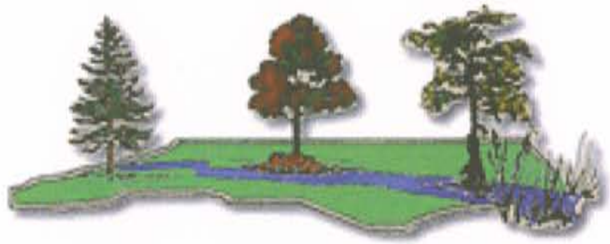
STREAM RESTORATION PLAN

Little Bugaboo Creek
Wilkes County, North Carolina



N.C. Wetlands Restoration Program

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April 2002

E A R T H T E C H

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1.0 INTRODUCTION

The North Carolina Wetlands Restoration Program (NCWRP) has identified Little Bugaboo Creek (LBC) and an Unnamed Tributary to Little Bugaboo Creek (UT) as a potential stream restoration site. A tributary to the Roaring River, Little Bugaboo Creek (NCDWQ Stream Index Number – 12-48-1-(1)) is located on agricultural land northeast of the town of Roaring River in Wilkes County, North Carolina (Figure 1).

The Wilkes County Soil and Water Conservation District (WCSWCD) staff first identified LBC as a potential restoration site through their work with farmers throughout the county. Landowners main concern is loss of land, due to actively eroding streambanks, along the majority of the project length. Cattle access and the removal of vegetation are the main causes of degradation. Land adjacent to the streams is currently being used for cattle production and the spreading of chicken litter. Typical of many heavily agricultural areas, land to spread litter is at a premium.

Vegetation throughout the majority of the site is degraded as a result of cattle access. Pastures adjacent to the stream consist of fescue with sparse trees along drainages. Most streambanks are vertical with little or no vegetation and are actively eroding. There are numerous signs of lateral meander migration. This is a Rosgen 'F' type system where the channel appears to have down cut and is presently eroding its banks to establish a flood plain at the new channel elevation. The existing channel appears to be in a state of transition. Streambanks are very unstable and meanders are continuing to migrate, creating a wider floodplain as necessary to reach stability.

The combination of extreme streambank erosion, degraded vegetation, poor cattle management practices, and willing landowners make this an excellent potential restoration site.

Restoration requires determining how far the stream has departed from its natural stability and then establishing the stable form of the stream under the current hydrologic conditions within the drainage area. The proposed restoration will construct a stable meander geometry, modify channel cross-sections, and establish a floodplain at the existing stream elevation, thus, restoring a stable dimension, pattern, and profile. This restoration is based on analysis of current watershed hydrologic conditions, field evaluation of the project site, and assessments of stable reference reaches. The following recommendations are included in this restoration plan:

- Form a stable channel with the proper dimension, pattern, and profile.
- Establish a floodplain along the stream channel.
- Place natural material structures in the stream to improve stability and enhance aquatic habitat.
- Stabilize stream banks with herbaceous and woody vegetation.
- Establish a permanent conservation easement along the project.
- Restore/enhance the streams riparian zone.

1.1 PROJECT DESCRIPTION

The Little Bugaboo Creek project site is located northeast of the town of Roaring River in Wilkes County, North Carolina. Roaring River is located 7 miles east, northeast of North Wilkesboro. The project is fully contained within the property of five landowners. LBC flows northwest to southeast, and the UT flows north to south. The project ends at the confluence of LBC and the UT. The project reach is bound to the north by Tharpe Road (S.R. 2014) and to the south by Hoots Road (S.R. 1924). Bedrock outcroppings, in the form of waterfalls, border the project to the east and west. The western boundary has been set by land constraints as a result of property lines (Figure 2). Both LBC and the UT flow through cattle pasture.

1.2 GOALS AND OBJECTIVES

This project has the following goals and objectives:

1. Provide a stable stream channel that neither aggrades nor degrades while maintaining its dimension, pattern, and profile with the capacity to transport its watershed's water and sediment load.
2. Improve water quality and reduce further property loss by stabilizing eroding stream banks.
3. Reconnect the stream to its floodplain or establish a new floodplain at a lower elevation.
4. Improve aquatic habitat with the use of natural material stabilization structures such as root wads, cross vanes, woody debris and a riparian buffer.
5. Provide aesthetic value, wildlife habitat and bank stability through the creation or enhancement of a riparian zone.
6. Exclude cattle from the riparian zone and establish stable crossings for cattle movement.
7. Stabilize and enhance small drainages entering the site.

1.3 STREAM SURVEY METHODOLOGY

The US Forest Service General Technical Report RM-245, Stream Channel Reference Sites: An Illustrated Guide to Field Technique is used as a guide when taking field measurements. Accurate field measurements are critical to determine the present condition of the existing channel, conditions of the floodplain, and watershed drainage patterns.

Earth Tech contracted The Rose Group to conduct a topographic survey of the restoration site in February 2002. This mapping was used to evaluate present conditions, new channel alignment, and grading volumes. Mapping also provided locations of property pins, large trees, vegetation lines, culverts, roads, and elevation contours.

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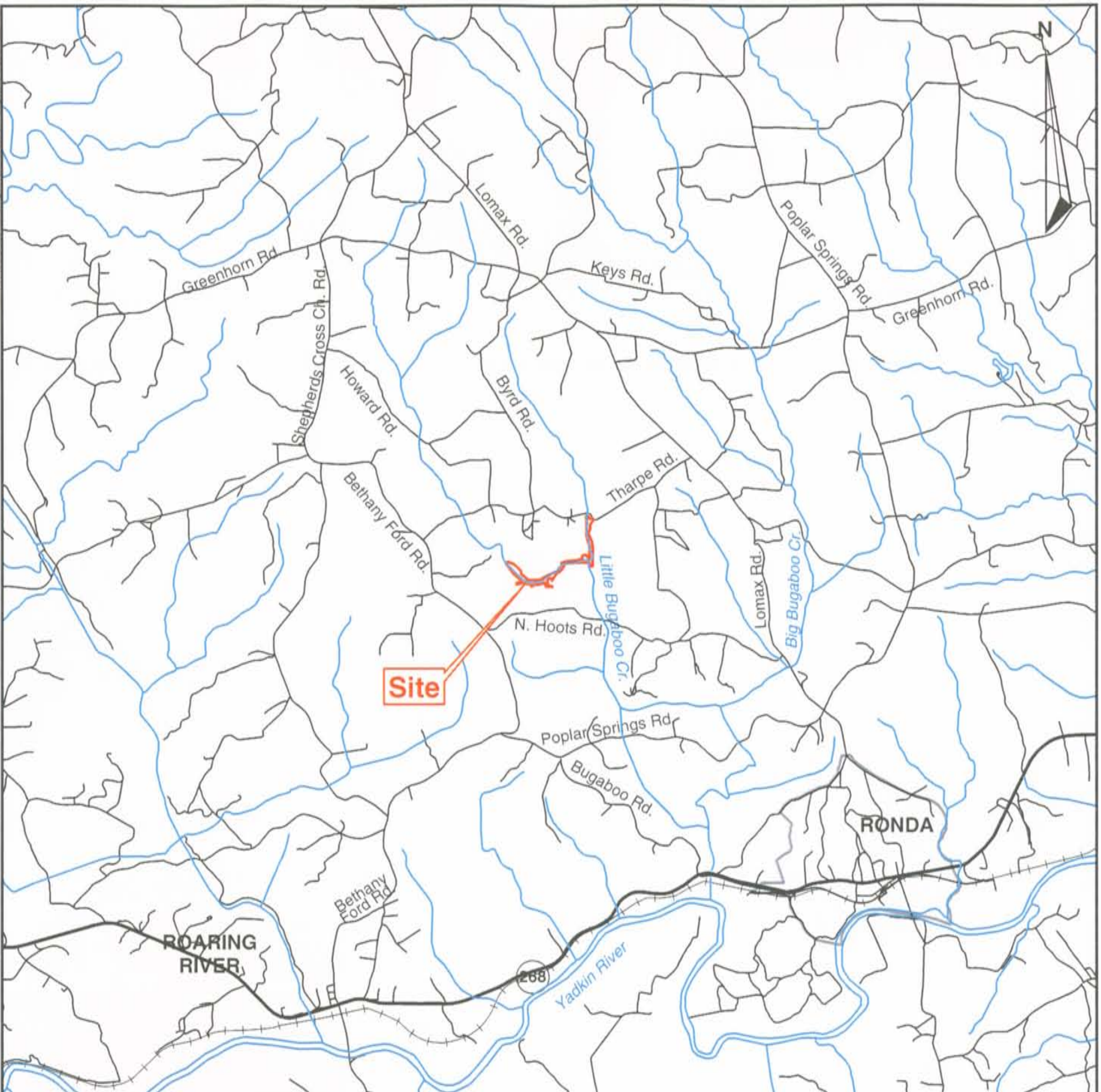

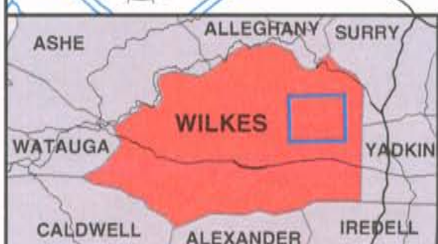

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FIGURE 1
Location Map

Little Bugaboo Creek Restoration Plan
Wilkes County, North Carolina

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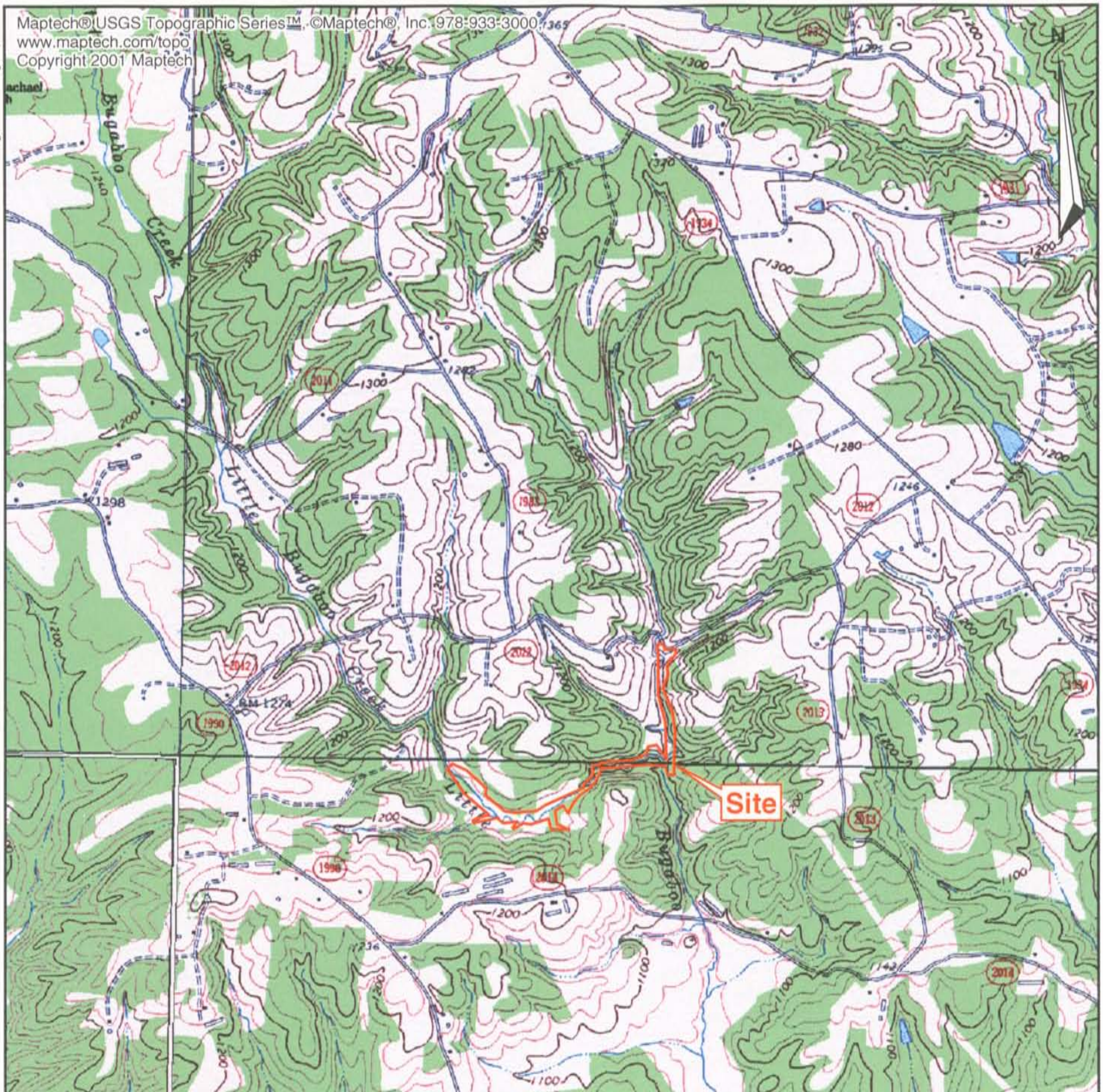

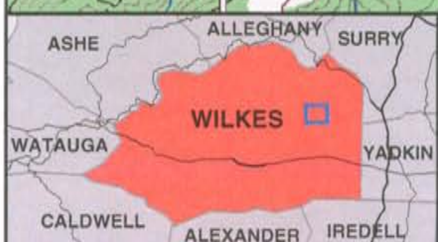

Source: USGS Quadrangles:
Thurmond, NC, 1971; Ronda, NC, 1971;
Roaring River, NC, 1966, Traphill, NC 1968.

0 1,000 2,000 4,000
Feet

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FIGURE 2
Vicinity Map

Little Bugaboo Creek Restoration Plan
Wilkes County, North Carolina

A walkover of the property was conducted to better evaluate the drainage properties of the area surrounding the restoration site. County Natural Resources Conservation Service Staff (NRCS) provided Geographic Information System (GIS) data to evaluate the watershed. A windshield survey was also conducted to determine the existing conditions within the watershed.

During the site visits, ten cross-sections were taken using standard differential leveling techniques. These cross-sections were used to gather detail on the present dimension and condition of the channel. Cross-sectional area was calculated using the bankfull features identified in the field. See Appendix B for a copy of the existing condition surveys.

1.3.1 Stream Delineation Criteria - Classification

Dave Rosgen developed his stream classification system in order to accomplish the following:

1) Predict a river's behavior
2) Develop specific hydraulic and sediment relationships for a given stream type and its state
3) Provide a mechanism to extrapolate site-specific data to stream reaches having similar characteristics
4) Provide a consistent frame of reference for communicating stream morphology and condition among a variety of disciplines and interested parties

The Rosgen Stream Classification System is based on five criteria: width/depth ratio, entrenchment ratio, slope, sinuosity, and channel materials. All cross-sections were classified using this system.

1.3.2 Bankfull Verification

The foundation of Dave Rosgen's classification system is the concept of bankfull stage, which is the point of incipient flooding. The classification depends on the correct assessment of bankfull. If bankfull is incorrectly determined in the field, the entire restoration effort will be based on faulty data. It is important to verify the physical indicators observed in the field with either gage data or a regional curve to ensure the correct assessment of the bankfull stage.

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

- The presence of a floodplain at the elevation of incipient flooding.
- The elevation associated with the top of the highest depositional feature (*e.g.* point bars, central bars within the active channel). These depositional features are especially good stage indicators for channels in the presence of terrace or adjacent colluvial slopes.

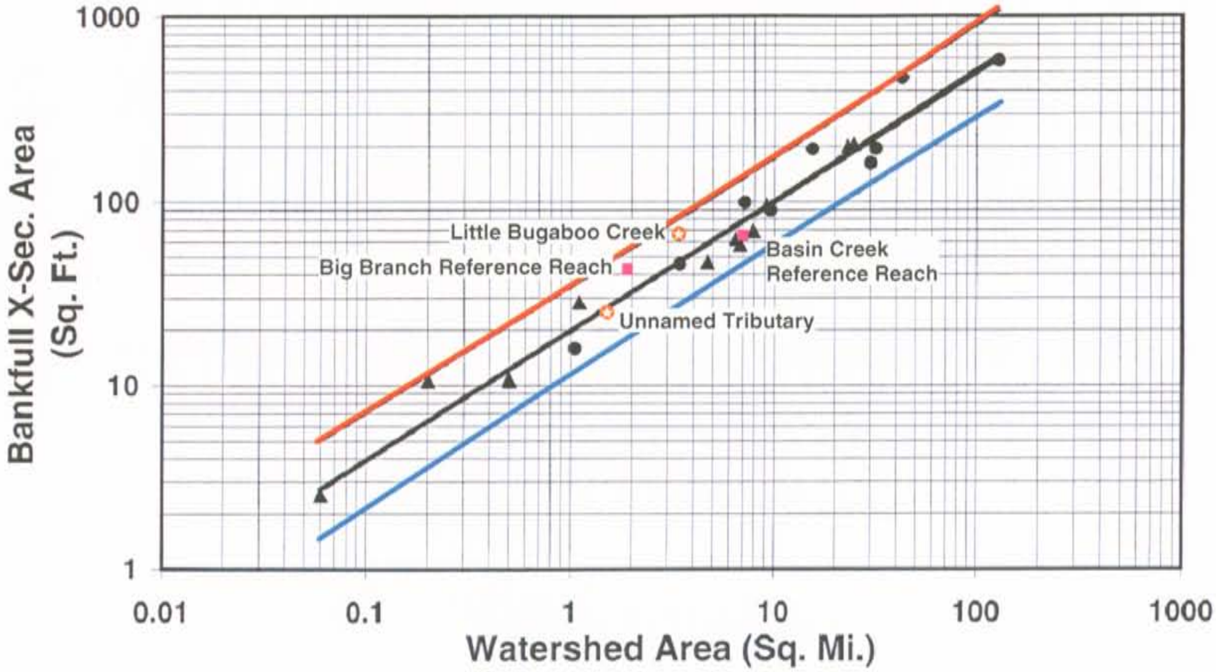
- A break in slope of the bank and/or a change in the particle size distribution, since finer material is associated with deposition by overflow, rather than deposition of coarser material within the active channel.
- Evidence of an inundation feature such as small benches below bankfull.
- Staining of rocks.

The most dominant bankfull indicators along LBC and the UT are high scour lines and the tops of point bars.

The most common method of verifying bankfull stage is to compare the field determined bankfull stage with measured stages at a stream gaging station. This calibration can be performed if there is a stream gage within the study area's hydrophysiographic region.

In ungaged areas, Dave Rosgen recommends verifying bankfull with the development of regional curves. The regional curves normally plot bankfull discharge (Q_{bkf}), cross-sectional area, width, and depth as a function of drainage area. The cross-sectional areas of LBC and the reference reach sites used for this report are plotted on the Rural and Urban, Piedmont Regional Curve of North Carolina developed by the North Carolina State University (NCSU) Water Quality Group, 2000 (Figure 3).

Data obtained from field surveys described in Section 2.2.2 was used to compute the morphological characteristics shown on the graph. The cross-sectional area for LBC plots above the trend line for the NC Rural Regional Curve but well within the 95% confidence limits. The cross-sectional area for the UT plots directly on the trend line for the NC Rural Regional Curve. The bankfull cross-sectional area for the design channel was determined from evaluating the North Carolina regional curve relationships and comparing them to the reference reach sites surveyed near the restoration site. HEC-RAS will be used to verify the design cross-sectional area for the project and estimate in-channel shear stress.



$A_{bkf} = 18.21\ A_w^{0.75}$; ($R^2 = 0.98$)

A_w = watershed drainage area (mi^2)

A_{bkf} = bankfull cross sectional area (ft^2)

- ▲ Reference Reaches
- ● Gage Stations
- ■ Reference Reaches
- ○ Project Site
- Upper 95%
- Predicted
- Lower 95%

FIGURE 3
North Carolina Regional Curve

Little Bugaboo Creek Restoration Plan
Wilkes County, North Carolina

2.0 EXISTING CONDITIONS

2.1 WATERSHED

2.1.1 General Description of the Watershed

Little Bugaboo Creek, a second order stream, is located within the Piedmont Physiographic Province of the Yadkin-Pee Dee River Basin (USGS Cataloging Unit 03040101). The watershed is located to the northeast of the town of Roaring River in Wilkes County, North Carolina. The headwaters of the project originate approximately 3 miles to the north-northwest of the restoration site. From the headwaters, LBC flows for approximately 4 miles before joining with the Big Bugaboo Creek. An Unnamed Tributary to Little Bugaboo Creek enters LBC at the end of the project site and is also included in the restoration project. The headwaters for UT originate approximately 1.6 miles from the restoration site. From the headwaters, UT flows for approximately 2.5 miles before the confluence with LBC. Several tributaries enter LBC along its extent.

The watershed for LBC is approximately 3.45 square miles (2,200 Acres) and the watershed for the UT is approximately 1.4 square miles (900 Acres) (Figure 4). The watershed is oriented northwest to southeast. The topography ranges from gently sloping to steep with relatively flat, narrow floodplains occurring along the larger drainages. Land surface elevations range from approximately 1,100 to 1,400 feet above mean sea level.

2.1.2 Surface Waters Classification

Surface waters in North Carolina are assigned a classification by the DWQ that is designed to maintain, protect, and enhance water quality within the state. LBC (NCDWQ Stream Index Number – 12-48-1-(1)) is classified as a class *C* water body (NCDENR, 2002). *Class C* water resources are waters protected for aquatic life propagation and survival, fishing, wildlife, secondary recreation, and agriculture. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner. There are no restrictions on watershed development activities.

NCDWQ has not assigned an index number to the UT.

2.1.3 Soils of the Watershed

The soils found in the watershed and adjacent to the stream can help determine the bed and bank materials occurring in the stream. The Rosgen stream classification system uses average particle size within the bankfull channel to help classify the stream. Knowing the make up of the soils in the watershed assists in understanding the anticipated bedload and sediment transport capacity of the stream.

Soils in upland areas within the watershed consist primarily of Masada sandy clay loam, Rion fine sandy loam, and Pacolet sandy loam soils (Soil Survey of Wilkes County, North Carolina, Natural Resources Conservation Service [NRCS], 1997). Chewacla loam soils occur primarily on the floodplains within the watershed. Depth to bedrock is mapped as greater than 5 feet for these soils. The upland soils have clayey sub-soils with rock fragments ranging from gravel to cobble size.

Masada sandy clay loam occurs on high stream terraces, and comprises only a small portion of the soils within the watershed. These very deep, sloping soils are well drained and have moderate permeability and medium to rapid runoff. They have formed in old alluvium derived from felsic rocks. The depth to the water table is greater than 6 feet. Masada soils are most likely in the hydrologic soil group C.

A Rion fine sandy loam occurs on side slopes and narrow ridgetops in a few places within the watershed. These soils are steep, very deep, and well drained. They have moderate to moderately rapid permeability, and surface runoff is rapid to very rapid. The depth to the water table is below a depth of 6 feet. This soil formed in the residuum from weathered granite, gneiss, and schist, and typically has clayey subsoil. Rion soils are in the hydrologic soil group B.

Pacolet sandy clay loam typically occurs on side slopes and ridgetops throughout the watershed. These soils are very deep, gently to strongly sloping and well drained. They have a moderate permeability, and surface runoff is medium to rapid. They have formed in the residuum from weathered granite, gneiss, and schist, and typically have clayey subsoil. The depth to the water table is greater than 6 feet. The Pacolet soils are in hydrologic soil group B.

Chewacla loam soils are found on the flood plains throughout the watershed. This nearly level, very deep, and somewhat poorly drained soil has moderate permeability, and surface runoff is slow. These soils form in recent alluvium derived from mixed felsic rocks. The depth to the water table is generally between 0.5 and 1.5 feet. Chewacla soils are in hydrologic soil group C.

2.1.4 Land Use of the Watershed

Land use within the watershed is predominately forest or agricultural (Figure 5). Evaluation of a USGS topographic map reveals that approximately 47% of the watershed is forested and 51% is agriculture. The remaining 2% consists of low density residential and roadways.

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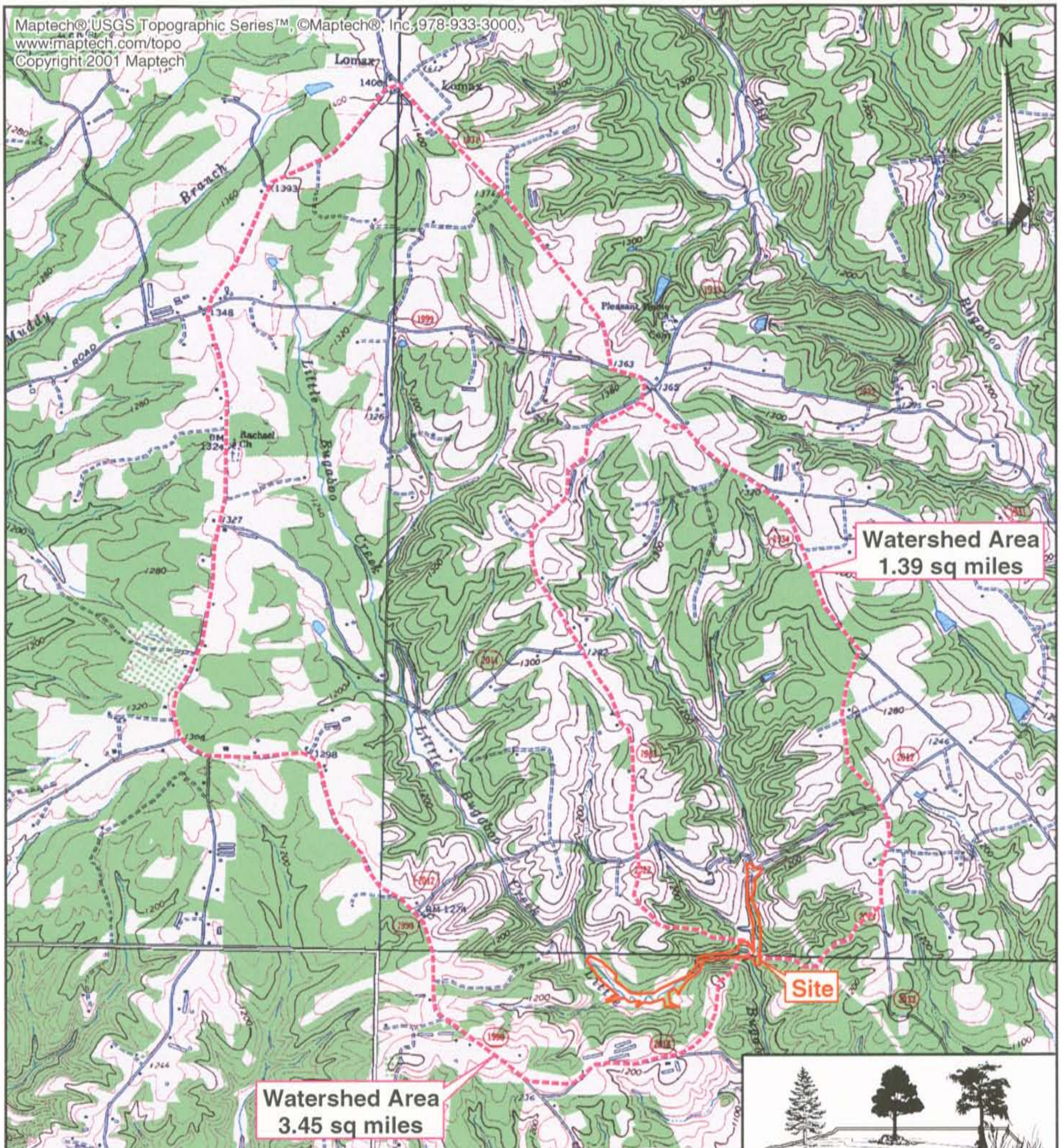

Source: USGS Quadrangles:
Thurmond, NC, 1971; Ronda, NC, 1971;
Roaring River, NC, 1966, Traphill, NC 1968.

