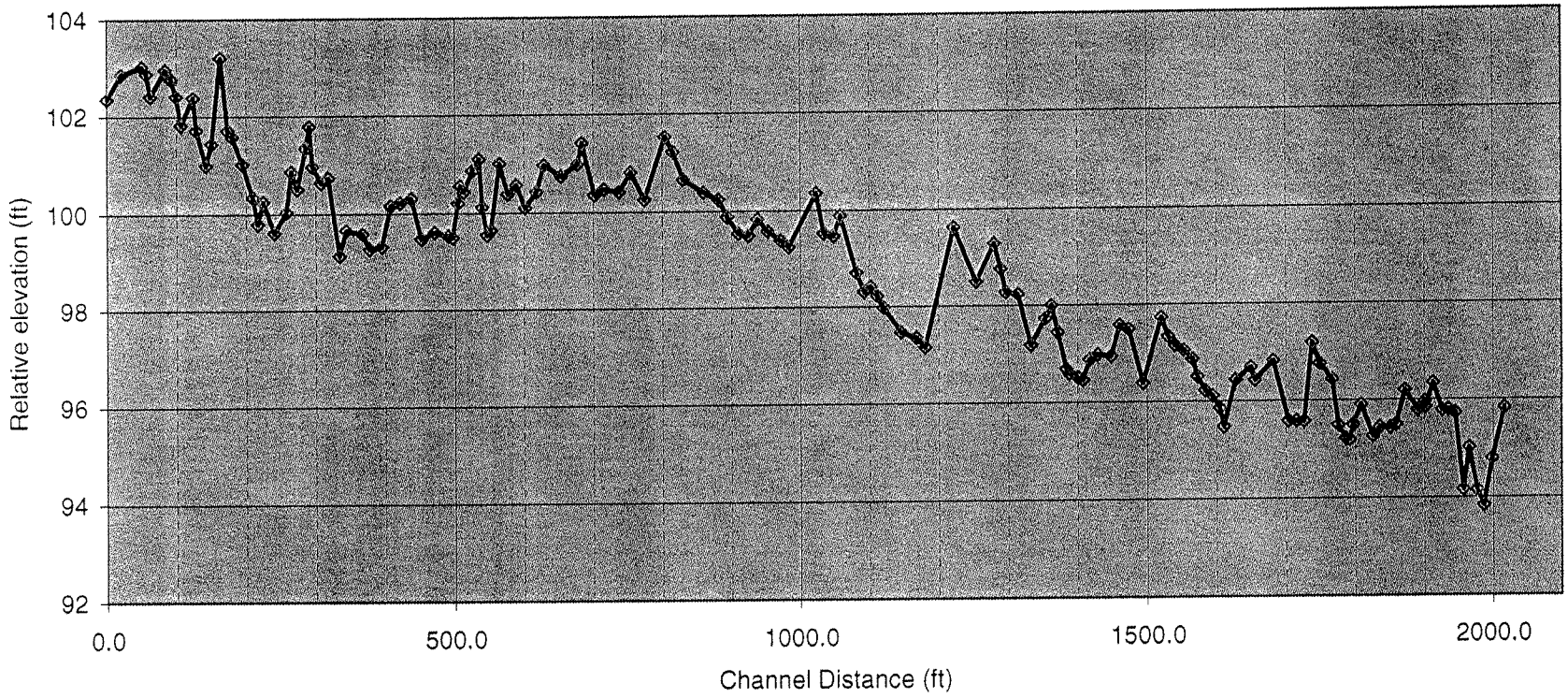
Figure A-2



UT2 Riffle Cross-section

UT Bear Creek Mitigation Plan
Chatham County, North Carolina

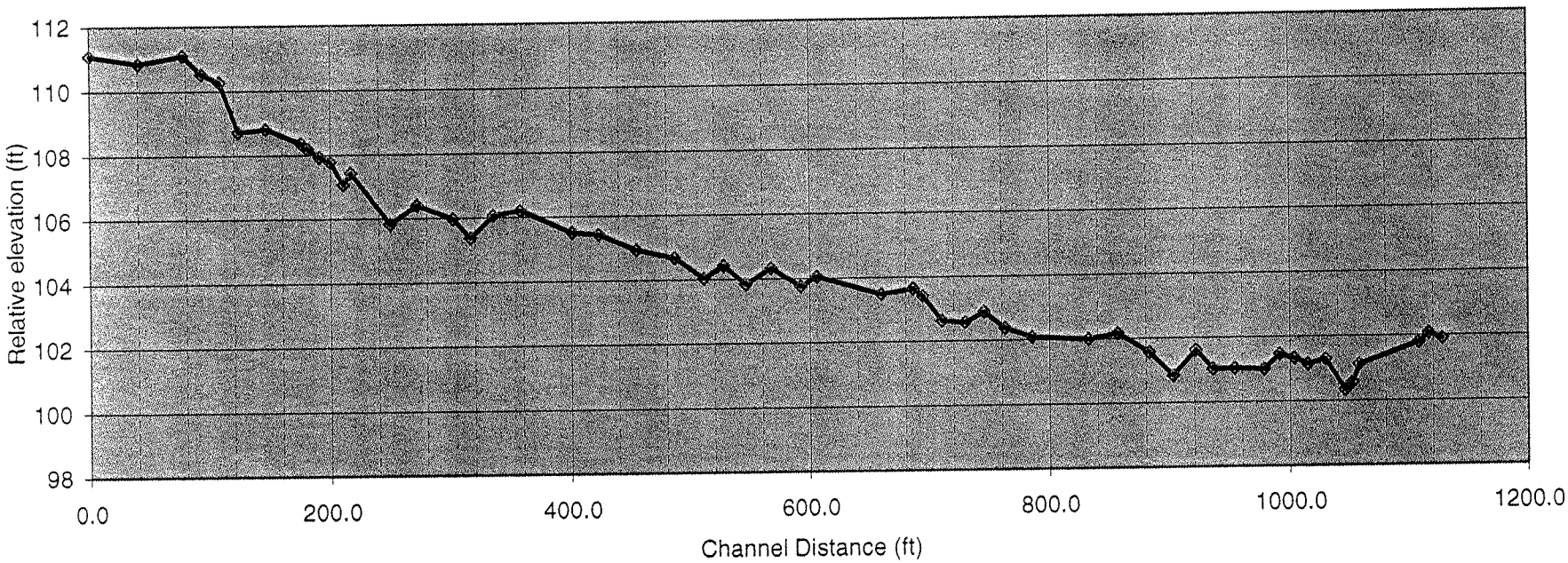
Figure A-3



UT Bear Creek Thalweg Survey

UT Bear Creek Mitigation Plan
Chatham County, North Carolina

Figure A-4



UT2 Thalweg Survey

UT Bear Creek Mitigation Plan
Chatham County, North Carolina

Figure A-5

PFANKUCH CHANEL STABILITY EVALUATION

Reach Location UT Bear Creek Date 16 July 2002 Observers Hayes Stream Type _____

	Category	Excellent		Good		Fair		Poor	
UPPER BANKS	1 Landform Slope	Bank Slope Gradient <30%	2	Bank slope gradient 30-40%	4	Bank slope gradient 40-60%	6	Bank slope gradient 60%+	(8)
	2 Mass Wasting	No evidence of past or future mass wasting.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly year long.	(9)	Frequent or large causing sediment nearly year long or imminent danger of same.	12
	3 Debris Jam Potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	(6)	Moderate to heavy amounts, predominately larger sizes.	8
	4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggest a deep dense soil binding root mass.	3	70-90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	<50-70% density. Lower vigor and fewer species form a shallow, discontinuous root mass.	9	<50% density, fewer species and less vigor indicate poor, discontinuous and shallow root mass.	(12)
LOWER BANKS	5 Channel Capacity	Ample for present plus some increases. Peak flows contained. W/D ratio <7	1	Adequate. Bank overflows rare. W/D ratio 8-15.	2	Barely contains present peaks. Occasional overbank floods. W/D ratio 15-25.	(3)	Inadequate. Ovebank flows common. W/D ratio >25.	4
	6 Bank Rock Content	65% with large angular boulders. 12"+ common	2	40-65%. Mostly small boulders to cobbles 6-12%.	4	20-40% with most in the 3-6" diameter class.	6	<20% rock fragments of gravel sizes, 1-3" or less.	(8)
	7 Obstructions to Flow	Rocks and logs firmly imbedded. Flow pattern without cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor poil filling. Obstructions newer and less firm.	4	Moderate, frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	(6)	Frequent obstructions cause erosion year-long. Sediment traps full, channel migration occurring.	8
	8 Cutting	Little or none. Infrequent raw banks less than 6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12-24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	(16)
