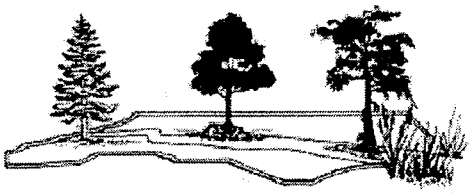

N.C. Wetlands Restoration Program
NCDENR DWQ

BILLY'S CREEK STREAM RESTORATION PLAN

AUGUST 11, 2003

PREPARED BY:

URS

URS Corporation - North Carolina
1600 Perimeter Park Drive
Morrisville, NC 27560

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1. INTRODUCTION

The North Carolina Wetlands Restoration Program (NCWRP) plans to restore a portion of an unnamed tributary to Billy's Creek in Franklin County. Billy's Creek is located in the Tar River drainage basin. Billy's Creek is considered Class WS-IV; NSW waters (Index No. 28-20) according to NC Division of Water Quality. The project site is located in the Piedmont hydrophysiographic province of North Carolina northwest of the city limits of Franklinton in Franklin County (Figure 1). The area is located in the Northern Outer Piedmont Ecoregion of North Carolina (Griffith, et al, 2002). The stream flows through agricultural land and has been significantly impacted by livestock grazing within the watershed, livestock utilization of the stream for watering, and removal of some of the riparian vegetation. The channel has been modified and the floodplain drained to facilitate the construction of a pond. The pond was never constructed. The section of stream where this restoration project will be conducted is found on the Kittrell USGS 7.5-minute quadrangle map.

2. GOALS AND OBJECTIVES

The North Carolina Wetlands Restoration Program has the following goals and objectives for the Billy's Creek Stream Restoration project.

1) To restore the tributary to Billy's Creek to a more natural dimension, pattern and profile so that the stream will be able to fully transport water and sediment loads provided by the watershed.
2) To reconnect the channel to it's historic floodplain where feasible.
3) To eliminate the excessive sediment contribution to the system by the mass wasting and erosion of the stream banks along the reach.
4) To repair and restore the riparian corridor along Billy's Creek in order to improve habitat and protect the stream from further erosion.

3. SITE LOCATION

The section of stream channel included in this restoration project is located south of SR 1210 (Montgomery Road), approximately three miles east of US 1 to the northeast of Franklinton on property privately held by the Grove family. The reach runs north to south through pasture. Unpaved farm roads demarcate the north and south end of the project reach (Figure 1). The reach flows approximately 2000 feet from the northern property line to the fence line near the southern border of the property.

4. GENERAL WATERSHED DESCRIPTION

4.1 Watershed Drainage Area

The drainage area for the tributary to Billy's Creek is approximately 143 acres or 0.22 square miles (Figure 2). A ridge approximately 800 feet north of Montgomery Road forms the north boundary of the project watershed. Montgomery Road (SR 1210) runs east-west through the northern third of the watershed. The watershed can be roughly divided in half by the unpaved

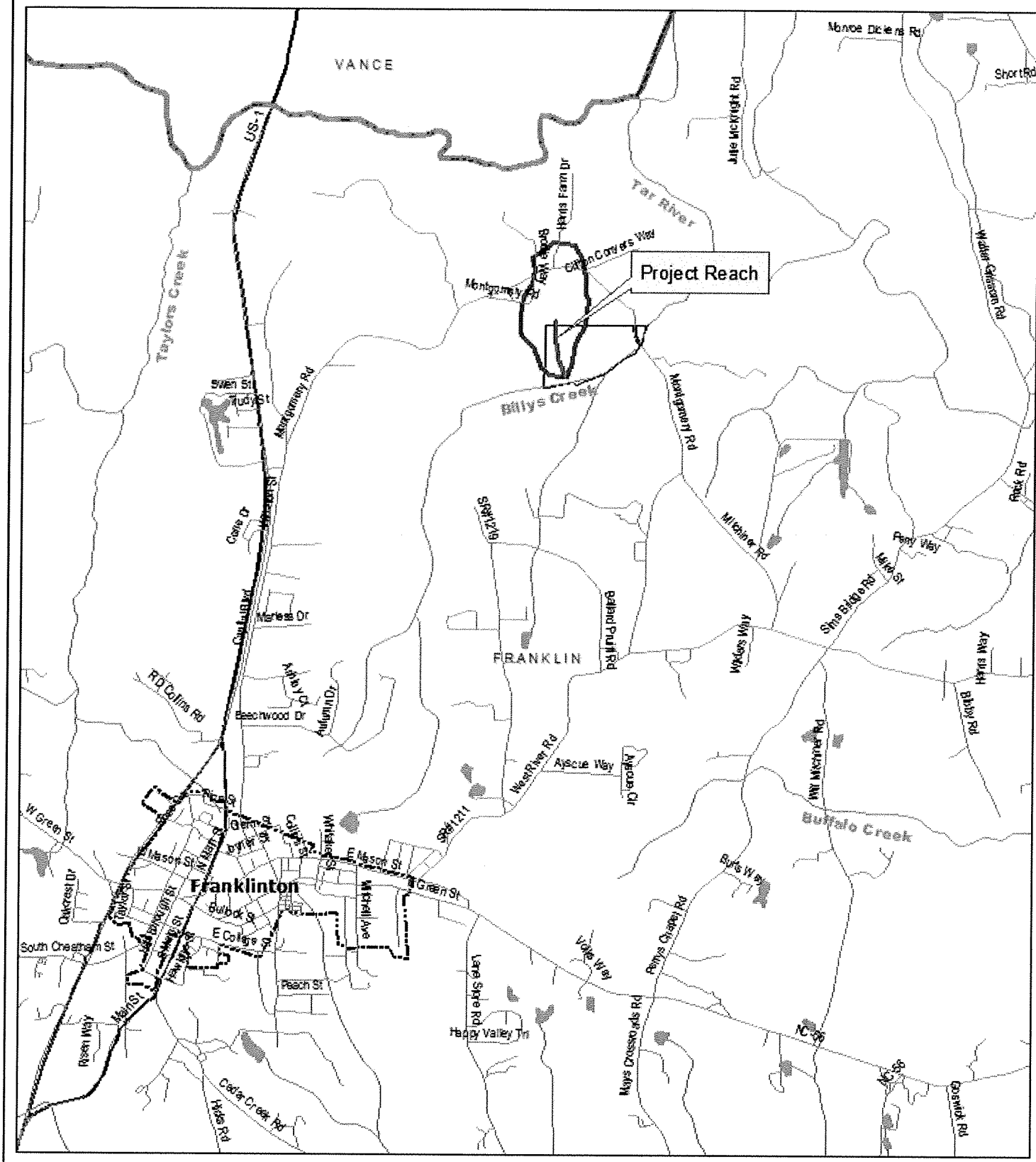
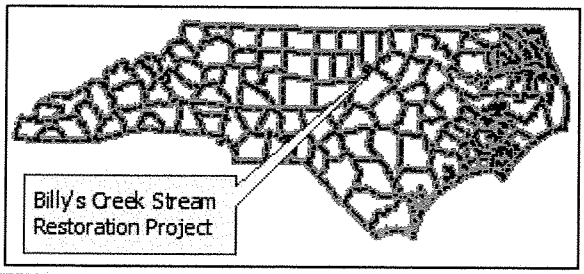


Figure 1 - Site Location
Billy's Creek Stream Restoration Project

NC Wetlands Restoration Program



- Project Reach
- Water Course
- Unnamed Tributary to Billy's Creek
- Water Body
- Parcel
- Municipal Boundary
- County Boundary

N

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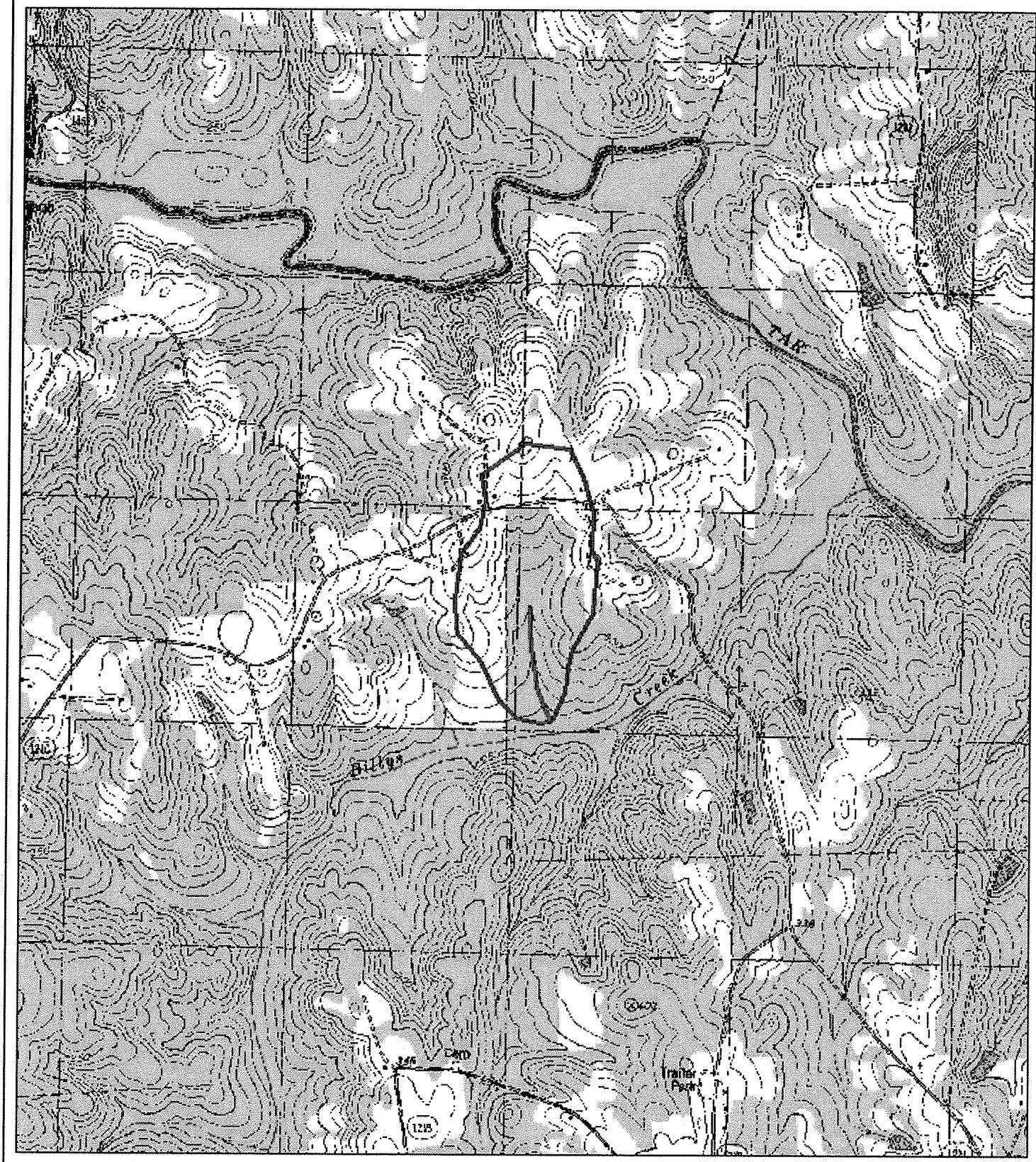
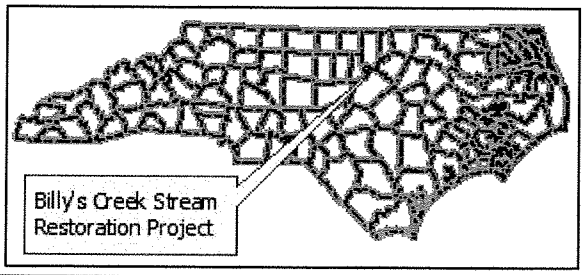


Figure 2 - Watershed Area
Billy's Creek Stream Restoration Project

NC Wetlands Restoration Program



Project Reach
Unnamed Tributary to Billy's Creek

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US Topo Quad: Kittrell (1979)

URS

farm road that crosses east-west at the north end of the restoration project reach. Ridges from the northernmost point form the watershed's western and eastern edges as they slope down toward Billy's Creek. The south end of project watershed is at the point where an unpaved farm road crosses the subject channel approximately 300 feet upstream from the confluence with Billy's Creek.

4.2 Soils of the Watershed

According to the *United States Department of Agriculture Natural Resources Conservation Service, Soil Survey of Franklin County, North Carolina,* Wedowee is the primary soil unit that is dominant within the watershed (1998) (Figure 3). The Wedowee unit consists of well-drained, yellowish-brown to brownish yellow loamy soils found on uplands. The major soil types found in the tributary to Billy's Creek watershed include:

- Altavista (Fine-loamy, mixed, semiactive, thermic Aquic Hapludults) – (11.4 percent of the watershed). The series consists of typically sandy or loamy sediment. The soil is moderately well drained, nearly level and gently sloping soils on low stream terraces. The soil formed in alluvial deposits.
- Cecil (Fine, kaolinitic, thermic Typic Kanhapludults) – (8.2 percent of the watershed). The soil consists of sandy or clay loams. The series has well-drained, gently sloping to strongly sloping soils of the uplands. They formed in residuum that weathered from granite, gneiss, and other acidic rocks.
- Chewacla and Wehadkee - (16.7 percent of the watershed).

  Chewacla (Fine-loamy, mixed, active, thermic Fluvaquentic Dystrudepts) – The series consists of nearly level, somewhat poorly drained soils of the stream flood plains and formed in recent alluvium. This soil is classified as a hydric soil.

  Wehadkee (Fine-loamy, mixed, active, nonacid, thermic Fluvaquentic Endoaquepts) The series consists of very deep, poorly drained and very poorly drained soils on flood plains along streams. They are formed in loamy sediments.
- Pacolet (Fine, kaolinitic, thermic Typic Kanhapludults) – (2.4 percent of the watershed). These are fine sandy loams to clay loams. They are well-drained, gently sloping to steep soils of the uplands. They formed in residuum from weathered granite, mica gneiss, schist, and other acidic rocks.
- Wake-Saw-Wedowee Complex – (7.3 percent of the watershed).

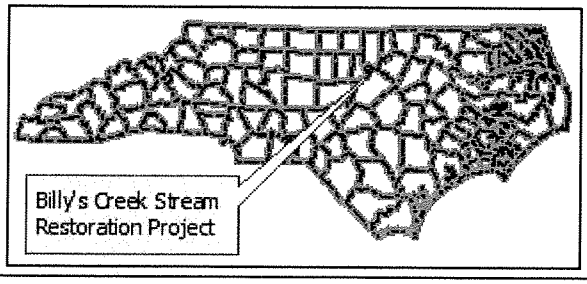
  Wake (Mixed, thermic Lithic Udipsamments). This series consists of excessively drained, shallow, sandy soil on uplands of the Southern Piedmont. The soil formed in residuum weathered from igneous and high-grade metamorphic rocks such as granite and gneiss.

  Saw (Fine, kaolinitic, thermic Typic Kanhapludults). This series consists of moderately deep, well drained soils on ridges and side slopes of uplands. They formed in residuum weathered from felsic igneous rocks such as porphyritic granite and granite.

  Wedowee (Fine, kaolinitic, thermic Typic Kanhapludults). The soil is a sandy loam. The series is a very deep, well drained soil that formed in residuum from weathered crystalline rock of the Piedmont Plateau.

Figure 3 - Soils of the Watershed
Billy's Creek Stream Restoration Project

NC Wetlands Restoration Program



Project Reach
Water Course
Unnamed Tributary to Billy's Creek

Soil

AaA, Altavista
ApB, Appling
CaB, Cecil
CaC, Cecil
CeB2, Cecil
ChA, Chewacla
HeB, Helena
PaC2, Pacolet
PaD2, Pacolet
W, Water
WaB, Wake
WeB, Wedowee
WeC, Wedowee
WeD, Wedowee
WwB, Winnsboro
WwE, Winnsboro

N

1:12,000

URS

- Wedowee (Fine, kaolinitic, thermic Typic Kanhapludults) – (53.9 percent of the watershed). The soil is a sandy loam. The series consists of very deep, well drained, moderately permeable soils that formed in residuum from weathered crystalline rock of the Piedmont Plateau. These soils are on narrow ridges and on side slopes of uplands.

4.3 Land use and Zoning

4.3.1 Existing Conditions

Agriculture and open space and agriculture and residential comprises almost the entirety of land use within the project area watershed, with a small area of roadway and high density residential (Figure 4, Table 1). Most of the agricultural land is in cattle pasture; however a substantial portion is forested. There are two residences and several farm buildings within the watershed. All of the project area is zoned as an Agricultural-Residential District. This zoning designation permits a mixture of agricultural, forestry, conservation, and very low-density residential uses with few public services (Franklin County, 2003).

Table 1. Land use in project watershed (Franklin County, 2003).

Land Use Type	Acres	Percent of Watershed
Agriculture & Open Space	86.4	60.7
Residential & Agricultural	53.5	37.6
Parking & Transportation	2.25	1.6
High Density Residential	0.3	0.2
Grand Total	142.5	100.0

4.3.2 Future Conditions

Future land use is not expected to differ from current conditions. There is the possibility for further building, as the entire area is zoned for agriculture/residential use, however development of any sort will likely be limited to a few homes or farm related buildings scattered through the area (Franklin County 2003).

4.4 Endangered/Threatened Species Documentation

The project is located in Franklin County on the Kittrell USGS 7.5 minute quadrangle map. The United States Fish and Wildlife Service (USFWS) and North Carolina Natural Heritage Program (NCNHP) databases were searched for known endangered or threatened species on March 26, 2003 (Table 2).

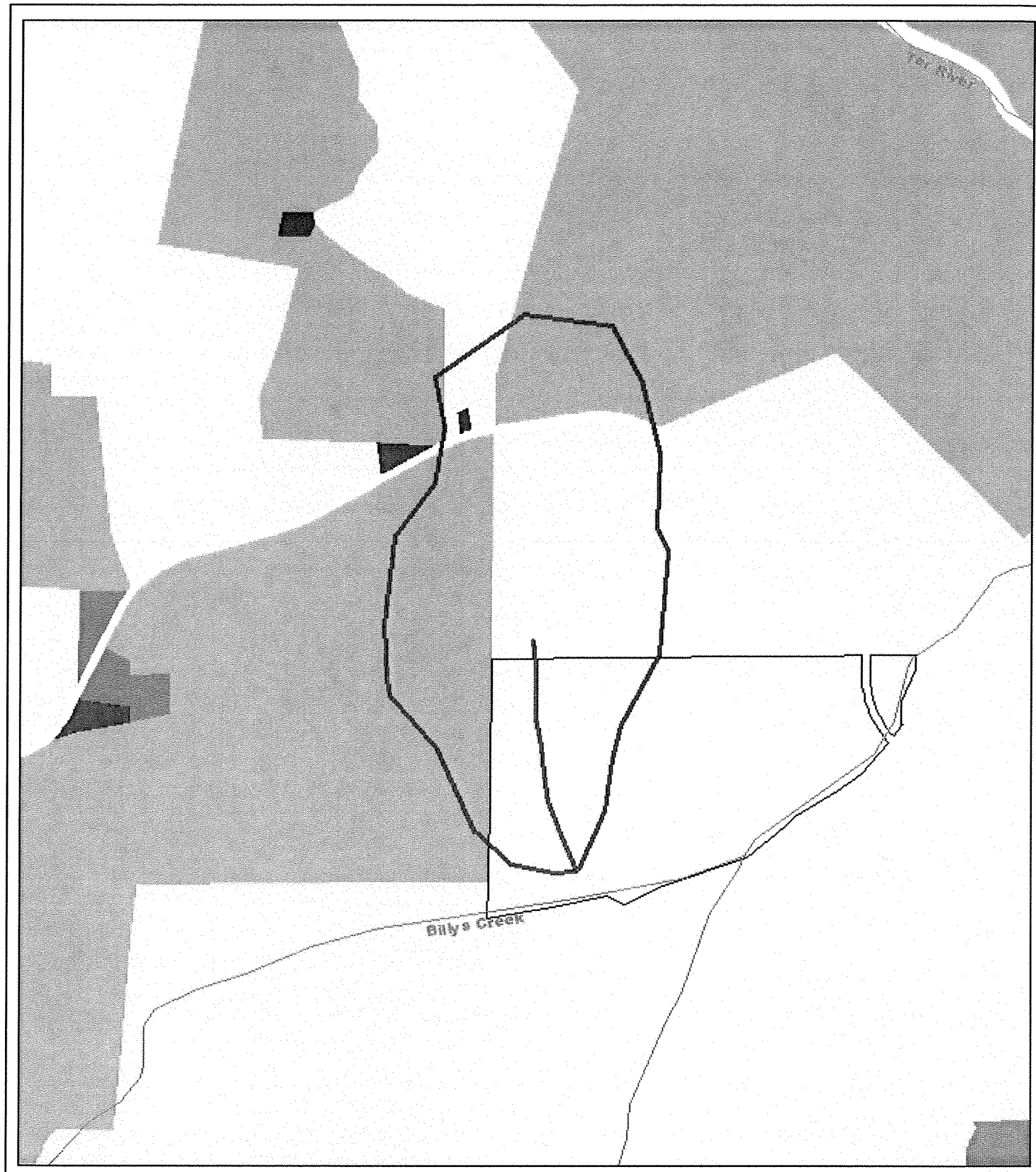
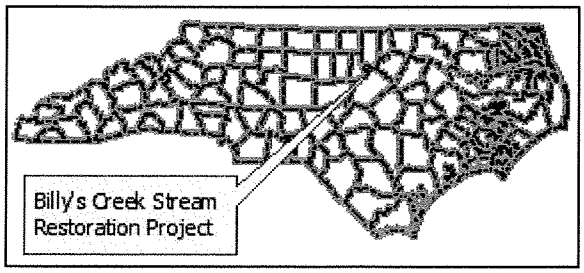


Figure 4 - Land Use within the Watershed
Billy's Creek Stream Restoration Project

NC Wetlands Restoration Program



Project Reach
Water Course
Unnamed Tributary to Billy's Creek
Parcel

LANDUSE

Agriculture & Open Space
Commercial & Industrial
Parking & Transportation
High Density Residential
Medium Density Residential
Residential & Agricultural

N

1:12,000

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Table 2. Endangered and Threatened Species.