0 1,250 2,500 5,000 Feet

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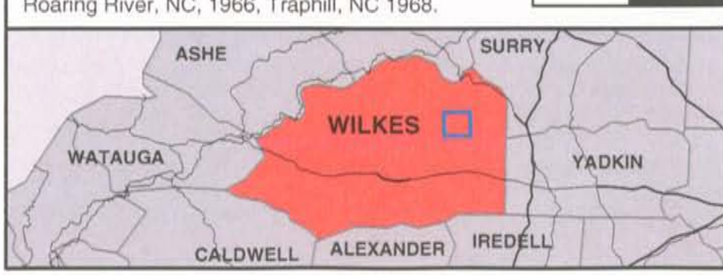

FIGURE 4
Little Bugaboo Creek Watershed

Little Bugaboo Creek Restoration Plan
Wilkes County, North Carolina

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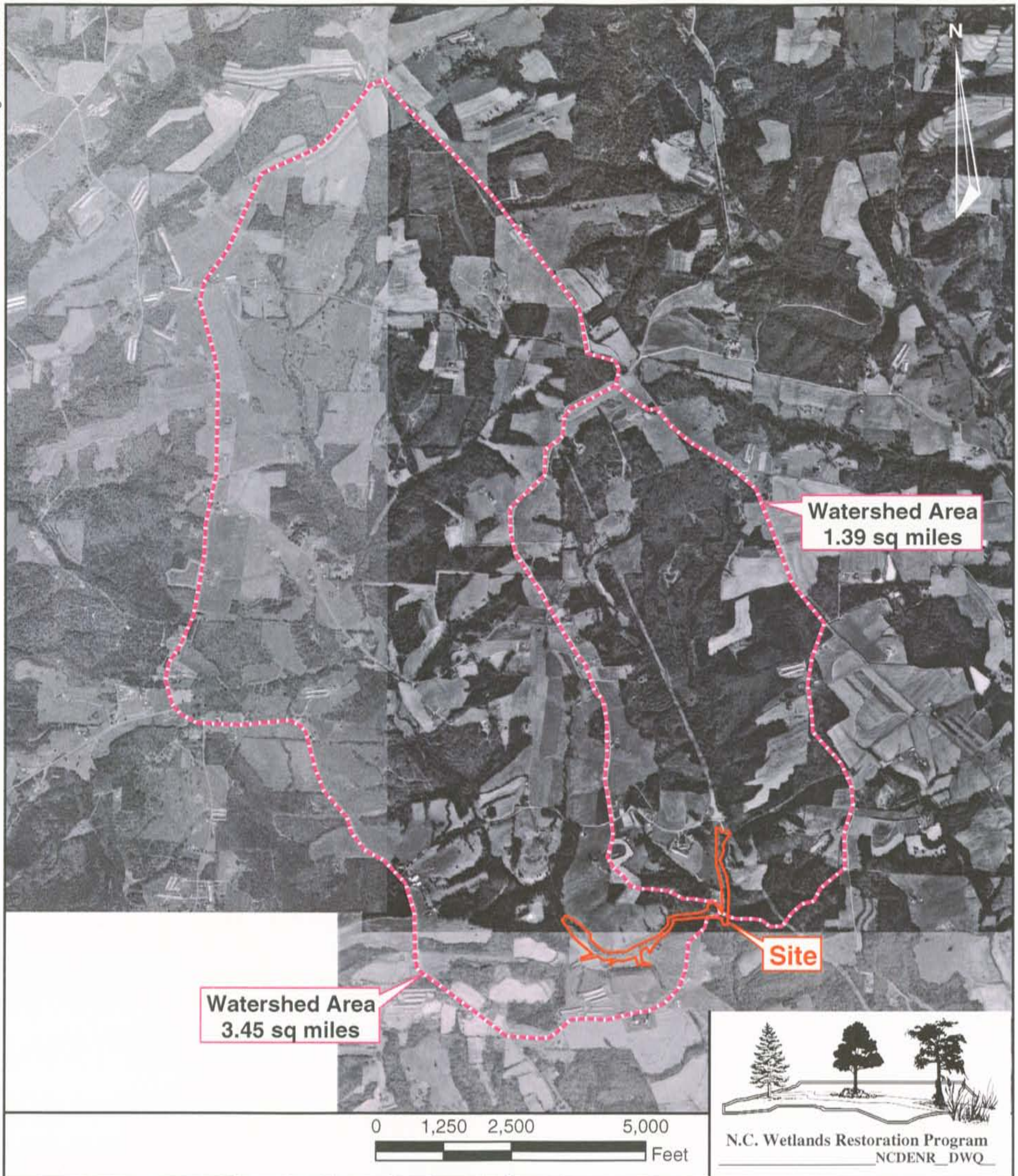

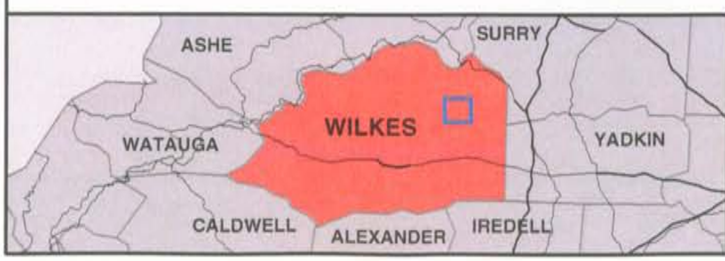

FIGURE 5
Watershed Aerial

Little Bugaboo Creek Restoration Plan
Wilkes County, North Carolina

2.2 RESTORATION SITE

The following sections provide a description of existing site conditions. This includes the current stream conditions, soils, and surrounding plant communities.

2.2.1 Site Description

The Little Bugaboo Creek restoration site begins approximately 4,420 feet from the confluence of LBC and UT. The project also includes the restoration of 1,924 feet of this tributary (UT). The project is located within the property boundaries of 5 different landowners (Figure 6). LBC flows from northwest to southeast through a 200 to 400-foot wide floodplain that narrows to less than 100-feet for the last 1,500-feet of the project. UT flows from north to south through a 100 to 200-foot wide valley. The UT is much straighter than LBC although both are increasing to meander over time.

Historically, a mill and dam were located about 150-feet below the confluence of LBC and UT. The milldam backed up water within approximately half of the project length (believed to be about elevation 1107 feet). Both streams have incised down to bedrock through the alluvial sediments of the historic pond. The dam was removed near the beginning of the 20th century. It is not known when the dam was constructed.

Landuse throughout the restoration site is predominantly agricultural land presently being used for cattle production and the spreading of chicken litter. Fences within the project area divide pastureland but do not restrict cattle access to the streams and drainages. LBC is bound upstream and downstream by bedrock outcroppings that result in significant (greater then 10-feet of fall) waterfalls. The UT is bound upstream by a bedrock outcropping and downstream by the confluence with LBC. The lower 1600 feet of LBC and 450 feet of the UT do have fencing along one side of each respective stream, which restricts cattle access

The causes of impairment throughout the restoration site are:

- Cattle access to the stream and riparian areas
- Incision partly due to aggradation of material from historic milldam below the end of the project limits.
- Indications of previous channelization along the reach
- Removal of riparian vegetation.

Cattle access to the stream and riparian areas has directly resulted in streambank erosion. Continual grazing has limited the ability of vegetation to reestablish itself along the majority of the stream. Dense rooting vegetation along the streambanks is extremely sparse for large lengths of stream. Additional degradation has resulted from historic channelization of the streams and tributaries. In effort to maximize available land for chicken littler spreading, landowners have straightened sections of LBC. This has increased the channel slope and significantly modified the channel dimension, pattern, and profile. The downstream portion of both reaches are deeply incised partly due to the

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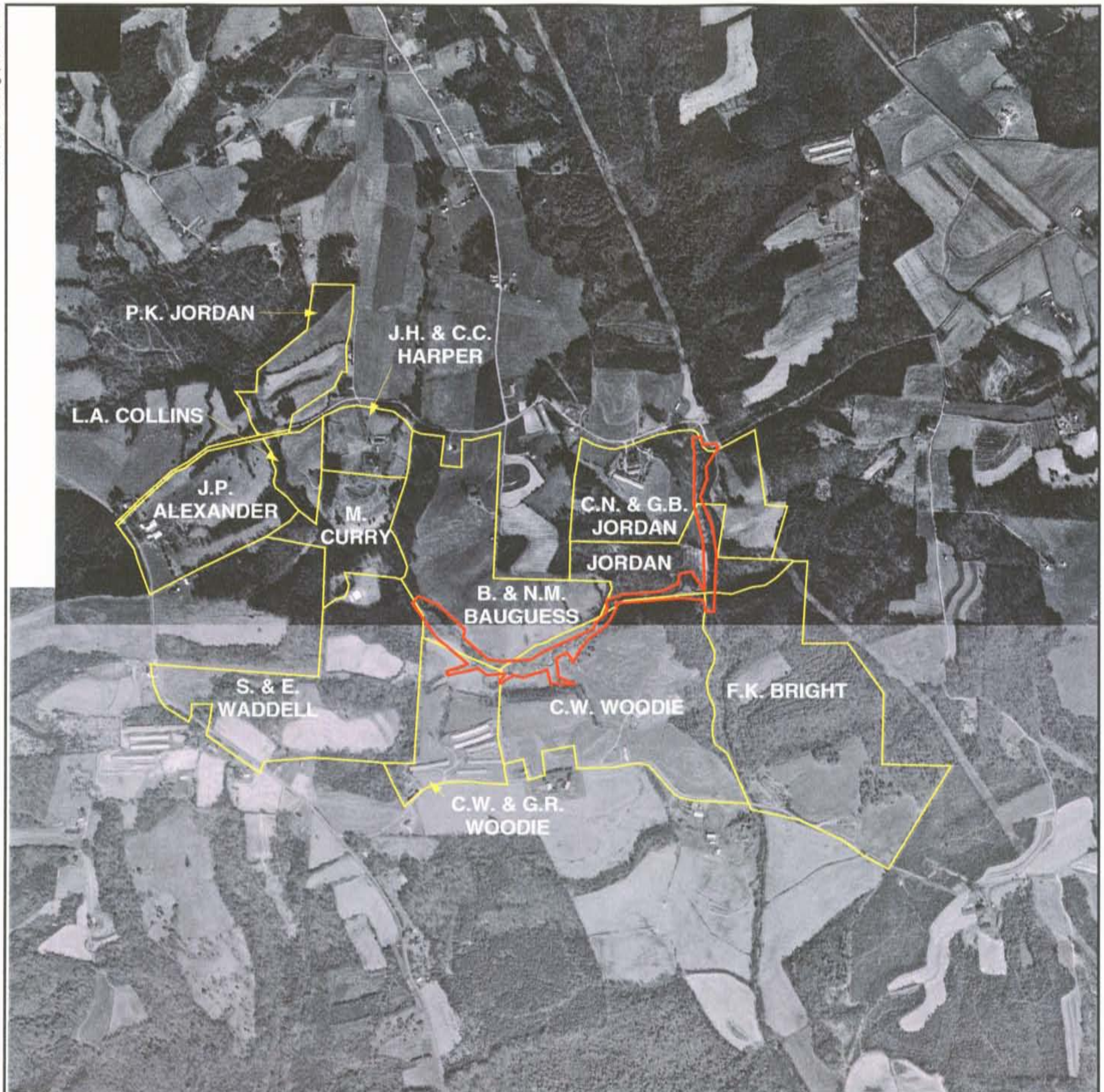

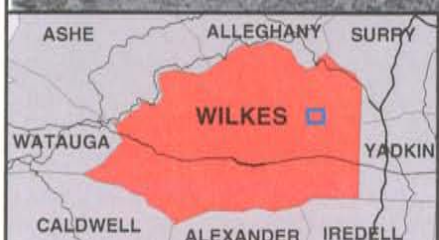

0 750 1,500 3,000
Feet

NOTE:
Approximate Parcel Locations

Source: Wilkes County.

N.C. Wetlands Restoration Program
NCDENR DWQ

FIGURE 6
Parcels

Little Bugaboo Creek Restoration Plan
Wilkes County, North Carolina

alluvial sediments that deposited during the existence of the downstream milldam. After the milldam was removed, a head cut worked up from the mill site through the deposited sediments.

2.2.2 Existing Stream Characteristics

Field surveys of the existing stream channel and site were conducted on February 12 through 15, 2002. Photographs of the site were taken and are provided in Appendix A. LBC Restoration Site can be typically described as a channel in transition. Deeply incised, the channel is currently widely meandering in an attempt to establish a stable dimension, pattern, and profile. There are indications of severe pattern changes resulting from large storm flow events throughout both LBC and UT. These pattern changes are typical of channel evolution from a 'F' type system to a 'C' type system in the Rosgen classification system. Cattle access to the existing stream and riparian areas has degraded the existing vegetation to the point that it is providing little or no root mass along the stream banks.

Stream bank erosion dominates the site resulting from the combination of incision of the streambed, pattern modifications, and lack of streambank vegetation. A complete assessment has not been conducted but landowners commented that banks were eroding at a rate of several feet per year in areas.

A total of ten tributaries/drainages enter LBC and UT within the project limits. As a result of the incision of LBC and UT, these tributaries/drainages have also incised significantly. Several are eroding, which is adding to the sediment load of the larger streams.

Riffle bankfull widths for LBC range from 27.0 to 37.5 feet with mean depths ranging from 1.8 to 2.8 feet. The cross-sectional areas for these riffles range from 53.3 to 89.7 square feet. The stream type varies along the site from E, F, and Bc, although the predominant stream type if F. The data for the existing channel is included in Appendix B. LBC has the following average characteristics:

Bankfull Width:	30.5 feet
Cross-sectional Area:	69.7 square feet
Mean Depth:	2.3 feet
Maximum Depth:	3.5 feet
Average Water Surface Slope:	0.0049 feet/feet
Entrenchment Ratio:	2.65
Sinuosity:	1.3
Bank Height Ratio	2.3

Riffle bankfull widths for UT range from 17.5 to 18.0 feet with mean depths of 1.2 feet in both riffle surveyed. The cross-sectional areas for these riffles range from 21.2 to 21.9 square feet. The stream type varies along the site from C to F, although the predominant stream type if F. The data for the existing channel is included in Appendix B. UT has the following average characteristics:

Bankfull Width:	17.8 feet
Cross-sectional Area:	21.6 square feet
Mean Depth:	1.2 feet
Maximum Depth:	2.3 feet
Average Water Surface Slope:	0.011 feet/feet
Entrenchment Ratio:	2.2
Sinuosity:	1.2
Bank Height Ratio	3.9

2.2.3 Soils of the Restoration Site

According to the Soil Survey of Wiles County, soils adjacent to LBC within the restoration site are mapped as Chewacla loam, Rion fine sandy loam, and Pacolet sandy loam soils (Figure 7). Investigation of the soils adjacent to the stream indicates that all three soils appear to be present, although Chewacla soils dominate the site. Chewacla soils are nearly level, very deep and somewhat poorly drained soils found on flood plains on the Piedmont. This soil has moderate permeability and surface runoff is slow in bare and unprotected areas. These soils formed in recent alluvium derived from mixed felsic rocks.

Rion fine sandy loams are steep, very deep, and well-drained soils typically found on piedmont side slopes. They have moderate permeability and surface runoff is rapid to very rapid in bare and unprotected areas. These soils formed in material weathered from rocks such as granite, gneiss, or schist.

Pacolet sandy loam soils in the project area are gently to steeply sloping, very deep, and well drained. These soils are typically found on ridgetops and side slopes in the Piedmont. They have moderate permeability and surface runoff is medium or rapid in bare and unprotected areas. These soils formed in material weathered from rocks such as granite, gneiss, or schist.

Soil textures encountered include sandy loams, sandy clay loams, and clay loams. Significant amounts of gravel and cobbles were noted in some horizons in some locations. Gravel and cobbles were more common in the portion of the project nearest the streambed. The channel has incised into the floodplain deep enough to expose cobbles, boulders, and bedrock in many places along the stream banks. The seasonal high water table is greater than 6 feet for Rion and Pacolet soils and 0.5 to 1.5 feet for Chewacla soils. Slopes range from 0 to 30 percent.

In depositional areas within the newly forming floodplain, inceptisols are present. These soils lack distinct horizons, and are extremely gravelly. They have formed from alluvial deposits and erosional deposits created when adjacent banks collapse into the stream. Surface material is generally a sandy loam with up to 20 percent gravel while underlying material is generally sandy clay, with 5-10 percent gravel. In some areas along the tributary to Little Bugaboo Creek cobbles and bedrock are present next to the stream.

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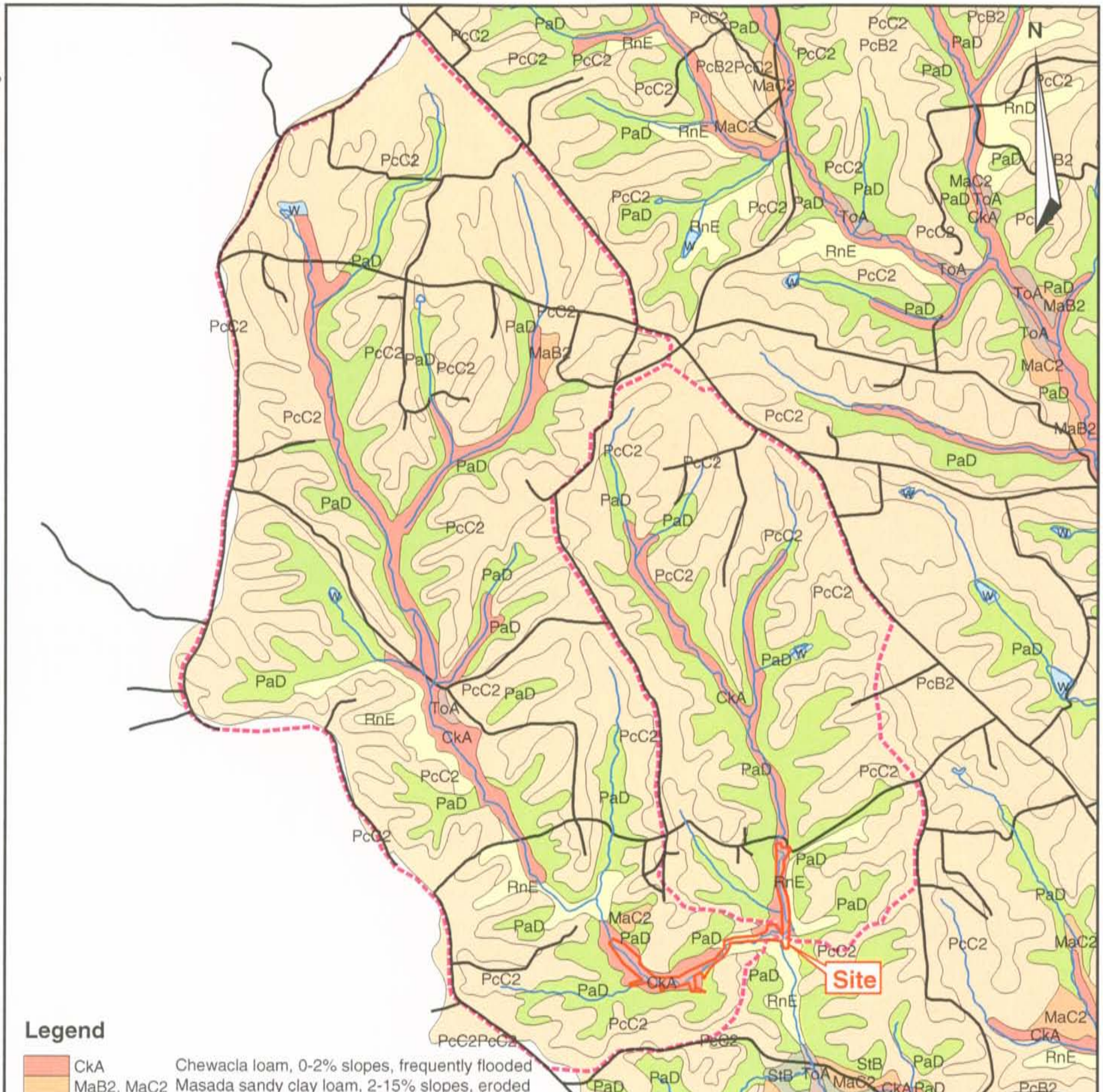

Legend

CkA	Chewacla loam, 0-2% slopes, frequently flooded
MaB2, MaC2	Masada sandy clay loam, 2-15% slopes, eroded
MuC	Masada-Urban land complex, 2-15% slopes
PaD	Pacolet sandy loam, 15-25% slopes
PcB2, PcC2	Pacolet sandy clay loam, 2-15% slopes, eroded
RnD, RnE	Rion fine sandy loam, 15-60% slopes
StB	State fine sandy loam, 1-6% slopes, rarely flooded
ToA	Toccoa sandy loam, 0-3% slopes, occasionally flooded
w	Water

0 1,250 2,500 5,000 Feet

Source: Surry County Soil Conservation Service, Soil Survey Field Sheet F-6, 1988.

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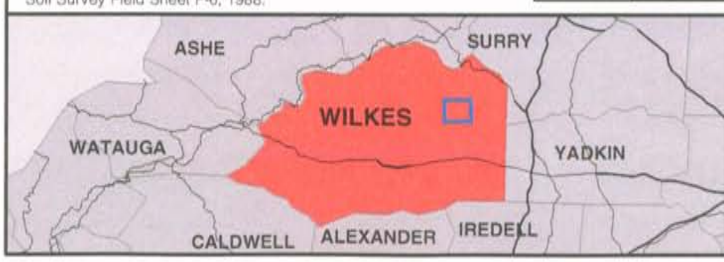

FIGURE 7
Soils

Little Bugaboo Creek Restoration Plan
Wilkes County, North Carolina

2.2.4 Terrestrial Plant Communities

The following sections describe the existing plant communities on and adjacent to the restoration site (Figure 8). For purposes of this project, five plant communities are described: Pasture Community, Floodplain Community, Dry Upland Forest Community, Mesic Upland Forest Community, and Wetland Community. Nomenclature follows Radford, et al. (1968). Cattle either currently have access to all areas within the project boundaries, or have had access to these areas in the recent past. For this reason, herbaceous vegetation and an underlying shrub layer are sparse throughout the majority of the project area.

2.2.4.1 Pasture Community

A community consisting of grazed pastureland is generally present in the floodplain of LBC and the UT throughout the project area. The only exceptions to this are a small area near the confluence of these streams, as well as a few patchy areas along the upper sections of LBC, and along the east side of the UT. A plowed area near the confluence of LBC and it's UT has is included in this community. The herbaceous vegetation that dominates this community are fescue grasses (*Festuca* sp.), white clover (*Trifolium repens*), and other unidentifiable weeds which are most likely to be *Veronica* sp., *Glechoma* sp., or *Lamium* sp.

Along the periphery of this community, many invasive species common to pastures and waste places can be found. These include jimsonweed (*Datura stamonium*), common mullein (*Verbascum thapsis*), multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), greenbriar (*Smilax* sp.), poison ivy (*Toxicodendron radicans*), blackberry (*Rubus* sp.), and Chinese privet (*Ligustrum sinense*).

2.2.4.2 Floodplain Community

A floodplain forest community is present throughout the majority of the project area. As mentioned earlier, cattle are allowed to graze nearly the entire stream length. For this reason, some areas of mature trees remain on the banks, while little other vegetation is present. An understory with varying degrees of density is associated with this community, depending on the degree of grazing. Dominant tree species in this community include river birch (*Betula nigra*), American sycamore (*Platanus occidentalis*), red maple (Acer rubrum*)*, tulip poplar (*Liriodendron tulipifera*), box elder (*Acer negundo*), and black willow (*Salix nigra*). Understory and edge species include Chinese privet, multiflora rose, greenbriar, and Japanese honeysuckle.

In the area near the confluence of the two streams black walnut (*Juglans nigra*), flowering dogwood (*Cornus florida*), sweet joe-pye weed (*Eupatorium pupureum*), and New York ironweed (*Veronia noveboracensis*) are common. Japanese grass (*Microstegium virmenium*) can also be found growing in dense patches in this area.

On the alluvial bars adjacent to the streams the vegetation is sparse, and is dominated by various unknown grasses and *Aster* species, with a few patches of rush (*Juncus effusus*). The only substantially dense stand of seedlings on the alluvial deposits is located near the cattle crossing on the upper reach of LBC and includes river birch, black willow, and American sycamore.

2.2.4.3 Dry Upland Forest Community

A dry upland forest community is present on the south-facing slopes within the project area. This is a mature forest with trees reaching 70 feet in height. The understory is relatively open except where this community adjoins the disturbed areas. Both upland forest communities described in this report contain many similar species. These include black cherry (*Prunus serotina*), scarlet oak (*Quercus coccinea*), shortleaf pine (*Pinus echinata*), white pine (*Pinus strobus*), American holly (*Ilex opaca*), yellow jasmine (*Gelsemium sempervirens*), Christmas fern (*Polystichum acrostichoides*), and wild garlic (*Allium canadense*). On the driest slopes, this upland community also includes white oak (*Quercus alba*), Southern red oak (*Quercus falcata*), American beech (*Fagus grandifolia*), chestnut oak (*Quercus montana*), post oak (*Quercus stellata*), red cedar (*Juniperus virginiana*), and mockernut hickory (*Carya tomentosa*).

2.2.4.4 Mesic Upland Forest Community

A moist upland forest community can be found on the north-facing slopes within the project area. This is also a mature community with trees reaching 70 feet in height. The understory is relatively open except where this community adjoins the disturbed areas. This community contains many of the same species found in the dry upland forest community, as mentioned earlier. Other dominant species include red maple, tulip poplar, and mountain magnolia (*Magnolia frasieri*). The understory in this forest is typically composed of Catawba rhododendron (*Rhododendron catawbiense*), mountain laurel (*Kalmia latifolia*), and violet (*Viola* sp.).

2.2.4.5 Wetland Community

Two small wetlands are located in the pasture near stations 29+00 and 34+00. Each wetland is located at the toe of a large hill slope and is fed partly or entirely by spring seeps. Two pipes that apparently drain an underground spring feed the largest wetland community. This wetland is triangular in shape and approximately 0.3 acres in size. It is bounded by a dirt road on the south side and pasture on the other two sides. The water has been channelized on the northern side and flows to its confluence with LBC near station 29+00.

Another wetland is found just to the east of the wetland described above. This wetland is 1/3 to ¼ the size of the larger wetland. A very large pile of limbs and stumps conceals a spring that feeds this wetland. Only a few scattered trees remain here, and the standing water in the wetland and associated channel is stagnant, with heavy algae growth. A ditch drains this wetland also, and enters LBC near station 34.

Cattle have access to both of these wetlands and have severely impaired the growth of new vegetation. Woody vegetation is sparse and very little herbaceous cover can be found. The dominant tree species include tag alder (*Alnus serrulata*), red maple, flowering dogwood and American holly. Multiflora rose, greenbriar, and Japanese honeysuckle also proliferate. Fescue is the primary herbaceous species. The soils of these wetlands are hydric, but have indiscernible layers due to cattle trampling the soil.

2.2.5 Wildlife Observations

Wildlife and signs of wildlife were noted during on-site visits, however, a formal wildlife survey was not performed. Tracks of white tailed deer (*Odocoileus virginianus*) and raccoon (*Procyon lotor*) were observed along the stream banks, and in the adjacent pastures. A muskrat (*Ondatra* zibethicus) was also observed near the stream. A variety of birds were seen in the thickets, shrubs, and forests surrounding the stream channel including: blue jay (*Cyanocitta cristata*), eastern bluebird (*Sialia* sialis), American goldfinch (*Carduelis* tristis), tufted titmouse (*Parus bicolor*), American crow (*Corvus* brachyrhynchos), Carolina wren (*Thryothorus ludovicianus*), Carolina chickadee (*Parus* caolinensis), white-breasted nuthatch (*Sitta* carolinensis), downy woodpecker (*Picoides pubescens*), mourning dove (*Zenaida* macroura), red-tailed hawk (*Buteo* jamaicencis), turkey vulture (*Cathartes aura*) eastern phoebe (*Sayornis phoebe*), American robin (*Turdus migratorius*), European starling (*Sturnus* vulgaris), and song sparrow (*elospiza melodia*). Small fish were seen in LBC near the wetland communities.

The USFWS lists 1 species under federal protection and four species of federal concern for Wilkes County as of February 2002 (USFWS 2001). These species are listed in Table 1. The NC Natural Heritage Program lists the regal fritillary as a Federal Species of Concern in Wilkes County, however it does not appear on the USFWS list for this county. This is most likely because the NC NHP files were updated more recently than the USFWS files. For this reason, the regal fritillary is included in this report.

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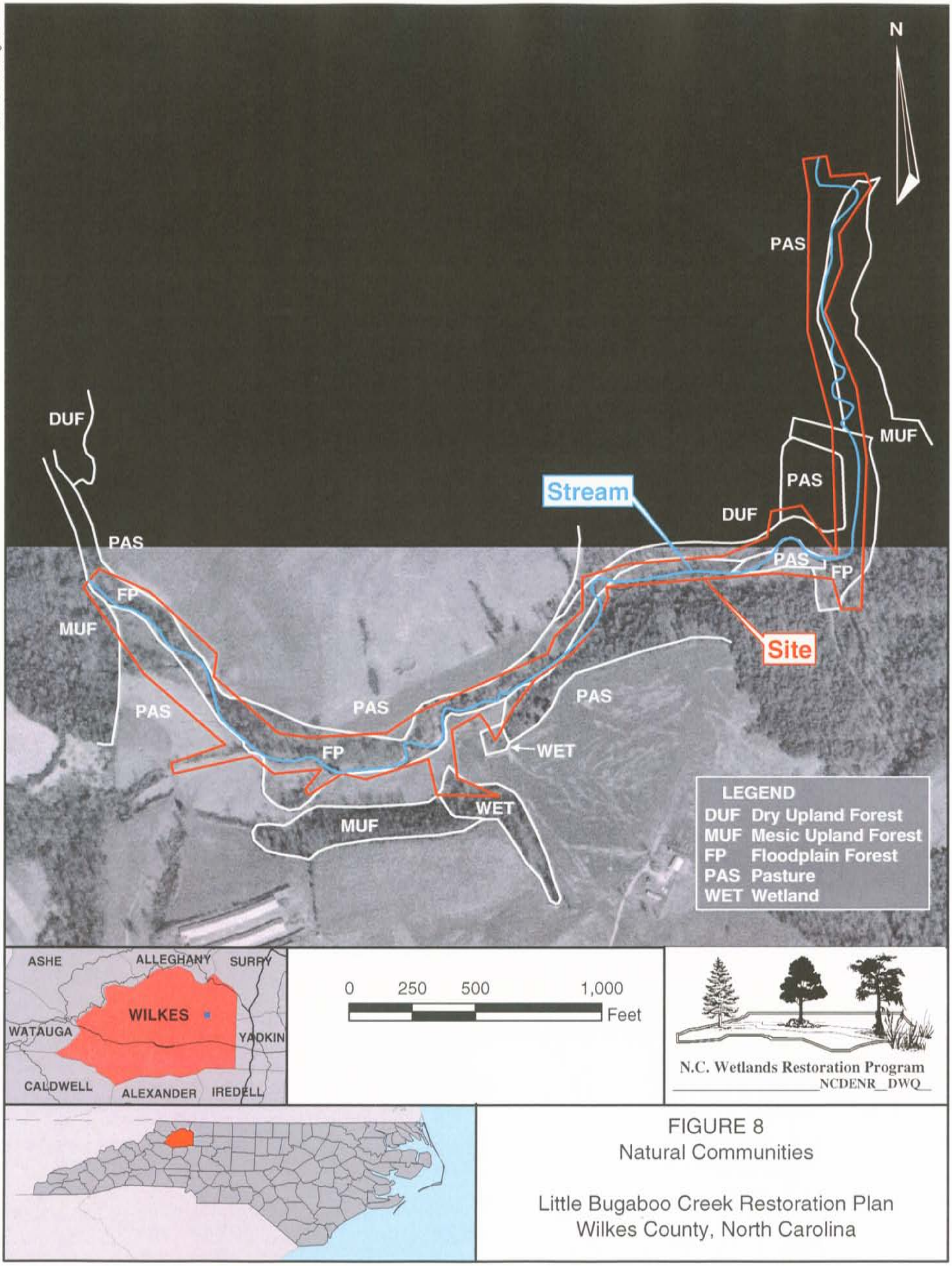

FIGURE 8
Natural Communities

Little Bugaboo Creek Restoration Plan
Wilkes County, North Carolina

Table 1. Species Under Federal Protection in Wilkes County

Scientific Name	Common Name	Federal Status
Vertebrates		
Cerulean Warbler	*Dendroica cerulea*	FSC
Bog turtle	*Clemmys muhlenbergii*	T(S/A)
Invertebrates		
Diana Fritillary	Speyeria Diana	FSC
Regal Fritillary	Speyeria idalia	FSC
Moss		
Keever's Bristle-moss	*Orthotrichum keeverae*	FSC

Notes:
E Endangered-A species that is threatened with extinction throughout all or a significant portion of its range.
T Threatened-A species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
T(S/A) Threatened due to similarity of appearance.
FSC Federal species of concern.