	9 Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate deposition of new gavel and course sand on old and some new bars.	12	Extensive deposits of predominately fine particles. Accelerated bar development.	(16)
BOTTOM	10 Rock Angularity	sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges, surfaces smooth, flat.	2	Corners and edges well rounded in two dimensions.	(3)	Well rounded in all dimensions, surface smooth.	4
	11 Brightness	Surfaces dull, dark, or stained. Generally not bright.	(1)	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright. I.e, 35-65% mixture range.	3	Predominately bright, 65% exposed or scoured surfaces.	4
	12 Consolidation of Particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	(6)	No packing evident. Loose assortment easily moved.	8
	13 Bottom Size Distribution	No size change evident. Stable matter. 80-100%	4	distribution shift light. Stable material 50-80%.	8	Moderate change in sizes. Stable materials 20-50%	(12)	Marked distribution change. Stable materials 0-20%.	16
	14 Scouring and Deposition	<5% of bottom affected by scour or deposition.	6	5-30% affected. Scour at constrictions and where grades sharpen. Some deposition in pools.	12	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly year-long.	(24)
	15 Aquatic Vegetation	Abundant. Growth moss-like, dark green, perennial. In swift water too.	1	Common. Algal forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algal growth makes rocks slick.	(3)	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	4
		Totals	(1)		0		48		84

Stream width _____ Avg depth _____ Mean Velocity _____ =Q _____ cfs

Gauge Ht _____ Reach Gradient _____ Stream Order _____ Sinuosity Ratio _____

Width Bf _____ Depth Bf _____ W/D Ratio _____ Bf Discharge _____

Drainage Area _____ Valley Gradient _____ Stream Length _____ Valley Length _____

Sinuosity _____ Entrenchment Ratio _____ Length Meander _____ Belt Width _____

Sediment Supply: Extreme ____ Very High ✓ High ____ Moderate ____ Low ____

Stream Bed Stability: Aggrading ____ Degrading ✓ Stable ____

Width/Depth Ratio Condition: Normal ____ High ____ Very High ✓

TOTAL SCORE for Reach: E 1 +G 0 +F 48 +P 84 =

Remarks _____

From Table: Stream Type F4-F6; Pfankuch Rating 133; Reach Condition POOR

Stream Type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair	44-47	44-47	91-129	96-142	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor	48+	48+	130+	143+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream Type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Q:\utility\Forms\Brian_stream1.doc