Federal and State Protected Plant and Animal Species Potentially Occurring in the Billy's Creek Stream Project Area

Scientific Name	Common Name	Status[1,4] Federal/ State	Found in County[2,3]	Found on Quadrangle[2,3]	Listing Details
FISH					
Lampetra aepyptera	Least Brook Lamprey	NF / T	X		Current in County
MOLLUSKS					
Alasmidonta heterodon	Dwarf Wedgemussel	E / E	X		Current in County
Alasmidonta undulata	Triangle Floater	NF / T	X		Current in County
Elliptio lanceolata	Yellow Lance	FSC / E	X	X	Current in County
Elliptio steinstansana	Tar River Spinymussel	E / E	X		Current in County
Fusconaia masoni	Atlantic Pigtoe	FSC / E	X		Current in County
Lampsilis cariosa	Yellow Lampmussel	FSC / E	X	X	Current in County
Lampsilis radiata radiate	Eastern Lampmussel	NF / T	X		Current in County
Strophitus undulatus	Squawfoot	NF / T	X	X	Current in County
PLANTS					
Camassia scilloides[5]	Wild Hyacinth	NF / T		X	Current on Quad
Isoetes piedmontana	Piedmont Quillwort	NF / T	X		Current in County
Portulaca smallii	Small's Portulaca	NF / T	X		Current in County
Rhus michauxii	Michaux's Sumac	E / E-SC	X		Current in County

[1] All species are Federal or State listed
T = Threatened
E = Endangered

[2] Based on County Distribution Lists

[3] Based on Historic Documented Sightings (Natural Heritage Databases or State Wildlife Agency Databases)

[4] NF=No Federal legal status, FSC=Federal Species of Concern

[5] Found in areas on the quadrangle, but not found in Franklin County.

The search yielded no federally listed Endangered or Threatened species within the quadrangle boundaries; however, three federally listed species are found in the county. Besides those three, the state lists nine other species as State Endangered or Threatened within Franklin County. One species, wild hyacinth (*Camasia scilliodes*), is found on the Kittrell Quadrangle within Vance County and is not known to occur in Franklin County at this time.

There is potential for the wild hyacinth to be found within the particular quadrangle boundaries; however, there are known occurrences of the species in Franklin County. The wild hyacinth is not Federally listed but is State-listed as Threatened. Wild hyacinth habitat includes moist meadows and thickets, rich levees, slopes and bottomlands. The project area does contain

potential wild hyacinth habitat, however, the site is grazed by cattle at this time and it is unlikely that the species could persist. The restoration of the site and restriction of cattle within the stream and surrounding buffer could create habitat for the species in the future.

The Piedmont quillwort (*Isoetes piedmontana*) and Small's Portulaca (*Portulaca smallii*) are State-listed as Threatened. Habitat for the species includes granite flatrocks and diabase glades. Small's Portulaca is generally restricted to granite outcrops that occur along the outer margin of the Piedmont province. The project area does not contain any granite outcrops or diabase glades; therefore, the species will not be affected in any way by the project.

Michaux's sumac (*Rhus michauxii*) is Federally- and State-listed as Endangered. The plant prefers sandhills, sandy forests, woodlands, and woodland edges. The plant tends to grow best in disturbed areas, often found along powerline right of ways, roadsides, and where forests have been opened up by harvest or blowdowns from storms. Although the stream is found within a woodland area, it is not an area that would support Michaux's sumac due to the overhead canopy.

The least brook lamprey (*Lampetra aepyptera*) is State-listed as Threatened. The species is found in the county and habitat includes the Tar and Neuse drainages. The species prefers clean, clear gravel riffles and runs of creeks and small rivers. Although, the fish is found in the county, this tributary to Billy's Creek would not support the fish and it is highly unlikely that the species will be affected in any way by restoration of this stream reach.

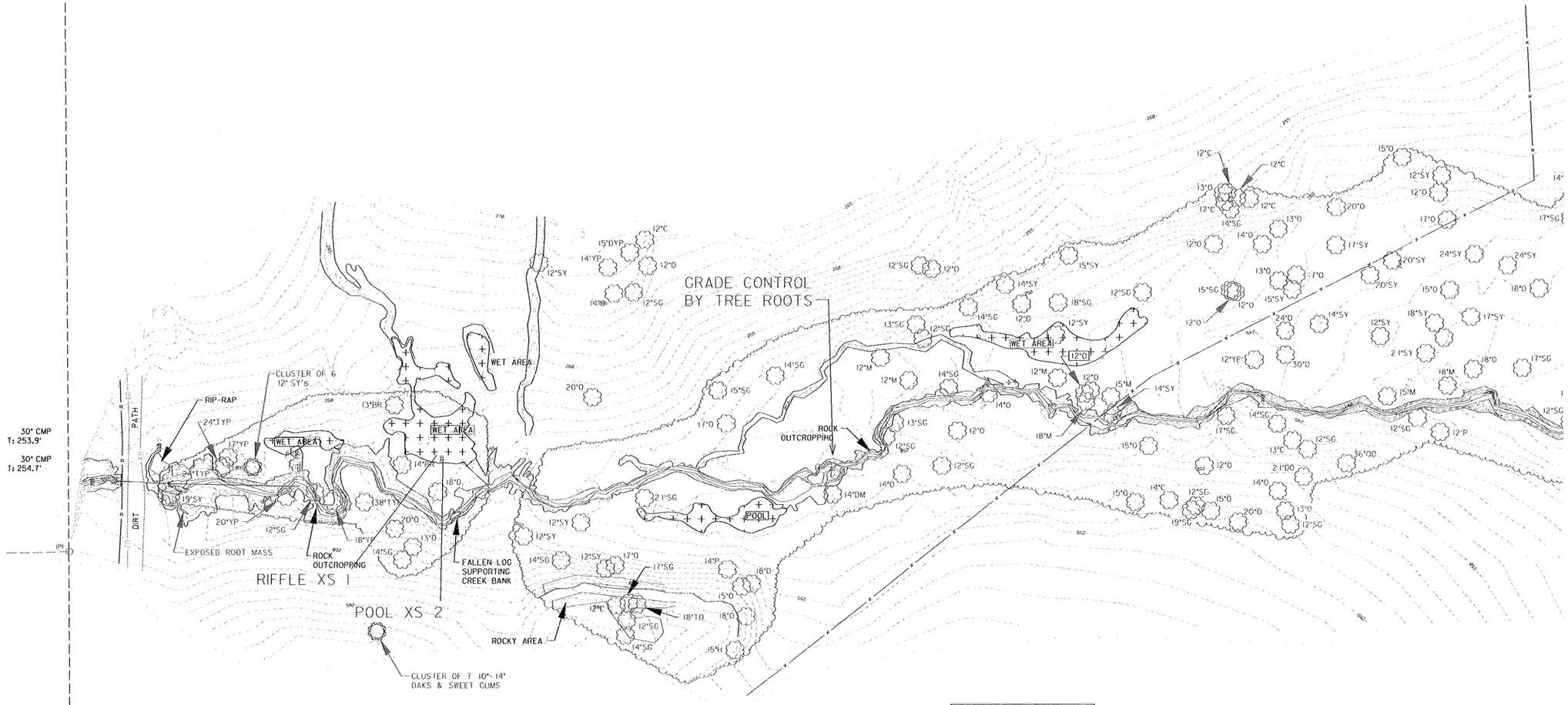
Eight species of Federally- or State listed Endangered or Threatened mussels are found within Franklin County and three of those are found on the Kittrell Quadrangle. The tributary to Billy's Creek is a small stream channel and can not support the mussel or fish species listed in the county. However, the stream drains into Billy's Creek which flows into the Tar River. Due to that fact, special concern will be taken during construction to minimize or avoid any negative impacts to the mussel species that could be found in the Tar Drainage.

5. EXISTING STREAM CONDITIONS

5.1 Description

The project reach of the un-named tributary to Billy's Creek is a 1800-foot long section of a perennial, degraded stream that occupies the lower portion of a 0.22 square mile drainage area (Figure 5 and Appendix A). The project reach is framed by 30-inch diameter culverts under unpaved farm roads at the north and south ends and pastured slopes to the east and west. There is at least one intermittent and four or more ephemeral tributary channels that flow into the project channel segment. The ephemeral channels were created to provide drainage within the floodplain. Approximately 600 feet south of the northern end of the project, the stream runs through an area of fairly active floodplain. Here, wetlands have developed in the relict channels and floodplain adjacent to the main channel of the stream. Downstream from this area, severe incision in the stream channel becomes apparent following a major grade control point. It appears that several trees and their root systems are providing the grade control at this location. The soil downstream of the trees is actively eroding and threatening the root system of these trees.

Downstream of the grade control point, the floodplain and stream system has been modified. Drainage ditches were cut within the floodplain to allow for grading to install a pond. The pond



TREE CODE TABLE	
BR	BIRCH
C	CEDAR
DM	DOUBLE MAPLE
DO	DOUBLE OAK
DSG	DOUBLE SWEET GUM
H	HICKORY
HW	HAWTHORNE
O	OAK
P	PINE
QO	QUADRUPLE OAK
SG	SWEET GUM
SY	SYCAMORE
TO	TRIPLE OAK
TYP	TRIPLE YELLOW
P	POPLAR
YP	YELLOW POPLAR

40 20 0 40 80

1" = 80'

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FIGURE:
FIGURE 5-1
PROJECT REACH
EXISTING CONDITIONS

PROJECT:
TRIBUTARY TO BILLY'S CREEK
FRANKLIN COUNTY

TITLE:
RESTORATION PLAN

NC Wetlands Restoration Program

CLIENT:
NORTH CAROLINA
DEPARTMENT OF
ENVIRONMENT AND
NATURAL RESOURCES

DATE: JULY 2003

SCALES
HORIZ.: 1"=80'

CREATED DRAINAGE DITCHES

PROFILE

POOL XS 3

RIFFLE XS 4

TEMPORARY BENCH MARK:
RAILROAD SPIKE IN N.E. SIDE OF 12" PINE, 2' ABOVE GROUND;
ELEVATION (NGVD 29): 248.12'

30" CMP
INVERT: 227.2'

30" CMP
INVERT: 227.8'

DIRT PATH

PROPERTY LINE

40 20 0 40 80
1" = 80'

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Morrisville, North Carolina 27560
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FIGURE:
FIGURE 5-2
PROJECT REACH
EXISTING CONDITIONS

PROJECT:
TRIBUTARY TO BILLY'S CREEK
FRANKLIN COUNTY

TITLE:
RESTORATION PLAN

NC Wetlands Restoration Program

CLIENT:
NORTH CAROLINA
DEPARTMENT OF
ENVIRONMENT AND
NATURAL RESOURCES

DATE: JULY 2003

SCALES
HORIZ.: 1"=80'

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was never installed, but areas of spoil line the banks of the stream throughout this reach. The banks range from four to six feet high. The culvert at the southern end of the project has provided a grade control point preventing the stream from down cutting further. The banks are steep and largely unvegetated. There are several boulder outcrops throughout the reach that are providing additional grade control.

5.2 Soils of the stream site

The *United States Department of Agriculture-Natural Resources Conservation Service, Soil Survey of Franklin County, North Carolina (1998),* indicated soils present along the tributary to Billy's Creek are exclusively Chewacla and Wehadkee (see Figure 3). The Chewacla series consists of nearly level, somewhat poorly drained soils of stream floodplains. The Wehadkee series consists of poorly drained soils on nearly level to slightly concave slopes. These soils are alluvium from soils that formed in residuum derived from metamorphic or igneous rock.

The Chewacla and Wehadkee soil units are recognized by the United States Department of Agriculture-Natural Resources Conservation Service (NRCS) as hydric soils or soils that may have inclusions of hydric soils within the proposed project area (NRCS, 1995). Hydric soil characteristics are evident along the existing stream in areas identified as wetlands; however, the length of the entire stream reach does not exhibit hydric soils or jurisdictional wetlands (see Section 7.2 for a discussion of wetland impacts).

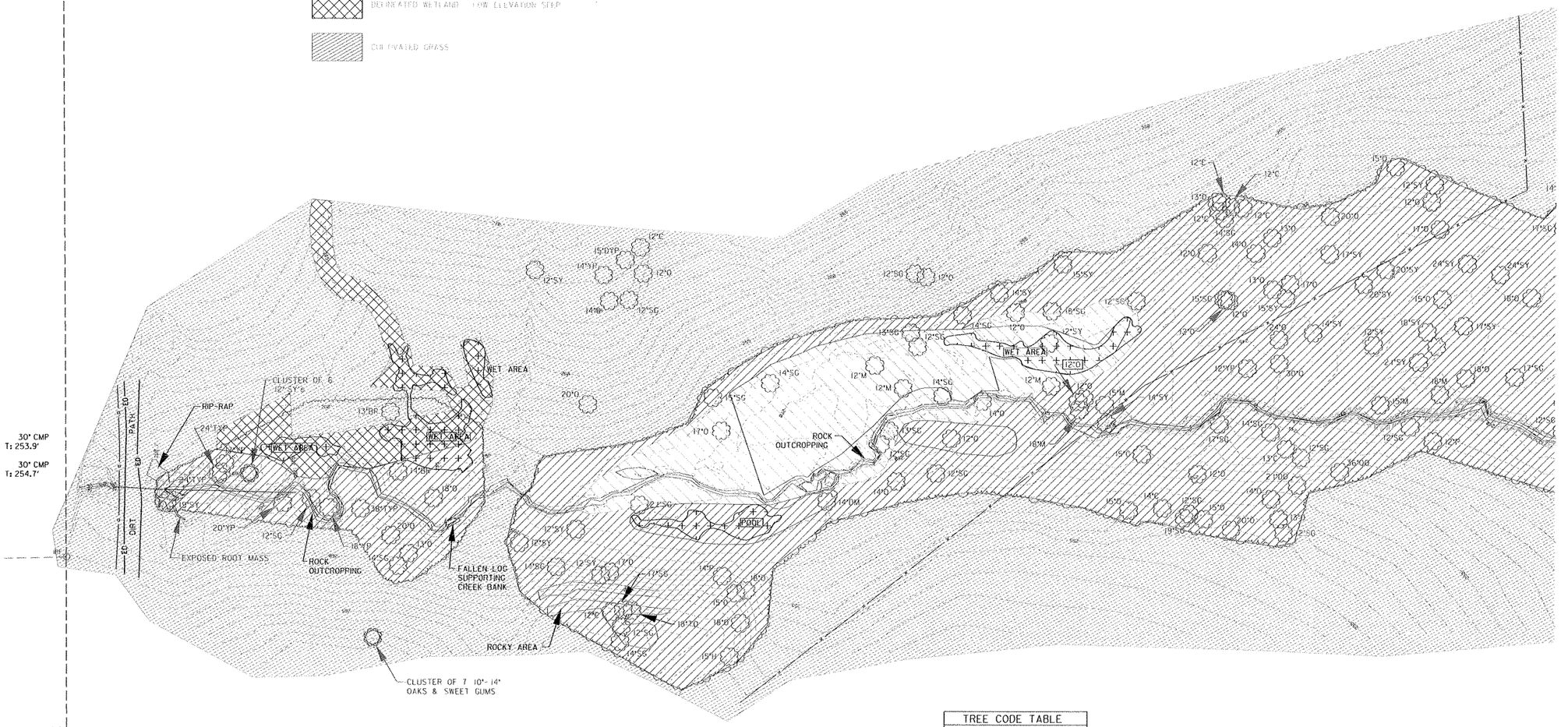
5.3 Existing Vegetative Communities and Wildlife Observations

There are four distinct vegetative communities adjacent to the project reach of the unnamed tributary to Billy's Creek (Figure 6). Three of these community types are described by Schafale and Weakley (1990).

- Piedmont/Mountain Bottomland Forest. A belt averaging approximately 200 feet wide at the bottom of the valley forms the vegetative matrix around the project segment of the stream. In most areas the dominant canopy species were American sycamore (*Platanus occidentalis*), sweetgum, and red maple. Tulip poplar (*Liriodendron tulipifera*), black willow (*Salix nigra*), ironwood (*Carpinus caroliniana*), and American elm (*Ulmus americana*) were also present. The shrub level was fairly dense at the pasture margins and became sparser toward the riparian area. Shrub species present included Chinese privet (*Ligustrum sinense*) and saplings of the canopy tree species. Grape (*Vitus spp.*), sweetbrier (*Smilax spp.*), poison ivy (*Toxicodendron radicans*) and Japanese honeysuckle (*Lonicera japonica*) were present throughout. In the lower half of the project reach, thickets of Chinese privet with honeysuckle were very dense.
- Sand and Mud Bar. This community was located centered on the stream channel within the bottomland forest matrix. It appears to cover around 12,000 square feet at the approximate halfway point on the project reach. The Sand and Mud Bar community appears to experience frequent flooding and accumulations of alluvial deposits typical of this community type were noted. The upper canopy in this community was not closed and was dominated by black willow, sweetgum, and red maple. Scattered individual American elms were also present. The shrub layer was very sparse and was composed of scattered saplings of the canopy tree species and some small Chinese privet. The herb layer was also very sparse and contained

EXISTING NATURAL COMMUNITIES

- PIEDMONT/MOUNTAIN BOTTOMLAND FOREST
- SAND AND MUD BAR
- DELINEATED WETLAND
- DELINEATED WETLAND - LOW ELEVATION STEP
- CULTIVATED GRASS



TREE CODE TABLE	
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DSG	DOUBLE SWEET GUM
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SG	SWEET GUM
SY	SYCAMORE
TO	TRIPLE OAK
TYP	TRIPLE YELLOW
P	POPLAR
YP	YELLOW POPLAR

40 20 0 40 80
1" = 80'

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FIGURE:
FIGURE 6-1
EXISTING PLANT COMMUNITIES

PROJECT:
TRIBUTARY TO BILLY'S CREEK
FRANKLIN COUNTY

TITLE:
RESTORATION PLAN

NC Wetlands Restoration Program

CLIENT:
NORTH CAROLINA
DEPARTMENT OF
ENVIRONMENT AND
NATURAL RESOURCES

DATE: JULY 2003

SCALES
HORIZ.: 1"=80'

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FIGURE:
FIGURE 6-2
EXISTING PLANT COMMUNITIES

PROJECT:
TRIBUTARY TO BILLY'S CREEK
FRANKLIN COUNTY

TITLE:
RESTORATION PLAN

NC Wetlands Restoration Program

CLIENT:
NORTH CAROLINA
DEPARTMENT OF
ENVIRONMENT AND
NATURAL RESOURCES

DATE: JULY 2003

SCALES
HORIZ.: 1"=80'

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scattered sprouts of Japanese honeysuckle and patches of chickweed (*Stellaria media*). Some larger vines of catbrier and Japanese honeysuckle were also noted.

- Low Elevation Seep. Two examples of this community type were identified in pasture areas up-slope of the bottomland forest matrix. One was on the west side of the project reach at the project's southern end and adjacent to the unpaved farm road. The other was on the east side of the project reach, approximately 50 feet south of northern unpaved farm road. Vegetation identified in both locations is typical of these communities. Species observed included *Juncus spp.*, *Carex spp.*, elderberry (*Sambucus canadensis*), blackberry (*Rubus spp.*), black willow, sweetgum, and honeysuckle. Standing water approximately 12 inches deep was noted in both areas and thick algal growth was observed in the water.

A community type identified adjacent to the project reach is not regarded as a naturally occurring community, but resulted from human induced disturbance and is described for purposes of this report.

- Cultivated Grass. Upslope to the east and west of the project channel, the pastured hillsides are vegetated in agricultural grasses and have scattered individuals or small clumps of trees, predominantly sweetgum (*Liquidambar styraciflua*) and red maple (*Acer rubra*).

Wildlife species were noted in the study area through direct observation and signs such as tracks and scat. Gray squirrels (*Sciurus carolinensis*) were observed directly. Tracks and scat were noted for eastern cottontail (*Sylvilagus floridanus*), raccoon (*Procyon lotor*), and whitetail deer (*Odocoileus virginianus*). A ground hog (*Marmota monax)* den was identified on the east slope above the project stream and southern chorus frogs *(Pseudacris nigrita)* were heard vocalizing near the stream. Many bird species were observed; all are common throughout the Piedmont of North Carolina. Species observed included song sparrow (*Melospiza melodia*), white throated sparrow (*Zonotrichia albicollis*), northern cardinal *(Cardinalis cardinalis)*, brown thrasher (*Toxostoma rufum*), American robin (*Turdus migratorius*), Carolina chickadee (*Poecile carolinensis*), tufted titmouse (*Baeolophus bicolor*), and red-shouldered hawk (*Buteo lineatus*).

5.4 Wetlands within the Project Area

Six wetland areas were identified within the project area. One of the wetland areas was identified as a Sand and Mud Bar community. Two were identified as Low Elevation Seep communities. The other three wetland areas were located within the Piedmont Bottomland Forest community bordering the project stream segment. These communities are described in Section 5.3 above.

The soil underlying these wetland areas was identified from the soil survey as Chewacla and Wehadkee (Figure 3). The Chewacla series consists of nearly level, somewhat poorly drained soils of stream floodplains. The Wehadkee series consists of poorly drained soils on nearly level to slightly concave slopes. Both soil units are recognized by the NRCS as either hydric soils or potentially containing inclusions of hydric soils (NRCS, 1995). Standing water was apparent in all wetland areas. These areas were delineated by the three parameter method (Environmental Laboratories, 1987) in the spring of 2003, however jurisdictional concurrence has not been granted by United States Army Corps of Engineers.

5.5 Stream Classification

Most of the unnamed tributary to Billy's Creek is a class G5c with a section of E5 according to the Rosgen stream classification system. The width to depth ratio ranges from 5.2 to 10.4. The entrenchment ratio is between 1.3 and 2.9 for the entire reach and the slope is approximately 0.6% in the E section and 1.5% in the G5c. The sinuosity of the E section is 1.32 and the sinuosity of the G5c is 1.1. The morphologic characteristics are included in Table 3.

5.5.1 Dimension

The cross sectional area within the project reach was measured at two riffle cross sections (see Figure 5 and Appendix B). The first cross section in the flat sinuous section of the tributary. The cross sectional area was approximately 7.3 square feet. This cross sectional area is just below the Rural NC regional curve. The regional curve does not include data for drainage areas of this size. The equation was used to extrapolate the curve for the project site. A pool cross section was also taken in this section. The cross sectional area was 10.3 square feet. The second set of cross sections was taken in the impacted reach. The bankfull cross sectional area of the riffle was 8.2 square feet. This cross sectional area is very close to the 8 square feet calculated for the Rural Piedmont Regional Curve. The pool had a cross sectional area of 15 square feet.