No Threatened, Endangered or Species of Federal Concern were observed during the site visit, and none are recorded at NC National Heritage Program as occurring within 2 miles (3.2 km) of the project area. Furthermore, no suitable habitat for any of these federally listed species was observed during the site visit.

3.0 REFERENCE REACHES

3.1 BIG BRANCH

Big Branch, a second order stream, is located 1.5 miles south of Blevins Store in Surry County, North Carolina (Figure 9). Big Branch flows into the Fisher River approximately 1000 feet downstream of the reach surveyed. The stream has a drainage area of 1216 acres or 1.9 square miles. The watershed is mildly sloped (2.3 percent) with forested and agricultural areas throughout. The area surrounding the creek is forested and hilly on the south side. The north side has a thin row of trees along a road embankment. The vegetation is similar to that of the project site with dense shrub and deciduous vegetation lining its banks and adjacent floodplain. The floodplain area upstream of this reach is used for cattle grazing. The riparian area is fenced out so the cattle do not have access to the stream.

A complete biological assessment of the stream was conducted on August 16, 1999. A total of 204 benthic macroinvertebrates making up 38 taxa were found in Big Branch. Seventeen of these taxa were EPT taxa. According to this biological assessment, this stream appears to be in excellent condition. The NC biotic index value was 3.26 and the percentage of chironomids were low (6 percent).

The stream was surveyed on August 12, 1999. Channel dimension, pattern, and profile were measured for 330 linear feet of stream. The end point of the survey is located approximately 80 feet upstream of the Red Hill Creek Road bridge. The stream had a bankfull channel width of 21.5 feet and a bankfull mean depth of 2.0 feet. Big Branch is an E4 stream type from Rosgen Classification system. Longitudinal profile, cross-sections, and the pebble count for this reference reach is located in Appendix C.

3.2 BASIN CREEK

Basin Creek, a fourth order stream, is located entirely within Doughton Recreational Area in Allegheny and Wilkes Counties (Figure 10). The reach surveyed is located approximately 4000 feet up Grassy Gap Road within the park boundaries and below the junction of West Branch Basin Creek and Cove Creek. The drainage area for the reach surveyed is 4607 acres or 7.2 square miles. The watershed is steeply sloped (10.3 percent) with a heavily forested stable landuse. The entire watershed is located within State Park boundaries. Dense shrub and deciduous vegetation line the banks and adjacent hillslopes. The surveyed reach is located immediately downstream from the confluence of two colluvial B type streams.

A survey crew from Natural Resources Conservation Service and Surry County Soil and Water Conservation Service surveyed the stream on October 28, 1998. Channel dimension, pattern, and profile were measured for 953 linear feet of stream. The stream had a bankfull channel width of 33.2 feet and a bankfull mean depth of 2.1 feet. Basin creek is a C4 stream type. A biological assessment was not conducted on this stream.

Longitudinal profile, cross-sections, and the pebble count for this reference reach is located in Appendix D.

4.0 STREAM CHANNEL DESIGN

This restoration will classify as a Priority 2 restoration (Rosgen, 1997). The floodplain will be re-established to fit the existing stream profile. Table 2 describes and summarizes the four priorities of incised river restoration (Rosgen, 1997). The proposed stream restoration will restore a stable meander pattern, modify channel cross-section, restore bedform, improve sediment transport capacity, enhance habitat, and re-establish a floodplain for the stream.
The design was based upon Dave Rosgen's natural channel design methodology. As described in Section 4.0, Big Branch and Basin Creek were utilized as reference reaches on which the morphological characteristics were measured to determine a range of values for the stable dimension, pattern, and profile of the proposed channel. The existing and proposed morphological characteristics are shown in Table 3.

Ten tributaries/drainages enter LBC or the UT within the project limits. All will be stabilized or restored within the easement limits of the project. The two main perennial tributaries will be restored to a stable dimension, pattern, and profile. All of these tributaries/drainages have been previously straightened by landowners to improve drainage. Design parameters will based upon reference data from Big Branch.

A conceptual design was developed from the range of values listed in Table 3. This stream restoration project will restore approximately 4,500 linear feet of LBC and 1,900 linear feet of the UT. The plan view of the proposed restoration design can be seen in Figure 11 (a through e).

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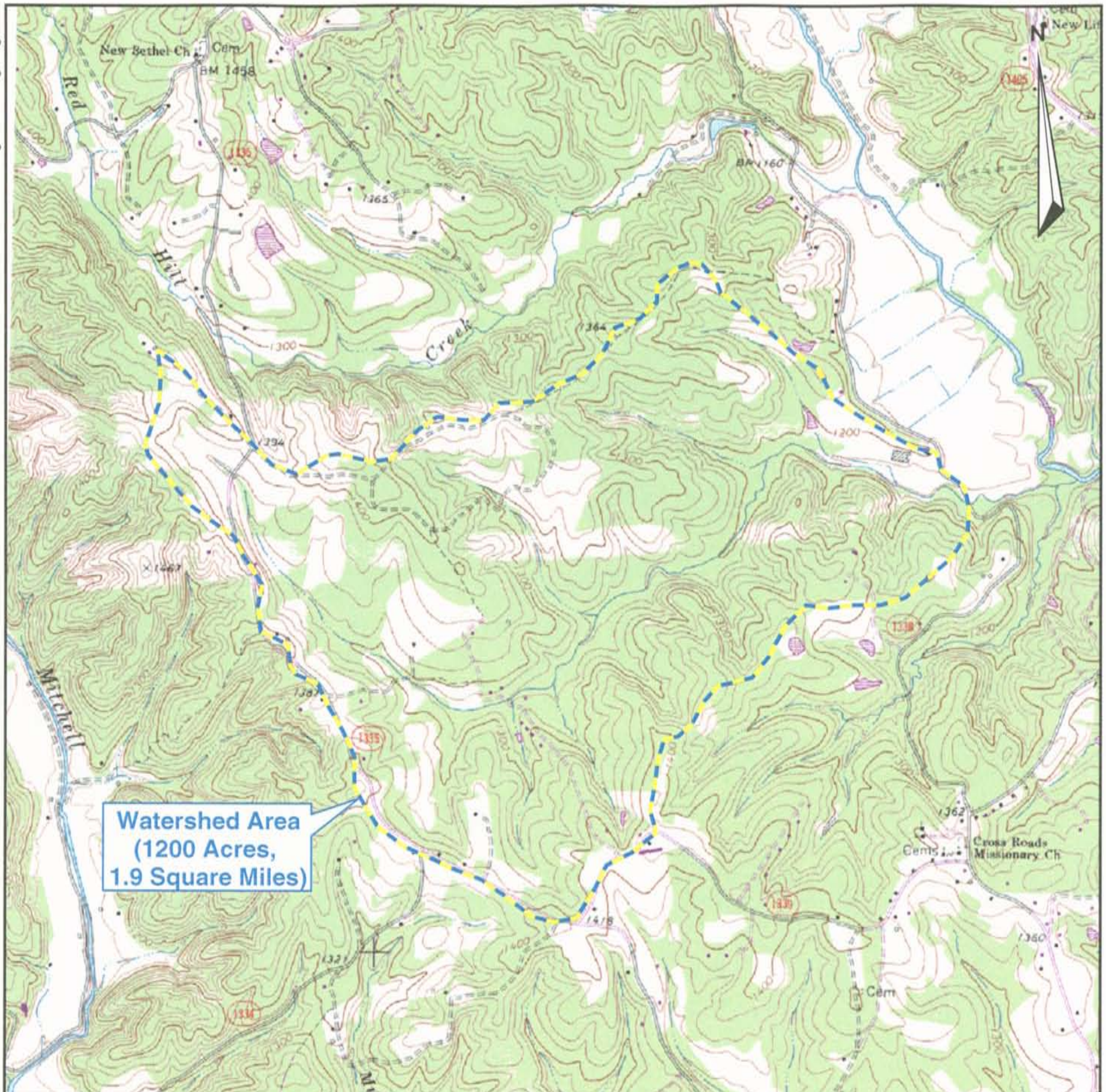

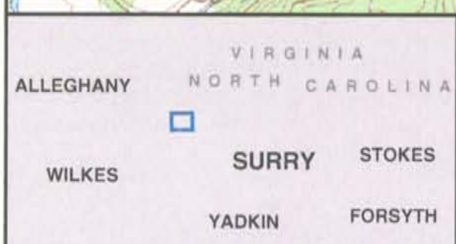

0 1,000 2,000 4,000
Feet

Source: USGS Quadrangles:
Bottom, NC, 1971.
"Maptech® U.S. Terrain Series,
©Maptech®, Inc. 603-433-8500"

N.C. Wetlands Restoration Program
NCDENR DWQ

FIGURE 9
Big Branch Watershed
Reference Reach
Little Bugaboo Creek Restoration Plan
Wilkes County, North Carolina

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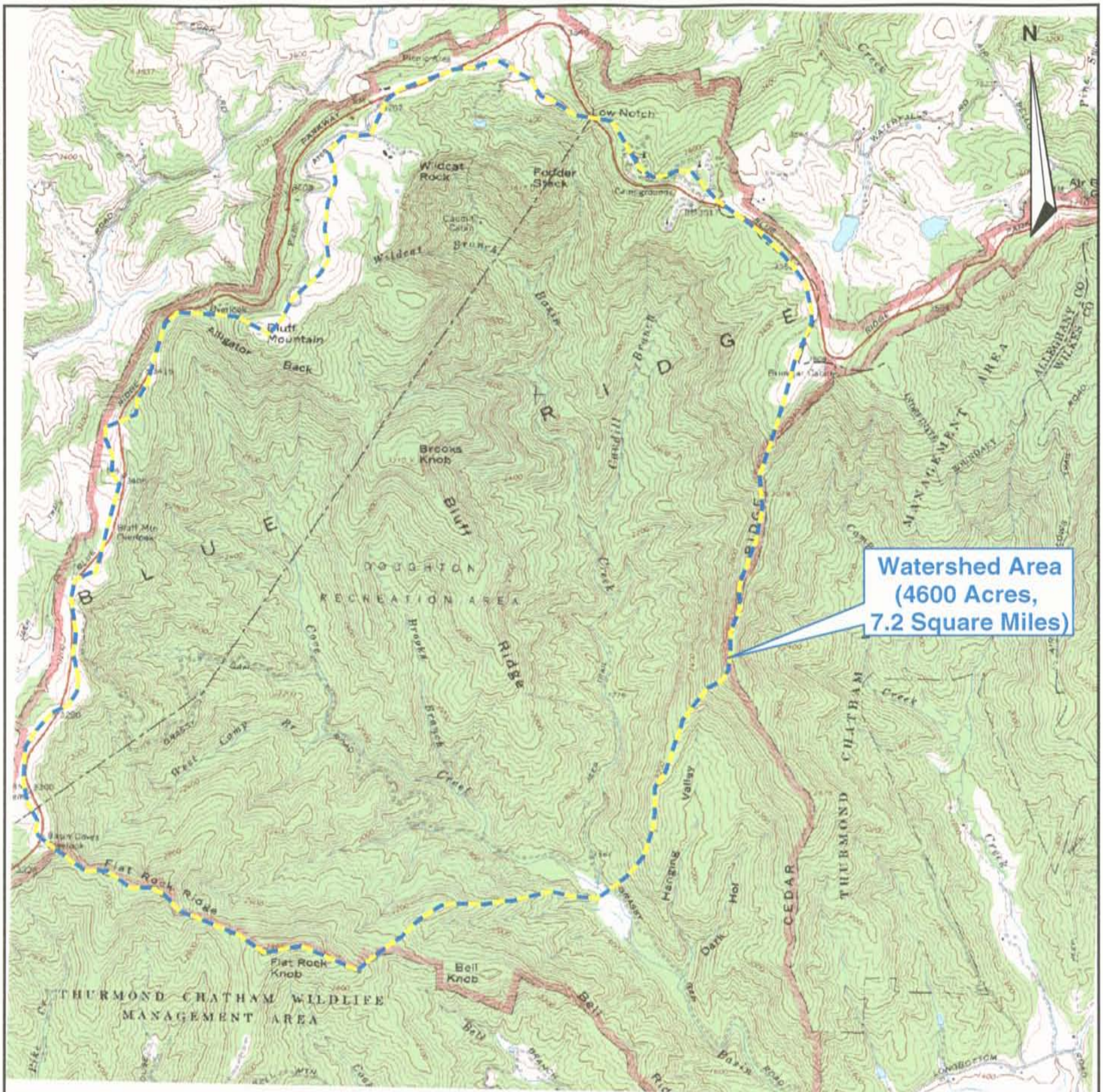
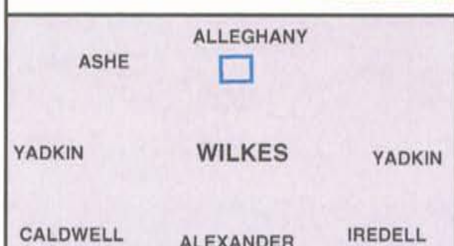




0 1,500 3,000 6,000
Feet

Source: USGS Quadrangles:
Whitehead, NC, 1968.
"Maptech® U.S. Terrain Series,
©Maptech®, Inc. 603-433-8500"

N.C. Wetlands Restoration Program
NCDENR DWQ

FIGURE 10
Basin Creek Watershed, Wilkes County
Reference Reach
Little Bugaboo Creek Restoration Plan
Wilkes County, North Carolina

Table 2. Priorities, Description and Summary for Incised River Restoration

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

Source: Rosgen, 1997, "A Geomorphological Approach to Restoration of Incised Rivers"

Table 3. Little Bugaboo Creek Morphology (Existing, Proposed, and Reference)

Variables	Existing Main Channel	Existing Tributary Channel	Reference Reach - Big Branch	Reference Reach-Basin Creek	Proposed Main Channel	Proposed Tributary Channel
Stream Type (Rosgen)	Bc, C, E, and F	C and F	E4	C4	**E**	**C**
Drainage Area (sq. mi.)	3.45	1.4	1.9	7.2	**3.45**	**1.4**
Bankfull Width (W_{bkf}, ft)	26.0 - 35.5	17.5 - 18.0	20.0 - 21.5	29.5 - 36.9	**25.7**	**18**
MEAN	30.5	17.8	20.8	33.2		
Bankfull Mean Depth (d_{bkf}, ft)	1.9 - 2.9	1.2	2.0	1.9 - 2.2	**2.34**	**1.5**
MEAN	2.3	1.2	2.0	2.1		
Width/depth Ratio (W_{bkf}/d_{bkf})	8.8 - 17.4	14.4 - 14.8	9.8 - 10.8	13.4 - 19.4	**11**	**12**
MEAN	13.7	14.6	10.3	16.4		
Bankfull Cross-sectional Area (A_{bkf} sq. ft.)	54.0 - 87.7	21.2 - 21.9	40.9 - 42.8	64.9 - 71.9	**60.0**	**27.0**
MEAN	69.7	21.6	41.9	68.4		
Bankfull Maximum Depth (d_{max} ft)	2.7 - 4.1	2.2 - 2.3	2.5 - 2.7	3.0 - 3.2	**3.5**	**2.1**
MEAN	3.5	2.3	2.6	3.1		
Ratio Bankfull Maximum Depth to Mean Bankfull Depth (d_{max}/d_{bkf})	1.5	1.9	1.4 - 1.3	1.5	**1.5**	**1.4**
Lowest Bank Height to Bankfull Maximum Depth Ratio	1.9 - 2.9	3.3 - 4.5	1.0	1.0	**1.0**	**1.0**
MEAN	2.3	3.9	-	-		
Width of Flood Prone Area (W_{fpa} ft)	90	38	130	329	**255**	**170**
Entrenchment Ratio (W_{fpa}/W_{bkf})	2.7	1.8 - 2.5	65	8.9	**9.9**	**9.4**
Meander Length (L_m ft)	133 - 590	87 - 355	185 - 260	350	**196 - 366**	**129 - 224**
MEAN	278	193	222	350	**269**	**163**
Ratio of Meander Length to Bankfull Width (Lm/Wbkf)	4.4 - 19.3	4.9 - 19.9	8.9 - 12.6	10.5	**6.5 - 12.2**	**8 - 12**
MEAN	9.1	10.9	10.7	10.5	**9.0**	**10**
Radius of Curvature (R_c ft)	62 - 234	27 - 98	42 - 63	40.1 - 69.3	**60 - 90**	**35 - 70**
MEAN	113	52	55	51.2	**74**	**47**
Ratio of Radius of Curvature to Bankfull Width (Rc/Wbkf)	2.0 - 7.7	1.5 - 5.5	2.0 - 3.0	1.2 - 2.1	**2.0 - 3.0**	**1.8 - 3.7**
MEAN	3.7	2.9	2.6	1.5	**2.5**	**2.5**
Belt Width (W_{blt} ft)	36 - 140	26 - 74	31 - 44	59 - 75		
MEAN	73	45	37	64.7		
Meander Width Ratio (W_{blt}/W_{bkf})	1.2 - 4.6	1.5 - 4.2	1.5 - 2.1	1.7 - 2.3	1.1 - 6.0	1.5 - 8.3
MEAN	2.4	2.5	1.8	1.9	3.4	3.6
Sinuosity (Stream Length/Valley Length, k - ft/ft)	1.3	1.2	1.1	-	**1.2**	**1.3**
Valley Slope (S_{valley}) ft/ft	0.0061	0.013	0.009	-	**0.0062**	**0.013**
Average Water Surface Slope (S_{avg})	0.0049	0.011	0.0087	0.0144	**0.0054**	**0.010**
Pool Slope (S_{pool})**	0.0002 - 0.0017	0.00057	0 - 0.0004	0.0 - 0.005		
MEAN	0.0008	0.00057	0.0001	0.006473		
Ratio of Pool Slope to Average Slope (S_{pool}/S_{avg})	0.16	0.044	0.011	0.45	**0.20**	**0.20**
Riffle Slope (S_{riff} ft/ft)*	0.0005 - 0.0087	0.0096 - 0.032	0.015 - 0.019	0.018 - 0.02		
MEAN	0.0057	0.021	0.017	0.02082	**0.009**	**2.010**
Ratio of Riffle Slope to Average Slope (S_{riff}/S_{avg})	0.10 - 1.78	0.87 - 2.91	1.95	1.44		**2.0**
MEAN	1.16	1.91	1.95	1.39	**1.7**	**1.7**
Maximum Pool Depth (d_{pool} ft)	3.4 - 3.8	2.3	3.5 - 4.0	4.1 - 5.2	**5.2**	**3.3**
MEAN	3.6	2.3	3.8	4.8		
Ratio of pool depth to mean bankfull depth (d_{pool}/d_{bkf})	1.6	1.9	1.9	2.3	**2.2**	**2.2**
Pool Width (W_{pool} ft)	34.2 - 74.5	34.2	17.8 - 19.0	35 - 68	**31.0**	**21.6**
MEAN	52.6	34.2	18.4	50.3		
Ratio of Pool Width to Bankfull Width (W_{pool}/W_{bkf})	1.1 - 2.4	1.9	0.9	1.5	**1.2**	**1.2**
MEAN	1.7	1.9	-	-		
Pool to Pool Spacing (P-P ft)	57 - 287	33 - 176	98 - 180	271 - 334	106 - 217	64 - 166
MEAN	145	99	139	305	160	100
Ratio of P-P to Bankfull Width (P-P/W_{bkf})	1.9 - 9.4	1.9 - 9.9	4.7 - 8.7	8.2 - 10.1	3.8 - 7.8	3.4 - 8.7
MEAN	4.7	5.6	6.7	9.2	5.7	5.3

*The avg. water surface slope neglects the final 200 feet of stream where grade will be lowered to tie into Fisher River.
**Existing Riffle and Pool slopes were not measured.
***The Max. Riffle Slope do not include grade changes produced by cross-vanes.

4.1 RESTORATION TECHNIQUES

Stream dimension, pattern, and profile will be adjusted so the new stream channel can maintain stability while transporting its water and sediment load. The Priority 2 restoration (see Table 2) will involve modifying the existing channel at its existing elevation to create a stable channel (Figure 11 (a through e)).

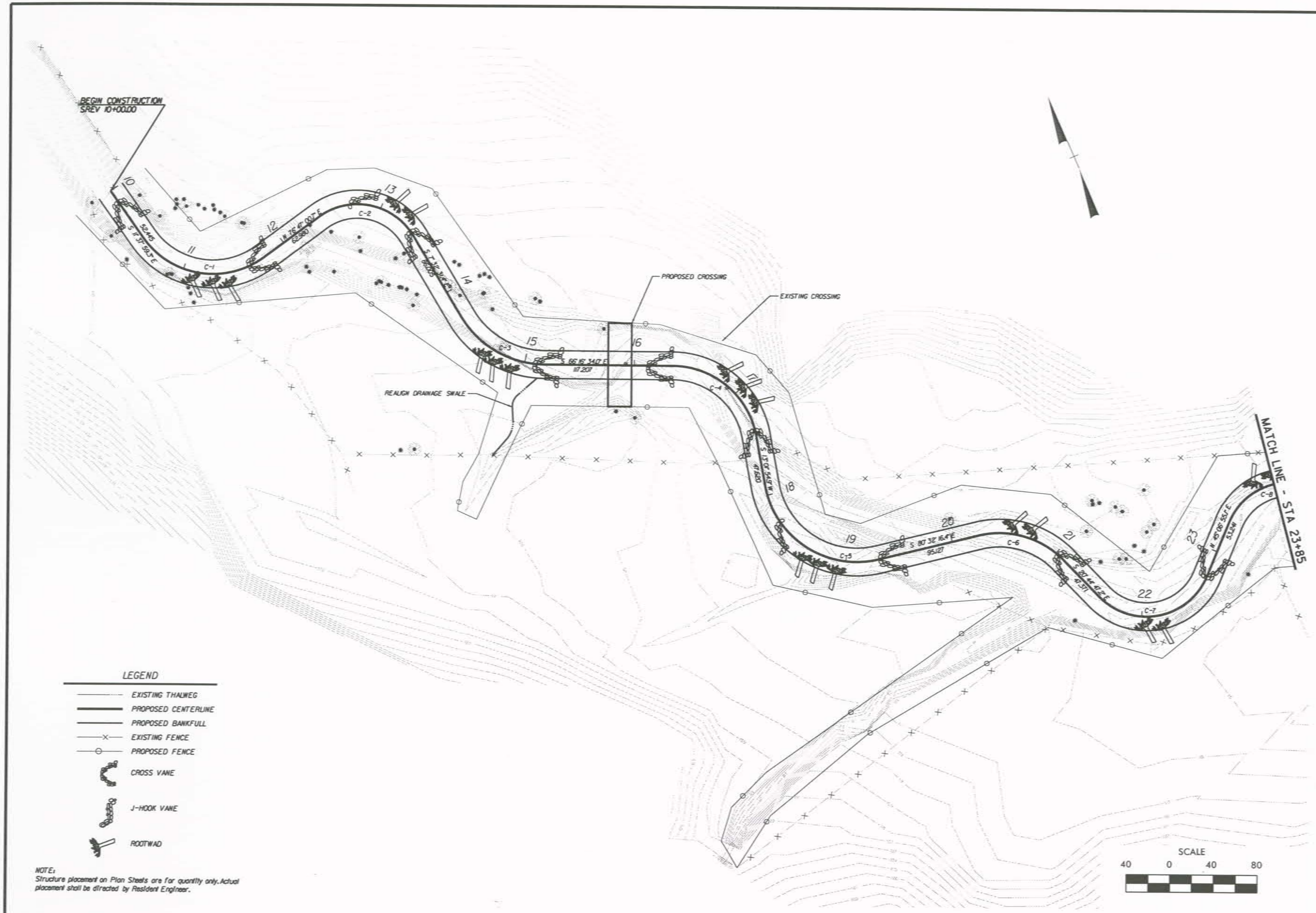
Vegetation will be utilized to provide stability and provide habitat along the stream banks and in the riparian area. The permanent conservation easement will be fenced to restrict cattle access to this area. Stable cattle and farm equipment crossings will be established to provide landowners with access to both sides of the stream while keeping cattle outside the riparian zone. Local NRCS staff will work with landowners to install watering systems for cattle. The greatest advantage of this Priority 2 restoration will be to create a floodplain that the active channel can actively access. Other advantages of a Priority 2 restoration include improving aesthetics, improving habitat, reduction of bank height and streambank erosion, and lowering of the in-channel shear stress.

4.1.1 Dimension

The present bankfull channel width for LBC ranges from 26.0 to 35.5 feet with a cross-sectional area ranging from 54.0 to 87.7 square feet and the present bankfull channel width for the UT ranges from 17.5 to 18.0 feet with a cross-sectional area ranging from 21.2 to 21.9 square feet. The design channel will be constructed to bankfull target dimensions that are based on a combination of reference reach surveys, HEC RAS modeling, and regional curve information. Typical cross-sections can be seen in Figure 12.

A design width of 25.7 feet for LBC and 18.0 feet for the UT will be applied to the proposed reach. This width was back-calculated from the cross-sectional area taken from the NC Piedmont Regional Curve and a width-to-depth ratio of 11.0 for LBC and 12 for the UT. Required mean depth of the channel was verified using critical dimensionless shear stress relationships to ensure there is enough design depth to transport the channel bedload without aggrading or degrading. These characteristics will provide a stream channel that classifies as an E-type channel for LBC and C-type channel for the UT according to the Rosgen classification system.

The existing channel, with bank height ratio's ranging from 1.9 to 4.5, will have benches cut at the bankfull elevation. This bankfull bench will establish a floodplain at the bankfull elevation of the existing channel. This bankfull bench will provide an accessible floodplain for the restored channel. The proposed channel will be able to access a floodplain and effectively transport the sediment load.