Field Data Form

BANK EROSION POTENTIAL

Stream Name VT Bear Creek Date 16 July 2012
Xsec. No. Riffle 1 Crew Hayes & Gay
Location/Note Sta 80

Bank Height (ft) 4.4
Bankfull Height (ft) 2.0
Root Density (%) < 30 %
Bank Angle (degrees) > 60°
Surface Protection (%) 25%

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME	
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX
Bank Ht/Bkf Ht	1.0-1.1	1.0-1.9	1.1-1.9	2.0-3.9	1.2-1.5	4.0-5.9	1.6-2.0	6.0-7.9	2.1-2.8	8.0-9.0	>2.8	10.0
Root Depth/ Bank Ht	1.0-0.9	1.0-1.9	0.89-0.50	2.0-3.9	0.49-0.30	4.0-5.9	0.29-1.15	6.0-7.9	0.14-.05	8.0-9.0	<0.5	10.0
Root Density (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-19	6.0-7.9	5-14	8.0-9.0	<5.0	10.0
Bank Angle (degrees)	0-20	1.0-1.9	21-60	2.0-3.9	61-80	4.0-5.9	81-90	6.0-7.9	91-119	8.0-9.0	>119	10.0
Surface Prot. (%)	80-100	1.0-1.9	55-79	2.0-3.9	30-54	4.0-5.9	15-29	6.0-7.9	10-15	8.0-9.0	<10	10.0
TOTALS						29.16						
		5.0-9.5		10-19.5		20-29.5		30-39.5		40-45		46-50
Numerical Adjustments						10						

BANK MATERIALS:

BEDROCK: BANK EROSION POTENTIAL ALWAYS VERY LOW

BOULDERS: BANK EROSION POTENTIAL LOW

COBBLE: DECREASE BY ONE CATEGORY UNLESS MIXTURE OF GRAVEL/SAND IS OVER 50%, THEN NO ADJUSTMENT

GRAVEL: ADJUST VALUES UP BY 5-10 POINTS DEPENDING ON COMPOSITION OF SAND

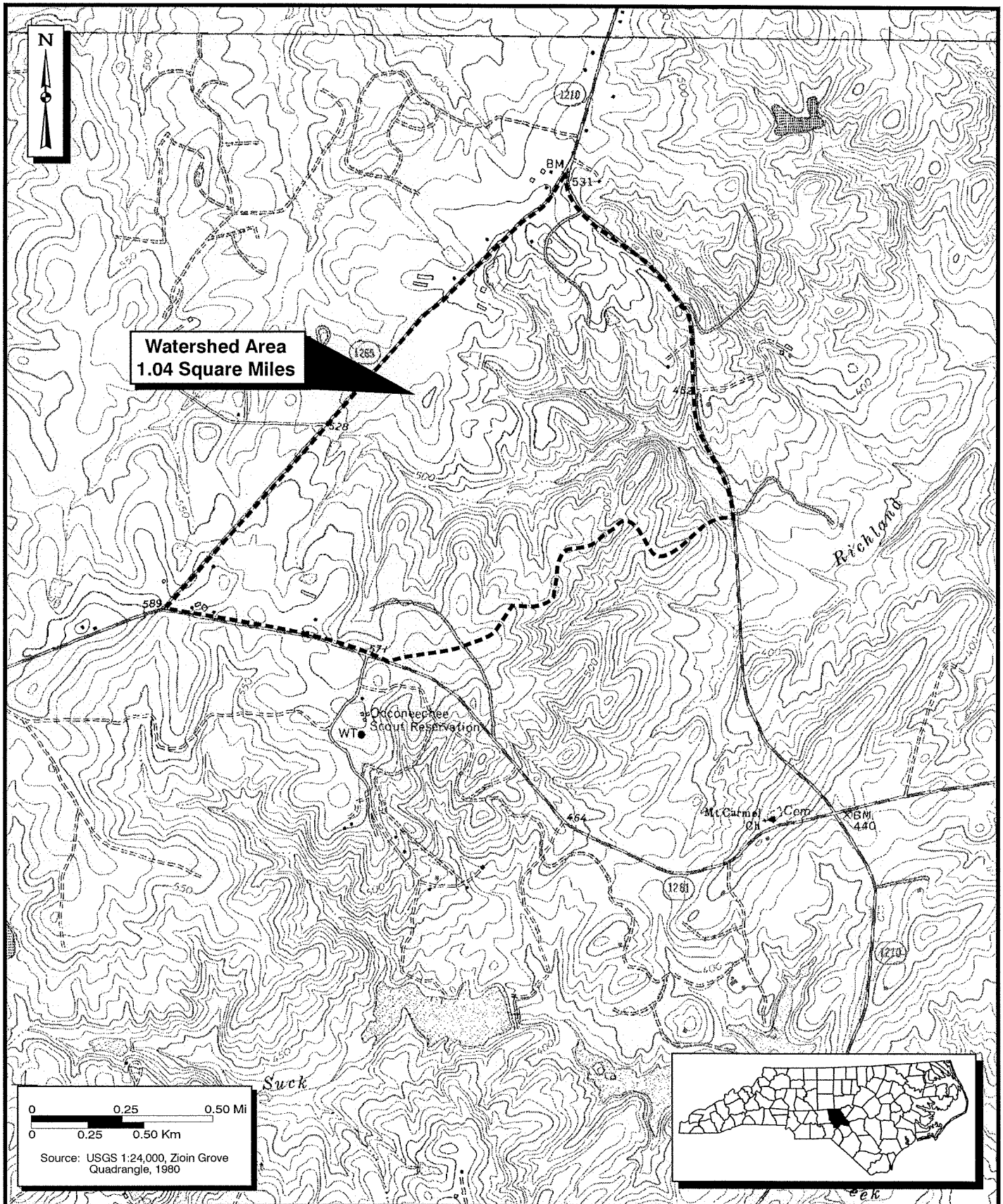
SAND: ADJUST VALUES UP BY 10 POINTS

SILT/CLAY: NO ADJUSTMENT

STRATIFICATION: 5-10 POINTS (UPWARD) DEPENDING ON POSITION OF UNSTABLE LAYERS IN RELATION TO BANKFULL STAGE

BEHI 39.16 it.gh

APPENDIX B
REFERENCE REACHES

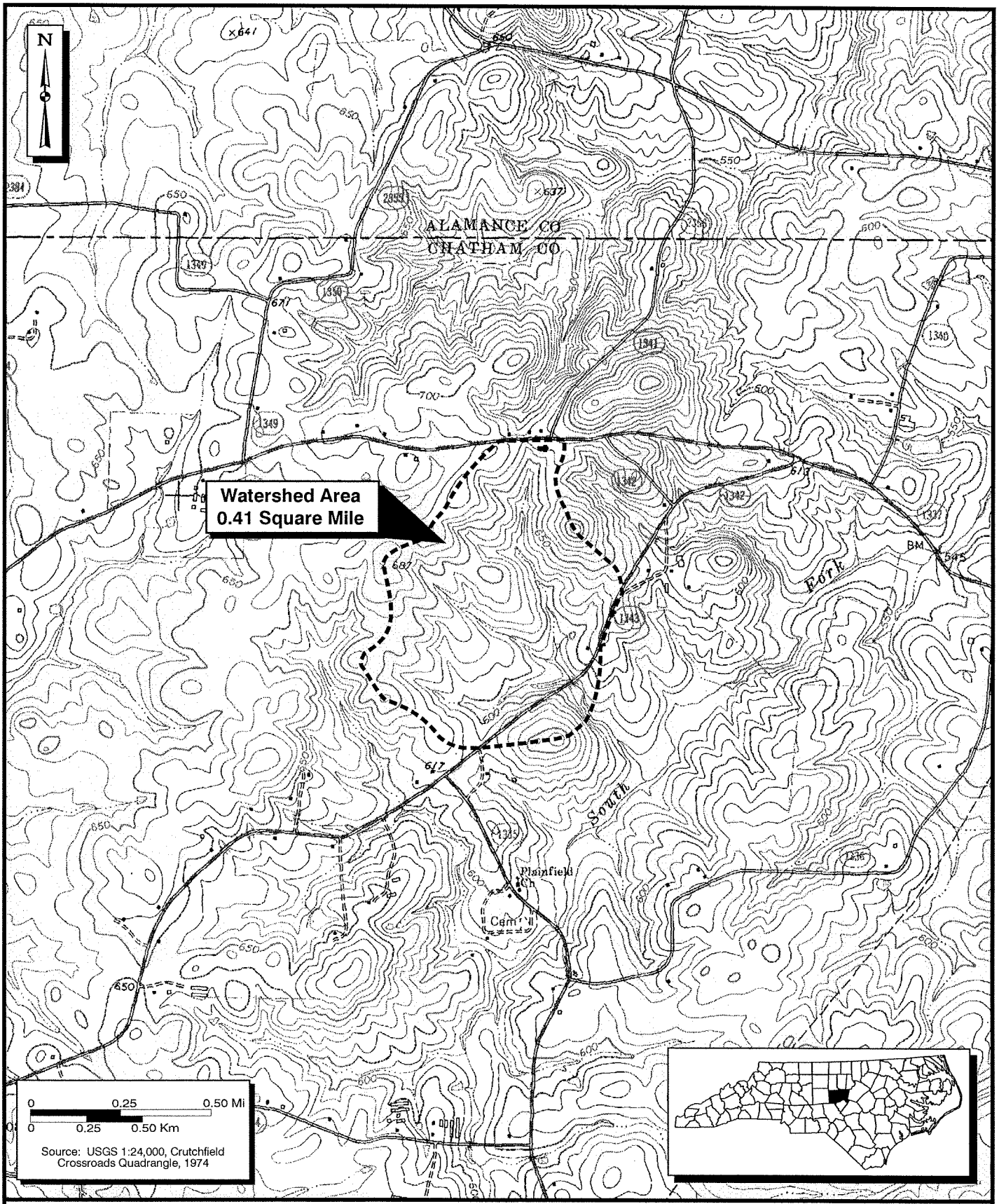


Environmental Services, Inc.