5.5.2 Pattern

The sinuosity of the stream channel of the E channel is 1.3. There is one significant section of meander bends about 100 feet downstream of the start of the project. The radii range from 14 feet to 23 feet and the beltwidth is between 27 and 38 feet. The meander length was between 31 and 43 feet. Downstream of these meanders, the stream is straight with intermittent bends. Downstream of the grade control the stream is fairly straight with only the necessary bends to follow the fall of the valley. It appears that the stream was pushed to one side of the floodplain. The channel was modified and has been cleaned out with heavy equipment. It appears to be just beginning the lateral migration process.

5.5.3 Profile

The stream lacks a significant riffle-pool sequence. The channel is riffle-run with lateral scour pools. A representative longitudinal profile is included in Appendix B. The overall slope of the channel is approximately 1.25%. Much of this slope is dissipated in several steep drops of more than two feet in some cases. The slope of the E section is approximately 0.6% and the slope of the G section is approximately 1.5%. The longitudinal profile showed a representative slope of 0.7% in the surveyed section.

5.5.4 Channel Substrate Material

The channel is sandy with small gravel in the riffles. Upstream of the impacted reach, the dominant channel material is slightly more coarse. There are some boulder outcrops within the reach. The D50 of the channel is approximately a 1.3 mm sand particle.

Table 3. Morphological Characteristics of the Existing Channel, Proposed Channel, and Reference Reach Data

VARIABLES	MEAN/ RANGE	EXISTING CHANNEL REACH 1	EXISTING CHANNEL REACH 2	PROPOSED CHANNEL	UT to UT to Billy's Creek REFERENCE REACH
Stream Type		E5	G5c	E5	E5
Drainage Area (sq mi)		0.22	0.22	0.22	0.16
Bankful width (ft)	*Mean:*	8.7	6.5	9	6.3
	Range:				6.2-6.3
Bankfull Mean Depth (ft)	*Mean:*	0.8	1.3	0.88	0.71
	Range:				0.68-0.74
Width/Depth Ratio	*Mean:*	10.4	5.2	10.1	8.9
	Range:				8.6-9.3
Bankfull Cross-sectional Area	*Mean:*	7.3	8.2	8	4.5
	Range:				4.2-4.7
Bankfull Mean Velocity (ft/s) (Mannings)	*Mean:*	3.1	3.7	3.4	2.9
Bankfull Discharge (cfs) (Mannings)	*Mean:*	22.5	30.2	27	13
Bankfull Maximum Depth (dmax) (ft)	*Mean:*	1.2	1.8	1.3	1.05
	Range:				1.0-1.1
Max driff/dbkf ratio	*Mean:*	1.5	1.4	1.5	1.47
	Range:				1.47-1.49
Low bank height to Max (ft)	*Mean:*	1.25	3	1	1
	Range:				1
Width of Flood Prone Area (wfpa) (ft)	*Mean:*	25.3	8.3	**at least	36
	Range:			20 ft	33-39
Entrenchment ratio (wfpa/wbkf)	*Mean:*	2.9	1.3	>2.2	5.7
	Range:				5.3-6.2
Meander Length (Lm) (ft)	*Mean:*	36	35	56	40.1
	Range:	31-43		29-74	28.7-48.7
Ratio of Meander Length to Bankfull Width (Lm/wbkf)	*Mean:*	4.1	5.4	6.2	6.4
	Range:	3.6-4.9		3.2-8.3	4.6-7.7
Radius of Curvature (Rc)	*Mean:*	18	21	21	16.4
	Range:	14-23	13-32	12.5-34.5	10.2-29
Ratio of Radius of Curvature to bankfull Width (Rc/wbkf)	*Mean:*	2.1	3.2	2.4	2.6
	Range:	1.6-2.6	2-4.9	1.4-3.8	1.6-4.6
Belt Width (wblt) (ft)	*Mean:*	34	14	25	17.1
	Range:	27-38	13-15	16-35	13.2-21.5
Meander Width Ratio (wblt/wbkf)	*Mean:*	3.9	2.2	2.8	2.7
	Range:	3.1-4.4	2-2.3	1.8-3.9	2.1-3.4
Sinuosity (stream length/valley distance) (k)		1.32	1.11	1.22	1.2
Valley Slope (ft/ft)		0.740%	1.700%	1.460%	0.9%
Average Slope (savg)		0.560%	1.500%	1.190%	0.8%
Pool Slope (spool)	*Mean:*	*	0.60%	0.50%	0.35%
	Range:		0-1%		0-1%
Ratio of Pool Slope to Average Slope (spool/sbkf)	*Mean:*	*	0.40	0.42	0.45
	Range:		0-0.66		
Maximum Pool Depth (dpool) (ft)	*Mean:*	1.9	2.3	1.8	1.4
	Range:				1.2-1.6
Ratio of Pool Depth to Average Bankfull Depth (dpool/dbkf)	*Mean:*	2.4	1.8	2.0	2
	Range:				1.7-2.2
Pool Width (wpool) (ft)	*Mean:*	9.5	9.7	12.6	
	Range:				
Ratio of Pool Width to Bankfull Width (wpool/wbkf)	*Mean:*	1.1	1.5	1.4	1.2
	Range:				0.9-1.4
Ratio of Pool Area to Bankfull Area	*Mean:*	1.4	1.8	1.2	1.15
	Range:				1.1-1.2
Pool to Pool Spacing (p-p) (ft)	*Mean:*	*	22	31.1	18
	Range:		20-23.5	18.1-49.9	11.7-26.7
Ratio of p-p spacing to bankfull width (p-p/wbkf)	*Mean:*	*	3.4	3.5	2.9
	Range:		3.1-3.6	2-5.5	1.9-4.2

*Detailed profile not taken - sections taken for classification purposes only.

**In most cases the floodprone area is much greater than 20 ft. The final grading limits have not been established at this point, but the entrenchment ratio will be no less than 2.2.

Billy's Morphologic table

6. STREAM REFERENCE REACH STUDY

6.1 Reference Reach: Un-named Tributary, Franklin County, NC

The drainage area of the un-named stream used for reference data measures approximately 102 acres (.16sqmi). This stream runs into a larger tributary to Billy's Creek approximately 4,500 ft due south of the project area (Figure 7). The drainage area for this stream section lies between SR 1219 and SR 1210.

6.1.1 Stream Classification

Reference data was collected along 108 feet of the channel. In this reach, the stream is a first order, perennial type E5 stream. The reach had an average riffle cross sectional area of 4.5 with a width to depth ratio of 9. The entrenchment ratio was approximately 5.7. The sinuosity was 1.2. The radius of curvature ranged from 10.2 to 29 feet. The section of the stream that was surveyed was fairly flat. Upstream and downstream of the surveyed reach, the stream had either bedrock or large boulders providing areas of steps to dissipate the energy due to the slope. The remaining information and photos are included in the morphological table (Table 3) and in Appendix C.

6.1.2 Soils of the Watershed and Stream Site

The watershed of Reference Reach 1 falls across five different soil series types. Wedowee Sandy Loam has been identified as the primary soil unit within the watershed (USDA 1998). Reference Reach 1 is situated in the Wake-Wateree Complex soil unit. The major soil types found within the watershed of Reference Reach 1 include (USDA 1998):

- Appling (Fine, kaolinitic, thermic Typic Kanhapludults) – (11.9 percent of the watershed). These soils are very deep, well drained, and moderately permeable soils on ridges and side slopes of Piedmont uplands. They formed in residuum weathered from felsic igneous and metamorphic rocks.
- Cecil (Fine, kaolinitic, thermic Typic Kanhapludults) – (10.1 percent of the watershed). The soil consists of sandy or clay loams. The series has well-drained, gently sloping to strongly sloping soils of the uplands. They formed in residuum that weathered from granite, gneiss, and other acidic rocks.
- Chewacla and Wehadkee - (2.1 percent of the watershed).

  Chewacla (Fine-loamy, mixed, active, thermic Fluvaquentic Dystrudepts) – The series consists of nearly level, somewhat poorly drained soils of the stream flood plains and formed in recent alluvium. This soil is classified as a hydric soil.

  Wehadkee (Fine-loamy, mixed, active, nonacid, thermic Fluvaquentic Endoaquepts) The series consists of very deep, poorly drained and very poorly drained soils on flood plains along streams. They are formed in loamy sediments.
- Wake-Wateree Complex (6.1 percent of the watershed). Reference Reach 1 flows through this soil unit.

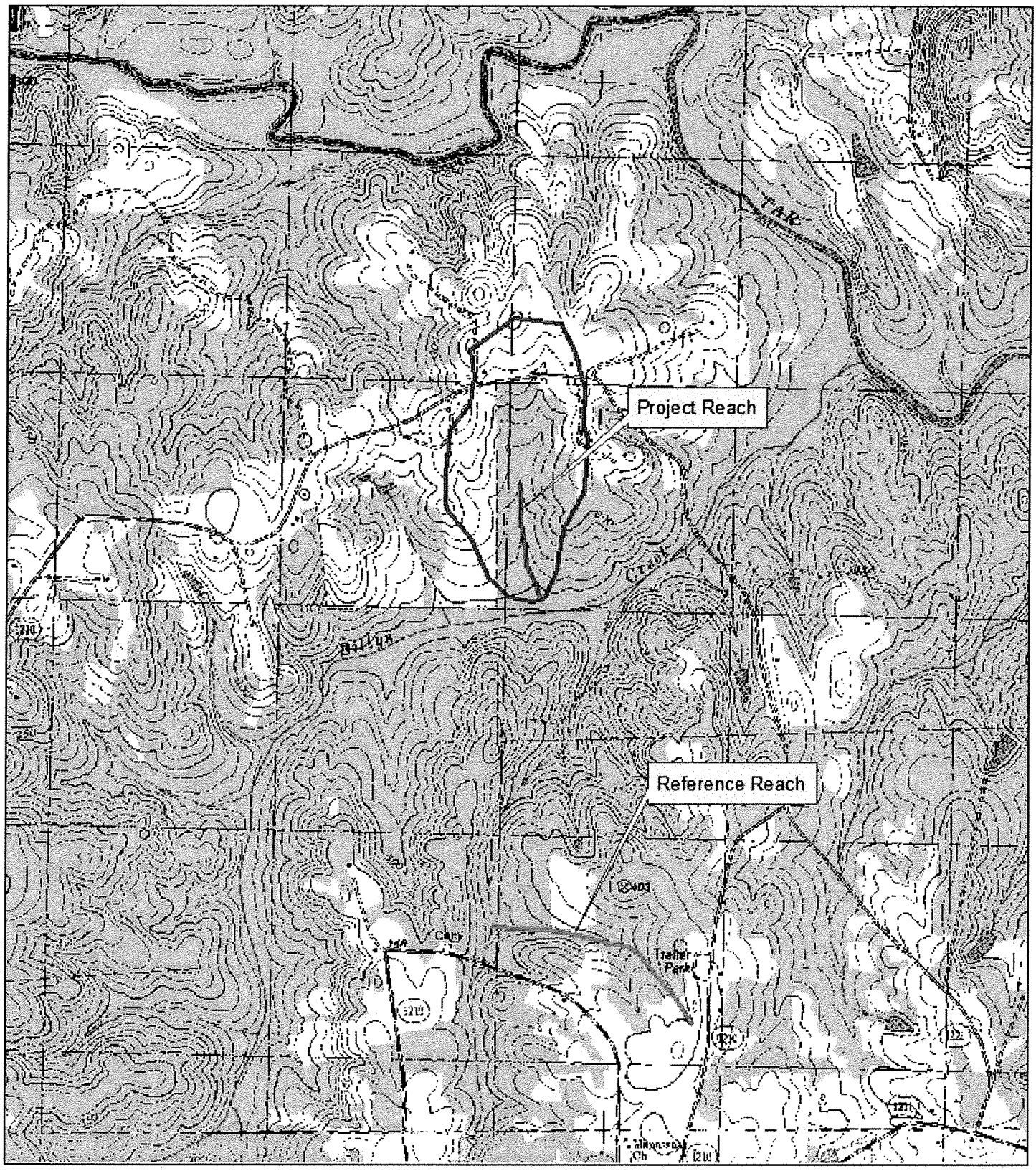
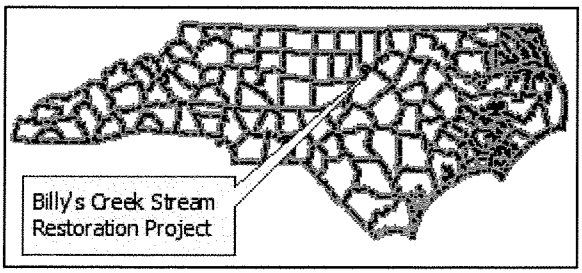


Figure 7 - Reference Reach Location
Billy's Creek Stream Restoration Project

NC Wetlands Restoration Program



Project Reach
Reference Reach
Unnamed Tributary to Billy's Creek

N

1:24,000

URS

US Topo Quad: Kittrell (1979)

Wake (Mixed, thermic Lithic Udipsamments). This soil consists of excessively drained, shallow, sandy soil on uplands of the Southern Piedmont. The soil formed in residuum weathered from igneous and high-grade metamorphic rocks such as granite and gneiss.

Wateree (Coarse-loamy, mixed, semiactive, thermic Typic Dystrochrepts). This soil is moderately deep, well drained, and found on ridges and hill slopes in the Piedmont. It is formed of residuum weathered from felsiccrystalline rock, commonly granite and gneiss.

- Wake-Saw-Wedowee Complex – (7.3 percent of the watershed).

  Wake (Mixed, thermic Lithic Udipsamments) This series consists of excessively drained, shallow, sandy soil on uplands of the Southern Piedmont. The soil formed in residuum weathered from igneous and high-grade metamorphic rocks such as granite and gneiss.

  Saw (Fine, kaolinitic, thermic Typic Kanhapludults) This series consists of moderately deep, well drained soils on ridges and side slopes of uplands. They formed in residuum weathered from felsic igneous rocks such as porphyritic granite and granite.

  Wedowee (Fine, kaolinitic, thermic Typic Kanhapludults) The soil is a sandy loam. The series is a very deep, well drained soil that formed in residuum from weathered crystalline rock of the Piedmont Plateau.

- Wedowee Sandy Loam (Fine, kaolinitic, thermic Typic Kanhapludults) – (59.7 percent of the watershed). This is a very deep, well drained sandy loam typically found on convex side slopes in the Piedmont.

6.1.3 Vegetative Communities and Wildlife Observations

There are two distinct natural communities adjacent to Reference Reach 1 (Schafale and Weakley 1990). It should be noted that this site is at the eastern edge of the Piedmont near the Coastal Plain and there is some mixing of community types and species between the two eco-regions.

- Piedmont/Mountain Bottomland Forest. This community was observed bordering the stream in the floodplain. Species forming the upper canopy included sweetgum, red maple, tulip poplar, loblolly pine *(Pinus taeda)*, swamp chestnut oak *(Quercus michauxii)*, and bitternut hickory *(Carya cordiformis)*. The shrub layer was fairly open and composed of saplings of the canopy tree species and other species including black gum *(Nyssa sylvatica)*, ironwood *(Carpinus caroliniana)*, American holly *(Ilex opaca)*, flowering dogwood *(Cornus florida)*, and strawberry bush *(Euonymus americanus)*. This community had a rich, dense herb layer with jewelweed *(Impatiens capensis)*, sedges *(Carex spp.)*, netted chainfern *(Woodwardia areolata)*, ferns and other herbaceous material. Grape, sweetbrier, poison ivy were present throughout. Japanese honeysuckle was the only invading exotic species noted and very few individuals were observed.

- Mixed Mesic Hardwood Forest. This community was observed on the slopes bordering the floodplain. Dominant tree species included tulip poplar, beech *(Fagus grandifolia)*, white oak *(Quercus alba)*, northern red oak *(Q. rubra)*, and loblolly pine. Swamp chestnut oak and red maple were also present in the upper canopy. Shrub species observed in this community included deerberry *(Vaccinium stamineum)*, sourwood *(Oxydendrum arboreum)*, eastern redcedar *(Juniperus virginiana)*, flowering dogwood, American holly, and black gum. The

herb layer in this area was very sparse. Grape, sweetbrier, poison ivy were present as scattered individuals.

Wildlife species were noted by direct observation and the presence of signs such as tracks and scat. Many individual tufted and ovenbirds *(Seiurus aurocapillus)* were both seen and heard vocalizing in the hardwood community. Ruby-throated hummingbirds *(Archilochus colubris)*, red-shouldered hawk, northern flickers *(Colaptes auratus)* were heard vocalizing and flying. Several American crows *(Corvus brachyrhynchos)* appeared to be utilizing a roost tree located near the southern end of the study reach. Tracks, scat, and disturbance signs were observed for whitetail deer, raccoon, rabbit, and turkey *(Meleagris gallopavo)*.

7. STREAM RESTORATION PLAN

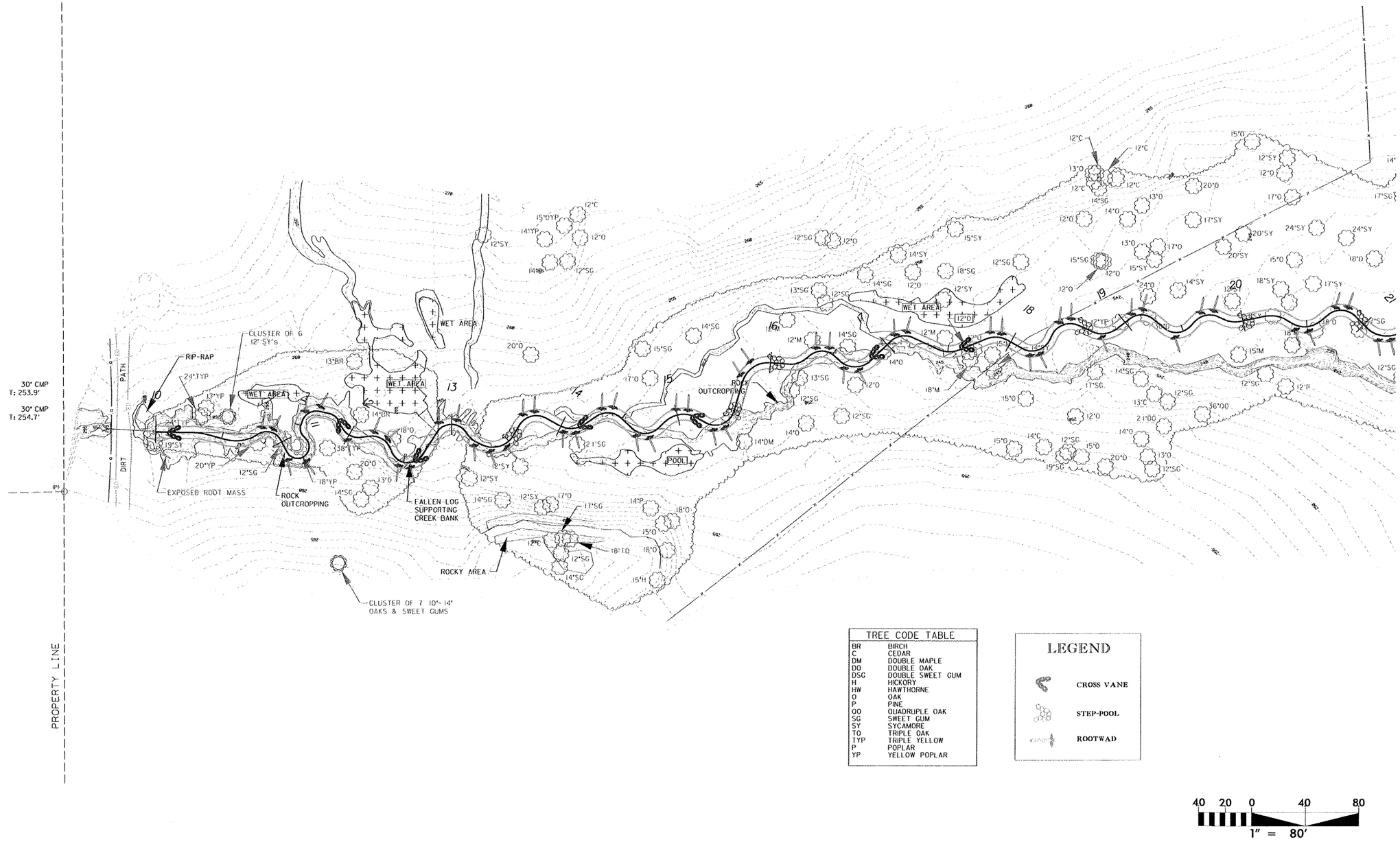
7.1 Stream Classification

An E5 stream type is proposed (Figure 8). Since some of the existing channel is already this stream type, the new channel will be raised to meet the floodplain where feasible and the E channel will be created. According to the landowner, prior to the modifications, the channel was very narrow and sinuous with a very wet floodplain. Therefore, the creation of an E type channel will allow for a narrow channel that has access to the floodplain. The removal of the drainage ditches will allow the floodplain to function as it has historically.

The slope required to meet the existing culvert at the end of the project will necessitate the installation of several steps. The majority of the stream restoration will be a Priority 1 restoration where the stream will be raised and reconnected to the floodplain. There will be some areas that the stream cannot be raised all the way to the floodplain and therefore these areas will be considered a Priority 2 restoration (Rosgen, 1997).

7.1.1 Dimension

The cross sectional area proposed has an area of approximately 8 square feet, which was field verified in the existing condition survey and by the Piedmont Rural Regional Curve. The width to depth ratio in the proposed stream is 10.1. While this is higher than the width to depth ratio of the reference reaches, this will allow for a constructible stream with no more than 2 to 1 side slopes. A lower width to depth ratio channel is very difficult to build and stabilize. A bankfull bench has been included in the cross section and will only be used where necessary. In most cases the floodplain will be the same as the existing ground surface. Where necessary the bench will be at least 20 feet wide.