ISSUED FOR BIDS 03/11/2002

NO	REVISIONS	DRN	CHK	DATE

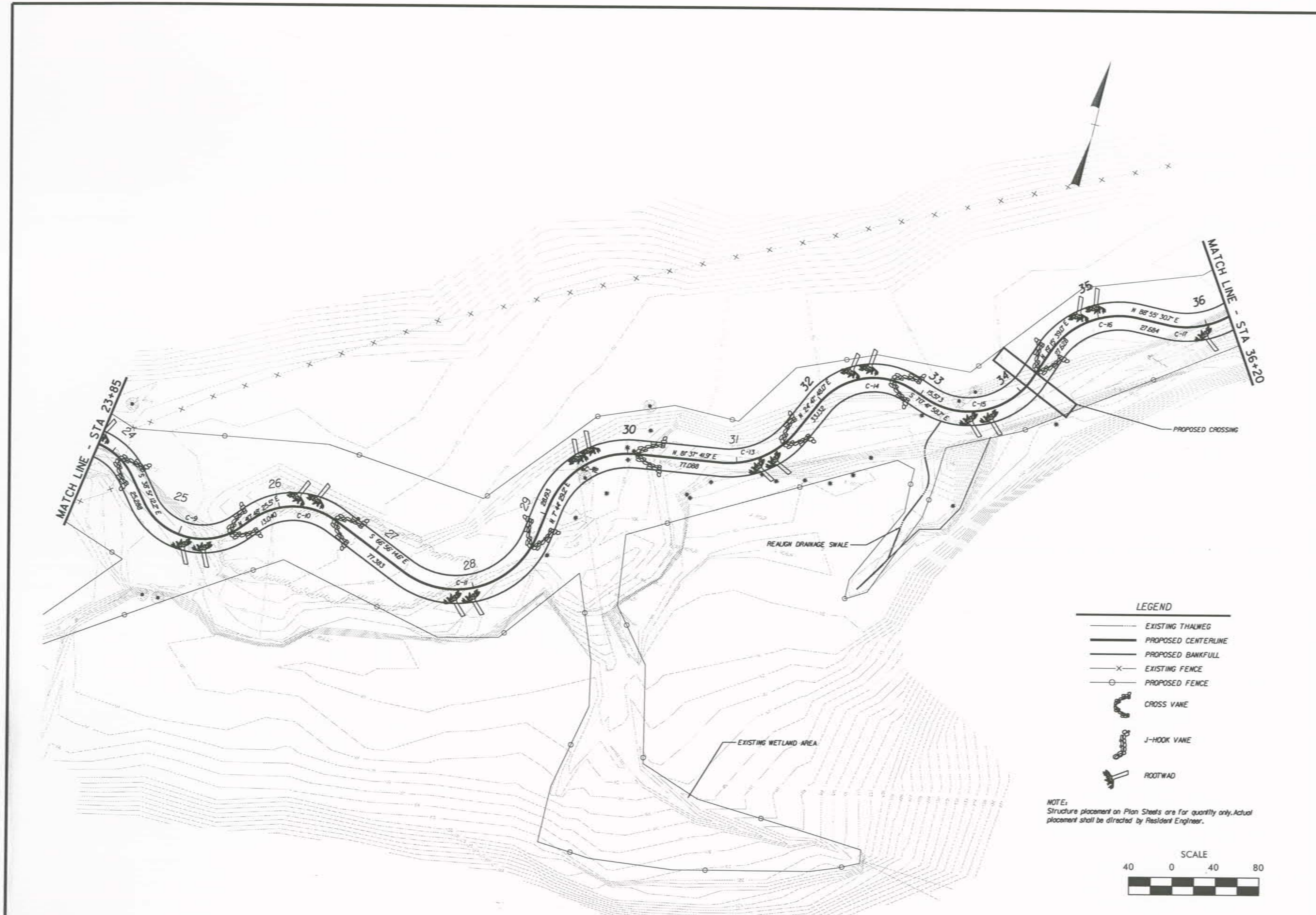
EARTHTECH

701 Corporate Center Drive, Suite 475 Raleigh, NC 27607
Phone (919) 854-6200 Fax (919) 854-6259

LITTLE BUGABOO CREEK STREAM RESTORATION
WILKES COUNTY
WETLANDS RESTORATION PROGRAM

FIGURE 11a

DATE	04/23/2002
PROJECT NO	53675
FILENAME	
SHEET NO	
DRAWING NO	



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NO REVISIONS DRN CHK DATE

EARTH TECH

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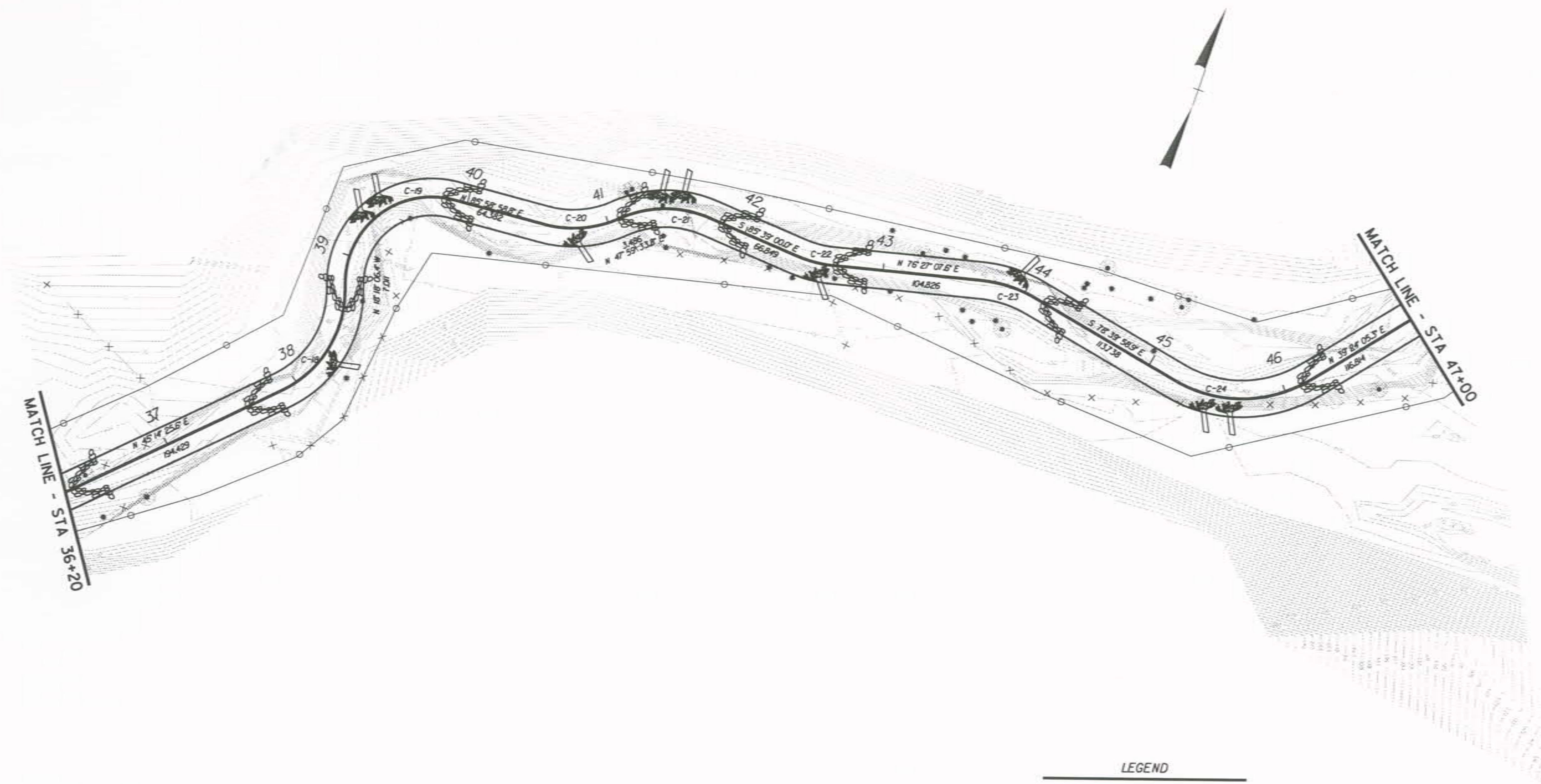
Phone (919) 854-6200 Fax (919) 854-6259

LITTLE BUGABOO CREEK STREAM RESTORATION
WILKES COUNTY
WETLANDS RESTORATION PROGRAM

FIGURE 11b

DATE 04/23/2002
PROJECT NO 53675
FILENAME
SHEET NO
DRAWING NO



LEGEND

EXISTING THALWEG
PROPOSED CENTERLINE
PROPOSED BANKFULL
EXISTING FENCE
PROPOSED FENCE
CROSS VANE
J-HOOK VANE
ROOTWAD

NOTE:
Structure placement on Plan Sheets are for quantity only. Actual placement shall be directed by Resident Engineer.

SCALE
40 0 40 80

NO	REVISIONS	DRN	CHK	DATE
	ISSUED FOR BIDS			03/11/2002

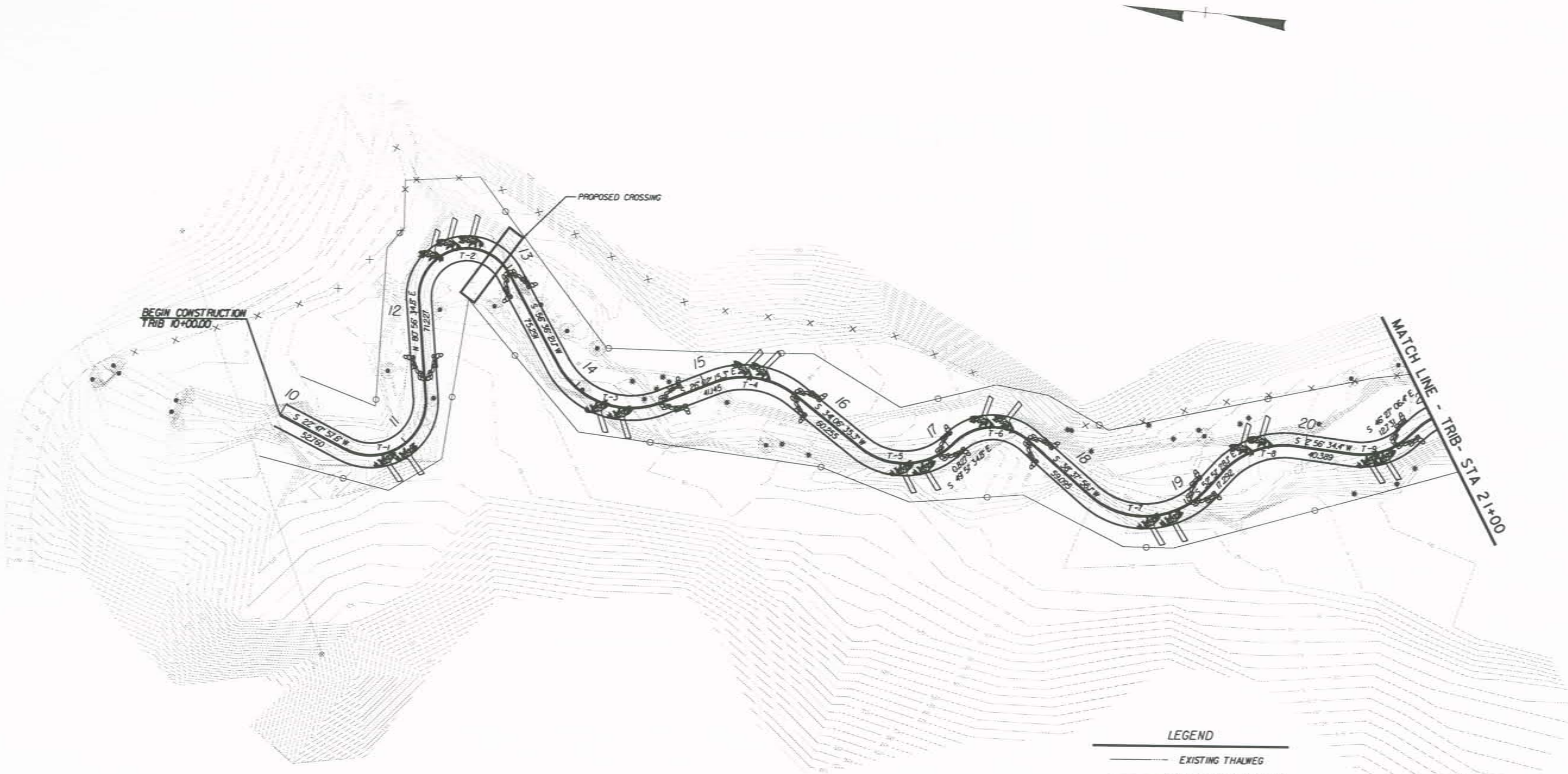
E A R T H T E C H

701 Corporate Center Drive, Suite #475 Raleigh, NC 27607
Phone (919) 854-6200 Fax (919) 854-6259

LITTLE BUGABOO CREEK STREAM RESTORATION
WILKES COUNTY
WETLANDS RESTORATION PROGRAM

FIGURE 11c

DATE	04/23/2002
PROJECT NO	53675
FILENAME	
SHEET NO	
DRAWING NO	



LEGEND

- EXISTING THALWEG
- PROPOSED CENTERLINE
- PROPOSED BANKFULL
- EXISTING FENCE
- PROPOSED FENCE
- CROSS VANE
- J-HOOK VANE
- ROOTWAD

NOTE:
Structure placement on Plan Sheets are for quantity only. Actual placement shall be directed by Resident Engineer.

SCALE
40 0 40 80

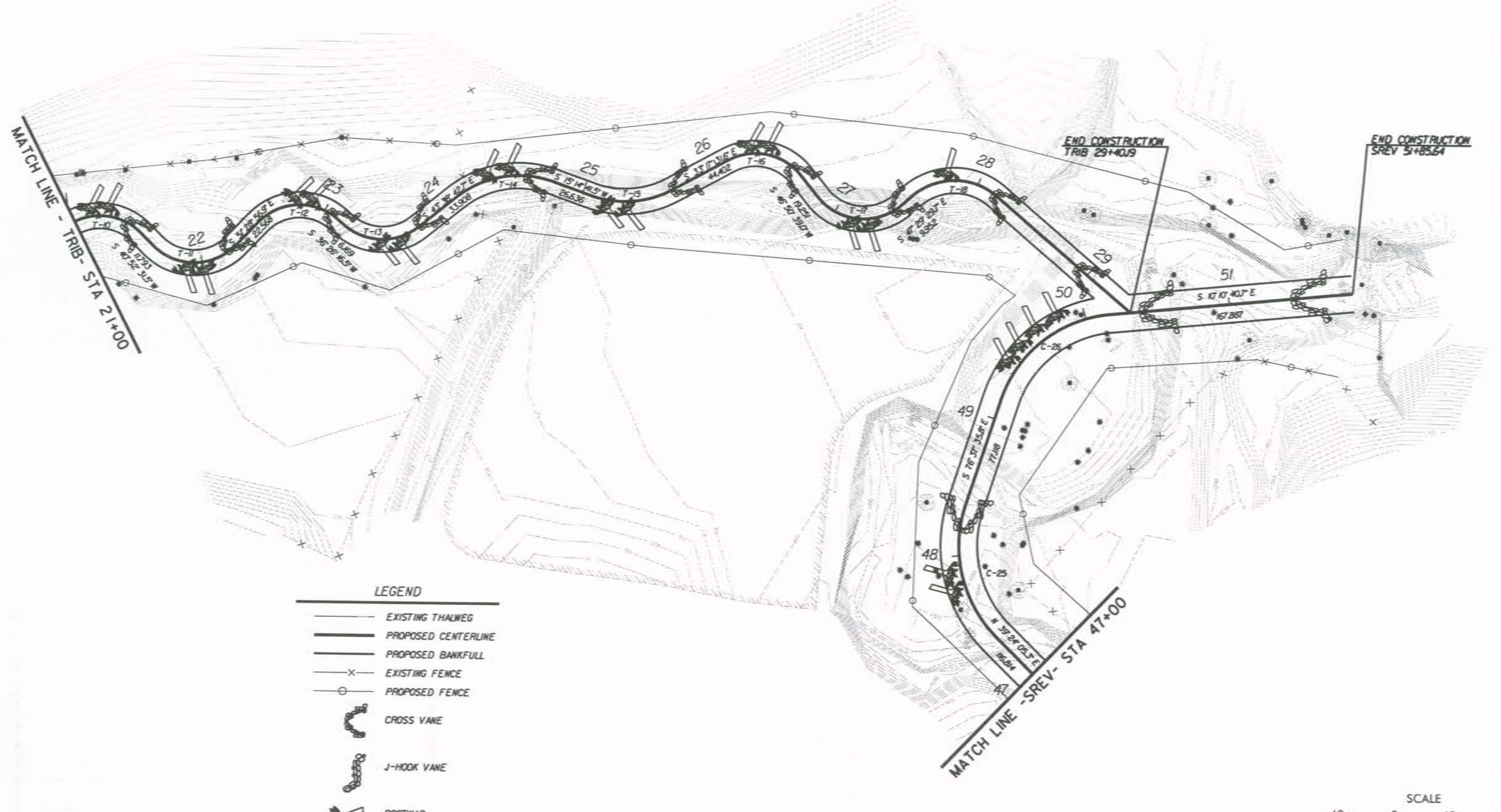
NO	REVISIONS	DRN	CHK	DATE
	ISSUED FOR BIDS			03/11/2002

EARTHTECH
701 Corporate Center Drive, Suite 475 Raleigh, NC 27607
Phone (919) 854-6200 Fax (919) 854-6259

LITTLE BUGABOO CREEK STREAM RESTORATION
WILKES COUNTY
WETLANDS RESTORATION PROGRAM

FIGURE 11d

DATE 04/23/2002
PROJECT NO 53675
FILENAME
SHEET NO
DRAWING NO



NOTE:
Structure placement on Plan Sheets are for quantity only. Actual placement shall be directed by Resident Engineer.

NO	REVISIONS	DRN	CHK	DATE
	ISSUED FOR BIDS			03/11/2002

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LITTLE BUGABOO CREEK STREAM RESTORATION
WILKES COUNTY
WETLANDS RESTORATION PROGRAM

FIGURE 11e

DATE 04/23/2002
PROJECT NO 53675
FILENAME
SHEET NO
DRAWING NO

4.1.2 Pattern

The existing pattern of LBC can be described as long straight reaches followed by severely tight meanders. The current sinuosity in LBC is 1.24 and in the UT is 1.18. Design sinuosity for LBC is 1.2 and for the UT is 1.3. Existing pattern measurements were taken from the topographic mapping are included in Table 3.

A stable pattern will be established by softening of tight meanders and establishing new meanders in long straight sections of the channel. This will be achieved by introducing meanders into the stream with appropriate radius of curvatures and lengths based on reference reach data and existing constraints. The maximum sinuosity has been designed into the new channel based on the reference data and project constraints. Introduction of these meanders will improve habitat while lowering slope and shear stress.

4.1.3 Bedform

The existing bedform along LBC and the UT is in poor condition. Long, straight sections of the channel consist of predominantly run bedform features. The design channel will incorporate riffles and pools to provide bedform common to E4/C4 stream types with gravel substrate (Figure 13). Pools will be located in the outside of meander bends with riffles in the inflection points between meanders. Riffles on LBC will have a thalweg depth of 3.5 feet while the pools will be deeper with a maximum depth of 5.2 feet. On the UT riffles will have a thalweg depth of 2.1 feet while the pools will be deeper with a maximum depth of 3.3 feet on UT. A graph of the proposed profile can be seen in Figure 14. The profile may be adjusted slightly during the final design phase of the project.

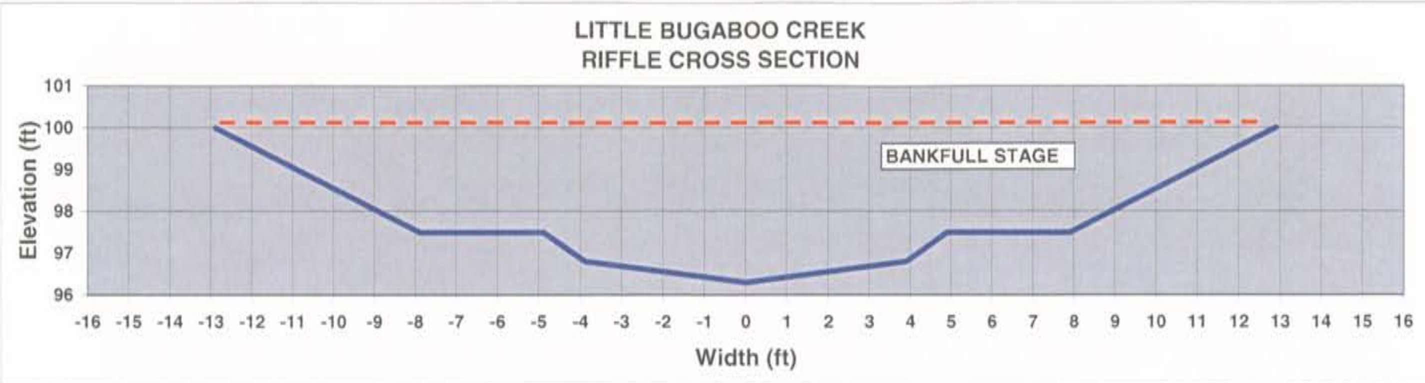
Cross-vanes will be utilized as grade control structures and to tie the relocated sections back into the existing channel. The cross vanes will be constructed out of natural materials such as boulders and wood. Existing bedrock outcroppings will also be incorporated into the proposed stream profile.

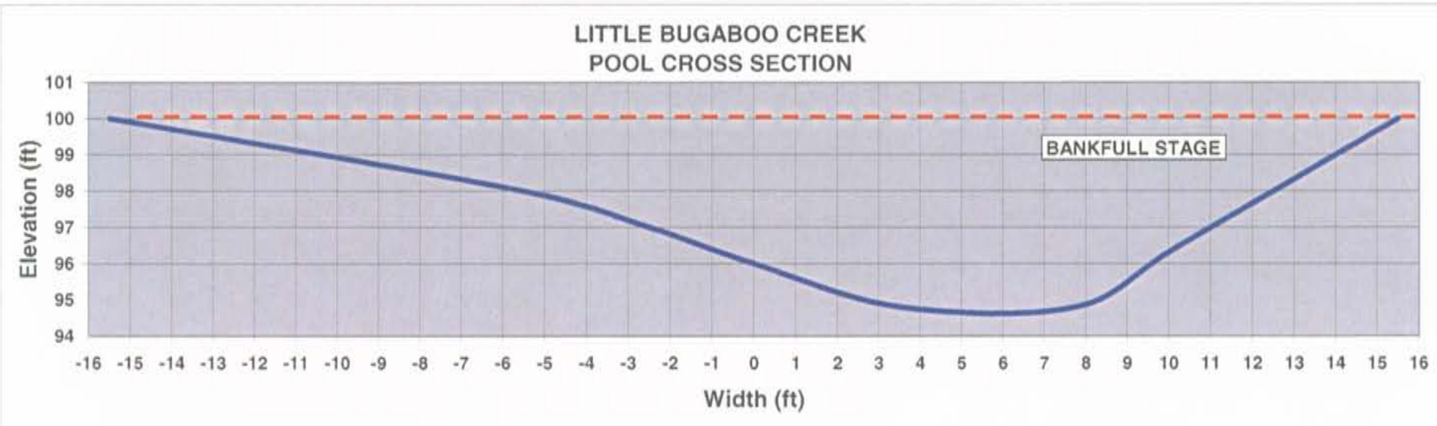
The existing pool-to-pool spacing is impaired in areas due to tight meander geometry. Existing pool-to-pool spacing on LBC is 57 to 287 feet and 33 to 176 on the UT. The proposed spacing is 106 to 217 feet for LBC and 64 to 166 feet on the UT, which is within the range of 3 and 12 bankfull widths as determined from the reference reach data. To accomplish this, pools will be realigned or constructed such that they will be located in the outside of the meander bends. Bedform will also be addressed through the strategic placement of natural material structures such as cross vanes, root wads, and large woody debris. Modifications to the bedform will provide stability and habitat to the channel.

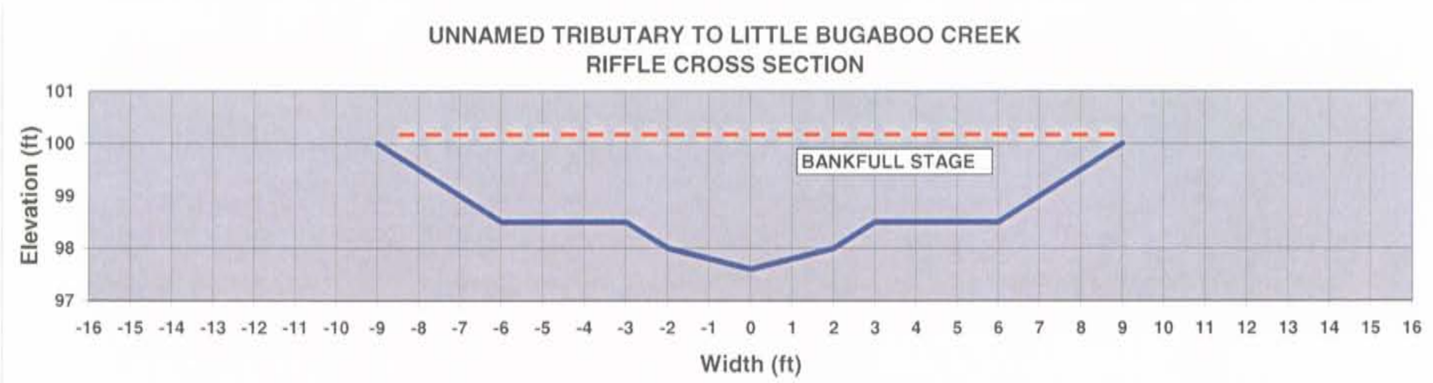
4.1.4 Wetland Area

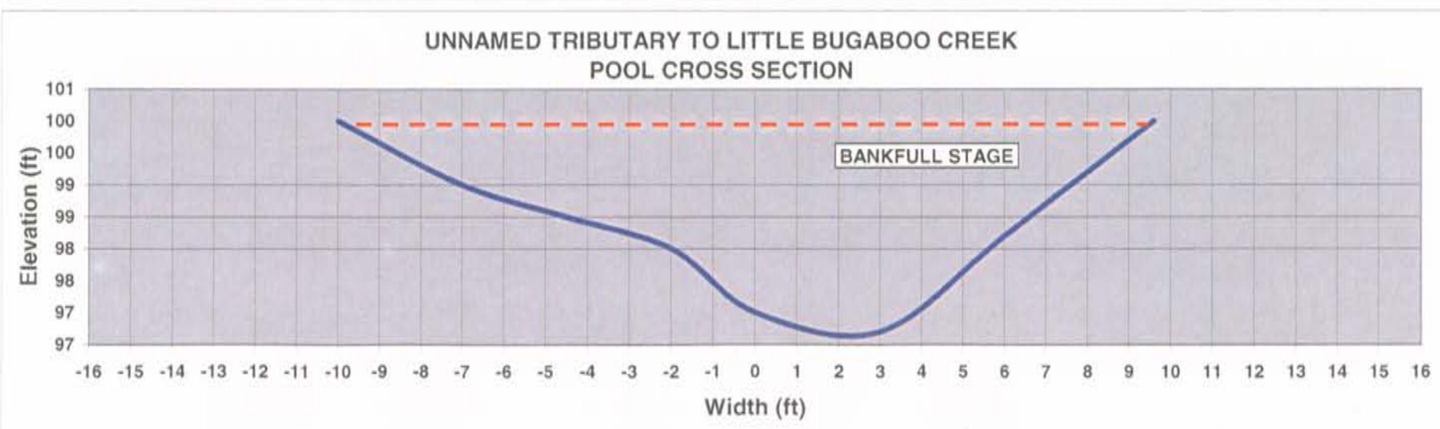
The wetland area near station 29+00 on LBC will be fenced, enhanced with native vegetation, and have earthen level spreaders constructed to help improve water quality on the site. A stable area will be constructed to provide a crossing for cattle and farm equipment. The earthen level spreaders will deter channeling of water through the wetland allowing sheet flow, and maximizing water quality improvement for the area.