Reference Reach-
Richland Creek Watershed
UT Bear Creek Mitigation Plan
Moore County, North Carolina

Figure:	B-1
Project:	ER02026.01
Date:	June 2003

ER02026.01/watershed_richlnd.cdr



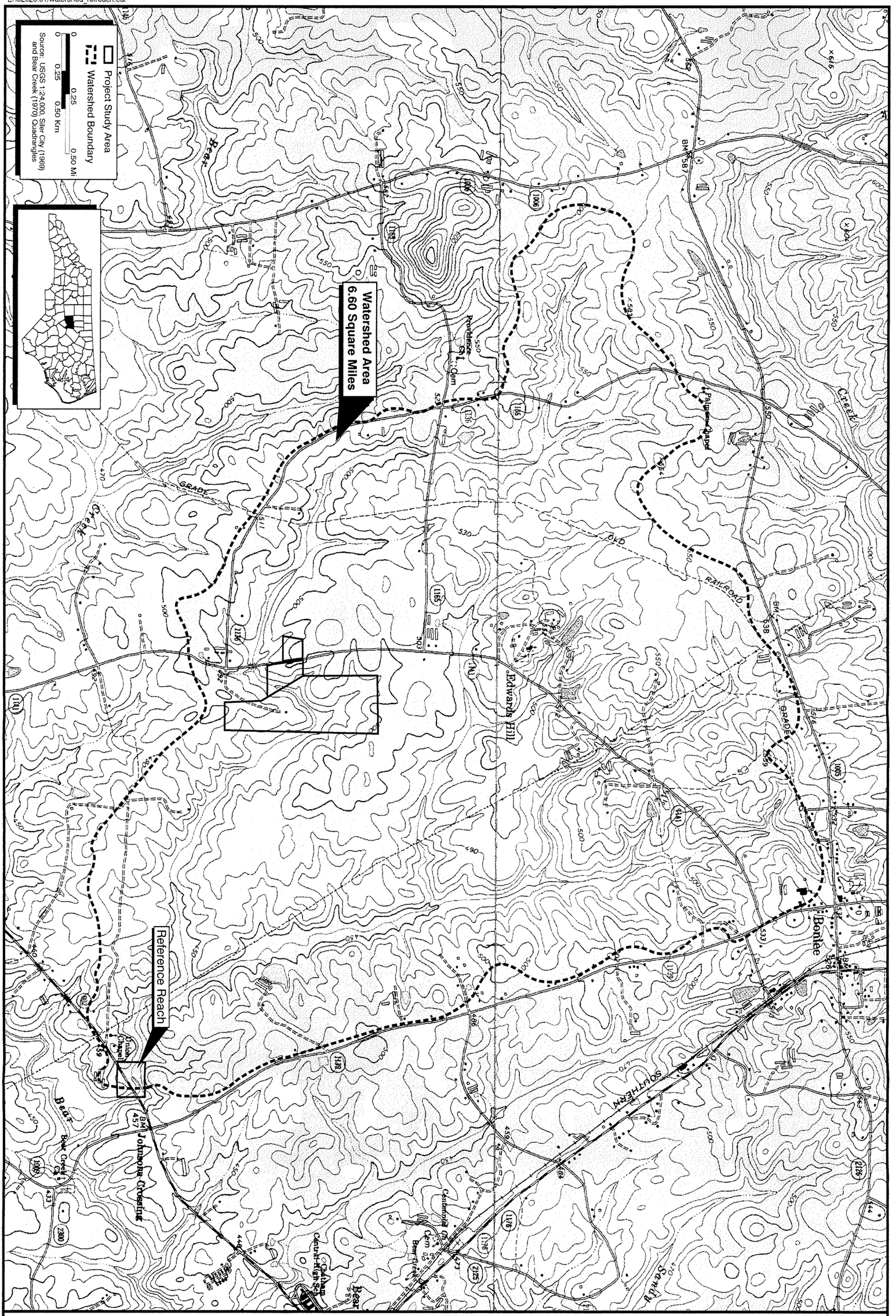
Environmental Services, Inc.

Reference Reach-
UT South Fork Cane Creek Watershed
UT Bear Creek Mitigation Plan
Chatham County, North Carolina