TREE CODE TABLE	
BR	BIRCH
C	CEDAR
DM	DOUBLE MAPLE
DO	DOUBLE OAK
DSG	DOUBLE SWEET GUM
H	HICKORY
HW	HAWTHORNE
O	OAK
P	PINE
QO	QUADRUPLE OAK
SG	SWEET GUM
SY	SYCAMORE
TO	TRIPLE OAK
TYP	TRIPLE YELLOW
P	POPLAR
YP	YELLOW POPLAR

LEGEND

- CROSS VANE
- STEP-POOL
- ROOTWAD

40 20 0 40 80

1" = 80'

Prepared by

URS

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Morrisville, North Carolina 27560
TELEPHONE (919) 461-1100 FAX (919) 461-1415

FIGURE:

FIGURE 8-I
PROPOSED STREAM CHANNEL

PROJECT:

TRIBUTARY TO BILLY'S CREEK
FRANKLIN COUNTY

TITLE:

RESTORATION PLAN

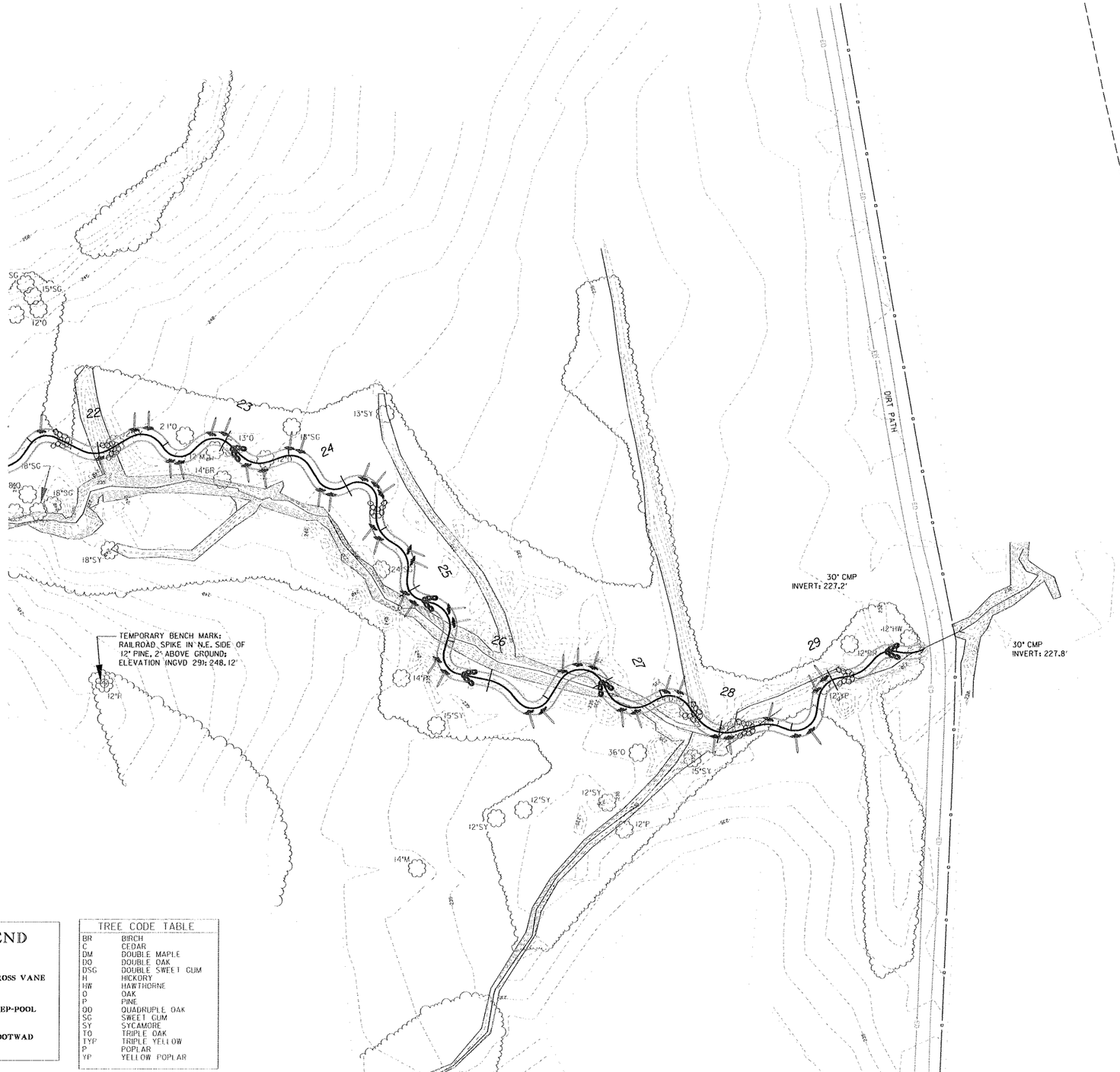
NC Wetlands Restoration Program

CLIENT:

NORTH CAROLINA
DEPARTMENT OF
ENVIRONMENT AND
NATURAL RESOURCES

DATE: JULY 2003

SCALES
HORIZ.: 1"=80'



LEGEND

- CROSS VANE
- STEP-POOL
- ROOTWAD

TREE CODE TABLE	
BR	BIRCH
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SG	SWEET GUM
SY	SYCAMORE
TO	TRIPLE OAK
TYP	TRIPLE YELLOW
P	POPLAR
YP	YELLOW POPLAR

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FIGURE:
FIGURE 8-2
PROPOSED STREAM CHANNEL

PROJECT:
TRIBUTARY TO BILLY'S CREEK
FRANKLIN COUNTY

TITLE:
RESTORATION PLAN

NC Wetlands Restoration Program

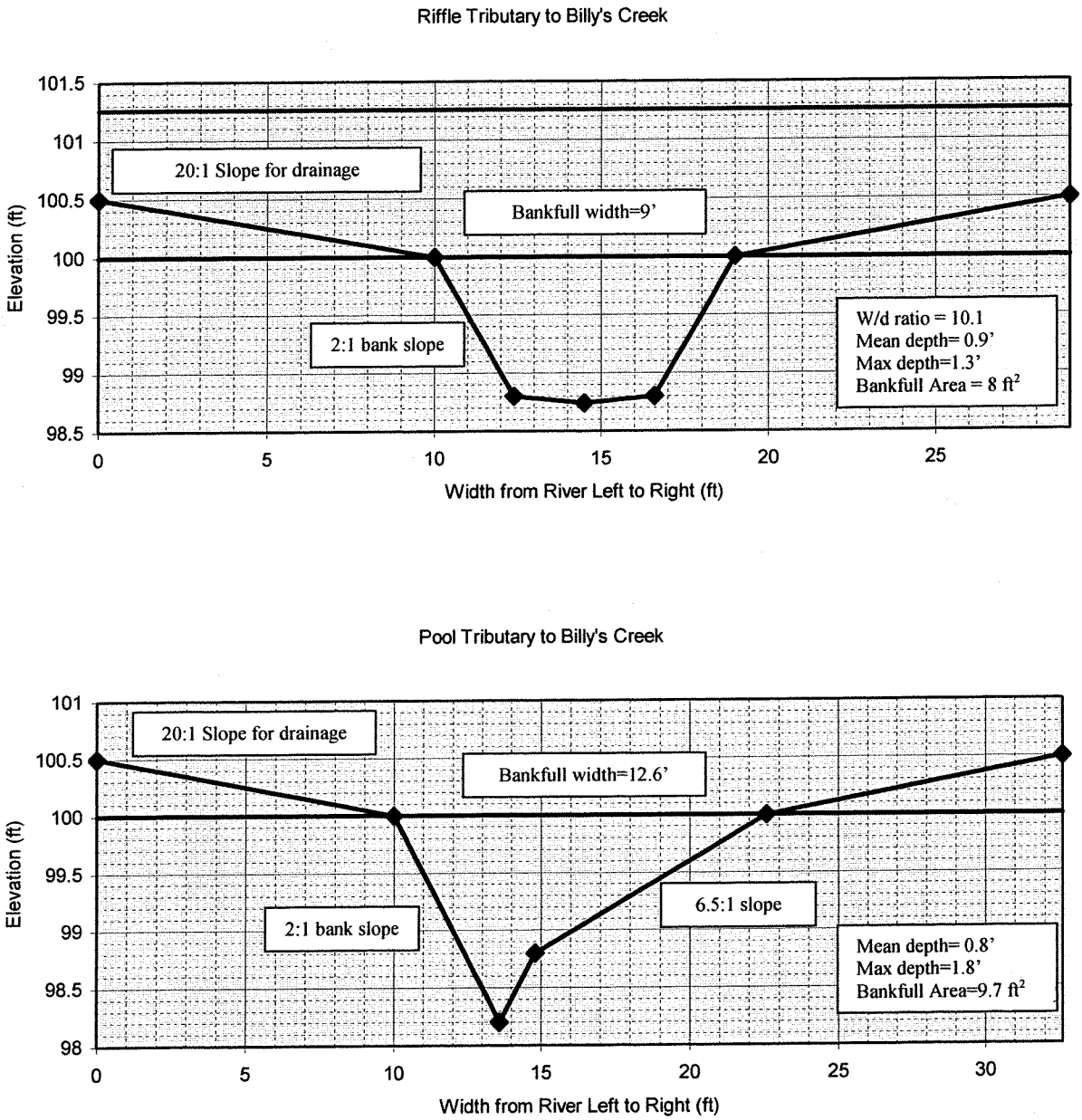
CLIENT:
NORTH CAROLINA
DEPARTMENT OF
ENVIRONMENT AND
NATURAL RESOURCES

DATE: JULY 2003

SCALES
HORIZ.: 1"=80'

...\Restoration Plan\figure8-2.dgn 08/11/2003 02:11:10 PM

Figure 9. Proposed Cross Sections.



7.1.2 Pattern

The sinuosity of the proposed stream is 1.22 with a radius of curvature range of 12.5 to 34.5 feet with a ratio of 1.4 to 3.8. The existing meander bend is the only area where the radius ratio is less than two to ensure constructability. The belt width ranges from 16 to 35 feet with a meander width ratio of 1.8 to 3.9. The average meander width ratio is 3.8, which is close to the average for the reference reach. The range is slightly larger than the reference reach due to the existing

ground surface and the existing meander bends that are being enhanced. The stream was located toward the center of the valley and this required turning in several places the match the fall of the valley. In most cases, the reference reaches were very well vegetated with mature vegetation, contributing to their ability to maintain a stable meander with less than a 2.0 radius of curvature ratio. The proposed channel will not have this type of vegetation available to protect the stream banks following construction, therefore rock vanes and root wads will be used to protect the meander bends (see Appendix D for vane details).

7.1.3 Profile

The profile of the channel will be improved to allow for defined riffles and pools. The existing overall slope of the stream is 1.24%. The slope will be slightly decreased due to the change in length of the channel to 1.19%. The slope is dictated by the existing culverts under the farm roads at the beginning and the end of the project. The maximum riffle slope will be 1.1%. Several steps will be included in the profile to provide the drop necessary. The steps will be used to dissipate the energy within the channel and provide grade control. The maximum pool slope will be 0.5% which is within the range of the reference reach. The slope on the pool is necessary to follow the existing ground surface. The pool to pool spacing ratio ranges from 2.0 to 5.5. This is outside of the range of the reference reach due to some long pool areas that had to be incorporated to follow the fall of the valley and because of existing meander bends. The energy in these areas will be dissipated with a step, which will provide a scour hole. The proposed profile is included in Appendix E.

7.1.4 Sediment Transport Analysis

The existing shear stress in the channel was calculated to be 0.32 (E section) and 0.42 (G section) pounds per square foot using the following equation:

$\tau = 62.4 * R * S$ Equation 1.

where

62.4 = density of water lbs/cu ft

R = hydraulic radius of the stream (ft) (Area/wetted perimeter)

S = Channel Slope (ft/ft)

The particle sizes from Shield's diagram are approximately 18 mm and 25 mm respectively. The proposed channel Shear stress is 0.37 pounds per square foot. The particle size from Shield's diagram is approximately 22 mm. The maximum particle size found in the sub-pavement sample was 24 mm. The largest particles were thrown out of the sample per Rosgen's statement that if you collect "larger particles from the subpavement than from the pavement layer, do not use these big rocks to determine the largest particle size" (Rosgen, 2002). The next largest particle size of 23 mm was used to determine the largest particle size. The data on Shield's diagram with Colorado data shows a range of sizes from 22 mm to approximately 80 mm.

Critical dimensionless shear stress is used for gravel and cobble bed streams, however the pavement and subpavement sample taken from the project site produced results within the ranges necessary for the calculations. The critical dimensionless shear stress was calculated to be 0.029. The required minimum bankfull mean depth was calculated to be 0.54 feet and the minimum required slope was calculated to be 0.29%.

$$\tau * ci = 0.0834 * (D50/\hat{D}50)^{-0.872}$$ Equation 2.

D50 = median diameter of the pavement sample

$\hat{D}50$ = median diameter of the sub - pavement sample

This equation was used because the ratio of $D50/\hat{D}50$ was between 3.0 and 7.0.

The channel will include grade control in the form of cross vanes and much of the energy will be dissipated through a series of steps throughout the project. These steps are necessary to follow the existing ground slope. The steps will provide energy dissipation and grade control within the project reach. This will prevent problems with excessive erosion.

7.2 Wetland impacts within the floodplain

The soil survey shows hydric soils within the floodplain of the tributary. A field visit identified specific areas of wetlands within the project reach. One of the wetland areas will be directly impacted by the construction of the stream. The impact is less than a 1/3 of an acre. To mitigate for this impact, the hydrology of the existing floodplain will be restored to allow it to function as was noted historically by the landowner. The existing ditches that are currently draining the floodplain will be filled and overland flow will be promoted. In addition, small depressional areas can be created within the floodplain near the newly filled ditches to provide a wetland habitat.

7.3 Proposed Vegetative Communities for un-named tributary to Billy's Creek Stream Restoration

Prior to the re-vegetation phase of the project, non-native floral species must be removed. Exotic species currently identified within the project area include Chinese privet and Japanese honeysuckle. These are fast growing species that will overwhelm and out-compete the plant communities proposed for stabilization of the new stream channel. These species are found throughout the project area, but are most prevalent in the southern half.

The proposed plantings will cover the constructed stream banks, floodplain, and slopes between the floodplain and existing ground level (Figure 10). Generally, throughout the project, the target natural community to be created is a Piedmont Bottomland Forest. Alteration of the vegetative makeup of Sand and Mud Bar community will be limited to the removal of the non-native species currently identified in this area and promotion of existing species.

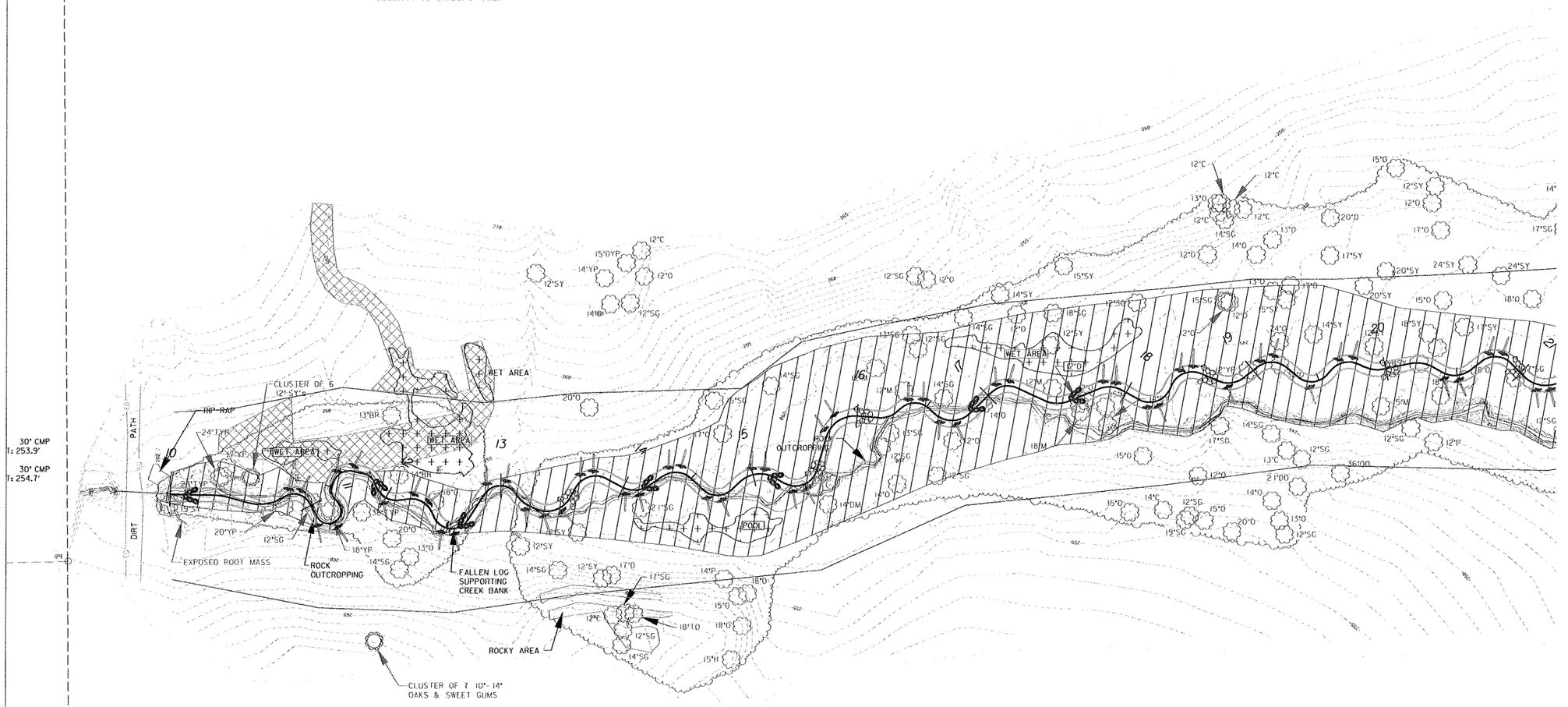
Immediately following construction activities in the stream bank and floodplain areas, a seed mixture of temporary or annual grasses, such as rye or millet, and perennial or permanent native grass and herb species tolerant of moist or wet growing conditions, will be applied (Table 4). These areas will then be covered with erosion control matting to maintain soil stability. A seed mixture containing the temporary and permanent species and native species more suited to lower moisture regimes will be applied on slopes and all other areas where construction activities have disturbed the soil in addition to areas specified by the project design plans (Table 4).

PROPOSED NATURAL COMMUNITIES

FLOODPLAIN - PLANT MIXTURE OF FLOODPLAIN SPECIES THROUGHOUT.

LOW ELEVATION SEEP - PLANT MIXTURE OF LIVE STAKES, FLOODPLAIN HERBS AND SHRUBS.

EASEMENT LINE
SLOPE - PLANT MIXTURE OF SLOPE SPECIES FROM EDGE OF FLOODPLAIN COMMUNITY TO EASEMENT LINE.



TREE CODE TABLE	
BR	BIRCH
C	CEDAR
DM	DOUBLE MAPLE
DO	DOUBLE OAK
DSG	DOUBLE SWEET GUM
H	HICKORY
HW	HAWTHORNE
O	OAK
P	PINE
QO	QUADRUPLE OAK
SG	SWEET GUM
SY	SYCAMORE
TO	TRIPLE OAK
TYP	TRIPLE YELLOW POPLAR
P	POPLAR
YP	YELLOW POPLAR

40 20 0 40 80
1" = 80'

Prepared by
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Morrisville, North Carolina 27560
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FIGURE:
FIGURE 10-1
PROPOSED VEGETATION
PLANNING ZONES

PROJECT:
TRIBUTARY TO BILLY'S CREEK
FRANKLIN COUNTY

TITLE:
RESTORATION PLAN

NC Wetlands Restoration Program

CLIENT:
NORTH CAROLINA
DEPARTMENT OF
ENVIRONMENT AND
NATURAL RESOURCES

DATE: JULY 2003

SCALES
HORIZ.: 1"=80'

...\prop_veg\figure10-1.dgn 08/11/2003 01:52:33 PM

TREE CODE TABLE	
BR	BIRCH
C	CEDAR
DM	DOUBLE MAPLE
DO	DOUBLE OAK
DSG	DOUBLE SWEET GUM
H	HICKORY
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TO	TRIPLE OAK
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P	POPLAR
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FIGURE:
FIGURE 10-2
PROPOSED VEGETATION
PLANNING ZONES

PROJECT:
TRIBUTARY TO BILLY'S CREEK
FRANKLIN COUNTY

TITLE:
RESTORATION PLAN

NC Wetlands Restoration Program

CLIENT:
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DATE: JULY 2003

SCALES
HORIZ.: 1"=80'

Live stakes (Table 5) will be used in stream banks on the outside of meander bends. These will be planted at a density of two to four stakes per square yard and in a random fashion to appear more natural. Sources exist for many of these along the existing stream but others may require offsite sources. These species were selected based on success rates in use as live stakes and availability in the project area.

Bare root plantings, randomly spaced on six-foot centers, will be placed upslope of the bankfull benches in the floodplain and slope areas (Tables 6 and 7). Tree species will be installed individually, but shrub plantings will be installed in same species groups of two to three individuals with the groups randomly arranged to promote a natural appearance. Plant placement may be further defined following completion of the design process.

In some areas a Piedmont Bottomland Forest community exists. As much as possible in these areas, the zone of construction activity will be limited to lessen damage to individual stems. Maintaining existing trees in place with intact root masses will contribute to post-construction stream bank retention. Areas with existing tree canopy will receive primarily herbaceous and shrub plantings. Further detail will be provided following completion of the design process.

Where opportunities exist to transplant existing trees for re-vegetation, those individuals will be moved to new positions along the constructed stream section. Individuals considered candidates for transplanting will not be larger than 1.5 inches in diameter at breast height (1.5"dbh).

Table 4. Grass and Herb Seed Mix.

Location	Scientific name	Common Name
Floodplain & Stream bank Herbaceous	*Eupatorium fistulosum*	Joe pye weed
	Helianthus angustifolius	Swamp sunflower
	Andropogon glomeratus	Bushy beard grass
	Panicum clandestimum	Deertongue
	Panicum virgatum	Switchgrass
	Vernonia noveboracensis	Ironweed
Slope Herbaceous	*Andropogon gerardii*	Big blue stem
	Eupatorium fistulosum	Joe pye weed
	Panicum virgatum	Switchgrass
	Sorghastrum nutans	Indian grass
	Tripsacum dactyloides	Eastern gama grass
	Vernonia noveboracensis	Ironweed

Table 5. Live Stake Species List.