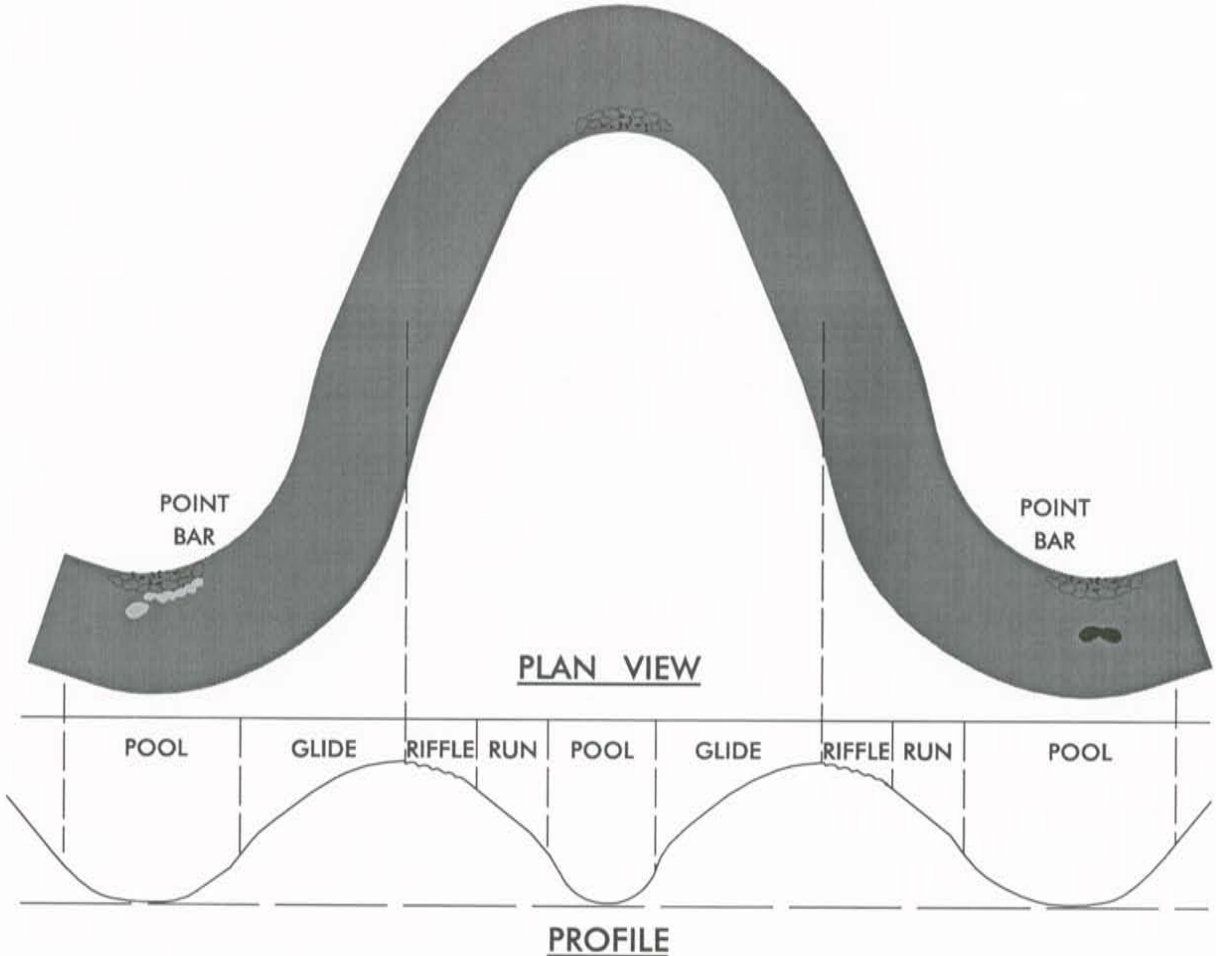
FIGURE 12
Typical Cross-Sections of New Channel











N.C. Wetlands Restoration Program
NCDENR DWQ

FIGURE 13
Bedform
Little Bugaboo Creek Restoration Plan
Wilkes County, North Carolina

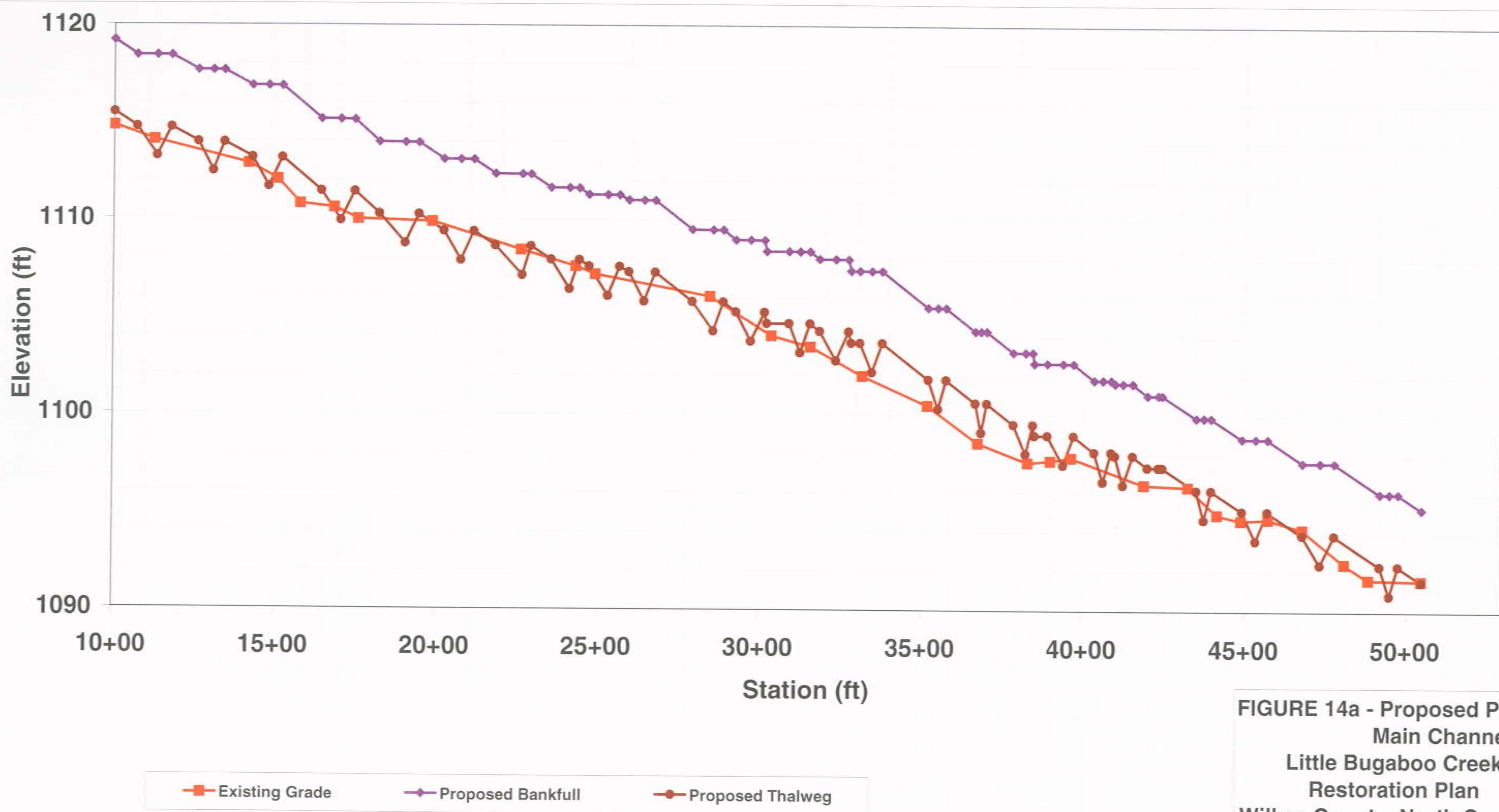


FIGURE 14a - Proposed Profile
Main Channel
Little Bugaboo Creek
Restoration Plan
Wilkes County, North Carolina

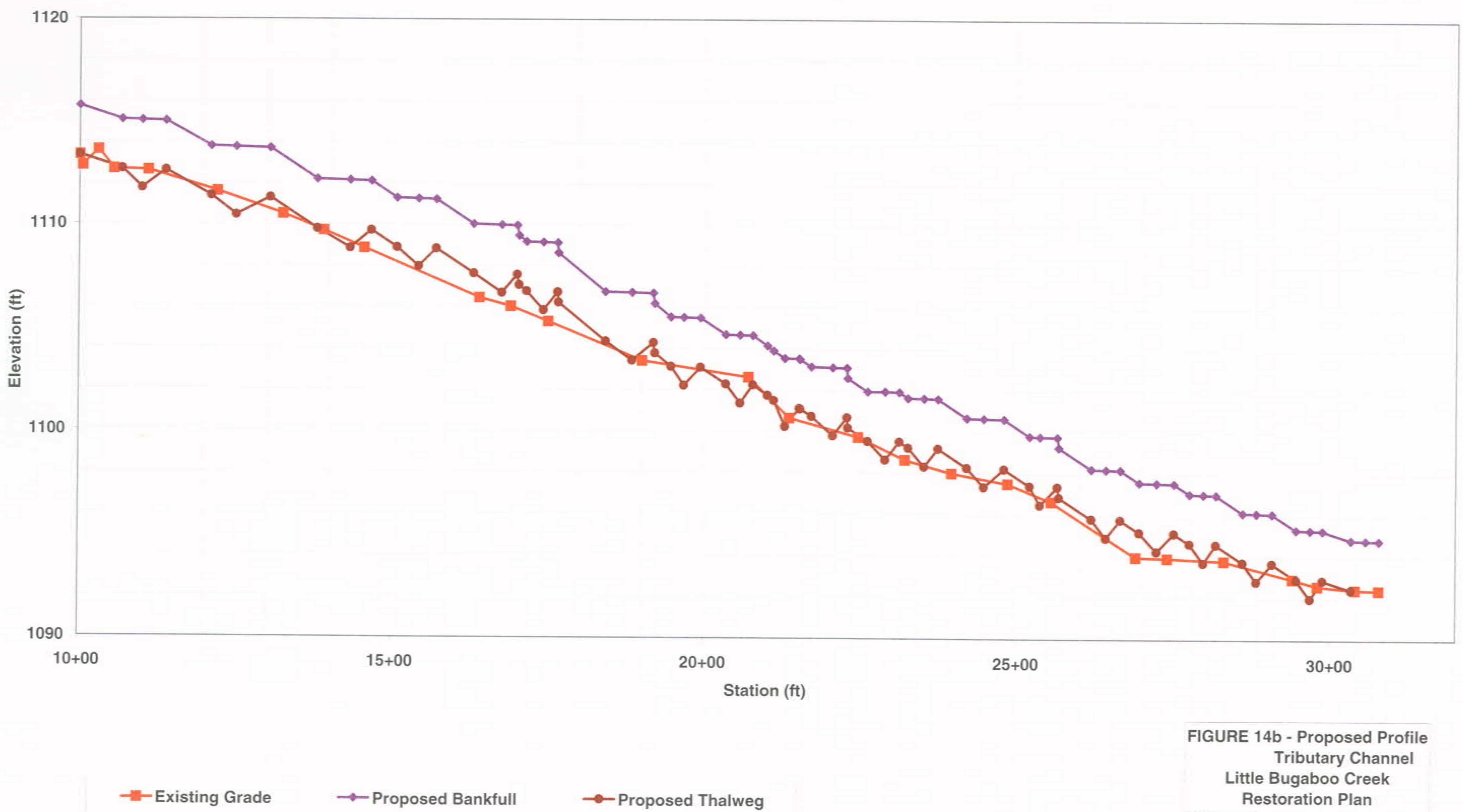


FIGURE 14b - Proposed Profile
Tributary Channel
Little Bugaboo Creek
Restoration Plan
Wilkes County, North Carolina

This area will be planted with appropriate riparian vegetation as described in Section 6.0 Habitat Restoration.

4.1.5 Riparian Areas

A riparian zone will be created around the new proposed stream channel to enhance both aquatic and terrestrial habitat as well as stabilize the stream channel. The riparian zone will extend 25 feet on average on either side of the channel from the top of bank (Figure 14). These areas will be planted with appropriate riparian vegetation as described in Section 6.0 Habitat Restoration.

4.2 SEDIMENT TRANSPORT

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

Critical dimensionless shear stress ($\tau *_{ci}$) can be calculated using a surface and subsurface particle sample from a representative riffle in the reach. . Since taking a subsurface sample is difficult, it is often estimated using the median grain size from a point bar sample. The sample is taken on the point bar face halfway between the thalweg and bankfull.

$$\tau *_{ci} = 0.0834\left(\frac{d_i}{\hat{d}_{50}}\right)^{-0.872}$$

where, $\tau*_{ci}$=critical dimensionless shear stress
d_i=d_{50} of riffle bed surface from pebble count (mm)
$\hat{d}_{50}$=subpavement d_{50} or bar d_{50} (mm)

A riffle bed surface pebble count was taken at a riffle on LBC using a method suggested by Angela Jessup of the Natural Resources Conservation Service, Yadkinville office. 100 particles were randomly selected along the wetted area throughout the entire length of a riffle on LBC and UT. The riffle bed surface d_{50} was then calculated to be 35 mm on LBC and 24mm on UT. A subsurface sample was taken at the same riffle and sieved to determine the subsurface d_{50}. The subpavement d_{50} was then calculated to be 13 mm on LBC and 11mm on UT. The data and particle distribution graphs can be found in Appendix B.

The critical dimensionless shear stress is then calculated as follows,

LBC:

$$\tau^*_{ci} = 0.0834\left(\frac{35.0mm}{13.0mm}\right)^{-0.872} = 0.035$$

UT:

$$\tau^*_{ci} = 0.0834\left(\frac{24.0mm}{11.0mm}\right)^{-0.872} = 0.042$$

Critical dimensionless shear stress can then be used to predict the water depth required to move the largest particle found within the active channel, which is 0.25 ft for the LBC and 0.23 ft for UT. The water depth is calculated by:

$$d = \frac{(\tau^*_{ci})(\rho_{sand} - \rho_{water})(D_i)}{s}$$

where, d=water depth (ft)
τ^*_{ci}=critical dimensionless shear stress
ρ_{sand}=denisty of sand (2.65 lb/ft^3)
ρ_{water}=density of water (1.0 lb/ft^3)
D_i=largest particle found in the bar sample (ft)
s=average bankfull slope

Thus,

LBC:

$$d = \frac{(0.035)(2.65\frac{lb}{ft^3} - 1.0\frac{lb}{ft^3})(0.25ft)}{0.0054\frac{ft}{ft}} = 2.6ft$$

UT:

$$d = \frac{(0.042)(2.65\frac{lb}{ft^3} - 1.0\frac{lb}{ft^3})(0.23ft)}{0.01\frac{ft}{ft}} = 1.5ft$$

For LBC a critical dimensionless shear stress value of 0.035, the depth of water required to move a 0.25 ft particle was predicted to be 2.6 ft. The proposed channel dimensions have an average bankfull depth of 2.34 ft, with a maximum depth of 3.5 ft. This design provides the depth required to move the 0.25 ft particle found in the bar sample. The channel dimensions will provide sufficient shear stress to accommodate sediment transport. Grade control will be established to reduce the possibility of down-cutting of the restored channel.

For UT a critical dimensionless shear stress value of 0.042, the depth of water required to move a 0.23 ft particle was predicted to be 1.5 ft. The proposed channel dimensions have an average bankfull depth of 1.5 ft, with a maximum depth of 2.1 ft. This design provides the depth required to move the 0.23 ft particle found in the bar sample. The channel dimensions will provide sufficient shear stress to accommodate sediment transport.

Shear stress at the riffle was also checked using Shield's Curve. The shear stress placed on the sediment particles is the force that entrains and moves the particles, given by:

$$\tau = \gamma R s$$

where, τ=shear stress (lb/ft^2)
γ=specific gravity of water (62.4 lb/ft^3)
R=hydraulic radius (ft)
s=average bankfull slope (ft/ft)

Hydraulic radius is calculated by:

$$R = \frac{A}{P}$$

where, R=hydraulic radius
A=cross-sectional area (ft^2)
P=wetted perimeter (ft)

Thus,

LBC:

$$R = \frac{60\,ft^2}{27.3\,ft} = 2.2\,ft$$

UT:

$$R = \frac{27\,ft^2}{19\,ft} = 1.42\,ft$$

Wetted perimeter was measured off of a CADD file of the typical riffle cross-section drawn to scale.

Therefore,

LBC:

$$\tau = (62.4\frac{lb}{ft^3})(2.2ft)(0.0054\frac{ft}{ft}) = 0.74lb/ft^2$$

UT:

$$\tau = (62.4\frac{lb}{ft^3})(1.42ft)(0.01\frac{ft}{ft}) = 0.88lb/ft^2$$

The critical shear stress for the proposed channel has to be sufficient to move the D_{84} of the riffle bed material, which is 45 mm for LBC and 43 mm for UT. Based on a shear stress of 0.74 lb/ft^2 for LBC and 0.88 lb/ft^2 for UT, Shield's Curve predicts that this stream can move a particle that is, on average, greater than 45 mm for LBC and 60mm. Since the D_{84} was 45 mm for LBC and 43 mm for UT and Shield's Curve predicts 45 mm for LBC and 60mm for UT, the proposed stream has the competency to move its bed load.

4.3 FLOODING ANALYSIS

This restoration site is in a FEMA/regulatory floodway zone and therefore, is subject to FEMA regulations. Currently there are no structures located in the floodway that would be impacted by floodplain alterations. The Priority 2 restoration of the stream will leave the stream's existing profile elevations essentially the same. A new floodplain will be established so that the active stream will be able to access it during larger storm events. Considering the type of restoration it is assumed that for smaller events the water surface elevations along the stream shall remain the same. During storms where the stream accesses the newly established floodplain, the new water surface elevations are expected to be lower than the existing water surface elevations for storms of the same magnitude. The restoration will create neither positive nor negative water surface elevation changes during the larger storm events (greater than 50-year). HEC-RAS will be used to analyze both existing and proposed conditions once the design is completed. Sheer stress and flood stages will be compared between the two conditions to evaluate the design. The USGS Method for estimating the magnitude and frequency of floods in rural basins was used to estimate the 2, 5, 10, 25, 50, and 100-year peak discharges for both stream reaches. The storm flows for each event are as follows:

Little Bugaboo Creek 3.5 mi^2	**Unnamed Tributary 1.4 mi^2**
Q_2 = 250 cfs	Q_2 = 150 cfs
Q_5 = 430 cfs	Q_5 = 250 cfs
Q_{10} = 590 cfs	Q_{10} = 330 cfs
Q_{25} = 830 cfs	Q_{25} = 450 cfs
Q_{50} = 1,040 cfs	Q_{50} = 560 cfs
Q_{100} = 1,290 cfs	Q_{100} = 670 cfs

The region-of-influence method describe in the USGS publication estimates flood discharges at ungaged basins by deriving, for a given ungaged rural site, regression relations between the flood discharges and basin characteristics of a unique subset of gaged stations. The latitude and longitude and drainage area for the LBC site is all the input that is required.

HEC-RAS, version 3.0, will be used to compute a flooding analysis for the existing and proposed conditions. This analysis will ensure that the project will not change existing floodwater limits and will determine whether personal or public property is at risk of damage.

4.4 STRUCTURES

Several different structures made of natural materials will be installed along LBC and the UT. These structures include cross vanes, J-hook vanes, and root wads. Natural materials such as boulders, logs, and root wads will be used to create these structures from off-site sources.

4.4.1 Cross Vane

A cross vane structure serves to maintain the grade of the stream. The design shape is roughly that of the letter "U" with the apex located on the upstream side at the foot of the ripple. Footer rocks are placed in the channel bottom for stability. Rocks are then placed on these footer rocks in the middle of the channel at approximately the same elevation as the ripple. On either side of the channel, rocks are placed at an angle to the stream bank, gradually inclining in elevation until they are located above the bankfull surface directly adjacent to the stream bank. Water flowing downstream is directed over the vane towards the middle of the channel. Rocks placed at the apex determine the bed elevation upstream. A cross vane is primarily used for grade control and to protect the stream banks.

4.4.2 Root Wads

The objectives of these structure placements are as follows: (1) protect the stream bank from erosion; (2) provide in-stream and overhead cover for fish; (3) provide shade, detritus, terrestrial insect habitat; (4) look natural, and (5) provide diversity of habitats (Rosgen 1996). A footer log and boulder are placed on the channel bottom abutting the stream bank along an outside meander that will provide support for the root wad and additional stability to the bank. A large tree root wad is then placed on the stream bank with additional boulders and rocks on either side for stability. Flowing water is deflected away from the bank and towards the center of the channel.

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

5.0 HABITAT RESTORATION

The restoration plan requires the establishment of riparian vegetation at the site. The proposed vegetation is described in the following sections.

5.1 Vegetation

Vegetation that develops a quick canopy has extensive root system, and a substantial above-ground plant structure is needed to help stabilize the banks of a restored stream channel in order to reduce scour and runoff erosion. In natural riparian environments, pioneer plants that often provide these functions are alder, river birch, silky dogwood, and willow. Once established, these trees and shrubs create an environment that allows for the succession of other riparian species including ashes, black walnuts, red maples, sycamores, oaks and other riparian species.

In the newly restored stream channel, revegetation will be vital to help stabilize the stream banks and establish a riparian zone around the restored channel. Revegetation efforts on this project will emulate natural vegetation communities found along relatively undisturbed stream corridors. To quickly establish dense root mass along the channel bank, a native grass mixture will be planted on the stream bed and bank. Shrubs will be utilized on the stream bank and along the floodplain to provide additional root mass. Extra care will be given to the outside of the meander bends to ensure a dense root mass in those areas of high stress. Coir matting will be used to provide erosion protection until vegetation can be established. Along the tops of the channel banks, trees, shrubs and a native grass mixture will be planted.

There are few suitable salvageable plants along the stream banks. As a result, a mixture of seeds, livestakes, bare root nursery stock, and transplants will be utilized to stabilize the banks. Proposed species to be planted include

Trees
Tulip poplar (*Liriodendron tulipifera*)
Black walnut (*Juglans nigra*)
Ironwood (*Carpinus caroliniana*)
River birch (*Betula nigra*)
Sycamore (*Platanus occidentalis*)
Persimmon (*Diospyros virginiana*)
Box elder (*Acer negundo*)

Shrubs
Dog-hobble (*Leucothoe* sp.)
Rhododendron (*Rhododendron minum*)
Serviceberry (*Amelanchier* arborea)
Silky dogwood (*Cornus amomum*)
Black willow (*Salix nigra*)
Tag alder (*Alnus serrulata*)
Winterberry (*Ilex verticillata*)
American holly (*Ilex opaca*0

Herbs- Permanent seed mixture

Gramminoids
Bluestem (*Andropogon glomeratus*)
Tussock sedge (*Carex stricta*)
River oats (*Chasmanthium latifolium*)
Wood oats (*Chasmanthium laxum*)
Virginia wildrye (*Elymus virginicus*)
Deertongue (*Panicum clandestinum*)
Silver plumegrass (*Saccharum alopecurodium*)
Little blue stem (*Schizachyrium scoparium*)
Woolgrass (*Scirpus cyperinus*)

Other herbaceous vegetation
Cut-leaved coneflower (*Rudbeckia laciniata*)
Wrinkle leaved goldenrod (*Solidago rugosa*)
New York Ironweed (*Vernonia noveboracensis*).

Areas that are currently vegetated with non-invasive trees or shrubs will remain undisturbed and succession will be allowed to proceed naturally. Woody vegetation will be planted between November and March to allow plants to stabilize during the dormant period and set root during the spring season. In the areas where invasive and exotic species are located, during construction and monitoring control by removal or appropriate herbicides will be implemented to prevent competition with the revegetation efforts. It is imperative that grubbing techniques be utilized to eradicate fescue grass within the construction area. Fescue is an invasive grass that may overtake planted areas if not properly eliminated prior to planting.

5.2 Riparian Buffers

A riparian buffer will be utilized to revegetate the floodplain. Any areas disturbed during construction will be replanted with bottomland hardwood forest vegetation to the existing tree line or a distance of 50 feet from the top of bank (Figure 15).

5.2.1 Bottomland Hardwood Forest

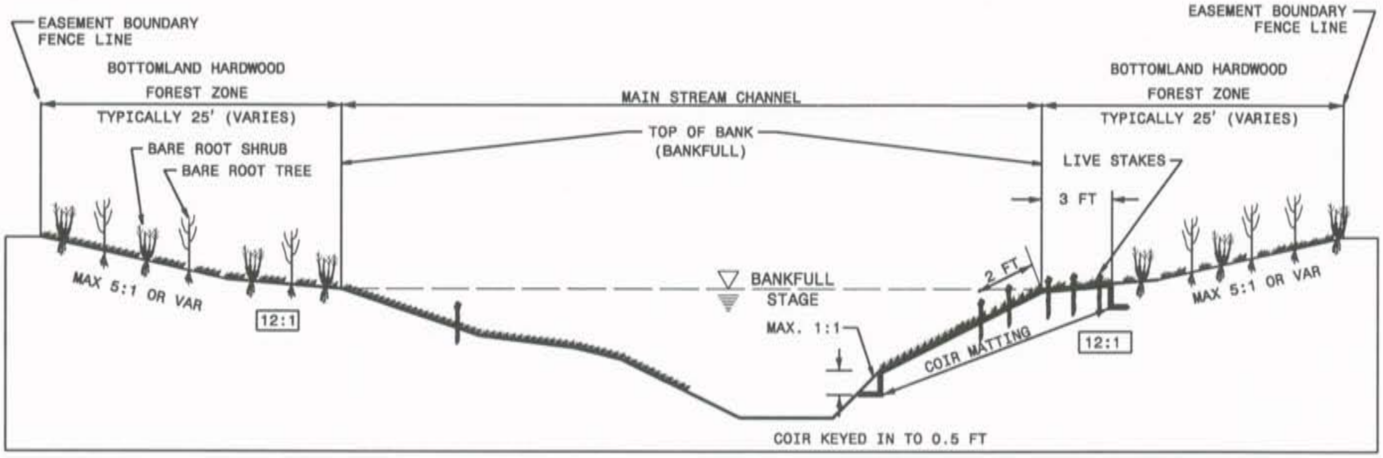
The riparian buffer will contain dominant vegetation similar to the Piedmont/Low Mountain Alluvial Forest community type described in Classification of the Natural Communities of North Carolina: Third Approximation (Schafle and Weakly 1990). Proposed species to be planted include trees, shrubs and permanent seed mixture listed under Streambank Vegetation (Section 6.1).

5.2.2 Wetlands

Cattle and various agricultural practices have heavily impacted the wetland communities adjacent to LBC. Fencing out the cattle, plugging existing ditches, and creating swales to spread out overland flow will greatly enhance the quality of these wetlands, as well as increase their overall size. Once construction is complete, the wetland will be planted with native, non-invasive vegetation including tag alder, silky dogwood, river birch, American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanicum*), buttonbush (*Cephalanthus occidentalis*), swamp chestnut oak (*Quercus michauxii*), and willow oak (*Quercus phellos*). It may also be beneficial to plant herbaceous species such as rushes (*Juncus effusus*) and bulrush (*Scirpus purshianus*).

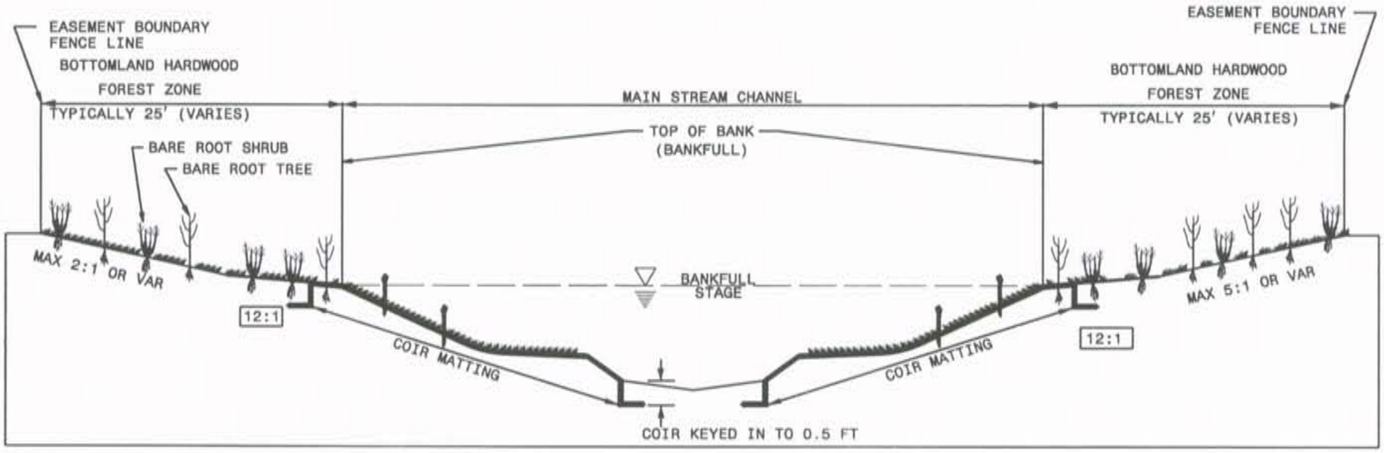
5.2.3 Temporary Seeding

A temporary seed mixture will be applied to all disturbed areas immediately after construction activities have completed. This temporary seed mixture will provide erosion control until permanent seed can become established.



VEGETATION ZONE DETAIL-POOL

SCALE: NTS



VEGETATION ZONE DETAIL- RIFFLE

SCALE: NTS

FIGURE 15

TYPICAL CROSS - SECTION SHOWING VEGETATION ZONES

LITTLE BUGABOO CREEK RESTORATION PLAN
WILKES COUNTY, NORTH CAROLINA

6.0 MONITORING

6.1 STREAM CHANNEL

Monitoring of the stability of the channel is recommended to occur approximately 6 months after restoration is complete or after bankfull (or greater) events and should continue annually for a period of 3 to 5 years. Monitoring practices may include, but are not limited to, installing bank erosion pins and a toe pin, monumented cross-sections, scour chains, macroinvertebrate studies, longitudinal profiles, conducting the bank erosion hazard rating guide and establishing photo reference points. The purpose of monitoring is to determine bank stability, bed stability, morphological stability, and overall channel stability. Table 4, below, can be used for selecting practices.

Table 4. Stream Monitoring Practices

PRACTICE	STABILITY ASSESSMENT
Bank Erosion Pins with Toe Pin	-Lateral or bank stability
Monumented Cross-Section	-Vertical or bed stability -Lateral or bank stability
Scour Chains	-Vertical or bed stability -Scour depth for a particular storm
Scour Chain w/ Monumented Cross-Section	-Vertical or bed stability -Sediment transport relations -Biological interpretations
Longitudinal Profile	-Channel profile stability
Bank Erosion Hazard Guide	-Bank erosion potential
Photo Reference Points	-Overall channel stability
Macroinvertebrate Studies	-Biological indication of water quality

6.2 VEGETATION

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

Competition control will be implemented if determined to be necessary during the early stages of growth and development of the tree species. Quantitative sampling of the vegetation will be performed between August 1 and November 30 at the end of the first year and after each growing season until the vegetation criteria is met.

In preparation for the quantitative sampling, 50 by 50 feet (0.05-acre) vegetative plots will be established in the reforested area. Plots will be evenly distributed throughout the site. For each plot, species composition and density will be reported. Photo points will be taken within each zone. Monitoring will take place once each year for five years.

Success will be determined by survival of target species within the sample plots. At least six different representative tree species should be present on the entire site. If the vegetative success criteria are not met, the cause of failure will be determined and appropriate corrective action will be taken.

6.3 MACROINVERTEBRATES

A monitoring period of 3 to 5 years is commonly suggested to determine changes in macroinvertebrate populations within a newly restored stream. The North Carolina Wetlands Restoration Program will determine a macroinvertebrate monitoring policy.