Figure:	B-2
Project:	ER02026.01
Date:	June 2003

ER02026.01/watershed_sthfork.cdr

ER02026.01/watershed_refreach.cdr



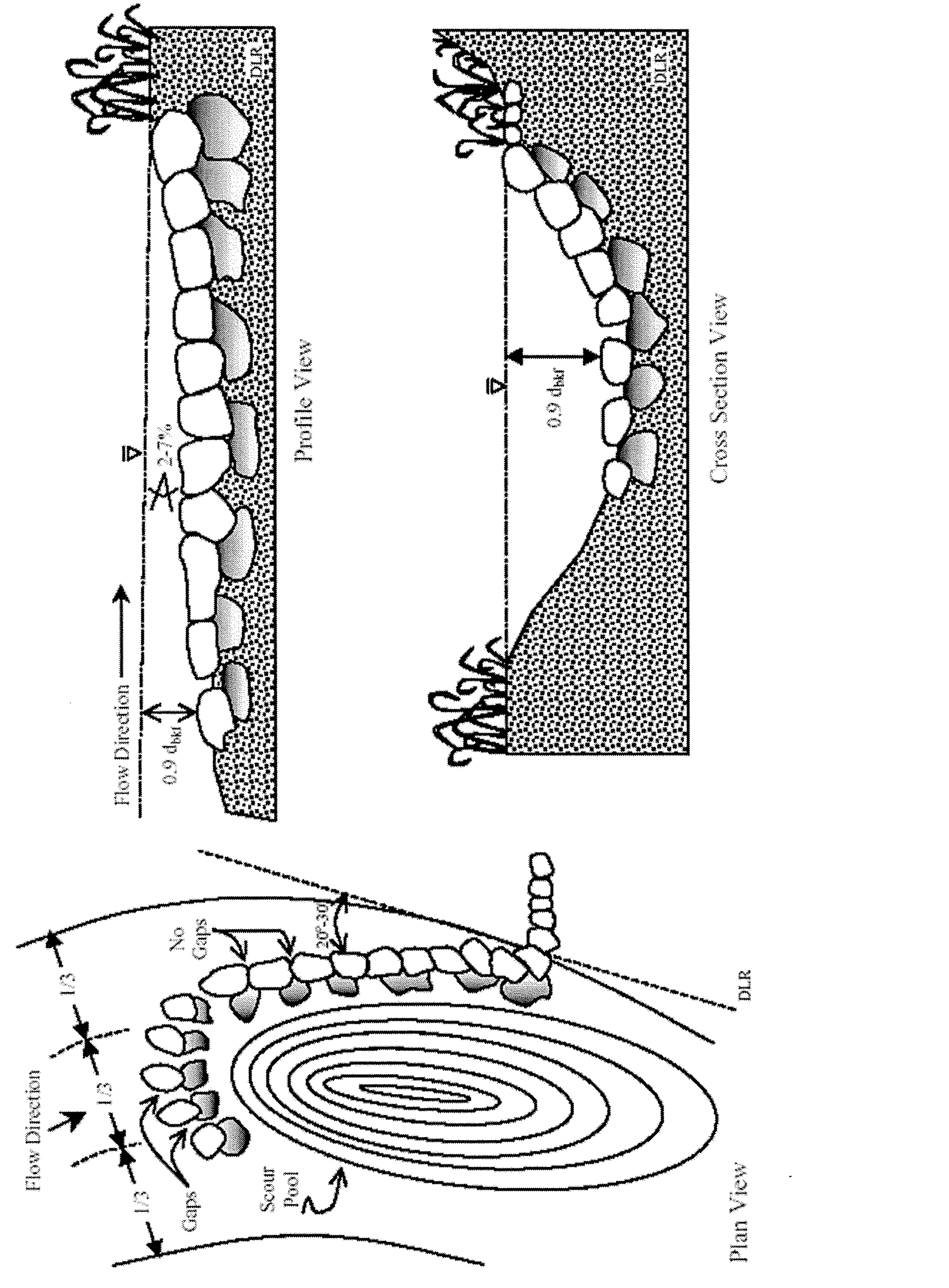
Environmental Services, Inc.	Reference Reach- UT Bear Creek Reference UT Bear Creek Mitigation Plan Chatham County, North Carolina	Figure: B-3 Project: ER02026.01 Date: June 2003

Table B-1. Summary of reference reach variables.

	Existing Conditions			Reference Conditions*			Proposed Conditions	
Variable	UT Bear Creek	UT2 Upper	UT2 Lower	Richland Creek	UT South Fork Cane Creek	UT Bear Creek Reference	UT Bear Creek	UT2
Watershed Size (mi^2)	1.68	0.15	0.15	1.04	0.41	6.6	1.68	0.15
Bankfull width (ft)	13.2	7.7	-	16.5	13.1	22.8	21.3	9.8
Bankfull depth (ft)	1.2	1.1	-	0.9	0.9	1.8	1.7	0.9
Bankfull area (ft^2)	19.5	5.9	-	15.3	11.9	41.7	37.1	9.1
Max. depth (ft)	2.0	1.3	-	1.5	1.4	2.6	2.0	1.3
Floodprone area (ft)	16	8.5	-	50-53	26-36	>70	25-50	25-50
Entrenchment ratio	1.2	1.6	-	3.2	2.4	>3.1	1.5	3.0
Width/depth ratio	8.9	5.1	-	17.8	14.3	12.7	12.2	10.8
Valley slope	0.0033	-	-	0.0136	0.0017	0.0026-0.0033	0.002-0.003	0.003-0.013
Sinuosity	1.2	-	-	1.2	1.2	1.2	1.2	>1.2
Water slope	0.017	-	-	0.0133	0.0078	0.0022-0.0029	0.001-0.0003	0.001
Riffle slope	0.01-0.03	-	-	0.01-0.03	0.0043-0.041	0.003-0.022	0.001-0.003	0.0017
Pool slope	-	-	-	0.0014-0.0003	0.000-0.0026	<0.001	<0.001	<0.001
Pool-to-pool spacing (ft)	-	-	-	37-96	37-81	153.0	53-75	24-75
Pool width (ft)	-	-	-	11.1	12.5	8-12	11-21	5-10
Max pool depth (ft)	-	-	-	1.5	2.7	0.9 (no flow)	3.0	1.4-2
Meander radius of curvature (ft)	-	-	-	16-26	16-25	105-411	19	19
Meander wave length (ft)	-	-	-	90-93	32-58	249-947	60-150	30-70
Meander belt width (ft)	-	-	-	25-40	14-30	234-323	24-35	24-35
Ratio meander length to bankfull width	-	-	-	5.5-5.7	2.4-4.4	10.9-41.5	3-7	3-7
Meander width ratio	-	-	-	1.8	1.5	12.2	1.1-1.6	1.1-1.6
Ratio radius of curvature to bankfull width	-	-	-	1.15	1.2-1.9	4.6-18.0	1.2-2.0	>2.0
Ratio Pool width to bankfull width	-	-	-	0.7	1.0	0.43	0.5-1.0	0.5-1.0
Rosgen Classification	G6	E6	-	C4	C4	C5	C4/C5	C4/C5