Location	Scientific name	Common Name
Stream Bank Live Stakes	*Cornus amomum*	Silky dogwood
	Physocarpus opulifolius	Ninebark
	Salix nigra	Black willow
	Sambucus canadensis	Elderberry
	Xanthorhiza simplieissima	Yellow root

Table 6. Floodplain Species List

Location	Scientific name	Common Name
Floodplain Shrub Species	*Alnus serrulata*	Tag alder
	Cornus amomum	Silky dogwood
	Carpinus caroliniana	Ironwood
	Hibiscus moscheutos	Marsh mallow
	Itea virginica	Virginia willow
	Physocarpus opulifolius	Ninebark
	Rhododendron viscosum	Swamp azalea
Floodplain Tree Species	*Carya ovata*	Shagbark hickory
	Celtis laevigata	Sugarberry
	Diospyros virginiana	Persimmon
	Fraxinus pennsylvanica	Green ash
	Quercus michauxii	Swamp Chestnut oak
	Quercus phellos	Willow oak
	Tilia heterophylla	Basswood

Table 7. Slope Species List.

Location	Scientific name	Common Name
Slope Shrub Species	*Amelanchier arborea*	Service berry
	Cercis canadensis	Redbud
	Cornus alternifolia	Alternate leaf dogwood
	Corylus americana	Hazel-nut
	Ilex decidua	Deciduous holly
	Symplocos tinctoria	Sweet leaf
	Viburnum dentatum	Southern arrow-wood
Slope Tree Species	*Carya cordiformis*	Bitternut Hickory
	Carya ovata	Shagbark hickory
	Celtis laevigata	Sugarberry
	Diospyros virginiana	Persimmon
	Fraxinus pennsylvanica	Green ash
	Nyssa sylvatica	Blackgum
	Prunus serotina	Black cherry
	Quercus phellos	Willow oak
	Tilia heterophylla	Basswood

8. STREAM PERFORMANCE CRITERIA AND MONITORING PLAN

Stream monitoring will begin after all channel modifications and re-vegetation has been completed. The monitoring will include both physical and biological properties of restored stream channel. The stream will be monitored for five years. Annual reports with the as-built plan, monitoring, and any corrective actions will be sent to NCDWQ for written concurrence.

8.1 Success Criteria for Stream Geometry

Permanent cross-sections will be established at intervals of every 500-600 feet depending on the reach to measure dimension. Measurements taken at these cross sections will be sufficient to determine the width to depth ratio, entrenchment ratio, low bank height ratio (low bank height/maximum bankfull depth).

Pattern measurements will include sinuosity, meander width ratio, and radius of curvature only on newly constructed meanders. The longitudinal profile will include slope measurements of the pools and riffles and pool to pool spacing.

Pebble counts will be done in both riffles and pools and based on the percentage of riffles and pools. Over time the D50 and D85 should increase in coarseness in the riffles and increase in fineness in the pools as particles settle out.

Permanent photo points will be established. Photos will be taken with at least one per cross section that shows the banks and channel. Several photos will be taken of different structures such as cross vanes and root wads along the channel.

8.2 Vegetation Success Criteria

The vegetation along the stream should act as a riparian buffer zone and stabilize the stream banks. The plantings along the stream channel will consist of only native vegetation that is endemic to the county. The survival rate of the vegetation must be 320 stems per acre for trees after five years.

REFERENCES

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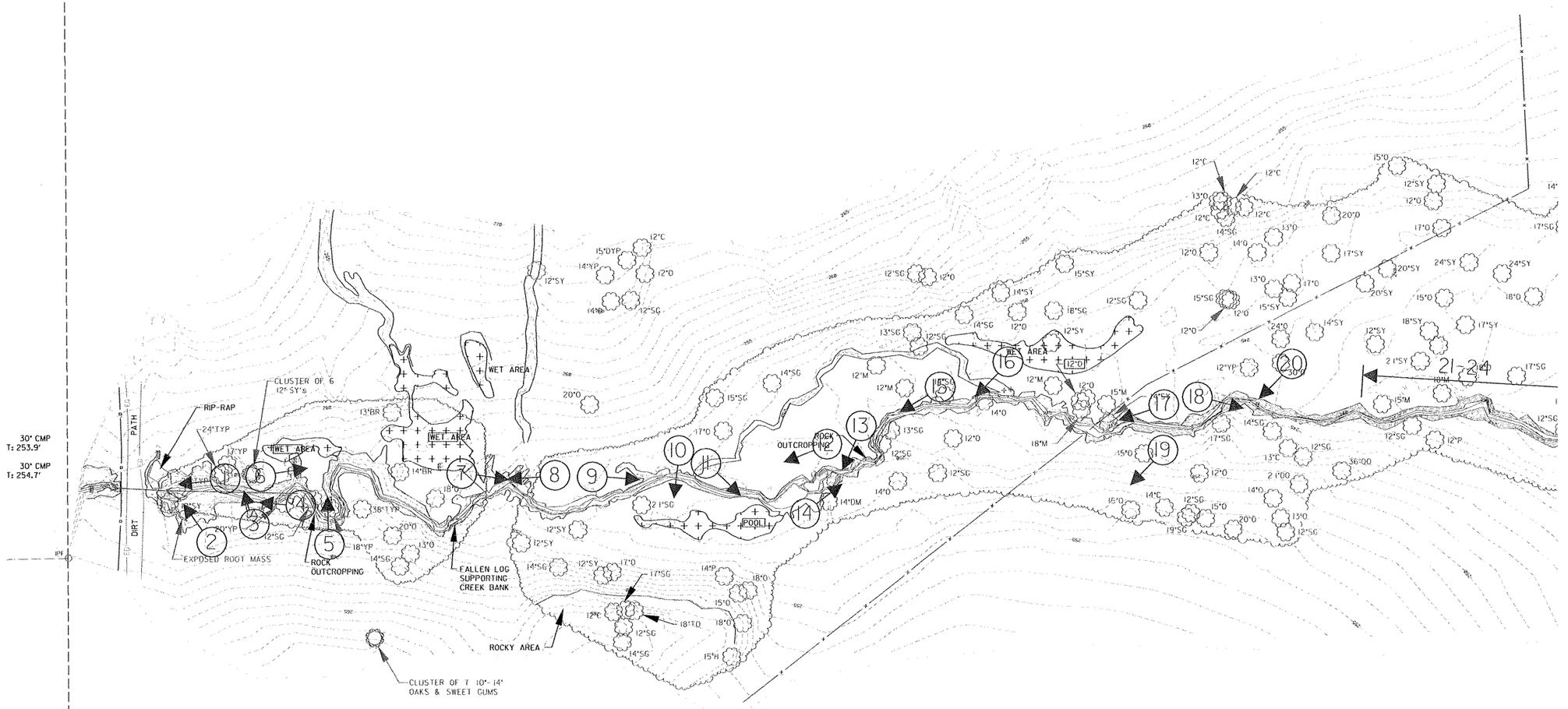
APPENDIX A. PHOTO LOG



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40 20 0 40 80
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FIGURE:
APPENDIX A
PHOTO LOG

PROJECT:
TRIBUTARY TO BILLY'S CREEK
FRANKLIN COUNTY

TITLE:
RESTORATION PLAN

NC Wetlands Restoration Program

CLIENT:
NORTH CAROLINA
DEPARTMENT OF
ENVIRONMENT AND
NATURAL RESOURCES

DATE: JULY 2003

SCALES
HORIZ.: 1"=80'

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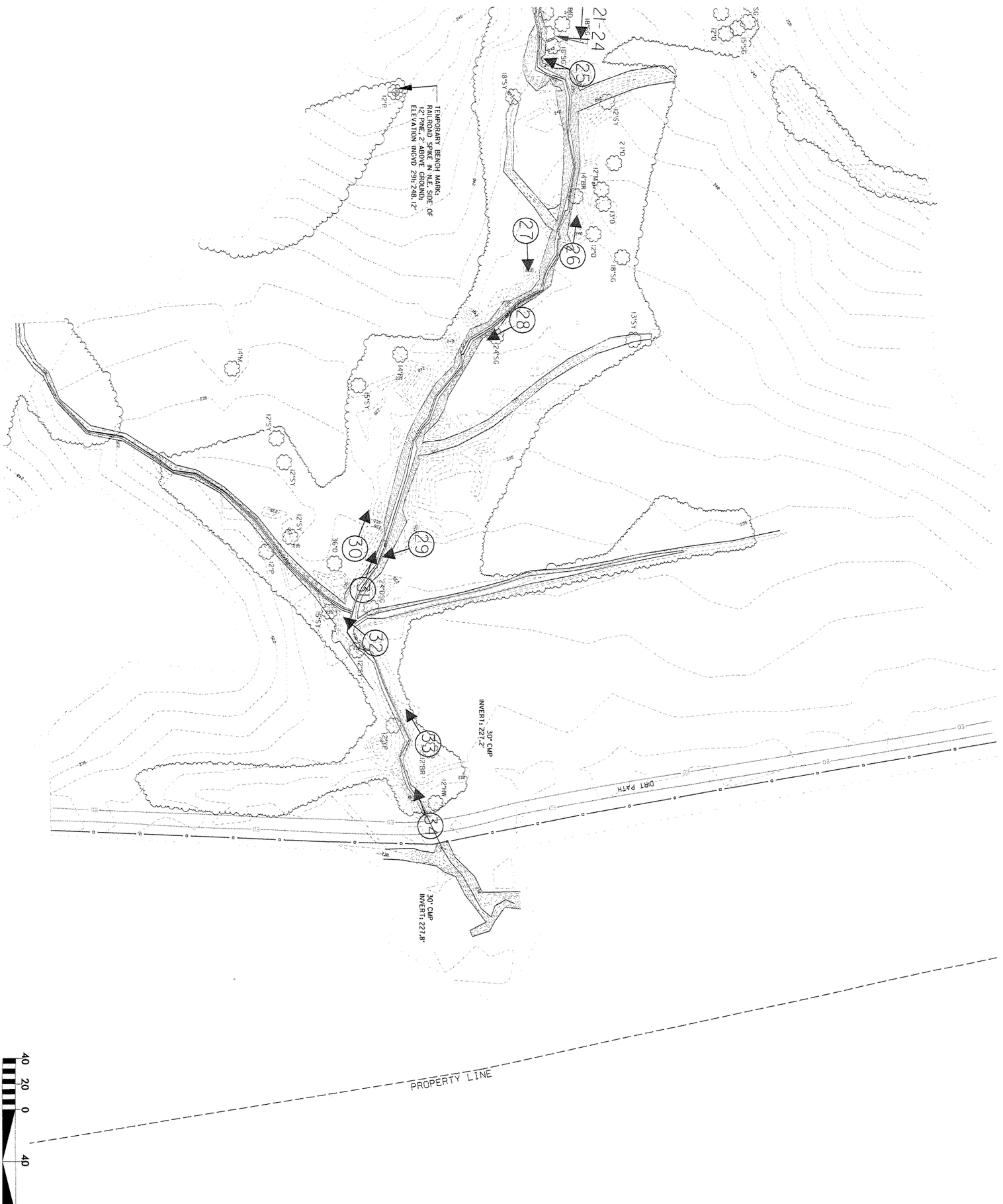

SCALES HORIZ.: 1"=80'	DATE: JULY 2003	CLIENT: NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES	NC Wetlands Restoration Program	PROJECT: TRIBUTARY TO BILLY'S CREEK FRANKLIN COUNTY TITLE: RESTORATION PLAN

FIGURE:

APPENDIX A
PHOTO LOG

Prepared by
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Morrisville, North Carolina 27560
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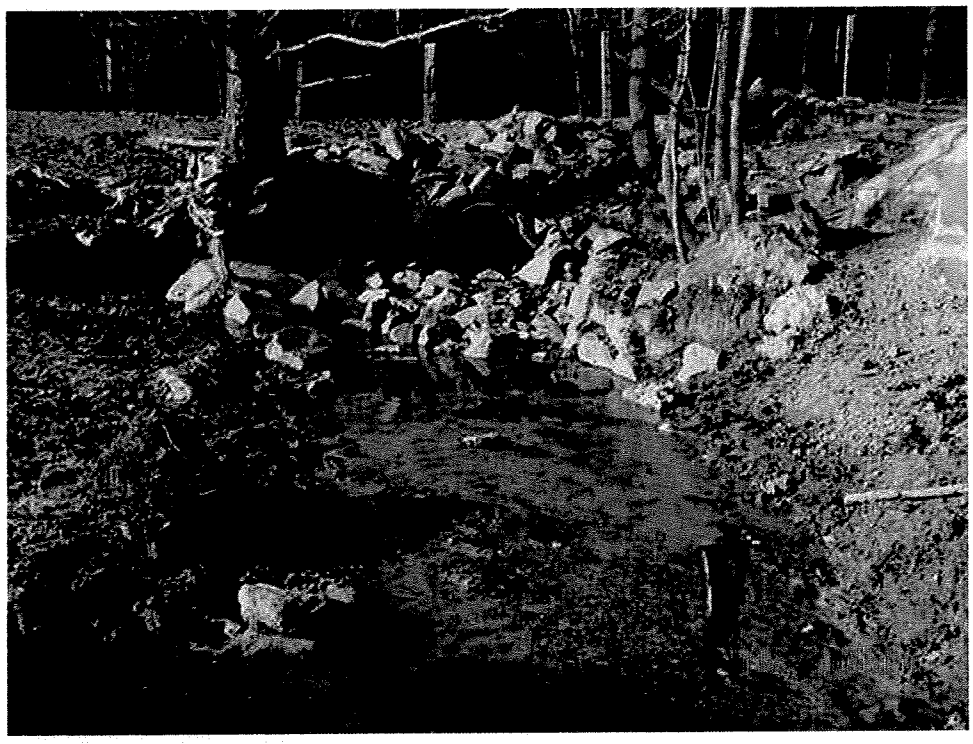
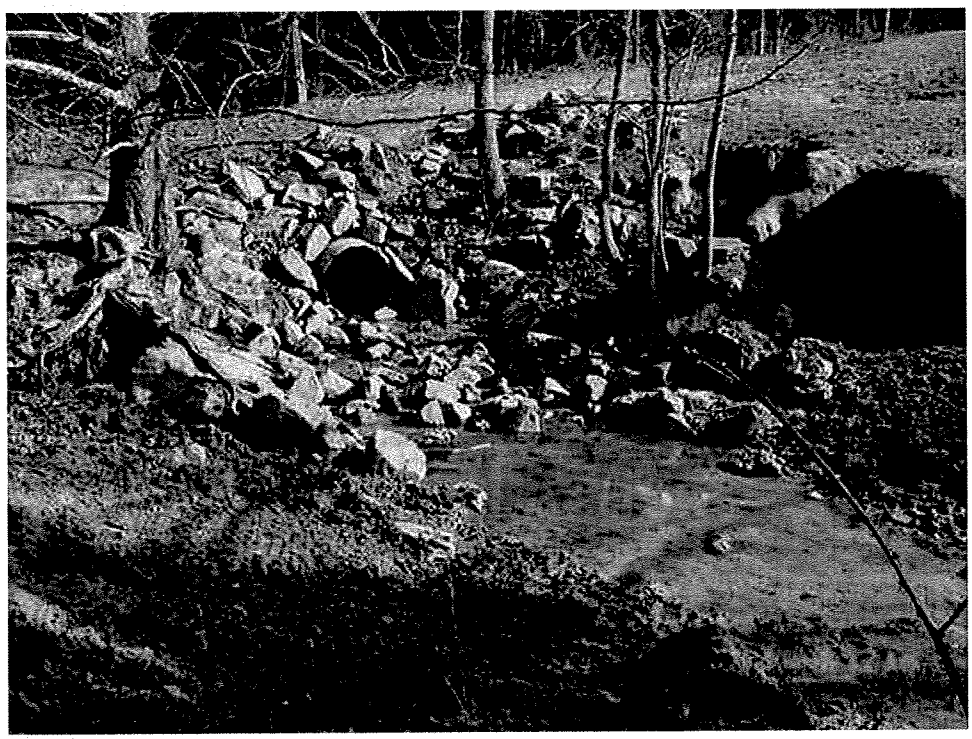
Appendix A. Photo Log

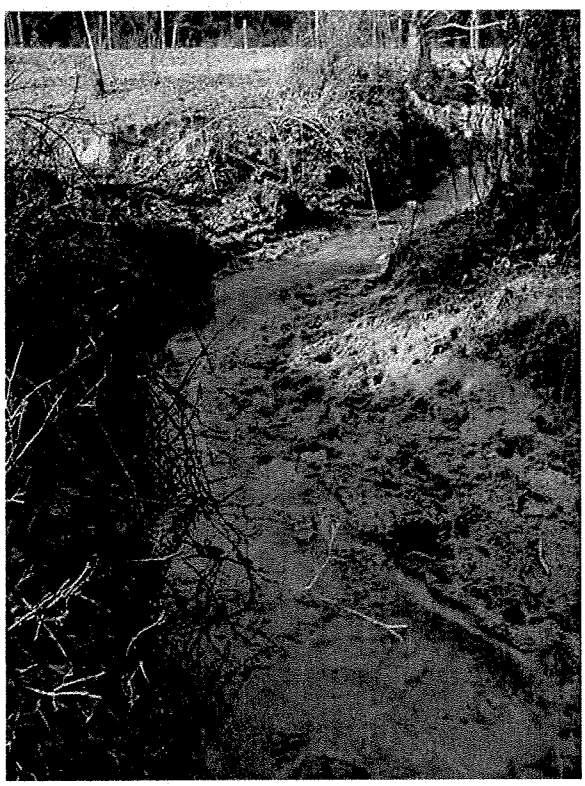


Picture 1. Culvert under farm road at north end of project reach, looking upstream.



Picture 2. Culvert under farm road at north end of project reach, looking upstream from west bank.

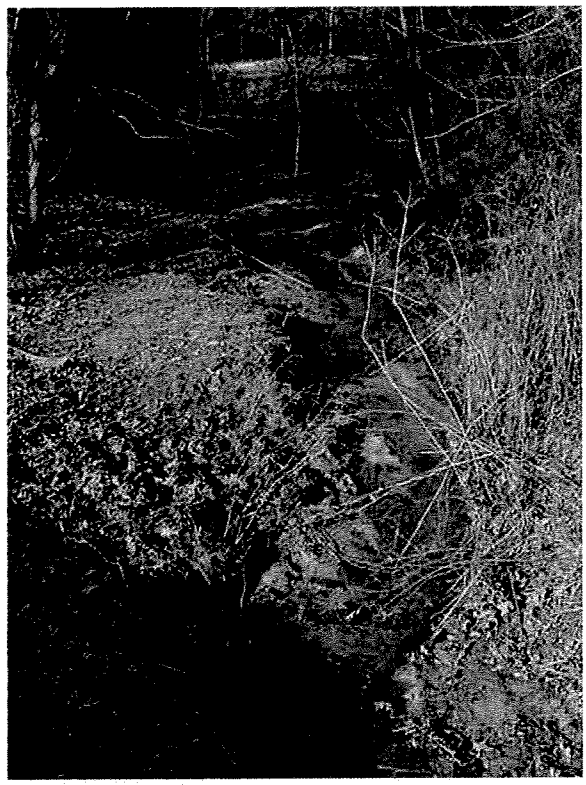
Picture 3. View of highly eroded east bank approximately 20 feet downstream from the north end of the project reach.



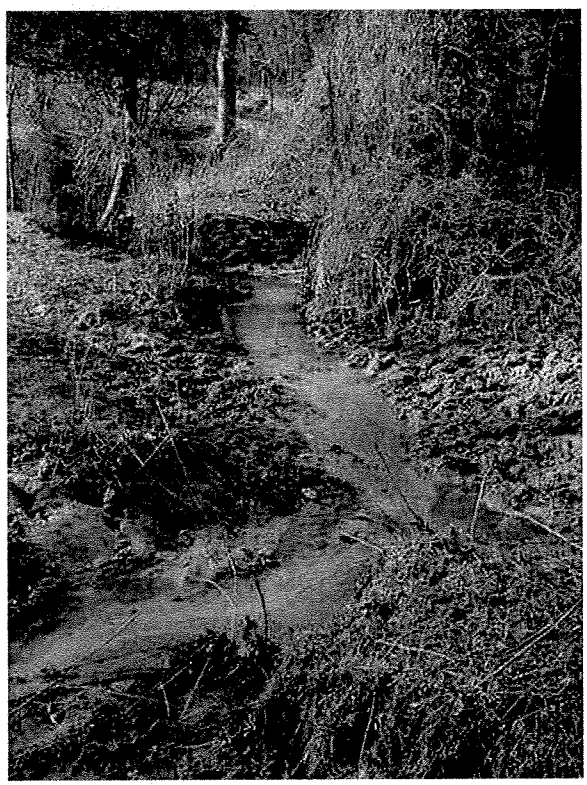
Picture 4. View of west bank of eroded area shown in Picture 3 from downstream.

Picture 5. View facing downstream looking over incised meander approximately 100' downstream from north end of project.

Picture 6. Area impacted by livestock crossing. View looking downstream.

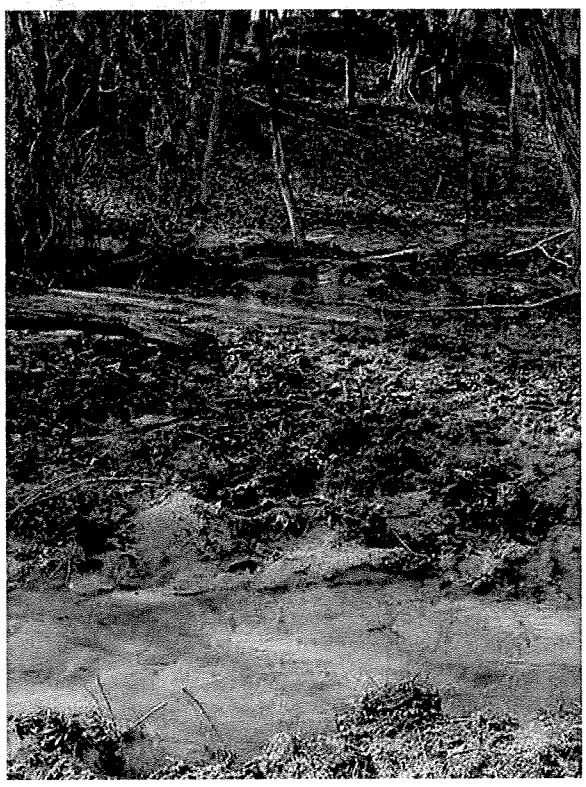


Picture 7. Area impacted by livestock crossing. View looking downstream.