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APPENDIX A

PHOTO LOG

Appendix A
Little Bugaboo Creek Photo Log
Existing Conditions

Picture 1. First Cross-section at the upstream end of Little Bugaboo Creek.

Picture 2. Little Bugaboo Creek upstream of existing crossing.
Bankfull bench forming on left bank.

Picture 3. Existing crossing on Little Bugaboo Creek.

Picture 4. Pool cross-section at severely eroding meander on Little Bugaboo Creek.

Picture 5. Pool cross-section at severely eroding meander on Little Bugaboo Creek. Looking downstream.

Picture 6. Drainage leaving wet area flowing into Little Bugaboo Creek.

Picture 7. Sharp eroding meander on Little Bugaboo Creek near the middle of the project.

Picture 8. Over widened area along Little Bugaboo Creek.
Floodplain being created on left bank.

Picture 9. Pool cross-section at station 17+20.

Picture 10. Pool cross-section at station at 13+20.

Picture 11. Existing bridge to be replaced.

Picture 12. Eroding bank with exposed roots.

Picture 13. Stream with no vegetation.

Picture 14. Overwidening channel with debris jam and central bar.

Picture 15. Mass wasting along one side of a central bar.

Picture 16. Central bar, typical throughout the mitigation site.

APPENDIX B

EXISTING CONDITIONS DATA

Summary of Cross Section Data

Prepared By: Ben Goetz, Dan Clinton, Russel Barbour and Heather Wallace
River Basin: Yadkin-Pee Dee
Watershed: Little Bugaboo Creek
Stream Reach:
Drainage Area (sq mi): 3.45 (main channel) and 1.4 (Tributary)
Date: 2/15/2002

Parameter	Cross Section									
	Main Channel							Tributary		
Station	1	2	3	4	5	6	7	8	9	10
Feature	Riffle	Run	Riffle	Pool/Run	Pool	Pool	Riffle	Pool	Riffle	Riffle
Stream Type	F	E	F	F	F	F	Bc	F	F	C
Bkf Cross Sec Area, Abkf (sq ft)	87.7	76.4	60.8	69.3	60.8	33.0	54.0	29.7	21.2	21.9
Bankfull Width, Wbkf (ft)	35.5	26.0	32.5	49.0	74.5	34.2	27.8	34.2	17.5	18
Bankfull Mean Depth, Dbkf (ft)	2.5	2.9	1.9	1.4	0.8	1.0	1.9	0.9	1.2	1.2
Bankfull Maximum Depth, Dmax (ft)	4.1	4.1	2.9	3.4	3.8	3.5	2.7	2.3	2.1	2.3
Width/Depth Ratio, Wbkf/Dbkf	14.4	8.8	17.4	34.6	91.3	35.5	14.3	39.3	14.4	14.8
Entrenchment Ratio	2.1	4.3	2.3	3.6	2.0	1.4	1.9	3.8	1.8	2.5
Bank Height Ratio	2.2	2.2	2.7	1.9	2.0	2.9	2.2	3.8	4.5	3.3
Slope	0.00865	0.00053	0.00535	0.00053	0.00167	0.00020	0.00805	0.00057	0.03167	0.00960

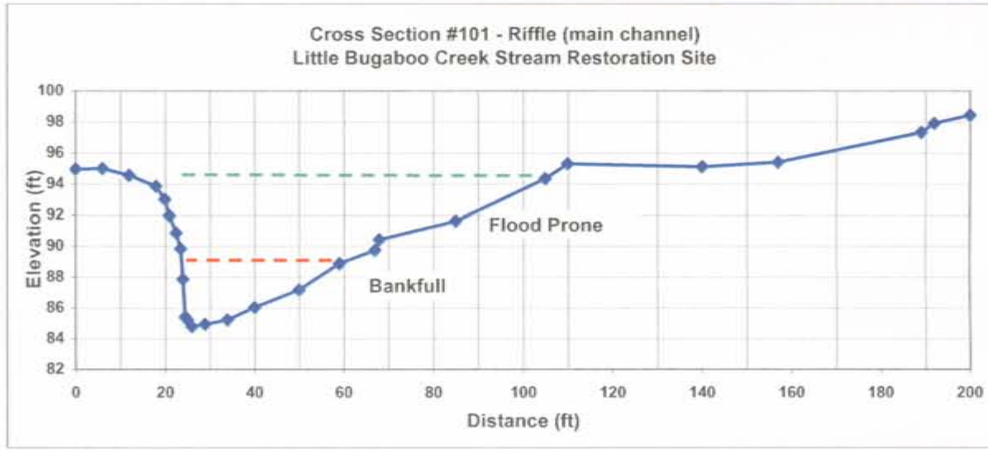
Prepared By: **Ben Goetz, Dan Clinton, Russel Barbour and Heather Wallace**
River Basin: **Yadkin-Pee Dee**
Watershed: **Little Bugaboo Creek**
Cross Section #: **1**
Drainage Area (sq mi): **3.45**
Date: **2/15/2002**
Station: **1+50**
Feature: **Riffle**
Description: **~ 150' downstream of fence marking the beginning of the project**

Station	HI Feet	FS Feet	Elevation Feet	Notes		
0.0	100.00	5.08	94.92			
6.0	100.00	5.04	94.96			
12.0	100.00	5.48	94.52			
18.0	100.00	6.19	93.81	RTOB		
20.0	100.00	7.05	92.95			
21.0	100.00	8.09	91.91			
22.5	100.00	9.19	90.81			
23.5	100.00	10.20	89.80	LBKF	???	
24.0	100.00	12.18	87.82			
24.5	100.00	14.62	85.38			
25.0	100.00	14.81	85.19	REW/WS		4.61
26.0	100.00	15.25	84.75	TW		
29.0	100.00	15.11	84.89			87.64
34.0	100.00	14.81	85.19	LEW		
40.0	100.00	14.01	85.99			
50.0	100.00	12.85	87.15			
59.0	100.00	11.15	88.85	RBKF	???	
67.0	100.00	10.29	89.71			
68.0	100.00	9.60	90.40			
85.0	100.00	8.41	91.59			
105.0	100.00	5.69	94.31			
110.0	100.00	4.72	95.28	LTOB		
140.0	100.00	4.92	95.08			
157.0	100.00	4.63	95.37			
189.0	100.00	2.70	97.30			
192.0	100.00	2.12	97.88			
200.0	100.00	1.61	98.39			

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0.0	-2.16	0
0.5	1.03	-0.28
0.5	3.47	1.13
0.5	3.66	1.78
1.0	4.10	3.88
3.0	3.96	12.09
5.0	3.66	19.05
6.0	2.86	19.56
10.0	1.70	22.80
9.0	0.00	7.65
35.5	SUM	87.65

8.0600



Summary Data

Bankfull Channel			*Top of Bank Channel*			**NC Regional Curve (Rural)**		
BKF A	87.7	sq ft	TOB A	296.5	sq ft	Watershed Size	3.45	sq mi
BKF W	35.5	ft	TOB W	73.0	ft	Bkf Area	49.7	sq ft
Max d	4.1	ft	TOB Max d	9.1	ft	Bkf Width	21.9	ft
Mean d	2.5	ft	TOB Mean d	4.1	ft	Bkf Depth	2.3	ft
W/D Ratio	14.4					Discharge	217.2	cfs
FPW	75.0	approx.						
Entrenchment Ratio	2.1							
Stream Type	F							
Bank Height Ratio	2.2							
Slope	0.0087							

BANK EROSION POTENTIAL

Date: 2/15/2002
Stream: **Little Bugaboo Creek**
Feature: **Riffle**
Station: **1**
Notes: Near start of the project.

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	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	2.2	**8.1**
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 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	1.0	**1.0**
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	25	**7.4**
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	72	**5.1**
Surface Protection (%)	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	35	**5.2**
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		**Sub-total:**	**26.8**

Adjustments: 5 Gravel/Sand

TOTAL 31.8
Bank Erosion Potential: High

Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

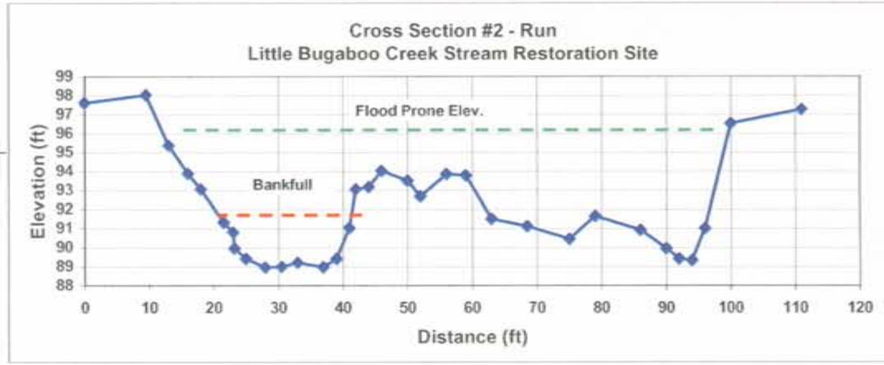
Stratification - 5 to 10 point upward adjustment depending on location of layers

Prepared By:	Ben Goetz, Dan Clinton, Russel Barbour and Heather Wallace
River Basin:	Yadkin-Pee Dee
Watershed:	Little Bugaboo Creek
Cross Section #:	2
Drainage Area (sq mi):	3.45
Date:	2/15/2002
Station:	Run/Straight Pool with silt bottom on gravel bed
Feature:	Run

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	2.42	97.58	
9.5	100.00	2.00	98.00	LTOB
13.0	100.00	4.67	95.33	
16.0	100.00	6.16	93.84	
18.0	100.00	6.97	93.03	LBKF
21.5	100.00	8.71	91.29	
23.0	100.00	9.24	90.76	
23.2	100.00	10.06	89.94	
25.0	100.00	10.60	89.40	LEW/WS
28.0	100.00	11.07	88.93	TW
30.5	100.00	11.03	88.97	
33.0	100.00	10.82	89.18	
37.0	100.00	11.05	88.95	
39.0	100.00	10.60	89.40	REW/WS
41.0	100.00	9.00	91.00	
42.0	100.00	6.97	93.03	RBKF
44.0	100.00	6.85	93.15	
46.0	100.00	6.00	94.00	
50.0	100.00	6.52	93.48	
52.0	100.00	7.35	92.65	
56.0	100.00	6.17	93.83	
59.0	100.00	6.24	93.76	
63.0	100.00	8.52	91.48	
68.5	100.00	8.91	91.09	
75.0	100.00	9.58	90.42	
79.0	100.00	8.93	91.64	
86.0	100.00	9.10	90.90	
90.0	100.00	10.07	89.93	Ox bo ws
92.0	100.00	10.60	89.40	
94.0	100.00	10.69	89.31	
96.0	100.00	9.02	90.98	
100.0	100.00	3.50	96.50	RTOB
111.0	100.00	2.76	97.24	

BKF Hydraulic Geometry

	Width Feet	Depth Feet	Area Sq. Ft.
	0.0	0.00	0
3.63	3.5	1.74	3.05
	1.5	2.27	3.01
	0.2	3.09	0.54
	1.8	3.63	6.05
	3.0	4.10	11.60
	2.5	4.06	10.20
	2.5	3.85	9.89
	4.0	4.08	15.86
	2.0	3.63	7.71
	2.0	2.03	5.66
	3.0	-0.12	2.86
	26.00	SUM	76.41



Summary Data

Bankfull Channel			Top of Bank Channel			NC Regional Curve (Rural)		
BKF A	76.4	sq ft	TOB A	438.9	sq ft	Watershed Size	3.45	sq mi
BKF W	26.0	ft	TOB W	90.5	ft	Bkf Area	49.7	sq ft
Max d	4.1	ft	TOB Max d	7.6	ft	Bkf Width	21.9	ft
Mean d	2.9	ft	TOB Mean d	4.9	ft	Bkf Depth	2.3	ft
W/D Ratio	8.8					CN #		
FPW	111.0					Discharge	217.2	cfs
Entrenchment Ratio	4.27							
Stream Type	E							
Bank Height Ratio	2.2							
Slope	0.00053							

BANK EROSION POTENTIAL

Date: 2/15/2002
Stream: Little Bugaboo Creek
Feature: Run
Station: 2
Notes: Straight reach below crossing

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME			
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE OBSERVED	SCORE
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	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	2.2	**8.1**
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 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	1	**1.0**
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	80	**1.9**
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	30	**2.4**
Surface Protection (%)	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	80	**1.9**
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		**Sub-total:**	**15.3**

Adjustments: 5 Gravel/sand

TOTAL 20.3
Bank Erosion Potential: Moderate

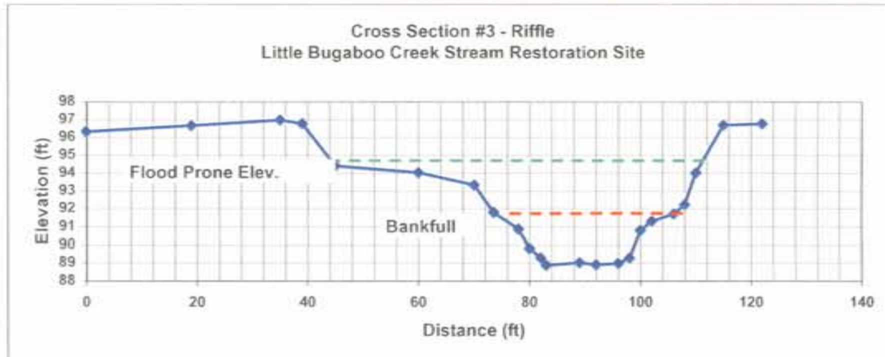
Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

Prepared By:	Ben Goetz, Dan Clinton, Russel Barbour and Heather Wallace
River Basin:	Yadkin-Pee Dee
Watershed:	Little Bugaboo Creek
Cross Section #:	3
Drainage Area (sq mi):	3.45
Date:	2/15/2002
Station:	Stable Riffle
Feature:	Riffle

Station	HI Feet	FS Feet	Elevation Feet	Notes		BKF Hydraulic Geometry Width Feet	Depth Feet	Area Sq. Ft.
0.0	100.00	3.71	96.29					
19.0	100.00	3.36	96.64					
35.0	100.00	3.05	96.95					
39.0	100.00	3.24	96.76	LTOB				
45.0	100.00	5.60	94.40					
60.0	100.00	5.98	94.02					
70.0	100.00	6.69	93.31	LBKF	better indicator			
73.5	100.00	8.21	91.79			0.0	0.00	0.00
78.0	100.00	9.15	90.85			4.5	0.94	2.11
80.0	100.00	10.20	89.80			2.0	1.99	2.93
82.0	100.00	10.72	89.28	LEW	4.03	2.0	2.51	4.50
83.0	100.00	11.13	88.87	TW		1.0	2.92	2.71
89.0	100.00	11.00	89.00			6.0	2.79	17.13
92.0	100.00	11.10	88.90			3.0	2.89	8.52
96.0	100.00	11.03	88.97			4.0	2.82	11.42
98.0	100.00	10.72	89.28	REW/WS		2.0	2.51	5.33
100.0	100.00	9.21	90.79			2.0	1.00	3.51
102.0	100.00	8.70	91.30		2.42	2.0	0.49	1.49
106.0	100.00	8.30	91.70	RBKF	better numbe	4.0	0.09	1.16
108.0	100.00	7.78	92.22					
110.0	100.00	6.00	94.00					
115.0	100.00	3.33	96.67	RTOB				
122.0	100.00	3.26	96.74			32.5	SUM	60.8

94.62



Summary Data

Bankfull Channel			*Top of Bank Channel*			**NC Regional Curve (Rural)**		
BKF A	60.8	sq ft	TOB A	330.5	sq ft	Watershed Size	3.45	sq mi
BKF W	32.5	ft	TOB W	80.0	ft	Bkf Area	49.7	sq ft
Max d	2.9	ft	TOB Max d	7.8	ft	Bkf Width	21.9	ft
Mean d	1.9	ft	TOB Mean d	4.1	ft	Bkf Depth	2.3	ft
W/D Ratio	17.4					CN #		
FPW	76.0	ft				Discharge	217.2	cfs
Entrenchment Ratio	2.3							
Stream Type	F							
Bank Height Ratio	2.7							
Riffle Slope	0.0054							

BANK EROSION POTENTIAL

Date: 2/15/2002
Stream: **Little Bugaboo Creek**
Feature: **Riffle**
Station: 3
Notes: Most Stable Cross Section

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	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	2.7	8.9
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 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	1	1.0
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	80	1.9
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	37	2.8
Surface Protection (%)	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	80	1.9
TOTALS		5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50	**Sub-total:**	**16.5**

Adjustments: **5** **Gravel/sand**

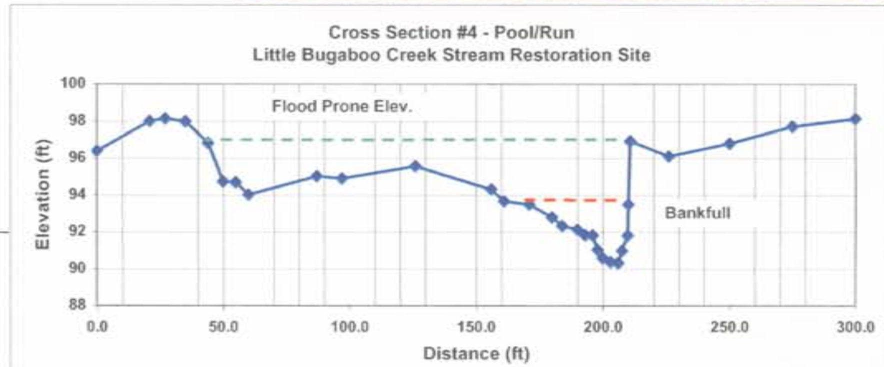
TOTAL 21.5
Bank Erosion Potential: Moderate

Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

Prepared By:	Ben Goetz, Dan Clinton, Russel Barbour and Heather Wallace
River Basin:	Yadkin-Pee Dee
Watershed:	Little Bugaboo Creek
Cross Section #:	4
Drainage Area (sq mi):	3.45
Date:	2/15/2002
Station:	Maximum width location at second oxbow
Feature:	Pool/Run

Station	HI Feet	FS Feet	Elevation Feet	Notes		BKF Hydraulic Geometry Width Feet	Depth Feet	Area Sq. Ft.
0.0	100.00	3.64	96.36					
21.0	100.00	2.03	97.97					
27.0	100.00	1.89	98.11					
35.0	100.00	2.05	97.95	LTOB				
44.0	100.00	3.19	96.81					
50.0	100.00	5.30	94.70					
55.0	100.00	5.33	94.67					
60.0	100.00	6.00	94.00					
87.0	100.00	5.00	95.00					
97.0	100.00	5.12	94.88					
126.0	100.00	4.45	95.55					
156.0	100.00	5.71	94.29					
161.0	100.00	6.35	93.65	LBKF		0.0	0.00	0.00
171.0	100.00	6.53	93.47			10.0	0.18	0.90
180.0	100.00	7.23	92.77			9.0	0.88	4.77
184.0	100.00	7.71	92.29			4.0	1.36	4.48
190.0	100.00	7.90	92.10			6.0	1.55	8.73
193.0	100.00	8.19	91.81			3.0	1.84	5.09
196.0	100.00	8.21	91.79			3.0	1.86	5.55
198.0	100.00	9.00	91.00	LEW		2.0	2.65	4.51
200.0	100.00	9.44	90.56			2.0	3.09	5.74
203.0	100.00	9.64	90.36			3.0	3.29	9.57
206.0	100.00	9.71	90.29	TW		3.0	3.36	9.98
207.5	100.00	9.05	90.95	REW	2.52	1.5	2.70	4.55
209.8	100.00	8.22	91.78			2.3	1.87	5.26
210.0	100.00	6.53	93.47	RBKF		0.2	0.18	0.20
210.8	100.00	3.10	96.90	RTOB		49.0	SUM	69.32
226.0	100.00	3.92	96.08		96.8			
250.0	100.00	3.21	96.79					
275.0	100.00	2.30	97.70					
300.0	100.00	1.88	98.12					



Summary Data

Bankfull Channel

BKF A	69.3	sq ft
BKF W	49.0	ft
Max d	3.4	ft
Mean d	1.4	ft
W/D Ratio	34.6	
FPW	176.0	approx.
Entrenchment Ratio	3.6	
Stream Type	F	
Bank Height Ratio	1.9	
Slope	0.00053	

Top of Bank Channel

TOB A	463.7	sq ft
TOB W	175.8	ft
TOB Max d	6.6	ft
TOB Mean d	2.6	ft

NC Regional Curve (Rural)

Watershed Size	3.5	sq mi
Bkf Area	49.7	sq ft
Bkf Width	21.9	ft
Bkf Depth	2.3	ft
CN #		
Discharge	217.2	cfs

BANK EROSION POTENTIAL

Date: 2/15/2002
Stream: **Little Bugaboo Creek**
Feature: **Pool/Run**
Station: **4**
Notes: Fist Eroading Meander

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME			
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE OBSERVED	SCORE
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	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	1.9	**7.8**
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 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.1	**8.5**
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	<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	80	**5.0**
Surface Protection (%)	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	<10	**10.0**
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		**Sub-total:**	**41.3**

Adjustments: 5 Gravel/Sand

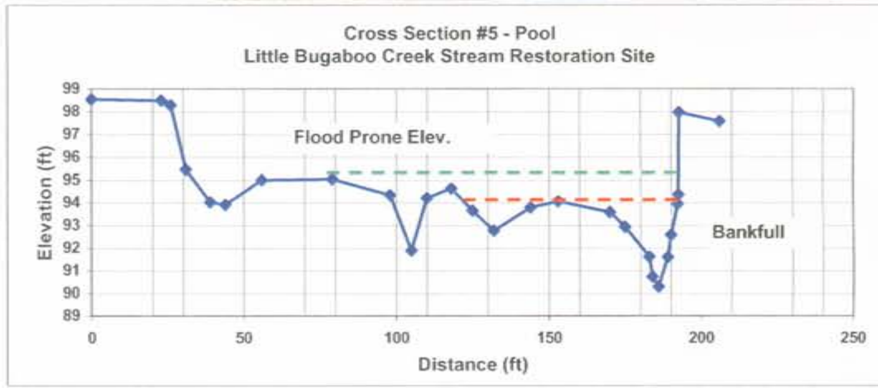
Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

TOTAL 46.3
Bank Erosion Potential: Very High

Prepared By:	Ben Goetz, Dan Clinton, Russel Barbour and Heather Wallace
River Basin:	Yadkin-Pee Dee
Watershed:	Little Bugaboo Creek
Cross Section #:	5
Drainage Area (sq mi):	3.45
Date:	2/15/2002
Station:	
Feature:	Pool

Station	HI Feet	FS Feet	Elevation Feet	Notes		BKF Hydraulic Geometry Width Feet	Depth Feet	Area Sq. Ft.
0.0	100.00	1.47	98.53					
23.0	100.00	1.53	98.47	LTOB				
26.0	100.00	1.72	98.28					
31.0	100.00	4.55	95.45					
39.0	100.00	5.99	94.01					
44.0	100.00	6.10	93.90					
56.0	100.00	5.00	95.00					
79.0	100.00	4.97	95.03					
98.0	100.00	5.68	94.32					
105.0	100.00	8.12	91.88					
110.0	100.00	5.80	94.20					
118.0	100.00	5.37	94.63			0.0	-0.58	0.00
125.0	100.00	6.36	93.64			7.0	0.41	-0.60
132.0	100.00	7.24	92.76			7.0	1.29	5.95
144.0	100.00	6.21	93.79			12.0	0.26	9.30
153.0	100.00	5.95	94.05	LBKF		9.0	0.00	1.17
170.0	100.00	6.41	93.59			17.0	0.46	3.91
175.0	100.00	7.07	92.93			5.0	1.12	3.95
183.0	100.00	8.38	91.62	LEW	94.10	8.0	2.43	14.20
184.0	100.00	9.26	90.74		2.75	1.0	3.31	2.87
186.0	100.00	9.71	90.29	TW		2.0	3.76	7.07
189.0	100.00	8.40	91.60	REW/WS		3.0	2.45	9.32
190.0	100.00	7.42	92.58			1.0	1.47	1.96
192.2	100.00	6.05	93.95			2.2	0.10	1.73
192.5	100.00	5.65	94.35	RBKF		0.3	-0.30	-0.03
192.7	100.00	2.04	97.96	RTOB		74.5	SUM	60.80
206.0	100.00	2.44	97.56					



Summary Data

Bankfull Channel			Top of Bank Channel			NC Regional Curve (Rural)		
						Watershed Size	3.5	sq mi
BKF A	60.8		TOB A	662.6	sq ft	Bkf Area	49.7	sq ft
BKF W	74.5		TOB W	169.7	ft	Bkf Width	21.9	ft
Max d	3.8		TOB Max d	7.7	ft	Bkf Depth	2.3	ft
Mean d	0.8		TOB Mean d	3.9	ft	Discharge	217.2	cfs
W/D Ratio	91.3	sq ft						
Stream Type	F	ft						
Bank Height Ratio	2.0	ft						
Slope	0.00167							

BANK EROSION POTENTIAL

Date: 2/15/2002
Stream: **Little Bugaboo Creek**
Feature: **Pool**
Station: **5**
Notes: Second Eroading Meander

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	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	2.0	**7.9**
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 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.1	**8.5**
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	<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	85	**6.5**
Surface Protection (%)	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	<10	**10.0**
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		**Sub-total:**	**42.9**

Adjustments: **5** **Gravel/Sand**

TOTAL **47.9**
Bank Erosion Potential: Very High

Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

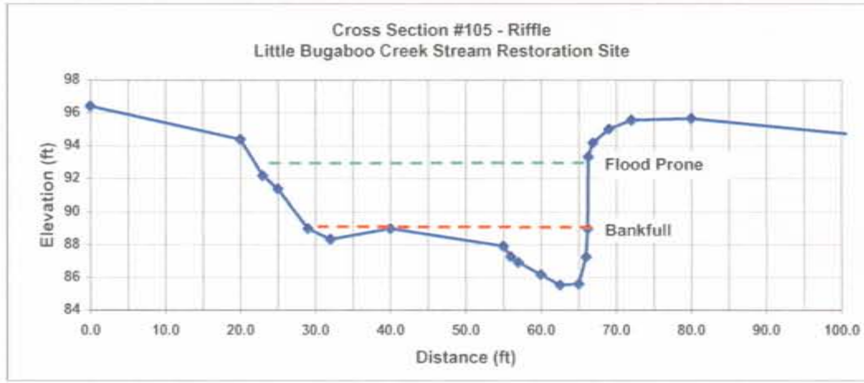
Prepared By:	**Ben Goetz, Dan Clinton, Russel Barbour and Heather Wallace**
River Basin:	**Yadkin-Pee Dee**
Watershed:	**Little Bugaboo Creek**
Cross Section #:	**6**
Drainage Area (sq mi):	**3.45**
Date:	**2/15/2002**
Station:	
Feature:	**Pool**

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	3.62	96.38	
20.0	100.00	5.65	94.35	LTOB
23.0	100.00	7.87	92.13	
25.0	100.00	8.66	91.34	
29.0	*100.00*	*11.05*	88.95	LBKF
32.0	100.00	11.70	88.30	
40.0	100.00	11.05	88.95	
55.0	100.00	12.11	87.89	
56.0	100.00	12.77	87.23	LEW
57.0	100.00	13.12	86.88	
60.0	100.00	13.86	86.14	
62.5	100.00	14.51	85.49	TW
65.0	100.00	14.44	85.56	
66.0	100.00	12.79	87.21	REW/WS
66.2	*100.00*	*11.05*	88.95	RBKF
66.3	100.00	6.70	93.30	
66.9	100.00	5.87	94.13	
69.0	100.00	5.01	94.99	
72.0	100.00	4.47	95.53	RTOB
80.0	100.00	4.37	95.63	
104.0	100.00	5.46	94.54	

-1.74

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0.0	0.00	0.00
8.0	0.65	2.60
15.0	0.00	4.88
1.0	1.06	0.53
1.0	1.72	1.39
3.0	2.07	5.69
2.5	2.81	6.10
2.5	3.46	7.84
1.0	3.39	3.43
0.2	1.74	0.51
0.1	0.00	0.09
34.2	SUM	33.0



Summary Data

Bankfull Channel			*Top of Bank Channel*			**NC Regional Curve (Rural)**		
BKF A	33.0	sq ft	TOB A	267.8	sq ft	Watershed Size	6.0	sq mi
BKF W	34.2	ft	TOB W	49.0	ft	Bkf Area	72.5	sq ft
Max d	3.5	ft	TOB Max d	8.9	ft	Bkf Width	27.0	ft
Mean d	1.0	ft	TOB Mean d	5.5	ft	Bkf Depth	2.7	ft
W/D Ratio	35.5					Discharge	323.5	cfs
FPW	46.9	approx.						
Entrenchment Ratio	1.4							
Stream Type	F							
Bank Height Ratio	2.9							
Slope	0.0002							

BANK EROSION POTENTIAL

Date: 2/15/2002
Stream: Little Bugaboo Creek
Feature: Pool
Station: 6
Notes:

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	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	2.9	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 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.8	2.4
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	40	4.8
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	81	6.0
Surface Protection (%)	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	60	2.4
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		Sub-total:	25.6

Adjustments: 10 Sand

TOTAL 35.6
Bank Erosion Potential: High

Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

Prepared By:	Ben Goetz, Dan Clinton, Russel Barbour and Heather Wallace
River Basin:	Yadkin-Pee Dee
Watershed:	Little Bugaboo Creek
Cross Section #:	7
Drainage Area (sq mi):	3.45
Date:	2/15/2002
Station:	
Feature:	Riffle