*All data provided by NCDOT

APPENDIX C
PROPOSED REACHES AND INFORMATION

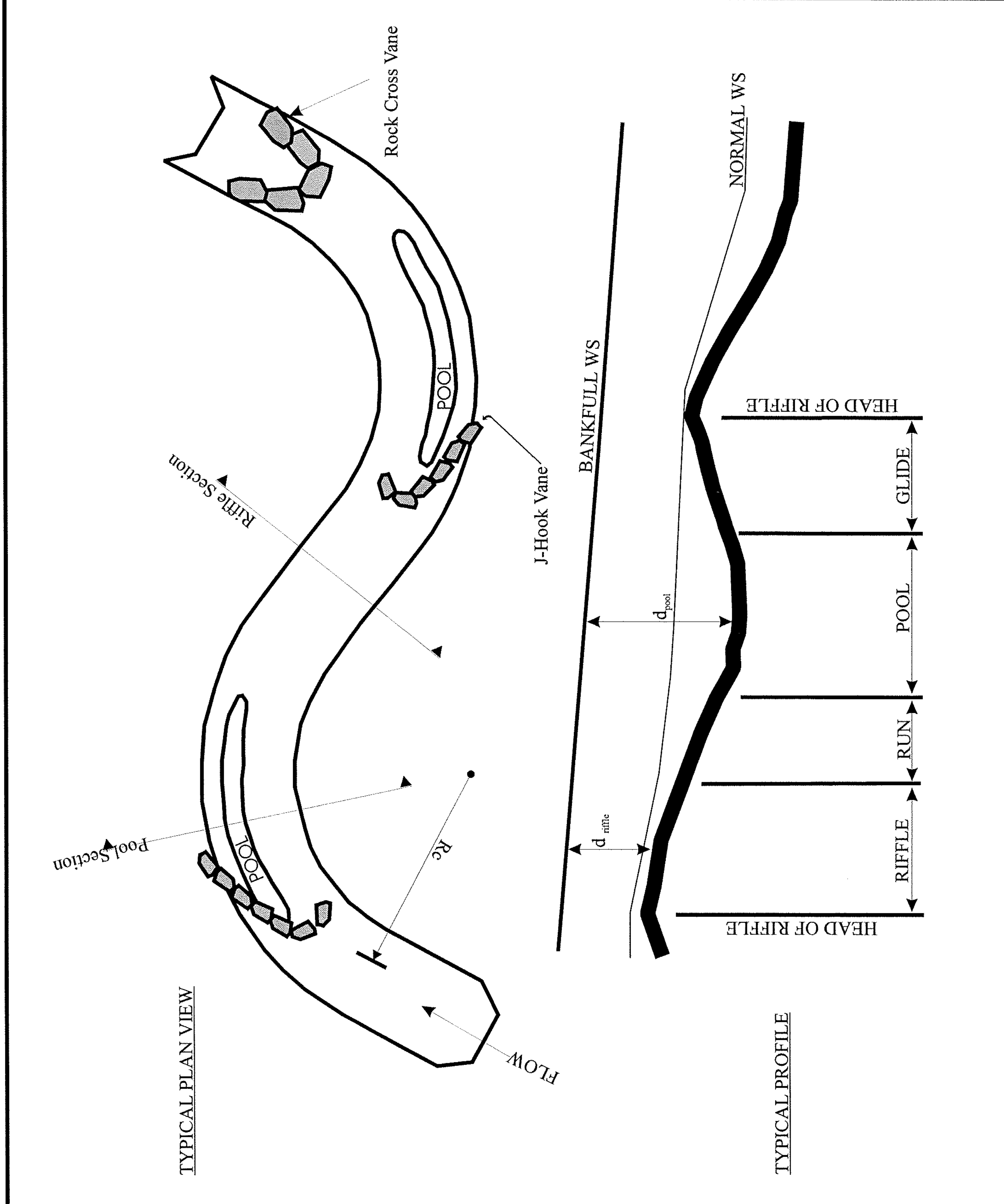


ER02026.01/PlanView_drawings.cdr

Environmental Services, Inc.

Structures and Cross Section
UT Bear Creek Mitigation Plan
Chatham County, North Carolina

Figure:	C-2
Project:	ER02026.01
Date:	June 2003



Environmental Services, Inc.

Typical Plan View and Profile
UT Bear Creek Mitigation Plan
Chatham County, North Carolina

Figure:	C-3
Project:	ER02026.01
Date:	June 2003

ER02026.01/PLANVIEW_ral.cdr

APPENDIX D
FEDERALLY THREATENED AND ENDANGERED SPECIES

Species with the federal classification of Endangered (E), Threatened (T), or officially Proposed (P) for such listing, are protected under the Endangered Species Act (ESA) of 1973, as amended (16U.S.C. 1531 et seq.). Four (4) species offered federal protection are considered by the U.S. Fish and Wildlife Service (USFWS) to have ranges which extend into Chatham County, North Carolina. Table 1 in Section 2.2.3.1 outlines these species with their respective federal designations as of 29 January 2003. Species descriptions, habitat requirements, and Biological Conclusions for these species follow. Reviews at the N.C. Natural Heritage Program (NHP) were conducted on 15 May 2003.