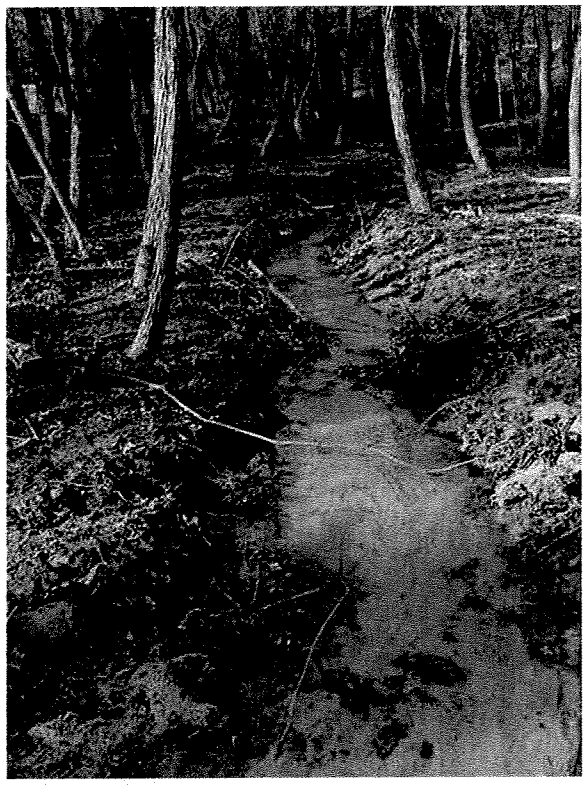


Picture 8. Area impacted by livestock crossing. View looking upstream.

Picture 9. North end of Sand and Mud Bar natural community area. View looking upstream.



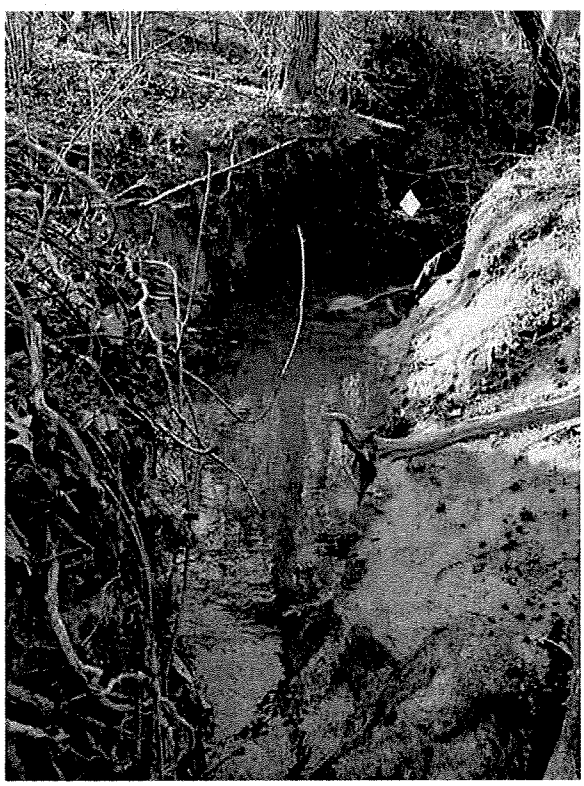
Picture 10. Near the north end of the Sand and Mud Bar natural community area. View looking toward west bank.



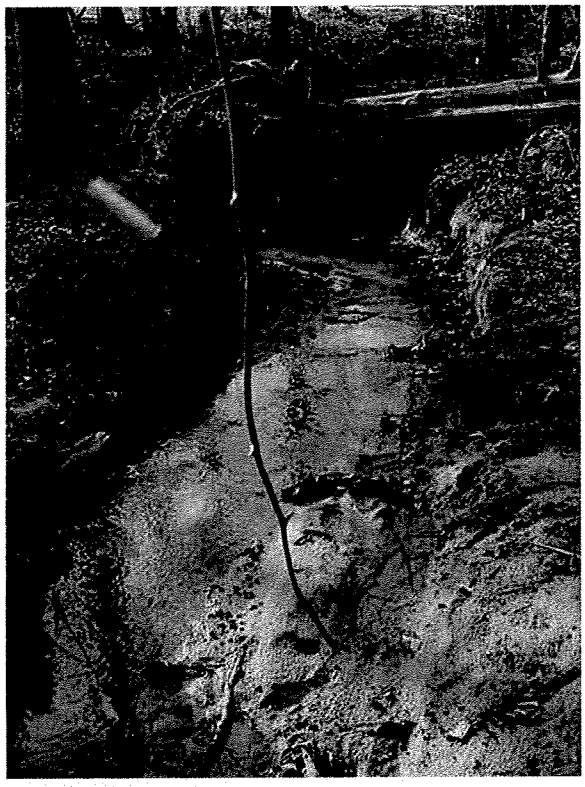
Picture 11. Near middle of Sand and Mud Bar natural community area. View looking downstream.

Picture 12. Near middle of Sand and Mud Bar natural community area. View looking upstream.

Picture 13. Grade Control Point.

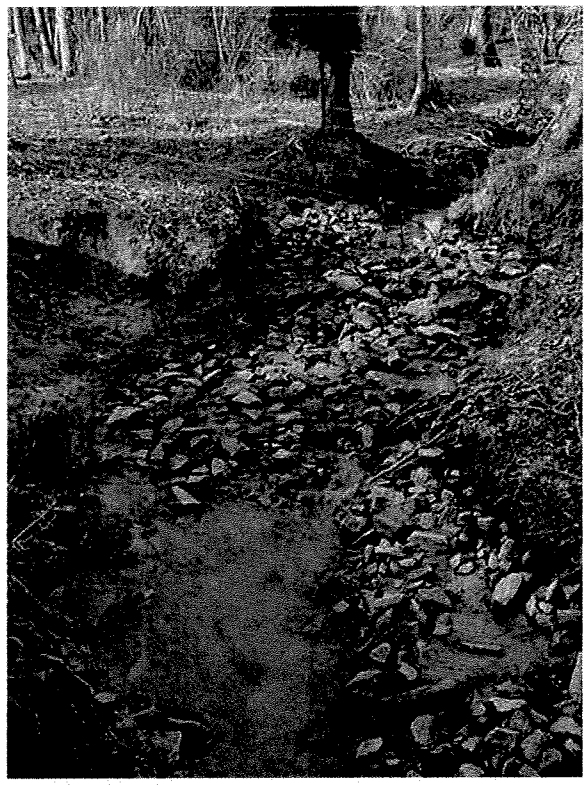


Picture 14. Downstream of Grade Control. Note highly incised stream banks on both sides.



Picture 15. Eroded stream bank and alluvial deposit in meander.

Picture 16. Grade control and undercutting in bank.

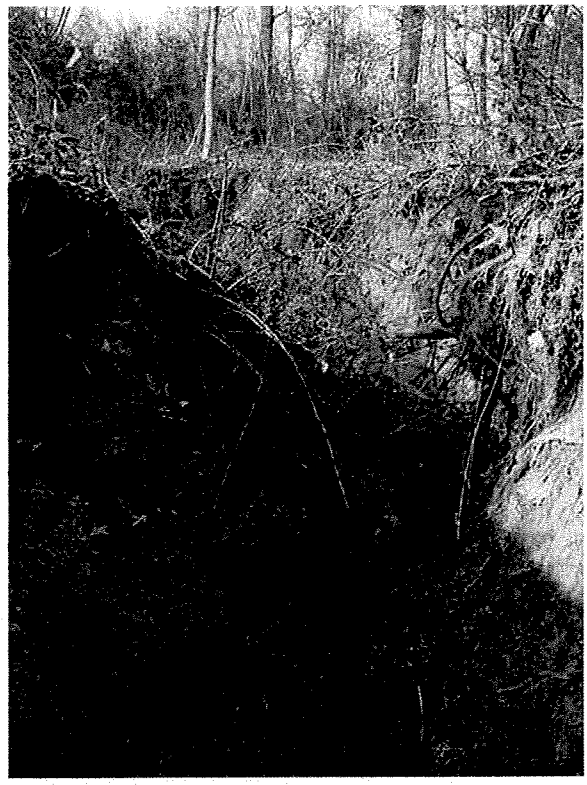


Picture 17. Impact from livestock crossing and stone added to stabilize banks at fence line.

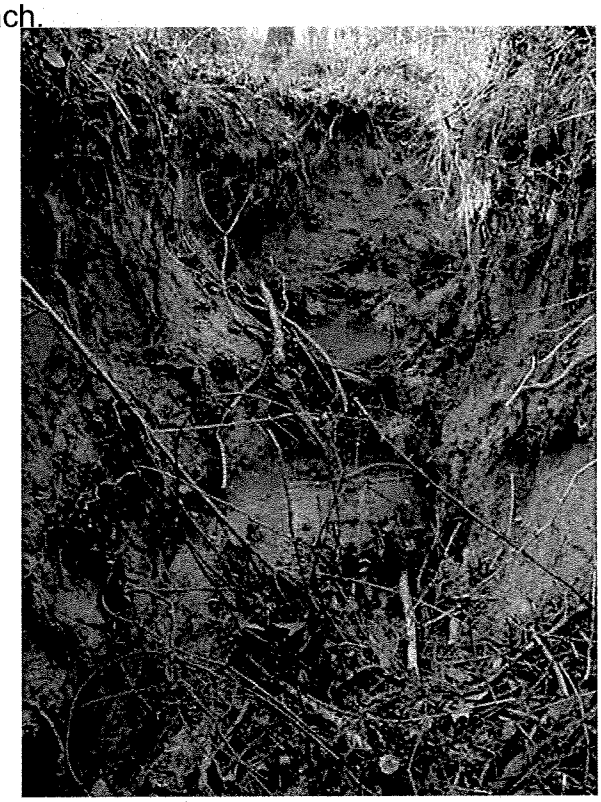
Picture 18. Highly incised banks downstream from fence line shown in Picture 17.

Picture 19. Highly incised and collapsing stream banks.

Picture 20. Highly incised stream banks.

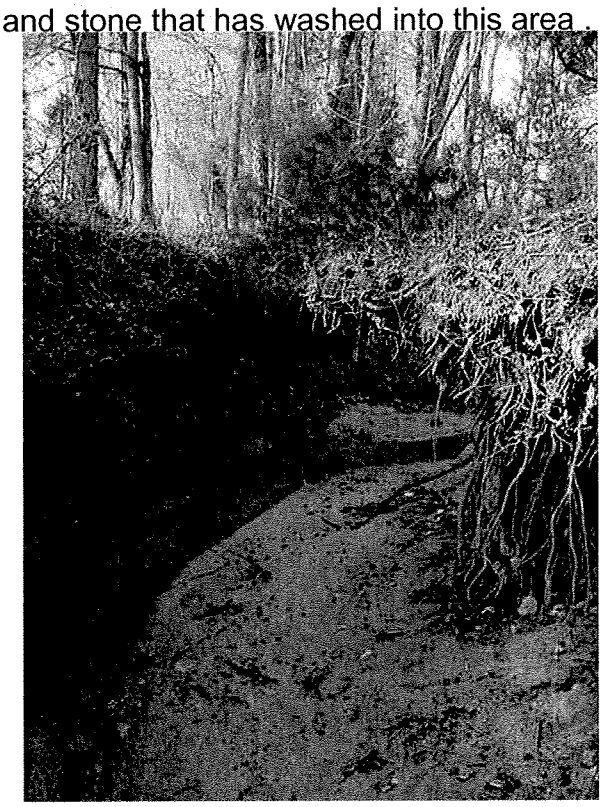


Picture 21. Highly incised and eroded stream banks south of center of project reach.



Picture 22. Highly incised and eroded stream banks downstream from Picture 21.

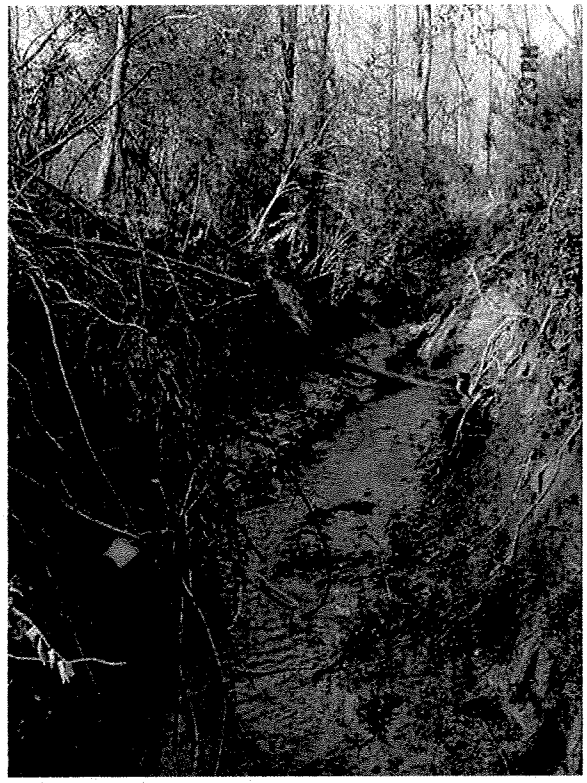
Picture 23. Highly incised and eroded stream banks. Note undercutting and stone that has washed into this area.



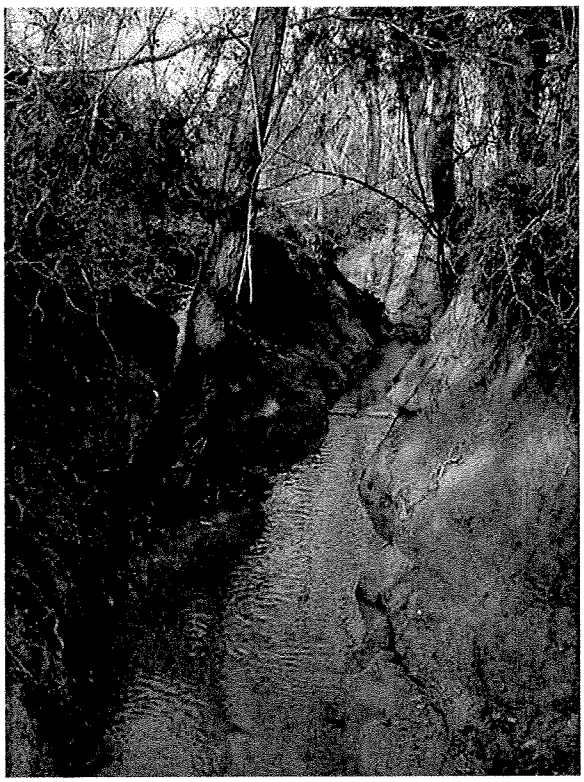
Picture 24. Highly incised and eroded stream banks. Note alluvial deposition and exposed root mass on inside of bend.

Picture 25. Highly incised and eroded stream banks. Debris added to stabilize channel.

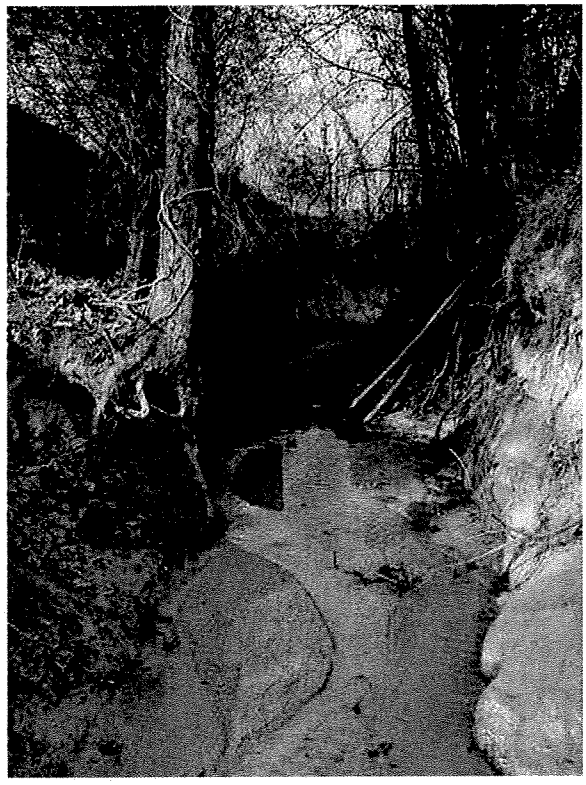
Picture 26. Highly incised eroded stream banks. Note woody debris collected in channel.



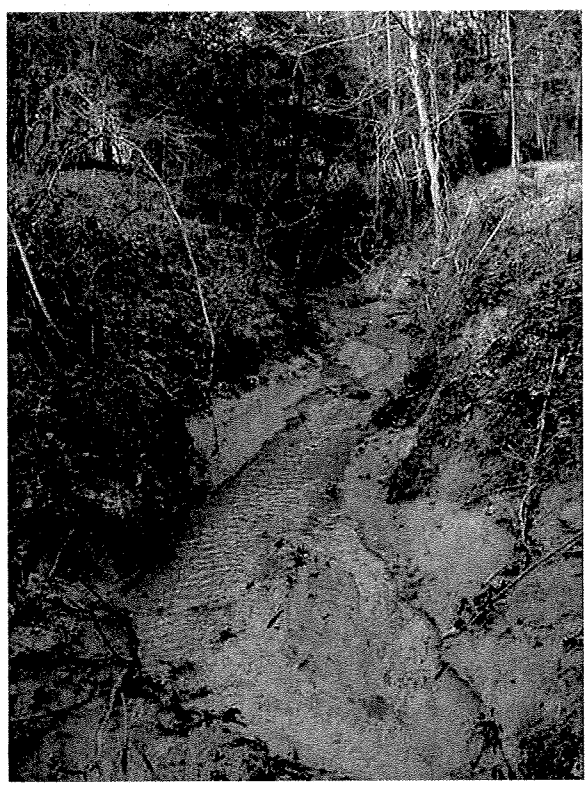
Picture 27. Highly incised channel. Pink flag indicates location of bankfull bench.



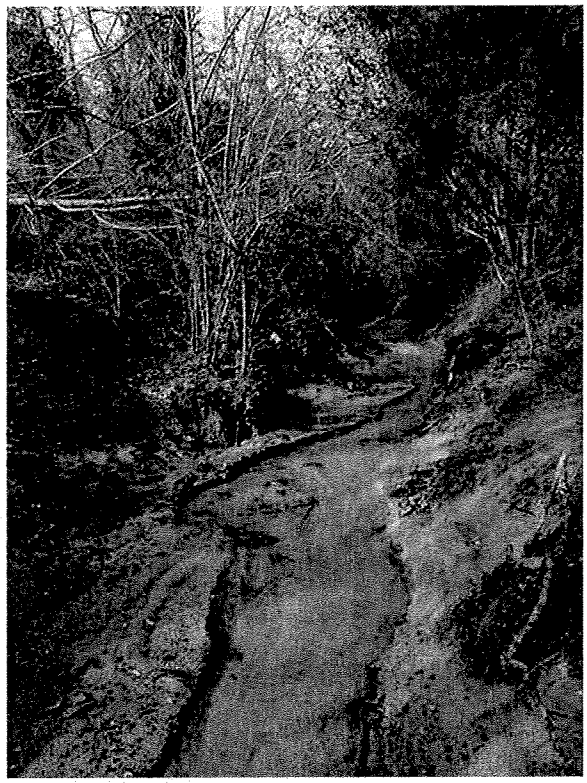
Picture 28. Highly incised and eroded stream banks. Note undercutting.



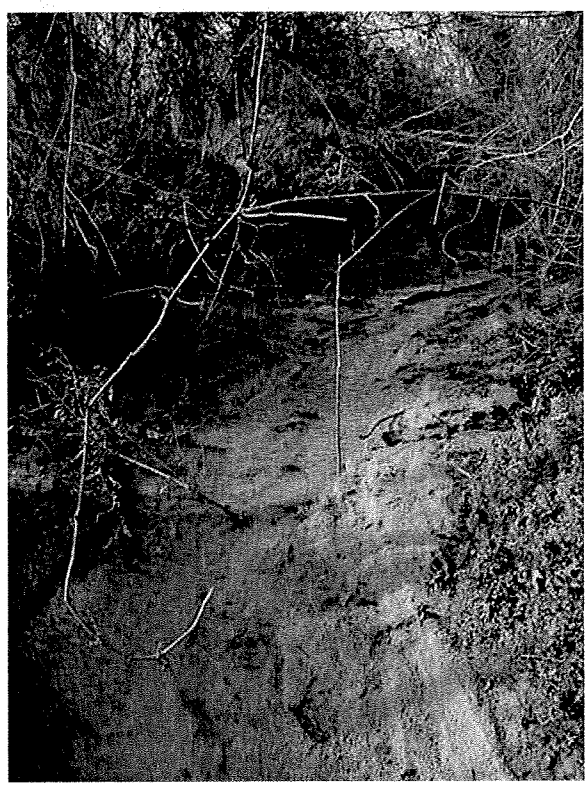
Picture 29. Highly incised and eroded stream banks.



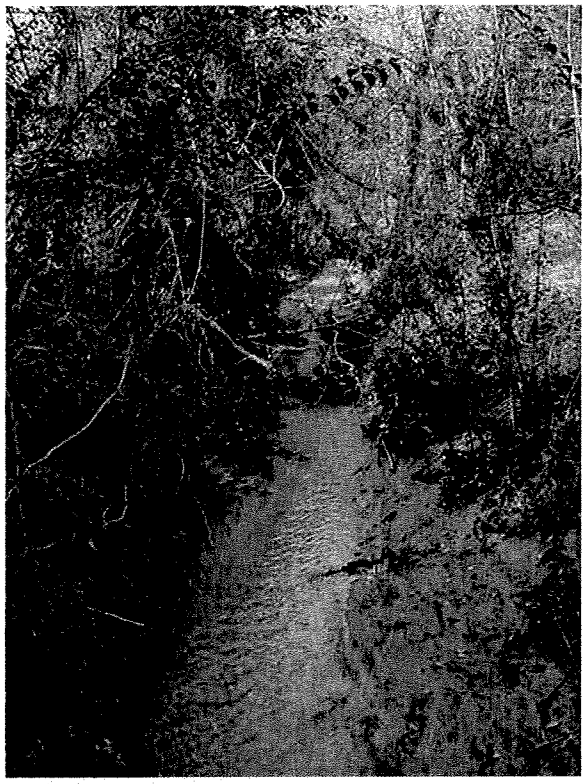
Picture 30. Highly incised and eroded stream banks.