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	3.95	96.05	
3.0	100.00	3.59	96.41	
11.0	100.00	5.47	94.53	
17.0	100.00	4.91	95.09	LTOB
22.0	100.00	5.33	94.67	
33.0	100.00	11.60	88.40	
40.0	100.00	11.29	88.71	
48.0	100.00	12.04	87.96	
50.5	100.00	12.55	87.45	
52.0	100.00	13.75	86.25	LBKF
53.0	100.00	16.12	83.88	LEW
54.0	100.00	16.49	83.51	TW
58.0	100.00	16.39	83.61	
61.0	100.00	16.12	83.88	REW/WS
63.0	100.00	15.78	84.22	
66.0	100.00	16.16	83.84	
70.0	100.00	15.60	84.40	
74.0	100.00	15.12	84.88	
77.0	100.00	15.15	84.85	
79.0	100.00	14.59	85.41	
80.8	100.00	13.75	86.25	RBKF
84.8	100.00	10.65	89.35	
86.0	100.00	10.53	89.47	RTOB
108.0	100.00	10.63	89.37	

2.37

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0.0	2.37	0.00
1.0	2.74	2.56
4.0	2.64	10.76
3.0	2.37	7.52
2.0	2.03	4.40
3.0	2.41	6.66
4.0	1.85	8.52
4.0	1.37	6.44
3.0	1.40	4.16
2.0	0.84	2.24
1.8	0.00	0.76
27.8	SUM	54.00

88.99

Summary Data			Top of Bank Channel			NC Regional Curve (Rural)		
Bankfull Channel						Watershed Size	3.5	sq mi
BKF A	54.0	sq ft	TOB A	175.9	sq ft	Bkf Area	49.7	sq ft
BKF W	27.8	ft	TOB W	53.0	ft	Bkf Width	21.9	ft
Max d	2.7	ft	TOB Max d	6.0	ft	Bkf Depth	2.3	ft
Mean d	1.9	ft	TOB Mean d	3.3	ft	Discharge	217.2	cfs
W/D Ratio	14.3							
Flood Prone Width	51.8							
Entrenchment Ratio	1.9							
Stream Type	Bc							
Bank Height Ratio	2.2							
Slope	0.0080							

BANK EROSION POTENTIAL

Date: 2/15/2002
Stream: Little Bugaboo Creek
Feature: Riffle
Station: 7
Notes:

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	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	2.2	8.2
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 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	1	1.0
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	80	1.9
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	35	2.7
Surface Protection (%)	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	80	1.9
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		Sub-total:	15.7
													Adjustments:	10 Sand
													TOTAL	25.7

Bank Erosion Potential: Moderate

Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

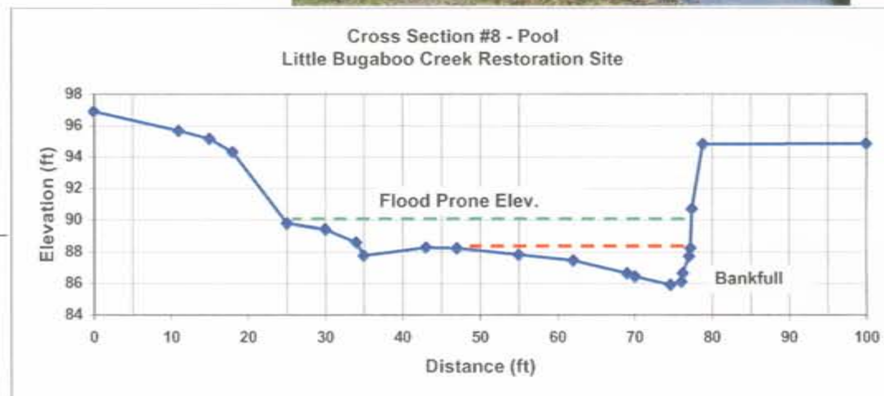
Stratification - 5 to 10 point upward adjustment depending on location of layers

Prepared By:	Ben Goetz, Dan Clinton, Russel Barbour and Heather Wallace
River Basin:	Yadkin-Pee Dee
Watershed:	Little Bugaboo Creek -Tributary
Cross Section #:	8
Drainage Area (sq mi):	1.4
Date:	2/15/2002
Station:	
Feature:	Pool

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	3.12	96.88	
11.0	100.00	4.35	95.65	
15.0	100.00	4.87	95.13	LTOB
18.0	100.00	5.72	94.28	
25.0	100.00	10.21	89.79	
30.0	100.00	10.59	89.41	
34.0	100.00	11.40	88.60	
35.0	100.00	12.24	87.76	
43.0	100.00	11.74	88.26	
47.0	100.00	11.77	88.23	LBKF
55.0	100.00	12.19	87.81	
62.0	100.00	12.56	87.44	
69.0	100.00	13.35	86.65	LEW/WS
70.0	100.00	13.56	86.44	
74.6	100.00	14.09	85.91	TW
76.0	100.00	13.90	86.10	
76.2	100.00	13.36	86.64	REW
77.0	100.00	12.30	87.70	
77.2	100.00	11.77	88.23	RBKF
77.4	100.00	9.31	90.69	
78.8	100.00	5.19	94.81	RTOB
100.0	100.00	5.18	94.82	

BKF Hydraulic Geometry

	Width Feet	Depth Feet	Area Sq. Ft.
	4.0	0.00	0.00
	8.0	0.42	1.68
	7.0	0.79	4.24
	7.0	1.58	8.30
	1.0	1.79	1.69
	4.6	2.32	9.45
	1.4	2.13	3.12
-1.59	0.2	1.59	0.37
	0.8	0.53	0.85
	0.2	0.00	0.05
90.55	34.2	SUM	29.74



Summary Data		
BKF A	29.7	sq ft
BKF W	34.2	ft
Max d	2.3	ft
Mean d	0.9	ft
W/D Ratio	39.3	
Stream Type	F	
Bank Height Ratio	3.8	
Slope	0.000571	

Top of Bank Channel		
TOB A	388.7	sq ft
TOB W	63.8	ft
TOB Max d	8.9	ft
TOB Mean d	6.1	ft

NC Regional Curve (Rural)		
Watershed Size	1.4	sq mi
Bkf Area	26.9	sq ft
Bkf Width	15.6	ft
Bkf Depth	1.7	ft
Discharge	113.4	cfs

BANK EROSION POTENTIAL

Date: 2/15/2002
Stream: **Little Bugaboo Creek Tributary**
Feature: **Pool**
Station: **8**
Notes:

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	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	3.8	**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 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.1	**8.5**
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	<5	**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	85	**7.0**
Surface Protection (%)	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	<10	**10.0**
TOTALS		5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50	**Sub-total:**	**45.5**
													Adjustments:	**0**

Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

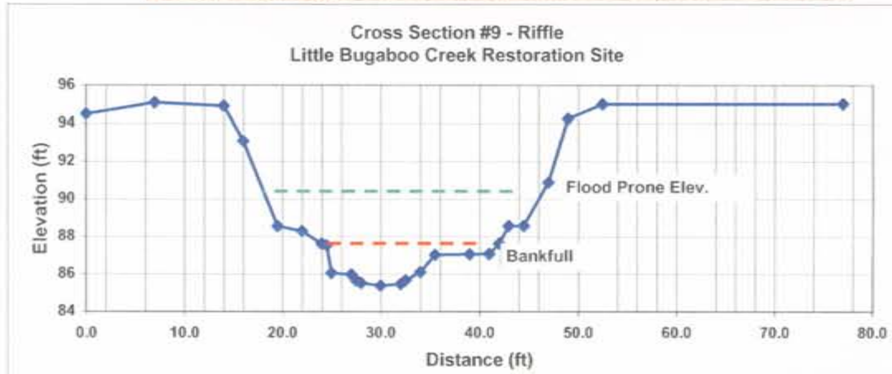
TOTAL **45.5**
Bank Erosion Potential: **Very High**

Prepared By:	**Ben Goetz, Dan Clinton, Russel Barbour and Heather Wallace**
River Basin:	**Yadkin-Pee Dee**
Watershed:	**Little Bugaboo Creek -Tributary**
Cross Section #:	**9**
Drainage Area (sq mi):	**1.40**
Date:	**2/15/2002**
Station:	**Beside plowed field in Trib near confluence**
Feature:	**Riffle**

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	5.52	94.48	
7.0	100.00	4.92	95.08	
14.0	100.00	5.10	94.90	LTOB
16.0	100.00	6.95	93.05	
19.5	100.00	11.46	88.54	
22.0	100.00	11.72	88.28	
24.0	100.00	12.40	87.60	
24.5	100.00	12.49	87.51	LBKF
25.0	100.00	13.97	86.03	
27.0	100.00	14.04	85.96	
27.5	100.00	14.36	85.64	LEW
28.0	100.00	14.50	85.50	
30.0	100.00	14.63	85.37	TW
32.0	100.00	14.55	85.45	
32.5	100.00	14.36	85.64	REW
34.0	100.00	13.91	86.09	
35.5	100.00	12.99	87.01	
39.0	100.00	12.95	87.05	
41.0	100.00	12.93	87.07	
42.0	100.00	12.39	87.61	RBKF
43.0	100.00	11.44	88.56	
44.5	100.00	11.45	88.55	
47.0	100.00	9.13	90.87	
49.0	100.00	5.77	94.23	
52.5	100.00	5.00	95.00	RTOB
77.0	100.00	4.99	95.01	

BKF Hydraulic Geometry

	Width Feet	Depth Feet	Area Sq. Ft.
	0.0	0.00	0.00
	0.5	1.48	0.37
	2.0	1.55	3.03
	0.5	1.87	0.86
	0.5	2.01	0.97
	2.0	2.14	4.15
	2.0	2.06	4.20
	0.5	1.87	0.98
	1.5	1.42	2.47
	1.5	0.50	1.44
1.97	3.5	0.46	1.68
	2.0	0.44	0.90
	1.0	-0.10	0.17
	17.5	SUM	21.22



Summary Data

Bankfull Channel			*Top of Bank Channel*			NC Regional Curve (Rural)		
BKF A	21.2	sq ft	TOB A	239.4	sq ft			
BKF W	17.5	ft	TOB W	38.5	ft	Watershed Size	1.4	sq mi
Max d	2.1	ft	TOB Max d	9.6	ft	Bkf Area	26.9	sq ft
Mean d	1.2	ft	TOB Mean d	6.2	ft	Bkf Width	15.6	ft
W/D Ratio	14.4					Bkf Depth	1.7	ft
FPW	31.0	approx.				Discharge	113.4	cfs
Entrenchment Ratio	1.8							
Stream Type	F							
Bank Height Ratio	4.5							
Slope	0.03167							

BANK EROSION POTENTIAL

Date: 2/15/2002
Stream: Little Bugaboo Creek Tributary
Feature: Riffle
Station: 9
Notes:

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	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	4.5	**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 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	1	**1.0**
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	95	**1.2**
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	55	**3.5**
Surface Protection (%)	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	85	**1.7**
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		**Sub-total:**	**17.4**

Adjustments: 5 Gravel/Sand

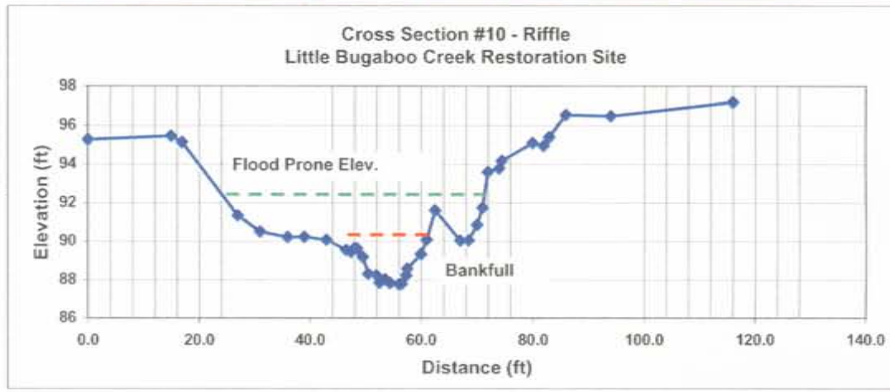
TOTAL 22.4
Bank Erosion Potential: Moderate

Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

Prepared By:	**Ben Goetz, Dan Clinton, Russel Barbour and Heather Wallace**
River Basin:	**Yadkin-Pee Dee**
Watershed:	**Little Bugaboo Creek -Tributary**
Cross Section #:	**10**
Drainage Area (sq mi):	**1.40**
Date:	**2/15/2002**
Station:	**Beside plowed field in Trib near confluence**
Feature:	**Riffle**

Station	HI Feet	FS Feet	Elevation Feet	Notes		BKF Hydraulic Geometry Width Feet	Depth Feet	Area Sq. Ft.
0.0	100.00	4.77	95.23					
15.0	100.00	4.59	95.41	LTOB				
17.0	100.00	4.91	95.09					
27.0	100.00	8.70	91.30					
31.0	100.00	9.52	90.48					
36.0	100.00	9.81	90.19					
39.0	100.00	9.79	90.21					
43.0	100.00	9.94	90.06	LBKF		0.0	0.00	0.00
46.5	100.00	10.48	89.52			3.5	0.54	0.95
47.5	100.00	10.58	89.42			1.0	0.64	0.59
48.0	100.00	10.38	89.62			0.5	0.44	0.27
48.5	100.00	10.42	89.58			0.5	0.48	0.23
49.5	100.00	10.85	89.15			1.0	0.91	0.70
50.5	100.00	11.71	88.29			1.0	1.77	1.34
52.0	100.00	11.80	88.20	LEW		1.5	1.86	2.72
52.5	100.00	12.16	87.84			0.5	2.22	1.02
53.5	100.00	11.99	88.01			1.0	2.05	2.14
54.4	100.00	12.20	87.80			0.9	2.26	1.94
56.0	100.00	12.27	87.73	TW	-1.85	1.6	2.33	3.67
56.5	100.00	12.25	87.75			0.5	2.31	1.16
57.3	100.00	11.79	88.21	REW		0.8	1.85	1.66
57.5	100.00	11.45	88.55			0.2	1.51	0.34
60.0	100.00	10.70	89.30			2.5	0.76	2.84
61.0	100.00	9.94	90.06	RBKF		1.0	0.00	0.38
62.5	100.00	8.42	91.58			18.0		21.94
67.0	100.00	10.00	90.00					
68.5	100.00	9.98	90.02		92.39			
70.0	100.00	9.18	90.82					
71.0	100.00	8.29	91.71					
72.0	100.00	6.44	93.56					
74.0	100.00	6.26	93.74					
74.5	100.00	5.85	94.15					
80.0	100.00	4.93	95.07					
82.0	100.00	5.08	94.92					
83.0	100.00	4.63	95.37					
86.0	100.00	3.49	96.51	RTOB				
94.0	100.00	3.55	96.45					
116.0	100.00	2.83	97.17					



Summary Data

Bankfull Channel			*Top of Bank Channel*			**NC Regional Curve (Rural)**		
BKF A	21.9	sq ft	TOB A	279.2	sq ft	Watershed Size	1.4	sq mi
BKF W	18.0	ft	TOB W	71.0	ft	Bkf Area	26.9	sq ft
Max d	2.3	ft	TOB Max d	7.7	ft	Bkf Width	15.6	ft
Mean d	1.2	ft	TOB Mean d	3.9	ft	Bkf Depth	1.7	ft
W/D Ratio	14.8					Discharge	113.4	cfs
FPW	45.0	approx.						
Entrenchment Ratio	2.5							
Stream Type	C							
Bank Height Ratio	3.3							
Slope	0.0096							

BANK EROSION POTENTIAL

Date: 2/15/2002
Stream: Little Bugaboo Creek Tributary
Feature: Riffle
Station: 10
Notes:

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	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	3.3	**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 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	1	**1.0**
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	90	**1.5**
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	30	**2.5**
Surface Protection (%)	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	90	**1.5**
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		**Sub-total:**	**16.5**
													Adjustments:	5 **Gravel/Sand**
													TOTAL	**21.5**

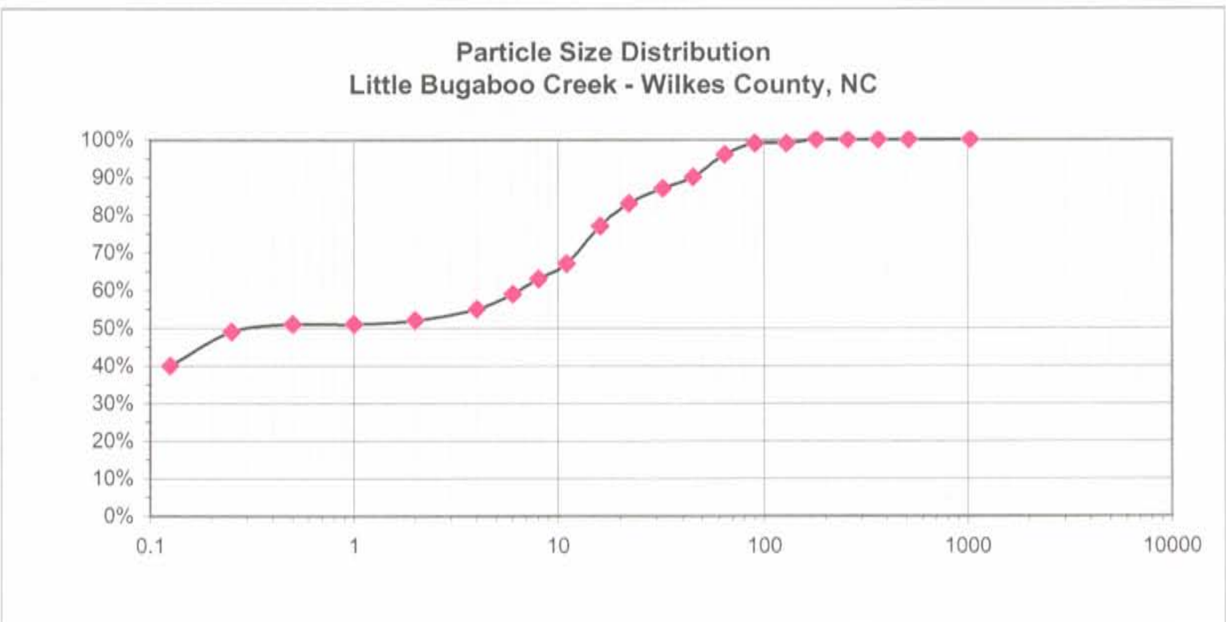
Bank Erosion Potential: Moderate

Adjustments

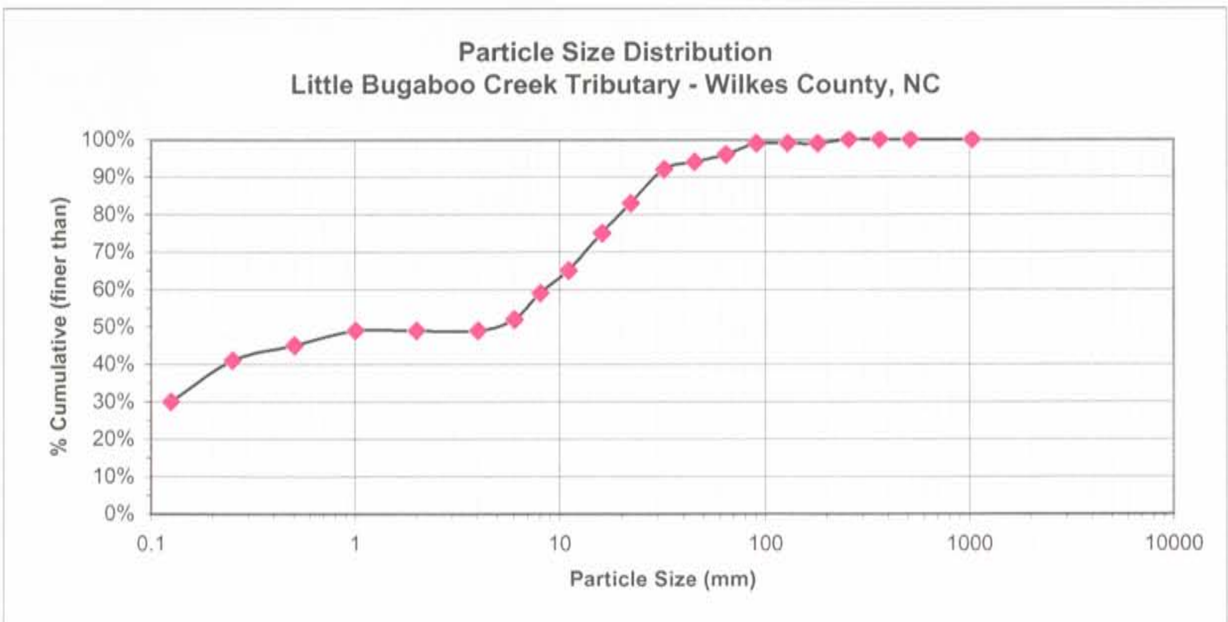
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

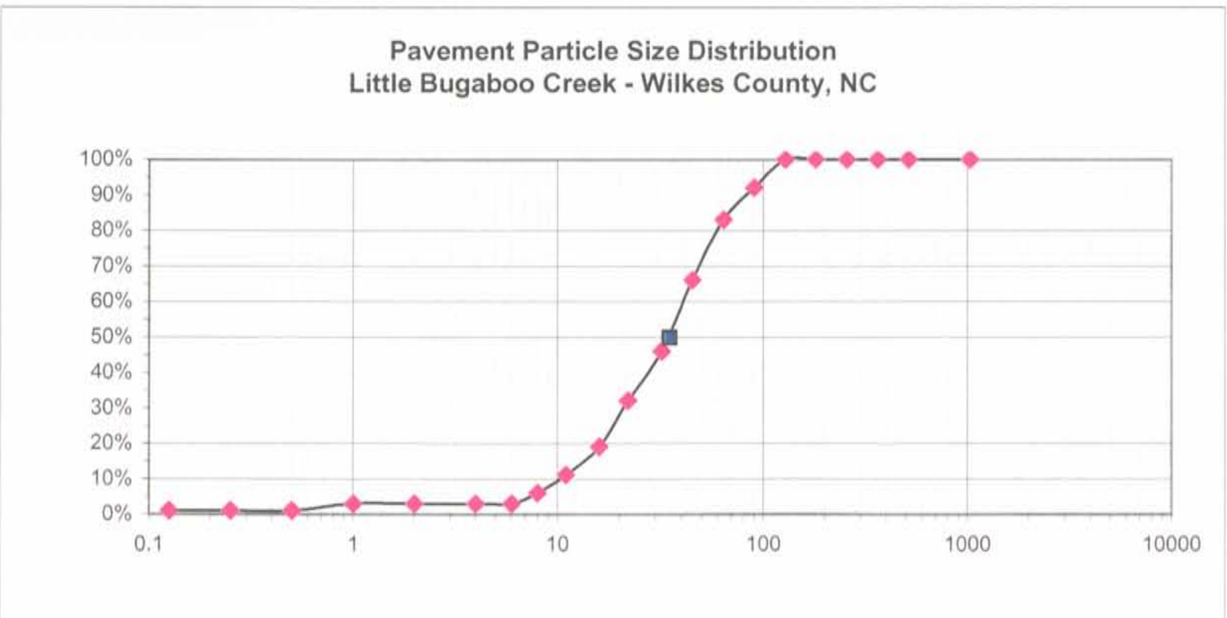
PEBBLE COUNT								
Site: Little Bugaboo Creek - Main Channel						2/14/2002		
Party: Ben Goetz, Heather Wallace, Dan Clinton						Reach: WRP Restoration		
				Particle Counts				
Inches	Particle	Millimeter		Riffles	Pools	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	**S/C**	5	19	24	24%	24%
	Very Fine	.062 - .125	**S**	1	15	16	16%	40%
	Fine	.125 - .25	**A**	5	4	9	9%	49%
	Medium	.25 - .50	**N**	1	1	2	2%	51%
	Coarse	.50 - 1.0	**D**	0	0	0	0%	51%
.04 -.08	Very Coarse	1.0 - 2.0	**S**	0	1	1	1%	52%
.08 - .16	Very Fine	2.0 - 4.0		0	3	3	3%	55%
.16 - .22	Fine	4.0 - 5.7	**G**	0	4	4	4%	59%
.22 - .31	Fine	5.7 - 8.0	**R**	0	4	4	4%	63%
.31 - .44	Medium	8.0 - 11.3	**A**	2	2	4	4%	67%
.44 - .63	Medium	11.3 - 16.0	**V**	4	6	10	10%	77%
.63 - .89	Coarse	16.0 - 22.6	**E**	6	0	6	6%	83%
.89 - 1.26	Coarse	22.6 - 32.0	**L**	4	0	4	4%	87%
1.26 - 1.77	Very Coarse	32.0 - 45.0	**S**	3	0	3	3%	90%
1.77 - 2.5	Very Coarse	45.0 - 64.0		6	0	6	6%	96%
2.5 - 3.5	Small	64 - 90	**C**	3	0	3	3%	99%
3.5 - 5.0	Small	90 - 128	**O**	0	0	0	0%	99%
5.0 - 7.1	Large	128 - 180	**B**	0	1	1	1%	100%
7.1 - 10.1	Large	180 - 256	**L**	0	0	0	0%	100%
10.1 - 14.3	Small	256 - 362	**B**	0	0	0	0%	100%
14.3 - 20	Small	362 - 512	**L**	0	0	0	0%	100%
20 - 40	Medium	512 - 1024	**D**	0	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	**R**	0	0	0	0%	100%
	Bedrock		**BDRK**	0	0	0	0%	100%
			Totals	**40**	**60**	**100**	**100%**	**100%**



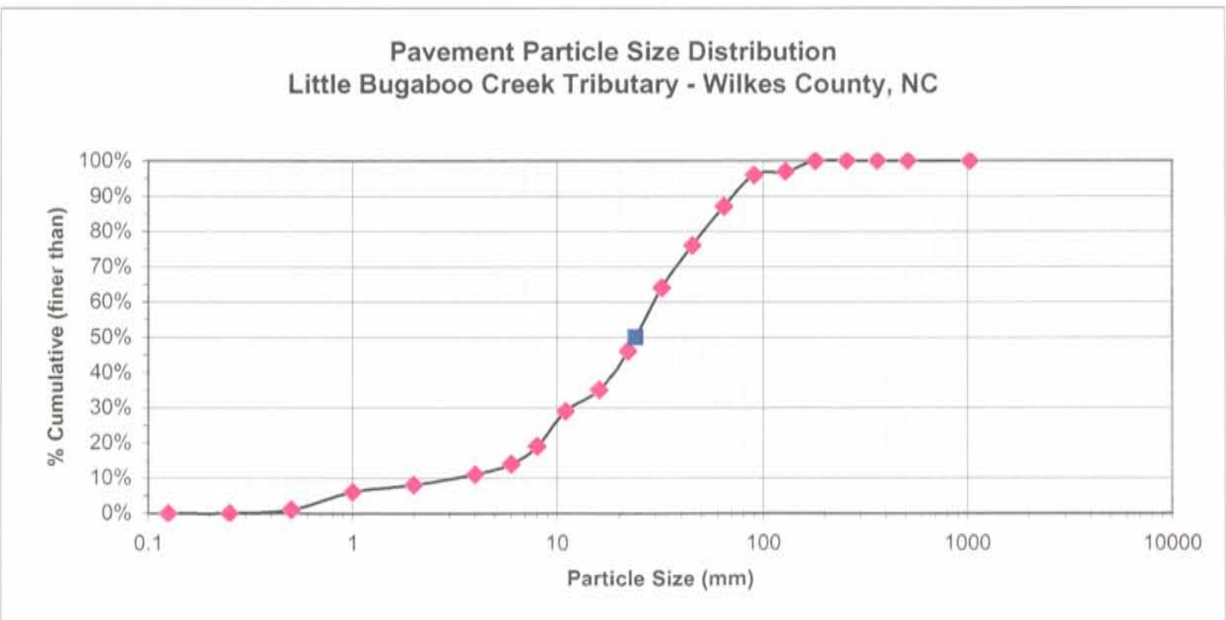
PEBBLE COUNT									
Site: Little Bugaboo Creek - Tributary Channel						2/14/2002			
Party: Ben Goetz, Heather Wallace, Dan Clinton						Reach: WRP Restoration			
				Particle Counts					
Inches	Particle	Millimeter		Riffles	Pools	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	**S/C**	2	15	17	17%	17%
	Very Fine	.062 - .125	**S**	2	11	13	13%	30%
	Fine	.125 - .25	**A**	3	8	11	11%	41%
	Medium	.25 - .50	**N**	2	2	4	4%	45%
	Coarse	.50 - 1.0	**D**	2	2	4	4%	49%
.04 -.08	Very Coarse	1.0 - 2.0	**S**	0	0	0	0%	49%
.08 - .16	Very Fine	2.0 - 4.0		0	0	0	0%	49%
.16 - .22	Fine	4.0 - 5.7	**G**	2	1	3	3%	52%
.22 - .31	Fine	5.7 - 8.0	**R**	4	3	7	7%	59%
.31 - .44	Medium	8.0 - 11.3	**A**	5	1	6	6%	65%
.44 - .63	Medium	11.3 - 16.0	**V**	6	4	10	10%	75%
.63 - .89	Coarse	16.0 - 22.6	**E**	7	1	8	8%	83%
.89 - 1.26	Coarse	22.6 - 32.0	**L**	9	0	9	9%	92%
1.26 - 1.77	Very Coarse	32.0 - 45.0	**S**	2	0	2	2%	94%
1.77 - 2.5	Very Coarse	45.0 - 64.0		2	0	2	2%	96%
2.5 - 3.5	Small	64 - 90	**C**	2	1	3	3%	99%
3.5 - 5.0	Small	90 - 128	**O**	0	0	0	0%	99%
5.0 - 7.1	Large	128 - 180	**B**	0	0	0	0%	99%
7.1 - 10.1	Large	180 - 256	**L**	0	1	1	1%	100%
10.1 - 14.3	Small	256 - 362	**B**	0	0	0	0%	100%
14.3 - 20	Small	362 - 512	**L**	0	0	0	0%	100%
20 - 40	Medium	512 - 1024	**D**	0	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	**R**	0	0	0	0%	100%
	Bedrock		**BDRK**	0	0	0	0%	100%
			Totals	**50**	**50**	**100**	**100%**	**100%**