Bald eagle - The bald eagle is a large raptor with a wingspan greater than 6 feet. Adult bald eagles are dark brown with white head and tail. Immature eagles are brown with whitish mottling on their tail, belly, and wing linings. In the Carolinas, nesting season extends from December through May (Potter *et al.* 1980).

Bald eagles typically nest in tall, living trees in a conspicuous location near water and forage over large bodies of water with adjacent trees available for perching (Hamel 1992). Preventing disturbance activities within a primary zone extending 750 to 1,500 feet outward from a nest tree is considered critical for maintaining acceptable conditions for eagles (USFWS 1987). USFWS recommends avoiding any disturbance activities, including construction and tree-cutting, within this primary zone. Within a secondary zone extending from the primary zone boundary out to a distance of 1 mile from a nest tree, construction and land-clearing activities should be restricted to the non-nesting period. USFWS also recommends avoiding alteration of natural shorelines where bald eagles forage, and avoiding significant land-clearing activities within 1,500 feet of roosting sites.

> **Biological Conclusion**: No effect. Potential nesting habitat for this species, consisting of large trees in a conspicuous location near open water, is not present within or near the project study area. NHP records do not document any occurrences of this species within 3.0 miles of the project study area. Mitigation activities will not affect this species.

Cape Fear Shiner – This minnow is a small (to 2 inches), moderately stocky fish. The Cape Fear shiner is pale silvery yellow with a black band along the sides and is distinguished from related shiners by having a double-looped alimentary tract visible through the gut wall (USFWS 1988). Habitat of the Cape Fear shiner is generally considered to consist of slow pools, riffles, and runs over gravel, cobble, and boulders (USFWS 1988). Little is known about the Cape Fear shiner's life history. This species is endemic to the Cape Fear River Basin and present distribution includes portions of Randolph, Chatham, Lee, Moore, and Harnett Counties (USFWS 2002). Approximately 0.5 river mile of Bear Creek, from the Chatham County Road 2156 Bridge downstream to the Rocky River, has been designated as Critical Habitat for this species.

> **Biological Conclusion**: No effect. Potentially suitable habitat for this species, consisting of slow pools, riffles, and runs of gravel, cobble, and boulders, does not exist within the project study area. The segments of UT Bear Creek located within the project

study area consist of intermittently filled pools and riffles primarily over clay substrate limited amounts of gravel substrate. NHP records do not document any occurrences of this species within 3.0 miles of the project study area. Mitigation activities will not affect this species. The project study area does not contain designated Critical Habitat and mitigation activities will not adversely affect designated Critical Habitat in Bear Creek.

Red-cockaded woodpecker (RCW) - This small woodpecker (7 to 8.5 inches long) has a black head, prominent white cheek patch, and black-and-white barred back. Males often have red markings (cockades) behind the eye, but the cockades may be absent or difficult to see (Potter *et al.* 1980). Primary habitat consists of mature to over-mature southern pine forests dominated by loblolly (*Pinus taeda*), long-leaf (*Pinus palustris*), slash (*Pinus elliotii*), and pond (*Pinus serotina*) pines (Henry 1989). Primary nest sites for RCWs include open pine stands greater than 60 years of age with little or no mid-story development. Nest cavity trees tend to occur in clusters, which are referred to as colonies (USFWS 1985). Foraging habitat is comprised of open pine or pine/mixed hardwood stands 30 years of age or older. Pine flatwoods or pine-dominated savannas which have been maintained by frequent natural fires serve as ideal nesting and foraging sites for this woodpecker. Development of a thick understory may result in abandonment of cavity trees. The woodpecker drills holes into the bark around the cavity entrance, resulting in a shiny, resinous buildup around the entrance that allows for easy detection of active nest trees (Henry 1989).

Biological Conclusion: No Effect. Potentially suitable nesting and foraging habitat for this species, consisting of large pines with open boles, does not exist within the project study area. NHP records do not document any occurrences of this species within 3.0 miles of the project study area. Mitigation activities will not affect this species.

Harperella - This annual herb grows to a height of 6 to 36 inches and typically occurs in two habitat types (USFWS 1990). The first habitat type is on rocky or gravel shoals and margins of clear, swift flowing stream sections. Specifically, harperella in this habitat type typically grows on rocky shoals, in crevices in exposed bedrock, and may also be found along sheltered muddy banks (USFWS 1990). Harperella in this habitat type is restricted by water depths and is not found in deep waters or in the shallowest or driest areas of the streams (USFWS 1990). The second habitat type consists of the edges of intermittent pineland ponds in the Coastal Plain.

Biological Conclusion: No Effect. Potentially suitable habitat for this species, consisting of clear, swift flowing stream channels, is not present within the project study area. The sections of UT Bear Creek within the project study area consist of a slow flowing (at best) stream channel over clay and sand substrate with occasional boulder and bedrock substrate seen, precluding the first habitat type. The project study area is located in the Piedmont region of North Carolina, precluding the second habitat type. NHP records do not document any known occurrences of this species within 3.0 miles of the project study area. Mitigation activities will not affect this species.

APPENDIX E
CHANNEL PHOTOGRAPHS

UT Bear Creek Bank Failures

Figure E-1

1

2

3

Proposed Machinery Crossing Location Figure E-2

UT Bear Creek

4

UT2

5

Rock Outcrop and Cattle Incursions

Figure E-3

6

UT2 Restoration Area Figure E-4

7

8