Picture 31. Alluvial deposits south of highly incised section.



Picture 32. Widening channel at south end of project looking upstream. Tributary entering on the left.

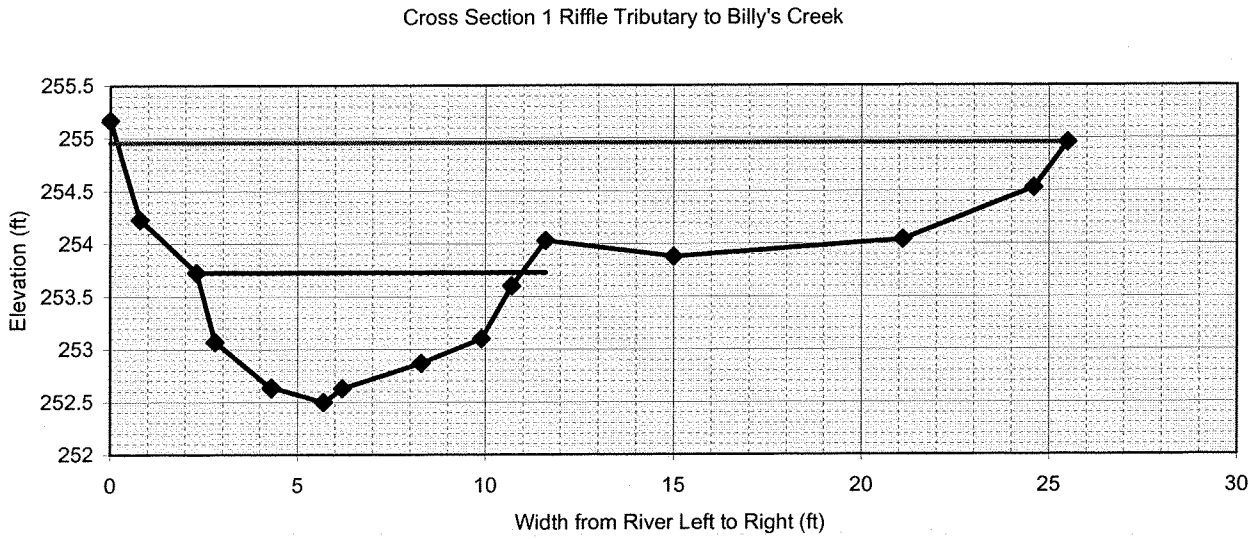


Picture 33. View looking north and upstream near southern end of project reach. Note invasive Chinese privet on west bank.

Picture 34. View looking upstream from culvert under farm road at southern end of project reach.

APPENDIX B. EXISTING CONDITIONS DATA

Cross Section



section:	Cross Section 1
	Riffle Tributary to Billy's Creek ---
description:	Riffle #1
height of instrument (ft):	271.03

notes	omit pt.	distance (ft)	FS (ft)	elevation
TOB	#☑#	0	15.86	255.17
	#☑#	0.8	16.8	254.23
BENCH/bk	#☐#	2.3	17.3	253.73
	#☐#	2.8	17.96	253.07
EW	#☐#	4.3	18.4	252.63
WS	#☐#	4.3	18.39	252.64
TW	#☐#	5.7	18.53	252.5
REW/WS	#☐#	6.2	18.4	252.63
	#☐#	8.3	18.16	252.87
	#☐#	9.9	17.93	253.1
	#☐#	10.7	17.43	253.6
TOB	#☐#	11.6	17	254.03
	#☑#	15	17.15	253.88
	#☑#	21.1	16.99	254.04
	#☑#	24.6	16.5	254.53
	#☑#	25.5	16.07	254.96
	#☐#			
	#☐#			
	#☐#			
	#☐#			
	#☐#			
	#☐#			
	#☐#			
	#☐#			
	#☐#			

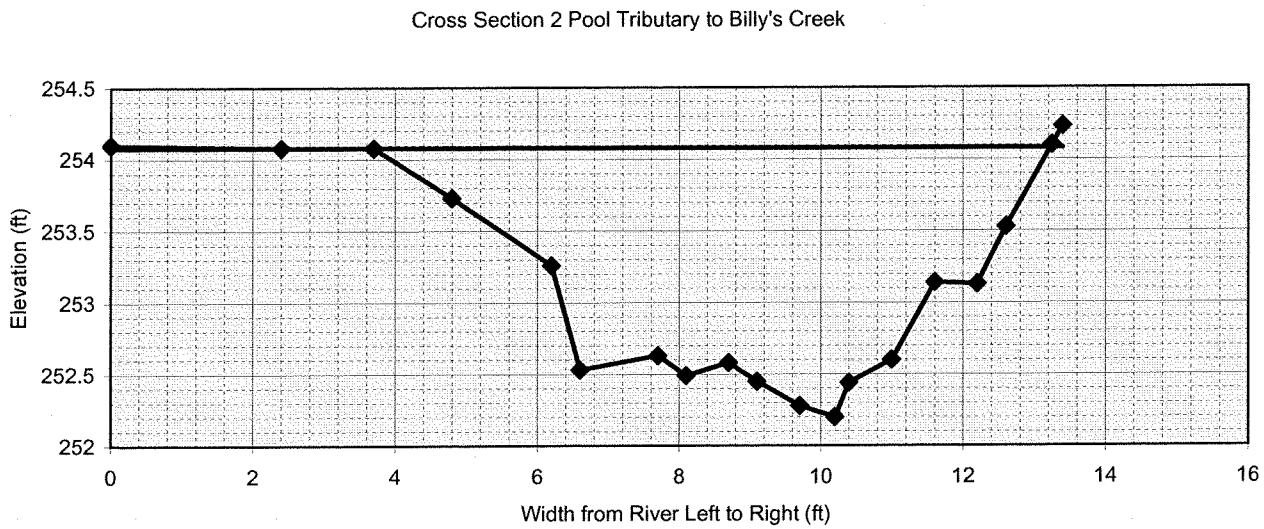
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
17.3	17	25.3	0.659	0.033
253.73	254.03			

dimensions			
7.3	x-section area	0.8	d mean
8.7	width	9.3	wet P
1.2	d max	0.8	hyd radi
1.5	bank ht	10.4	w/d ratio
25.3	W flood prone area	2.9	ent ratio

hydraulics	
3.1	velocity (ft/sec)
22.5	discharge rate, Q (cfs)
0.32	shear stress ((lbs/ft sq)
0.41	shear velocity (ft/sec)
1.068	unit stream power (lbs/ft/sec)
0.36	Froude number
7.6	friction factor u/u*
18.8	threshold grain size (mm)

check from channel material			
4	measured D84 (mm)		
61.9	relative roughness	13.0	fric. factor
0.019	Manning's n from channel material		

Cross Section



section:	Cross Section 2
	Pool
	Tributary to Billy's Creek
	---
description:	Pool-Cross Section 2
height of instrument (ft):	271.03

notes	omit pt.	distance (ft)	FS (ft)	elevation
	# #	0	16.93	254.1
	# #	2.4	16.95	254.08
TOB/BKF	# #	3.7	16.95	254.08
	# #	4.8	17.3	253.73
	# #	6.2	17.77	253.26
	# #	6.6	18.5	252.53
	# #	7.7	18.4	252.63
	# #	8.1	18.54	252.49
	# #	8.7	18.45	252.58
EW/WS	# #	9.1	18.58	252.45
	# #	9.7	18.75	252.28
TW	# #	10.2	18.83	252.2
REW/WS	# #	10.4	18.69	252.44
	# #	11	18.43	252.6
	# #	11.6	17.89	253.14
	# #	12.2	17.9	253.13
	# #	12.6	17.5	253.53
	# #	13.25	16.93	254.1
	# #	13.4	16.8	254.23
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			

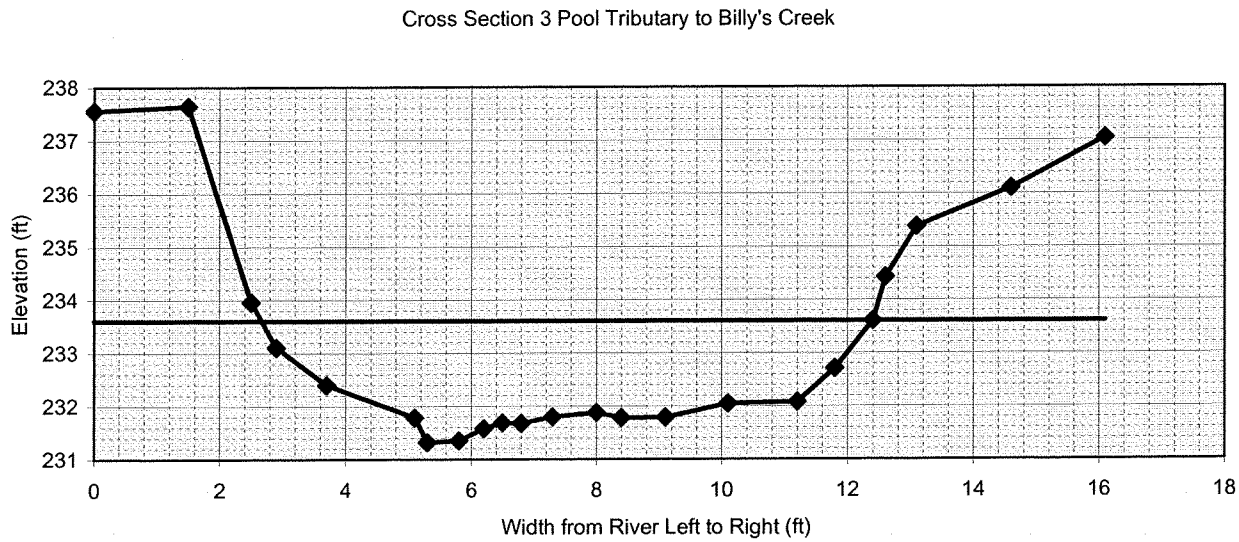
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
16.95	16.95			
254.08	254.08			

dimensions			
10.3	x-section area	1.1	d mean
9.5	width	10.9	wet P
1.9	d max	0.9	hyd radi
1.9	bank ht	~~8.8~~	w/d ratio
~~0.0~~	W flood prone area	~~0.0~~	ent ratio

hydraulics	
~~0.0~~	velocity (ft/sec)
~~0.0~~	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
~~0.000~~	unit stream power (lbs/ft/sec)
~~0.00~~	Froude number
~~0.0~~	friction factor u/u*
~~0.0~~	threshold grain size (mm)

check from channel material			
4	measured D84 (mm)		
~~79.9~~	relative roughness	~~13.7~~	fric. factor
~~0.000~~	Manning's n from channel material		

Cross Section



section:	Cross Section 3
	Pool Tributary to Billy's Creek ---
description:	Pool- Cross Section 3
height of instrument (ft):	244.24

notes	omit pt.	distance (ft)	FS (ft)	elevation
	#☐#	0	6.68	237.56
TOB	#☐#	1.5	6.6	237.64
	#☐#	2.5	10.28	233.96
	#☐#	2.9	11.13	233.11
	#☐#	3.7	11.84	232.4
WE/WS	#☐#	5.1	12.45	231.79
	#☐#	5.3	12.92	231.32
	#☐#	5.8	12.89	231.35
	#☐#	6.2	12.66	231.58
	#☐#	6.5	12.55	231.69
	#☐#	6.8	12.56	231.68
SAND BAR	#☐#	7.3	12.44	231.8
	#☐#	8	12.36	231.88
EDGE BAR	#☐#	8.4	12.46	231.78
REW/WS	#☐#	9.1	12.45	231.79
	#☐#	10.1	12.19	232.05
	#☐#	11.2	12.16	232.08
IB	#☐#	11.8	11.53	232.71
BKF	#☐#	12.4	10.63	233.61
	#☐#	12.6	9.81	234.43
	#☐#	13.1	8.86	235.38
	#☐#	14.6	8.14	236.1
	#☐#	16.1	7.2	237.04
	#☐#			
	#☐#			

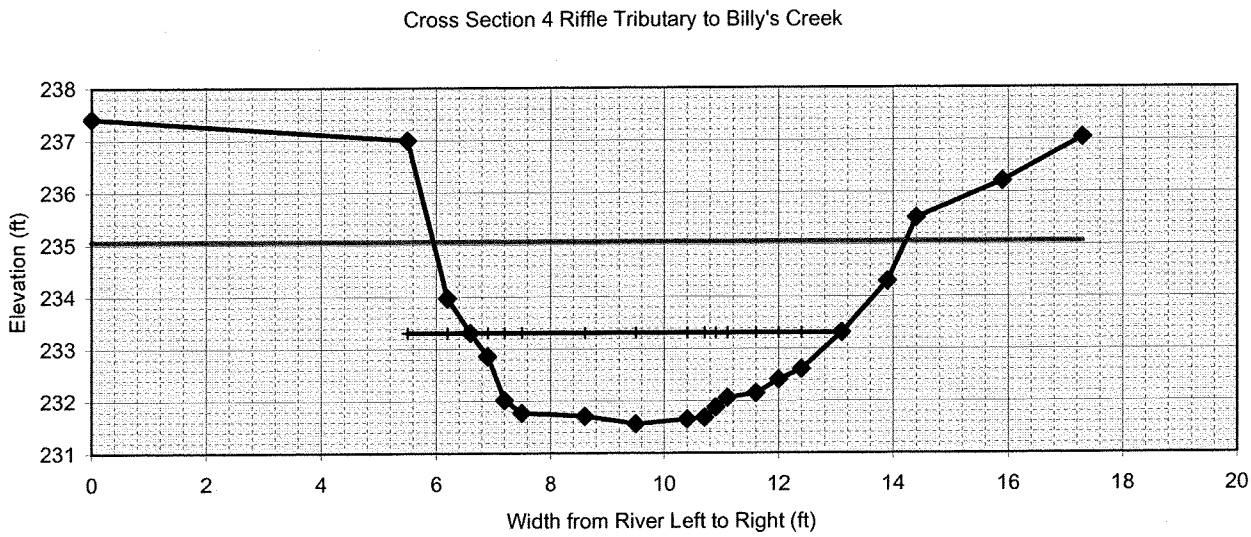
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
10.63	8.86			
233.61	235.38			

dimensions			
15.0	x-section area	1.5	d mean
9.7	width	11.7	wet P
2.3	d max	1.3	hyd radi
4.1	bank ht	~~6.3~~	w/d ratio
~~0.0~~	W flood prone area	~~0.0~~	ent ratio

hydraulics	
~~0.0~~	velocity (ft/sec)
~~0.0~~	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
~~0.000~~	unit stream power (lbs/ft/sec)
~~0.00~~	Froude number
~~0.0~~	friction factor u/u*
~~0.0~~	threshold grain size (mm)

check from channel material			
4	measured D84 (mm)		
~~113.8~~	relative roughness	~~14.6~~	fric. factor
~~0.000~~	Manning's n from channel material		

Cross Section



section:	Cross Section 4
	Riffle Tributary to Billy's Creek ---
description:	Riffle #2
height of instrument (ft):	244.24

notes	omit pt.	distance (ft)	FS (ft)	elevation
	# ✓ #	0	6.83	237.41
TOB	# #	5.5	7.24	237
	# #	6.2	10.26	233.98
bkf	# #	6.6	10.93	233.31
	# #	6.9	11.38	232.86
	# #	7.2	12.22	232.02
	# #	7.5	12.47	231.77
LEW/WS	# #	8.6	12.53	231.71
	# #	9.5	12.68	231.56
	# #	10.4	12.59	231.65
REW/WS	# #	10.7	12.56	231.68
	# #	10.9	12.36	231.88
	# #	11.1	12.18	232.06
	# #	11.6	12.09	232.15
IB	# #	12	11.83	232.41
	# #	12.4	11.63	232.61
BKF	# #	13.1	10.93	233.31
	# ✓ #	13.9	9.95	234.29
	# ✓ #	14.4	8.73	235.51
	# ✓ #	15.9	8.03	236.21
	# ✓ #	17.3	7.2	237.04
	# #			
	# #			
	# #			
	# #			

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
10.93	7.24	8.3	0.659	0.033
233.31	237			

dimensions			
8.2	x-section area	1.3	d mean
6.5	width	8.0	wet P
1.8	d max	1.0	hyd radi
5.4	bank ht	5.2	w/d ratio
8.3	W flood prone area	1.3	ent ratio

hydraulics	
3.7	velocity (ft/sec)
30.2	discharge rate, Q (cfs)
0.42	shear stress ((lbs/ft sq)
0.46	shear velocity (ft/sec)
1.914	unit stream power (lbs/ft/sec)
0.34	Froude number
8.0	friction factor u/u*
25.2	threshold grain size (mm)

check from channel material			
4	measured D84 (mm)		
92.9	relative roughness	14.0	fric. factor
0.019	Manning's n from channel material		

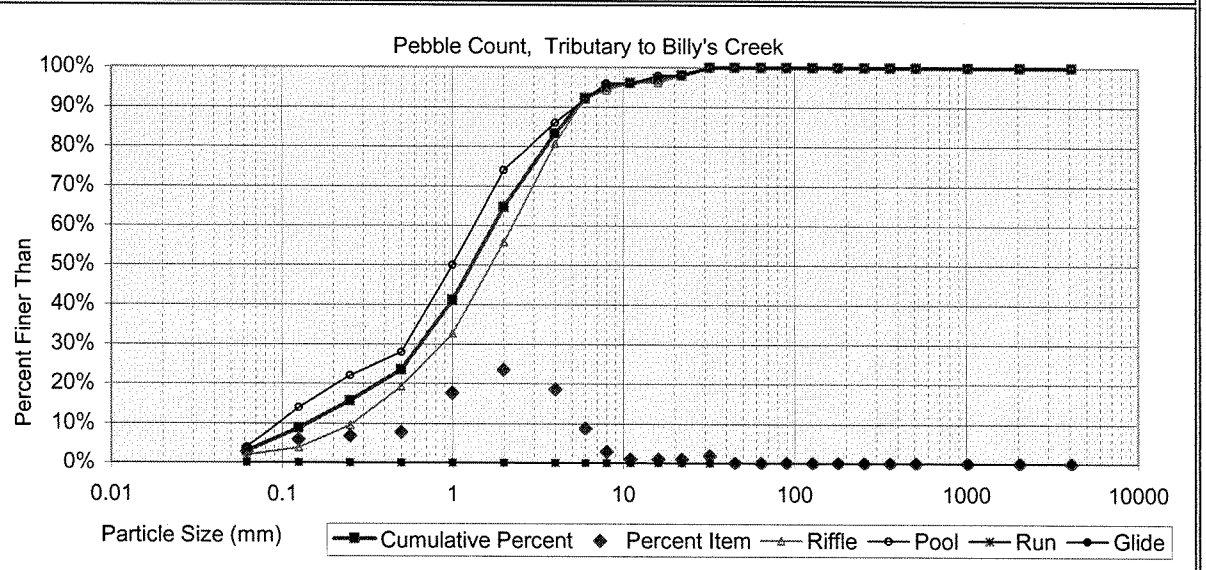
Weighted Pebble Count

Percent Riffle:	52	Percent Run:	
Percent Pool:	50	Percent Glide:	

Pebble Count,
Tributary to Billy's Creek

Grove property NE of Franklinton
Note:

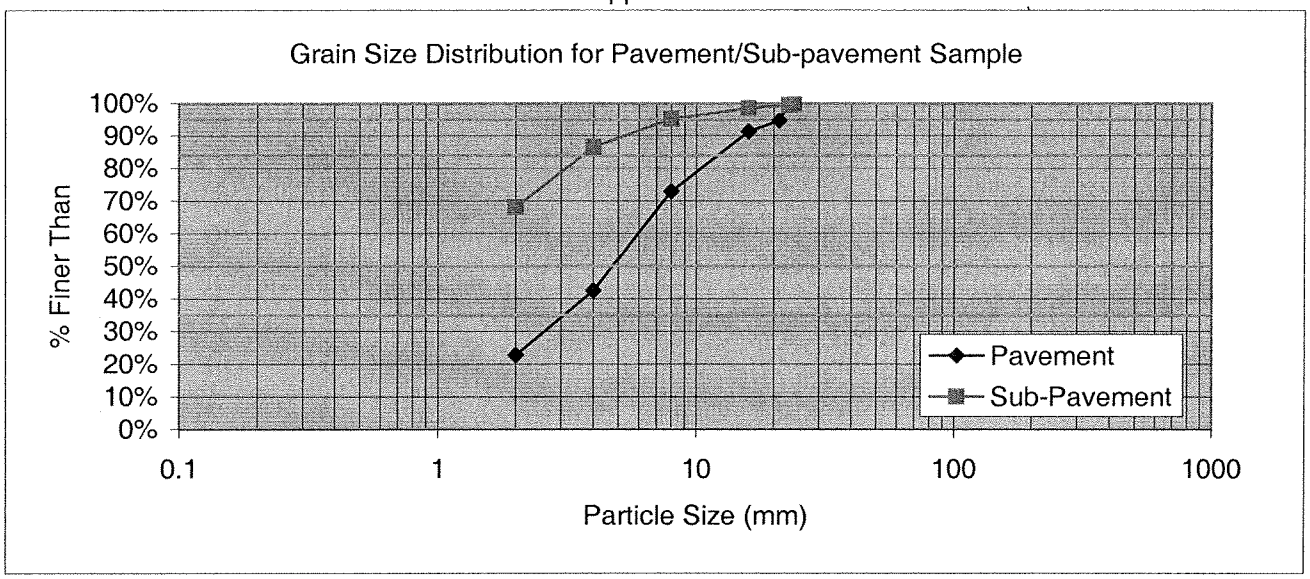
Material	Size Range (mm)		Total #	
silt/clay	0	0.062	3.0	#
very fine sand	0.062	0.13	6.0	#
fine sand	0.13	0.25	7.0	#
medium sand	0.25	0.5	8.0	#
coarse sand	0.5	1	18.0	#
very coarse sand	1	2	24.0	#
very fine gravel	2	4	19.0	#
fine gravel	4	6	9.0	#
fine gravel	6	8	3.0	#
medium gravel	8	11	1.0	#
medium gravel	11	16	1.0	#
coarse gravel	16	22	1.0	#
coarse gravel	22	32	2.0	#
very coarse gravel	32	45	0.0	#
very coarse gravel	45	64	0.0	#
small cobble	64	90	0.0	#
medium cobble	90	128	0.0	#
large cobble	128	180	0.0	#
very large cobble	180	256	0.0	#
small boulder	256	362	0.0	#
small boulder	362	512	0.0	#
medium boulder	512	1024	0.0	#
large boulder	1024	2048	0.0	#
very large boulder	2048	4096	0.0	#
bedrock			0.0	#
		Weighted Count:	102	
		True Total Particle Count:	102	



Size percent less than (mm)				
D16	D35	D50	D84	D95
0.257	0.78	1.3	4	8

Percent by substrate type					
silt/clay	sand	gravel	cobble	boulder	bedrock
3%	62%	35%	0%	0%	0%

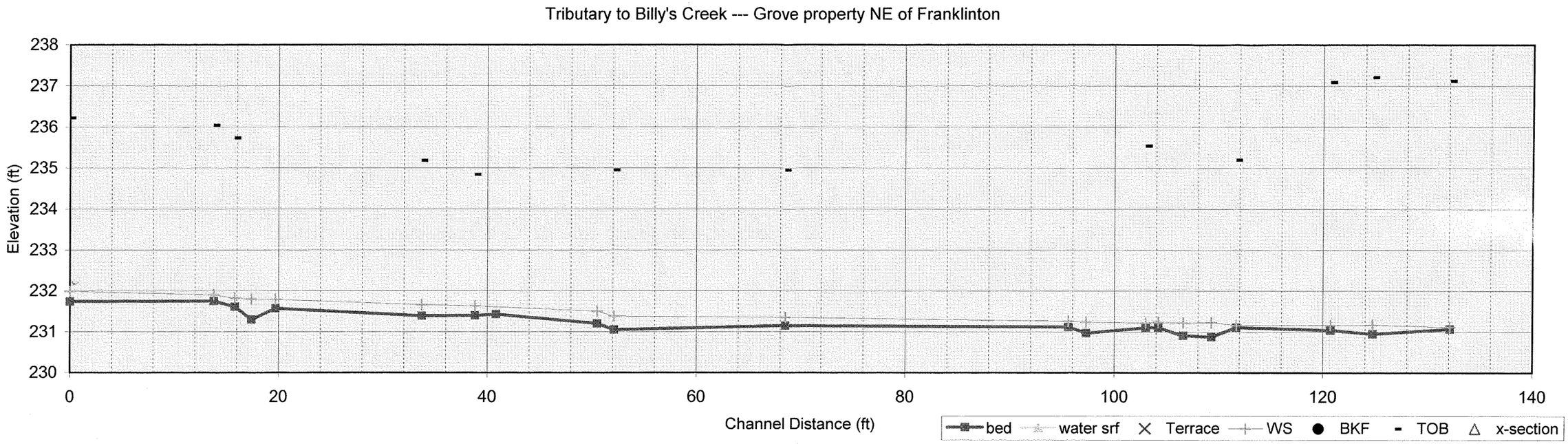
Appendix B.