RIFFLE PAVEMENT PEBBLE COUNT								
Site: Little Bugaboo Creek - Main Channel						2/14/2002		
Party: Ben Goetz, Heather Wallace, Dan Clinton						Reach: WRP Restoration		
				Particle Counts				
Inches	Particle	Millimeter		Riffles	Pools	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	**S/C**	0	0	0	0%	0%
	Very Fine	.062 - .125	**S**	1	0	1	1%	1%
	Fine	.125 - .25	**A**	0	0	0	0%	1%
	Medium	.25 - .50	**N**	0	0	0	0%	1%
	Coarse	.50 - 1.0	**D**	2	0	2	2%	3%
.04 -.08	Very Coarse	1.0 - 2.0	**S**	0	0	0	0%	3%
.08 - .16	Very Fine	2.0 - 4.0		0	0	0	0%	3%
.16 - .22	Fine	4.0 - 5.7	**G**	0	0	0	0%	3%
.22 - .31	Fine	5.7 - 8.0	**R**	3	0	3	3%	6%
.31 - .44	Medium	8.0 - 11.3	**A**	5	0	5	5%	11%
.44 - .63	Medium	11.3 - 16.0	**V**	8	0	8	8%	19%
.63 - .89	Coarse	16.0 - 22.6	**E**	13	0	13	13%	32%
.89 - 1.26	Coarse	22.6 - 32.0	**L**	14	0	14	14%	46%
1.26 - 1.77	Very Coarse	32.0 - 45.0	**S**	20	0	20	20%	66%
1.77 - 2.5	Very Coarse	45.0 - 64.0		17	0	17	17%	83%
2.5 - 3.5	Small	64 - 90	**C**	9	0	9	9%	92%
3.5 - 5.0	Small	90 - 128	**O**	8	0	8	8%	100%
5.0 - 7.1	Large	128 - 180	**B**	0	0	0	0%	100%
7.1 - 10.1	Large	180 - 256	**L**	0	0	0	0%	100%
10.1 - 14.3	Small	256 - 362	**B**	0	0	0	0%	100%
14.3 - 20	Small	362 - 512	**L**	0	0	0	0%	100%
20 - 40	Medium	512 - 1024	**D**	0	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	**R**	0	0	0	0%	100%
	Bedrock		**BDRK**	0	0	0	0%	100%
			Totals	**100**	**0**	**100**	**100%**	**100%**



RIFFLE PAVEMENT PEBBLE COUNT									
Site: Little Bugaboo Creek - Tributary Channel						2/14/2002			
Party: Ben Goetz, Heather Wallace, Dan Clinton						Reach: WRP Restoration			
				Particle Counts					
Inches	Particle	Millimeter		Riffles	Pools	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	0	0	0	0%	0%
	Very Fine	.062 - .125	S	0	0	0	0%	0%
	Fine	.125 - .25	A	0	0	0	0%	0%
	Medium	.25 - .50	N	1	0	1	1%	1%
	Coarse	.50 - 1.0	D	5	0	5	5%	6%
.04 -.08	Very Coarse	1.0 - 2.0	S	2	0	2	2%	8%
.08 - .16	Very Fine	2.0 - 4.0		3	0	3	3%	11%
.16 - .22	Fine	4.0 - 5.7	G	3	0	3	3%	14%
.22 - .31	Fine	5.7 - 8.0	R	5	0	5	5%	19%
.31 - .44	Medium	8.0 - 11.3	A	10	0	10	10%	29%
.44 - .63	Medium	11.3 - 16.0	V	6	0	6	6%	35%
.63 - .89	Coarse	16.0 - 22.6	E	11	0	11	11%	46%
.89 - 1.26	Coarse	22.6 - 32.0	L	18	0	18	18%	64%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	12	0	12	12%	76%
1.77 - 2.5	Very Coarse	45.0 - 64.0		11	0	11	11%	87%
2.5 - 3.5	Small	64 - 90	C	9	0	9	9%	96%
3.5 - 5.0	Small	90 - 128	O	1	0	1	1%	97%
5.0 - 7.1	Large	128 - 180	B	3	0	3	3%	100%
7.1 - 10.1	Large	180 - 256	L	0	0	0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0	0	0	0%	100%
14.3 - 20	Small	362 - 512	L	0	0	0	0%	100%
20 - 40	Medium	512 - 1024	D	0	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0	0	0	0%	100%
	Bedrock		BDRK	0	0	0	0%	100%
			Totals	**100**	**0**	**100**	**100%**	**100%**



APPENDIX C

BASIN CREEK REFERENCE REACH DATA

BASIN CREEK REFERENCE REACH - Rosgen Type C4
Location: Wilkes County, NC - Take Traphill Road to Long Bottom Road (SR 1737)
Reach: Station 0+00 at confluence of Basin and Cove Creeks
Quad Sheet: Whitehead, NC **Drainage Area:** 7.2 sq. mi.

Length	Riffles	Runs	Glides	Pools	
	42	10	13	17	
	43	18	15	38	
	30	32	16	42	
	32	45	23	53	
	175	64			
	245				
Total	567	169	67	150	953
Avg	94.5	33.8	16.8	37.5	
%	59%	18%	7%	16%	
%Riffles & Glides =	84%				

Channel Dimensions:

Riffle Depth (ft)	2.1	Riffle Width (ft)	33.2	Riffle Area (sq ft)	68.4
Run Depth (ft)	2.2	Run Width (ft)	44.8	Run Area (sq ft)	97.7
Glide Depth (ft)	2.7	Glide Width (ft)	38.3	Glide Area (sq ft)	98.7
Pool Depth (ft)	2.7	Pool Width (ft)	50.3	Pool Area (sq ft)	109.6

Ratios:

Pool Depth/Riffle Depth =	1.3	
Pool Width/Riffle Width =	1.5	
Pool Area/Riffle Area =	1.6	
Max Pool Depth/Mean Bankfull Depth =	2.3	
Lowest Bank Height/Max Bankfull Depth=	1.0 to 1.3	Mean value 1.2

Streamflow:

Est Mean Velocity @ BKF (ft/sec) =	5.5
Est Discharge @ BKF (cfs) =	375

Channel Pattern:

Meander Length (ft)	350	Belt Width (ft)	60	Radius of Curvature (ft)	44.3
			59		69.3
			75		40.1
Total	350	Total	194	Total	153.7
Average	350	Average	64.7	Average	51.2

Ratios:

MWR = belt width/bkf width =	1.9
Rc/bkf width =	1.5
Lm/bkf width =	10.5

Channel Profile:

Valley Slope (ft/ft) =		Avg Water Surface Slope (ft/ft) =	0.01437
Riffle Slope (ft/ft) =	0.02082	Pool Slope (ft/ft) =	0.001942
Run Slope (ft/ft) =	0.003064	Glide Slope (ft/ft) =	0.006473

Pool to Pool Spacing (ft)	334	Pool Length (ft)	17
	310		38
	271		42
			53
Sum	915	Sum	150
Average	305.0	Average	37.5

Ratios:

Riffle slope/Avg WS slope =	1.4
Run slope/Avg WS slope =	0.2
Pool slope/Avg WS slope=	0.1
Glide slope/Avg WS slope=	0.5
Glide depth/mean bkf depth =	1.3
Pool length/bkf width =	1.1
Pool to Pool spacing/bkf width =	9.2
Pebble Count	

Date: 10/28/1998
Party: Dick Everhart, Jerry Pate, Greg Goings and Joe Mickey

	Particle	Size(mm)	Total #	% Cum.	Cumulative (finer than)
	Silt/Clay	<0.062	2	2	0.062
SAND	Very Fine	0.062-0.125	8	10	0.125
	Fine	0.125-0.25	12	22	0.25
	Medium	0.25-0.50	4	26	0.5
	Course	0.50-1.0	0	26	1
	Very Course	1.0-2.0	0	26	2
GRAVEL	Very Fine	2-4	1	27	4
	Fine	4-5.7	0	27	5.7
	Fine	5.7-8	1	28	8
	Medium	8-11.3	1	29	11.3
	Medium	11.3-16	2	31	16
	Course	16-22.6	1	32	22.6
	Course	22.6-32	4	36	32
	Very Course	32-45	11	47	45
	Very Course	45-64	6	53	64
COBB	Small	64-90	12	65	90
	Small	90-128	9	74	128
	Large	128-180	10	84	180
	Large	180-256	8	92	256
BOULD	Small	256-362	4	96	362
	Small	362-512	2	98	512
	Medium	512-1024	0	98	1024
	Large-Vry Lrg	1024-2048	0	98	2048
	Bedrock	>2048	2	100	3000
				100	

Channel Materials:

% Sand = 26
% Gravel = 27
% Cobble = 39
% Boulder = 6
% Bedrock = 2

D16 = 0.17 mm
D35 = 29 mm
D50 = 58 mm
D84 =180 mm
D95 = 300 mm

APPENDIX D

BIG BRANCH REFERENCE REACH DATA

REFERENCE REACH SURVEY
Stream Name: **Big Branch**
Location:
Purpose: Longitudinal Profile and Cross-section measurements for Graduate Work
Date: 8/12/1999
Crew: Dan Clinton, Jan Patterson, Jim Buck
Ending Point LAT/LONG:
Watershed Area: 1.9 sq mi **STREAM TYPE: E4**

REFERENCE REACH Summary Data

Channel Dimensions

	Mean	Median	Min	Max
Max. Riffle Depth(drmax)(ft.):	2.6	2.6	1.4	1.5
Riffle Width(Wr)(ft.):	20.8	20.8	0.0	0.0
Riffle X-Sect. Area(Ar)(ft^2):	41.8	41.8	15.0	15.5
Riffle Mean Bankfull Depth(dmbkf):	2.0	2.0	0.9	0.9

	#1	#2
Max. Pool Depth(dpmax)(ft.):	4.0	3.5
Pool Width(Wp)(ft.):	17.8	19.0
Pool X-Sect. Area(Ap)(ft.):	51.7	51.0

	Mean	Median	Min	Max
Ratio: Max. Pool Depth/Max. Riffle Depth(dpmax/drmax):	1.53	1.53	2.49	2.64
Ratio: Pool Width/Riffle Width(Wp/Wr):	0.86	0.86	-	-
Ratio: Pool Area/Riffle Area(Ap/Ar):	1.24	1.24	3.45	3.34
Ratio: Max. Pool Depth/Mean Bankfull Depth(dpmax/dbkf):	1.96	1.96	4.40	4.40
Ratio: Lowest Bank Height/Max. Bankfull Depth(Bhlow/dmbkf):	1			
Streamflow: Estimated Mean Velocity(u) @ Bankfull Stage:		ft./sec.		
Streamflow: Estimated Discharge(Q) @ Bankfull Stage:		CFS		

Channel Pattern

	Mean	Median	Min	Max	
Meander Wavelength(Lm):	54	55	42	63	ft.
Radius of Curvature(Rc):	223	223	185	260	ft.
Beltwidth(Wblt):	37	37	31	44	ft.
Meander Width Ratio(MWR=Wblt/Wbkf):	1.80	1.80	-	-	
RATIO: Radius of Curvature/Bankfull Width(Rc/Wbkf):	10.72	10.72	-	-	
RATIO: Meander Wavelength/Bankfull Width(Lm/Wbkf):	2.58	2.67	-	-	

Channel Profile

	Mean	Median	Min	Max	
Valley Slope:	0.0087	ft./ft			
Water Surface Slope:	0.0087	ft./ft			
Riffle Slope:	0.0169	0.0163	0.02	0.0192	ft./ft
Pool Slope:	0.0001	0.0000	0.0000	0.0004	ft./ft
Run Slope:	0.0011	0.0011	0.001	0.0011	ft./ft
Glide Slope:	0.0015	0.0015	0.00	0.0030	ft./ft
Riffle Length:	58.5	74.0	23.4	78.0	ft.
Pool Length:	26.9	25.0	23.6	32.0	ft.
Run Length:	66.0	66.0	66.0	66.0	ft.
Glide Length:	9.0	9.0	8.0	10.0	ft.
Riffle to Riffle Spacing:	128.2	128.2	82.3	174.0	ft.
Pool to Pool Spacing:	138.7	138.7	97.5	179.8	ft.
Riffle to Pool Spacing:	63.0	44.5	23.5	121.0	ft.

	Mean	Median	Min	Max
RATIO: Riffle Slope/ Water Surface Slope:	1.95	1.87	1.76	2.21
RATIO: Pool Slope/Water Surface Slope:	0.02	0.00	0.00	0.05
RATIO: Run Slope/Water Surface Slope:	0.12	0.12	0.12	0.12
RATIO: Glide Slope/ Water Surface Slope:	0.17	0.17	0.00	0.34
RATIO: Max. Riffle Depth/Mean Bankfull Depth:	1.28			
RATIO: Max.Pool Depth/Mean Bankfull Depth:	1.96			
RATIO: Max. Run Depth/Mean Bankfull Depth:	n/a			
RATIO: Max. Glide Depth/Mean Bankfull Depth:	n/a			
RATIO: Riffle Length/Bankfull Width:	2.82	3.57	1.13	3.76
RATIO: Pool Length/Bankfull Width:	1.29	1.20	1.14	1.54
RATIO: Run Length/Bankfull Width:	3.18	3.18	3.18	3.18
RATIO: Glide Length/Bankfull Width:	0.43	0.43	0.39	0.48
RATIO: Riffle to Riffle Spacing/Bankfull Width:	6.18	6.18	3.97	8.39
RATIO: Pool to Pool Spacing/Bankfull Width:	6.68	6.68	4.70	8.67
RATIO: Riffle to Pool Spacing/Bankfull Width:	3.04	2.14	1.13	5.83

D84:	84	mm	Stretch
dmbkf:	610	mm	
dmbkf/D84:	7.26		
u/u* :	7.3	Reference: Rosgen Reference Reach Field Book	
Mannings 'n':	0.033	"	

REFERENCE REACH SURVEY
Stream Name: Big Branch
Location: Tributary to the Little Fisher River on Blevins Store Road past Red Hill Creek
Purpose: Longitudinal Profile and Cross-section measurements for Graduate Work
Date: 8/12/1999
Crew: Dan Clinton, Jan Patterson, Jim Buck
Ending Point LAT/LONG:
Watershed Area: 1.9 sq. miles **STREAM TYPE:** E4

LONGITUDINAL PROFILE
(Using Level)

Bench Mark #1=	100	ft.					
BS = 4.79	HI =	104.79	BM1 is nail at base of hemlock				
TP1 BS= 4.68	TP1 HI=	104.30	TP1 FS=	5.17	TP1 El.=	99.62	
TP2 BS= 3.97	TP2 HI=	102.81	TP2 FS=	5.46	TP2 El.=	98.84	
TP3 BS= 5.39	TP3 HI=	104.23	TP3 FS=	3.97	TP3 El.=	98.84	
TP4 BS= 4.8	TP4 HI=	104.41	TP4 FS=	4.62	TP4 El.=	99.61	
			FS to BM= 4.41		BM El.=	100.00	
					ERROR=	0.00	

TR= Top of riffle
TP=Top of Pool
TG= Top of glide
Trun= Top of Run
MP= Max Pool
LBKF = Left Bankfull
RBKF= Right Bankfull
TW= Thal Wag
LEW= Left Edge of Water
REW= Right Edge of Water

Distance	Thawl Wag (FS)	Thawl Wag Elev.	Water Surface (FS)	Water Surface Elev.	LBKF (FS)	BKF Elev.	IB (FS)	IB Elev.	Notes			Mid Feature Location	Feature
0.0	7.6	97.2	7.25	97.5	5.2	99.6			TR			11.7	R
3.0	7.5	97.3	7.27	97.5	5.0	99.8			x-sect #1				
11.0	7.7	97.1	7.50	97.3	5.4	99.4							
23.4	7.9	96.9	7.70	97.1	5.5	99.3	6.54	98.3	TP			35.2	P
35.0	9.2	95.6	7.62	97.2					X-Sect #2				
41.0	9.5	95.3	7.67	97.1	5.6	99.2			Pmax				
47.0	8.9	95.9	7.66	97.1	5.2	99.6			TG			51.0	G
55.0	8.0	96.8	7.64	97.2	5.3	99.5			TR			94.0	R
84.0	8.5	96.3	8.09	96.7	5.7	99.1							
92.0	8.4	96.4	8.11	96.7	5.7	99.1	7.17	97.6	X-Sect#3				
133.0	9.2	95.6	8.91	95.9	6.5	98.3	8.1	96.7	Trun			166.0	Run
166.0	9.4	94.9	8.45	95.9	6.1	98.2	7.4	96.9					
199.0	8.8	95.5	8.49	95.8	6.1	98.2			TP			215.0	P
216.0	9.3	95.0	8.47	95.8	6.0	98.3	7.75	96.6	Pmax				
231.0	8.8	95.5	8.49	95.8					TR			268.0	R
259.0	7.7	95.1	7.33	95.5	5.2	97.7							
305.0	8.4	94.5	8.13	94.7	5.7	97.1			TP			312.5	P
313.0	9.2	93.6	8.17	94.6	5.7	97.1	7.1	95.7	X-sect #4				
315.0	9.4	93.4	8.14	94.7					Pmax				
320.0	9.0	93.8	8.11	94.7					TG			325.0	G
330.0	8.5	94.3	8.14	94.7	5.7	97.1	7.35	95.5	TR				R

SLOPE & LENGTH OF FEATURES CALCULATIONS

Riffles

Number	Length	Elevation Change	Slope
1	23.4	0.5	0.0192
2	78.0	1.3	0.0163
3	74.0	1.1	0.0153
4			
5			
6			
7			
8			
9			
10			
	58.5	Mean	0.0169
	74.0	Median	0.0163
	23.4	Min	0.0153
	78.0	Max	0.0192

Riffles to Riffle

Number	Spacing (mid to mid)
1	82.3
2	174.0
3	
4	
5	
6	
7	
8	
9	
10	
Mean	128.2
Median	128.2
Min	82.3
Max	174.0

Pools

Number	Length	Elevation Change	Slope
1	23.6	0.0	0.0000
2	32.0	0.0	0.0000
3	25.0	0.0	0.0004
4			
5			
6			
7			
8			
9			
10			
	26.9	Mean	0.0001
	25.0	Median	0.0000
	23.6	Min	0.0000
	32.0	Max	0.0004

Pool to Pool (mid to mid)

Number	Spacing
1	179.8
2	97.5
3	
4	
5	
6	
7	
8	
9	
10	
Mean	138.7
Median	138.7
Min	97.5
Max	179.8

Glides

Number	Length	Elevation Change	Slope
1	8.0	0.0	0.0000
2	10.0	0.0	0.0030
3			
4			
5			
6			
7			
8			
9			
10			
	9.0	Mean	0.0015
	9.0	Median	0.0015
	8.0	Min	0.0000
	10.0	Max	0.0030

Riffle to Pool (mid to mid)

Number	Spacing
1	23.5
2	121.0
3	44.5
4	
5	
6	
7	
8	
9	
10	
Mean	63.0
Median	44.5
Min	23.5
Max	121.0

Runs

Number	Length	Elevation Change	Slope
1	66.0	0.1	0.0011
2			
3			
4			
5			
6			
7			
8			
9			
10			
	66.0	Mean	0.0011
	66.0	Median	0.0011
	66.0	Min	0.0011
	66.0	Max	0.0011

X_SECTION MEASUREMENTS

Riffle X-Section #1

Location : 0+03

HI= 104.79 (arbitrary… used depth off rod)

Distance	FS	Elev	Notes	Depth from BKF	Width	Area
0	0.6	104.2				
7	3.8	101.0				
12	4	100.8				
15	4.2	100.6				
17	4.4	100.4	LTOB			
19.5	5	99.8	LBKF	0.0	0.0	0.0
21	5.8	99.0		0.8	1.5	0.6
21.2	7.5	97.3	LEW	2.5	0.2	0.3
23	7.5	97.3	TW	2.5	1.8	4.5
26	7.4	97.4		2.4	3.0	7.4
29	7.4	97.4		2.4	3.0	7.2
30.5	7.27	97.5	REW/WS	2.3	1.5	3.5
34	7.1	97.7		2.1	3.5	7.6
36	6.9	97.9		1.9	2.0	4.0
38.5	7.1	97.7		2.1	2.5	5.0
41	5	99.8	RBKF	0.0	2.5	2.6
43	4.4	100.4			TOTAL	42.8
46	3.6	101.2	RTOB			
50	3.8	101.0				
56	4.2	100.6				
64.5	3.8	101.0				

BKF Width =	**21.5**
Area =	**42.8**
Max. depth =	**2.5**
FPW =	**130**
ER =	**6.0**
Mean Depth=	**2.0**
Width/Depth Ratio=	**10.8**
Sinuosity=	**1.1**
Water Surface Slope=	**0.0087**
Stream Type = E4	

Riffle X-Section #2

Location : 0+92

HI= 100.02 (arb.)

Distance	FS	Elevation	Notes	Depth from BKF	Width	Area
0.0	0.0	100.0				
5.0	1.1	98.9				
9.0	0.6	99.4				
11.0	0.4	99.6				
13.0	0.7	99.3	LTOB			
14.0	0.9	99.1	LBKF	0.0	0.0	0.0
16.0	2.1	97.9		1.2	2.0	1.2
16.7	2.7	97.3		1.8	0.7	1.0
16.8	3.6	96.4	LEW	2.7	0.1	0.2
18.8	3.5	96.5		2.6	2.0	5.2
21.0	3.3	96.7		2.4	2.2	5.4
23.3	3.4	96.6		2.5	2.3	5.5
28.2	3.6	96.4	TW	2.7	4.9	12.5
30.7	3.34	96.68	REW/WS	2.4	2.5	6.3
31.1	2.4	97.6	RIB	1.5	0.4	0.8
32.3	2.2	97.8		1.3	1.2	1.6
34	0.94	99.1	RBKF	0.0	1.7	1.1
37	0.1	99.9	RTOB			

BKF Width =	**20.0**
Area =	**40.9**
Max. depth =	**2.7**
FPW =	**130.0**
ER =	**6.5**
Mean Depth=	**2.0**
Width/Depth Ratio=	**9.8**
Stream Type = E4	

sum: 40.9 sq. ft.

Pool X-Section #1
Location : 0+35
HI= 100 (arb.)

Distance	FS	Elev	Notes	Depth from BKF	Width	Area
0.0	1.8	98.2				
3.0	3.6	96.4				
6.4	4.5	95.5				
10	4.9	95.1				
23	4.9	95.1				
24.5	4.8	95.2				
26	5.1	94.9	LTOB			
26.5	5.24	94.76	LBKF	0	0	0
27	5.59	94.41		0.4	0.5	0.1
29	6.8	93.2		1.6	2	1.9
29.2	7.9	92.1	LEW	2.7	0.2	0.4
32	8.2	91.8		3.0	2.8	7.9
35	9.1	90.9		3.9	3	10.2
37	9.2	90.8	TW	4.0	2	7.8
40	9	91		3.8	3	11.6
43	7.62	92.38	REW/WS	2.4	3	9.2
44.2	7.2	92.8		2.0	1.2	2.6
44.3	5.24	94.76	RBKF	0.0	0.1	0.1
44.4	5	95				
46	3.9	96.1	RTOB	sum:	51.7	sq. ft.

BKF Width =	17.8
Area =	51.7
Max. depth =	4.0
Mean Depth=	2.9
Width/Depth Ratio=	6.1

Pool X-Section #2
Location : 3+13
HI= 104.79 (arbitrary… used depth off rod)

Distance	FS	Elev	Notes	Depth from BKF	Width	Area
0	5.53	99.3				
0.5	5.72	99.1	LBKF	0.0	0.0	0.0
2	8.17	96.6	LEW/WS	2.5	1.5	1.8
4	8.87	95.9		3.2	2.0	5.6
7	9.2	95.6	TW	3.5	3.0	9.9
9	9.15	95.6		3.4	2.0	6.9
10	9.19	95.6		3.5	1.0	3.5
12	9.03	95.8		3.3	2.0	6.8
14	8.81	96.0		3.1	2.0	6.4
17	8.39	96.4	REW	2.7	3.0	8.6
17.1	7.1	97.7	RIB	1.4	0.1	0.2
18	6.35	98.4		0.6	0.9	0.9
18.8	5.79	99.0		0.1	0.8	0.3
19.5	5.72	99.1	RBKF	0.0	0.7	0.0
21	5.21	99.6	RTOB		TOTAL	51.0

BKF Width =	19.0
Area =	51.0
Max. depth =	3.5
FPW =	130
ER =	6.8
Mean Depth=	2.7
Width/Depth Ratio=	7.1
Stream Type = E4	

X-Section Summary Sheet

Riffle X-Section

	Mean	Median	Maximum	Minimum
BKF Width =	20.8	20.8		
Area =	41.8	41.8	15.5	15
Max. depth =	2.6	2.6	1.5	1.4
FPW =	130	130.0	53.0	50
ER =	6.3	6.3	3.3	3
Mean Depth=	2.0	2.0	0.9	0.9
Width/Depth Ratio=	10.3	10.3	18.0	17.5

Sinuosity=	1.1
Water Surface Slope=	0.0087
Stream Type =	E4

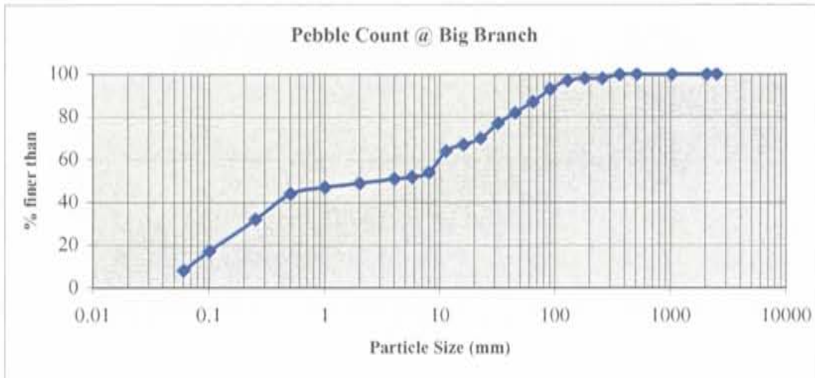
Pool X-Section

	#1	#2		
BKF Width =	17.8	19.0		
Area =	51.7	51.0		
Max. depth =	4.0	3.5		
Mean Depth=	2.9	2.7		
Width/Depth Ratio=	6.1	7.1		

Pebble Count

Site: Big Branch
Date: 8/12/1999
Party: Jim Buck, Jan Patterson, Dan Clinton

	Particle	Size(mm)	Total #	% Cum.
	Silt/Clay	<0.062	8	8
SAND	Very Fine	0.062-0.125	9	17
SAND	Fine	0.125-0.25	15	32
SAND	Medium	0.25-0.50	12	44
SAND	Course	0.50-1.0	3	47
SAND	Very Course	1.0-2.0	2	49
GRAVEL	Very Fine	2-4	2	51
GRAVEL	Fine	4-5.7	1	52
GRAVEL	Fine	5.7-8	2	54
GRAVEL	Medium	8-11.3	10	64
GRAVEL	Medium	11.3-16	3	67
GRAVEL	Course	16-22.6	3	70
GRAVEL	Course	22.6-32	7	77
GRAVEL	Very Course	32-45	5	82
GRAVEL	Very Course	45-64	5	87
COBB	Small	64-90	6	93
COBB	Small	90-128	4	97
COBB	Large	128-180	1	98
COBB	Large	180-256	0	98
BOULD	Small	256-362	2	100
BOULD	Small	362-512	0	100
BOULD	Medium	512-1024	0	100
BOULD	Large-Vry Lrg	1024-2048	0	100
	Bedrock	>2048	0	100
			100	100



D16: 0.06 mm
D50: 3 mm
D84: 50 mm
*all numbers extrapolated from data

Meander Geometry Data

Site: Big Branch
Date: 8/12/1999
Party: Jim Buck, Jan Patterson, & Dan Clinton

RADIUS OF CURVATURE

Meander	Mid-Ordinate(M)	Cord Length(C)	Rad. Of Curvature
1	1.2	20	42.3
2	3.6	42	63.1
3	1.8	28	55.3

Mean	54
Median	55
Max	63
Min	42

Meander Wavelength

1	185 ft.
2	260 ft.
Mean	222.5 ft.
Median	222.5 ft.
Max	260 ft.
Min	185 ft.

Belt Width

1	30.5 ft.
2	44 ft.
3	ft.
Mean	37.25 ft.
Median	37 ft.
Max	44 ft.
Min	31 ft.

Valley Length: 312 ft.