Sub-pavement			
Size	Weight (gm)	Percent	Cumulative percent finer than
2	1913.5	68%	68.1%
4	519	18%	86.5%
8	245.5	9%	95.3%
16	90.2	3%	98.5%
23	29.7	1%	99.5%
24	13	0%	100.0%
		0%	100.0%
		0%	100.0%
Total	2810.9	100%	100.0%

Pavement			
Size	Weight (gm)	Percent	Cumulative percent finer than
2	66.2	23%	22.7%
4	57.6	20%	42.5%
8	88.5	30%	72.9%
16	53.5	18%	91.3%
21	9.8	3%	94.7%
23	15.5	5%	100.0%
		0%	100.0%
Total	291.1	100%	100.0%

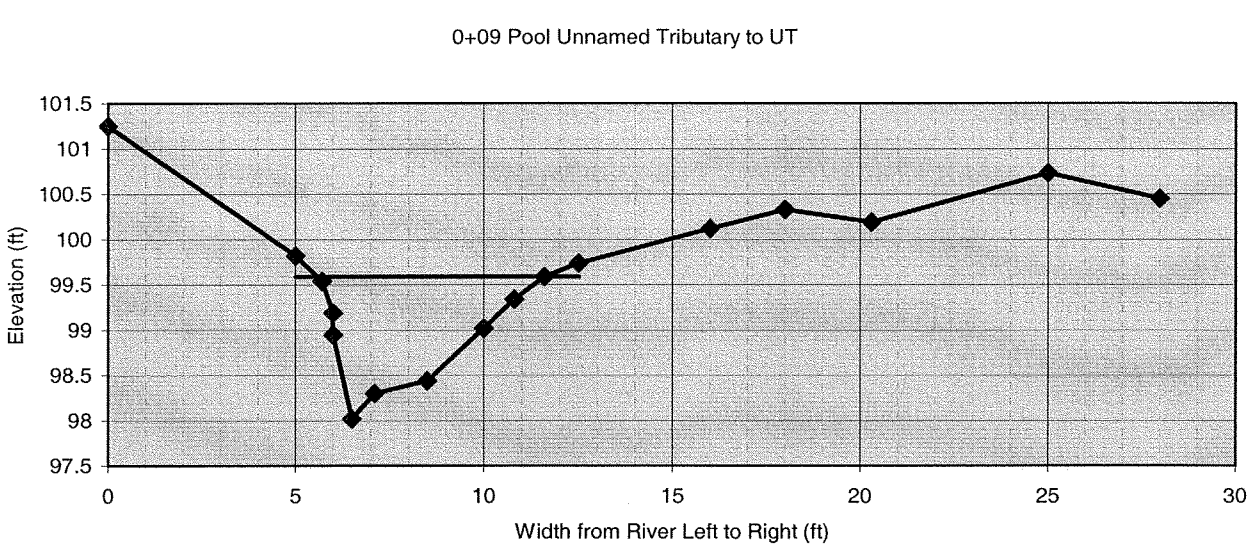
Slope Profile



244.24 :Elevation BM

APPENDIX C. REFERENCE REACH DATA

Cross Section



section:	0+09
	Pool
	Unnamed Tributary to UT
	Billy's Creek
description:	
height of instrument (ft):	105.65

notes	omit pt.	distance (ft)	FS (ft)	elevation
	#☑#	0	4.4	101.25
	#☐#	5	5.83	99.82
	#☐#	5.7	6.11	99.54
	#☐#	6	6.46	99.19
LEW	#☐#	6	6.7	98.95
	#☐#	6.5	7.63	98.02
REW/WS	#☐#	7.1	7.35	98.3
	#☐#	8.5	7.21	98.44
	#☐#	10	6.63	99.02
	#☐#	10.8	6.31	99.34
BKF	#☐#	11.6	6.06	99.59
	#☐#	12.5	5.91	99.74
	#☑#	16	5.53	100.12
	#☑#	18	5.32	100.33
	#☑#	20.3	5.46	100.19
	#☑#	25	4.92	100.73
	#☑#	28	5.2	100.45
	#☐#			
	#☐#			
	#☐#			
	#☐#			
	#☐#			
	#☐#			
	#☐#			
	#☐#			

☐

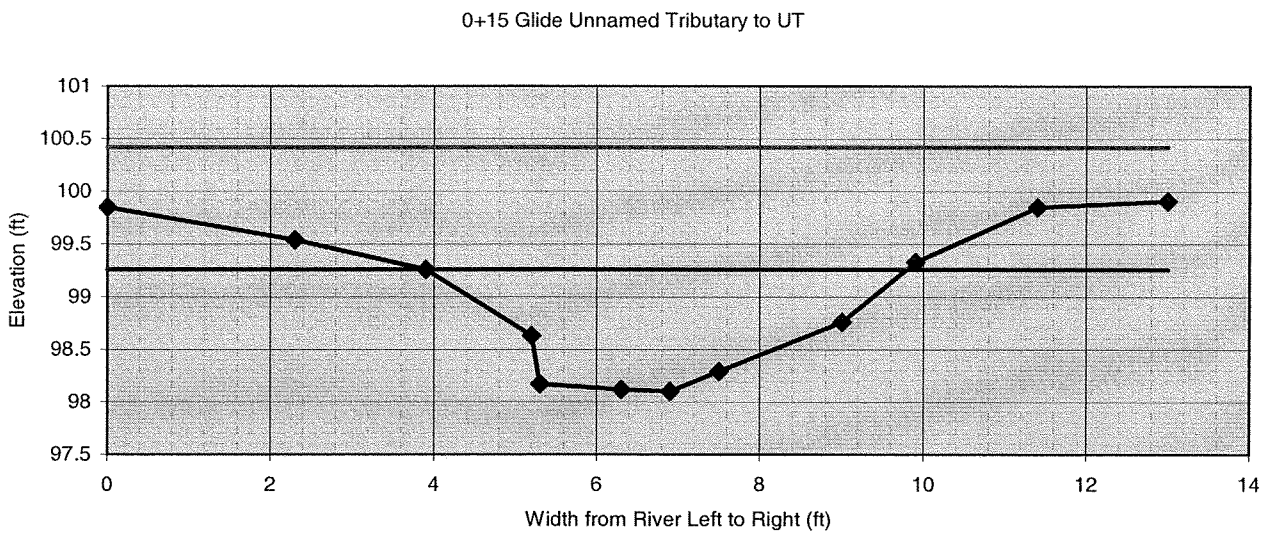
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
6.06	6.06			
99.59	99.59			

dimensions			
4.9	x-section area	0.8	d mean
6.0	width	7.3	wet P
1.6	d max	0.7	hyd radi
1.6	bank ht	~~7.4~~	w/d ratio
~~0.0~~	W flood prone area	~~0.0~~	ent ratio

hydraulics	
~~0.0~~	velocity (ft/sec)
~~0.0~~	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
~~0.000~~	unit stream power (lbs/ft/sec)
~~0.00~~	Froude number
~~0.0~~	friction factor u/u*
~~0.0~~	threshold grain size (mm)

check from channel material			
~~3~~	measured D84 (mm)		
~~82.2~~	relative roughness	~~13.7~~	fric. factor
~~0.000~~	Manning's n from channel material		

Cross Section



section:	0+15
	Glide
	Unnamed Tributary to UT
	Billy's Creek
description:	
height of instrument (ft):	105.65

notes	omit pt.	distance (ft)	FS (ft)	elevation
	# #	0	5.8	99.85
	# #	2.3	6.11	99.54
BKF	# #	3.9	6.39	99.26
EW	# #	5.2	7.02	98.63
	# #	5.3	7.48	98.17
	# #	6.3	7.53	98.12
	# #	6.9	7.55	98.1
EW/WS	# #	7.5	7.36	98.29
BACK BEN	# #	9	6.89	98.76
	# #	9.9	6.32	99.33
TOB	# #	11.4	5.8	99.85
	# #	13	5.74	99.91
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			
	# #			

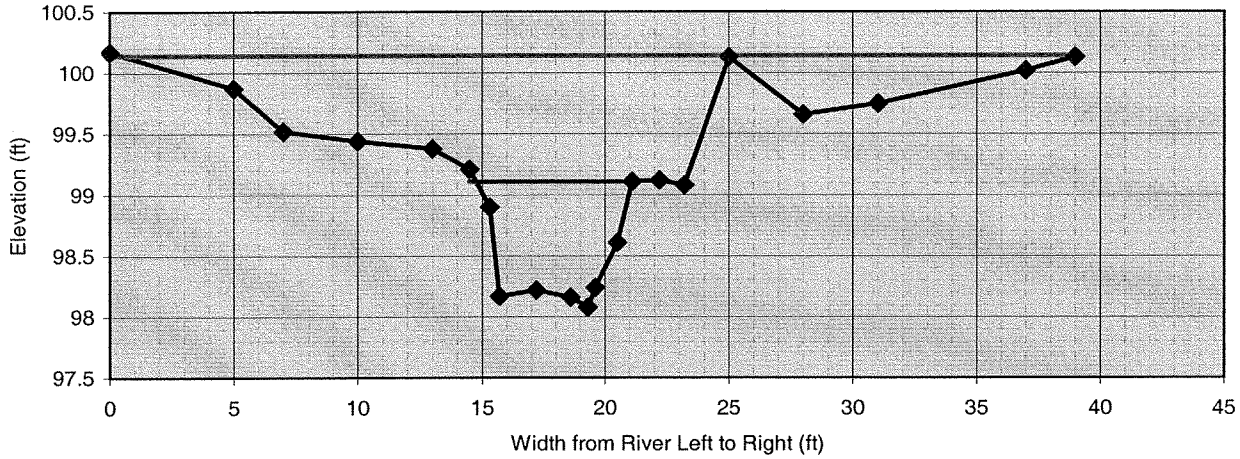
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
6.39				
99.26	---			

dimensions			
4.2	x-section area	0.7	d mean
5.9	width	6.7	wet P
1.2	d max	0.6	hyd radi
0.0	bank ht	~~8.2~~	w/d ratio
~~0.0~~	W flood prone area	~~0.0~~	ent ratio

hydraulics	
~~0.0~~	velocity (ft/sec)
~~0.0~~	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
~~0.000~~	unit stream power (lbs/ft/sec)
~~0.00~~	Froude number
~~0.0~~	friction factor u/u*
~~0.0~~	threshold grain size (mm)

check from channel material			
~~3~~	measured D84 (mm)		
~~72.7~~	relative roughness	~~13.4~~	fric. factor
~~0.000~~	Manning's n from channel material		

Cross Section



section:	0+25
	Riffle
	Unnamed Tributary to UT
	Billy's Creek
description:	
height of instrument (ft):	105.65

notes	omit pt.	distance (ft)	FS (ft)	elevation
	#☑#	0	5.48	100.17
	#☑#	5	5.78	99.87
	#☑#	7	6.13	99.52
	#☑#	10	6.21	99.44
	#☑#	13	6.27	99.38
	#☐#	14.5	6.44	99.21
	#☐#	15.3	6.75	98.9
	#☐#	15.7	7.48	98.17
LEW/WS	#☐#	17.2	7.43	98.22
	#☐#	18.6	7.49	98.16
	#☐#	19.3	7.57	98.08
REW/WS	#☐#	19.6	7.41	98.24
	#☐#	20.5	7.04	98.61
rbkf	#☐#	21.1	6.54	99.11
	#☑#	22.2	6.53	99.12
	#☑#	23.2	6.57	99.08
	#☑#	25	5.52	100.13
	#☑#	28	5.99	99.66
	#☑#	31	5.9	99.75
	#☑#	37	5.63	100.02
	#☑#	39	5.52	100.13
	#☐#			
	#☐#			
	#☐#			
	#☐#			

☐

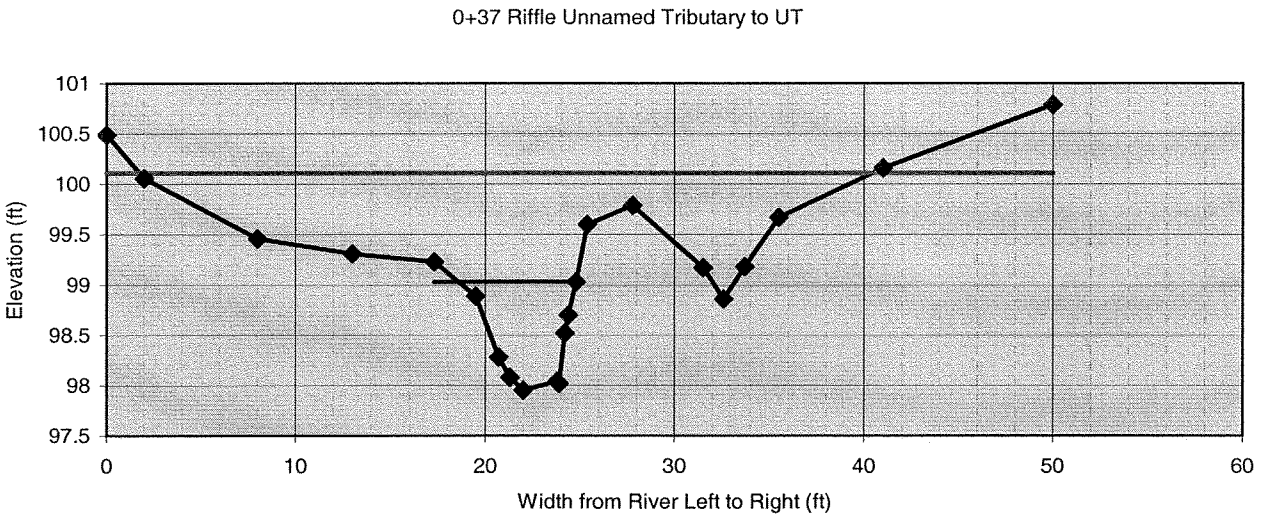
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
6.54	6.54	39.0	0.778	0.033
99.11	99.11			

dimensions			
4.7	x-section area	0.7	d mean
6.3	width	7.1	wet P
1.0	d max	0.7	hyd radi
1.0	bank ht	8.6	w/d ratio
39.0	W flood prone area	6.1	ent ratio

hydraulics	
3.0	velocity (ft/sec)
14.1	discharge rate, Q (cfs)
0.32	shear stress ((lbs/ft sq)
0.41	shear velocity (ft/sec)
1.082	unit stream power (lbs/ft/sec)
0.38	Froude number
7.4	friction factor u/u*
18.7	threshold grain size (mm)

check from channel material			
3	measured D84 (mm)		
74.7	relative roughness	13.5	fric. factor
0.018	Manning's n from channel material		

Cross Section



section:	0+37
	Riffle Unnamed Tributary to UT Billy's Creek
description:	BM is White Oak on stream left before meander bend (nail w/ blue flagging
height of instrument (ft):	105.65

notes	omit pt.	distance (ft)	FS (ft)	elevation
	#☑#	0	5.16	100.49
	#☑#	2	5.59	100.06
	#☑#	8	6.19	99.46
	#☑#	13	6.34	99.31
LTOB/BKF	#☐#	17.3	6.42	99.23
	#☐#	19.5	6.76	98.89
	#☐#	20.7	7.37	98.28
LEW	#☐#	21.3	7.57	98.08
TW	#☐#	22	7.7	97.95
	#☐#	23.8	7.61	98.04
REW	#☐#	23.9	7.63	98.02
	#☐#	24.2	7.13	98.52
	#☐#	24.4	6.95	98.7
	#☐#	24.8	6.62	99.03
RTOB	#☑#	25.4	6.05	99.6
	#☑#	27.8	5.86	99.79
	#☑#	31.5	6.48	99.17
	#☑#	32.6	6.79	98.86
	#☑#	33.7	6.47	99.18
	#☑#	35.5	5.98	99.67
	#☑#	41	5.49	100.16
	#☑#	50	4.86	100.79
	#☐#			
	#☐#			

☐

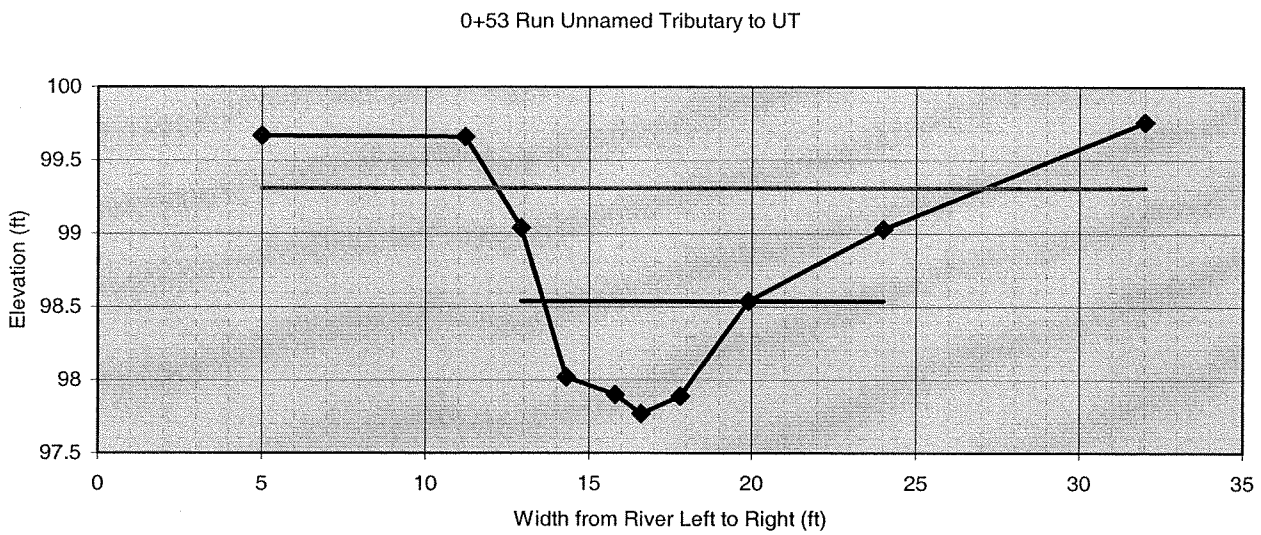
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
6.62	6.76	33.0	0.778	0.033
99.03	98.89			

dimensions			
4.2	x-section area	0.7	d mean
6.2	width	6.9	wet P
1.1	d max	0.6	hyd radi
0.9	bank ht	9.3	w/d ratio
33.0	W flood prone area	5.3	ent ratio

hydraulics	
2.8	velocity (ft/sec)
11.8	discharge rate, Q (cfs)
0.29	shear stress ((lbs/ft sq)
0.39	shear velocity (ft/sec)
0.924	unit stream power (lbs/ft/sec)
0.37	Froude number
7.3	friction factor u/u*
15.9	threshold grain size (mm)

check from channel material			
3	measured D84 (mm)		
67.7	relative roughness	13.3	fric. factor
0.018	Manning's n from channel material		

Cross Section



section:	0+53
	Run Unnamed Tributary to UT Billy's Creek
description:	
height of instrument (ft):	105.65

notes	omit pt.	distance (ft)	FS (ft)	elevation
	# ☑ #	5	5.98	99.67
TOB	# ☑ #	11.2	5.99	99.66
BKF	# ☐ #	12.9	6.61	99.04
	# ☐ #	14.3	7.63	98.02
LEW/WS	# ☐ #	15.8	7.75	97.9
	# ☐ #	16.6	7.88	97.77
	# ☐ #	17.8	7.76	97.89
	# ☐ #	19.9	7.11	98.54
BKF	# ☐ #	24	6.62	99.03
	# ☑ #	32	5.89	99.76
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			
	# ☐ #			

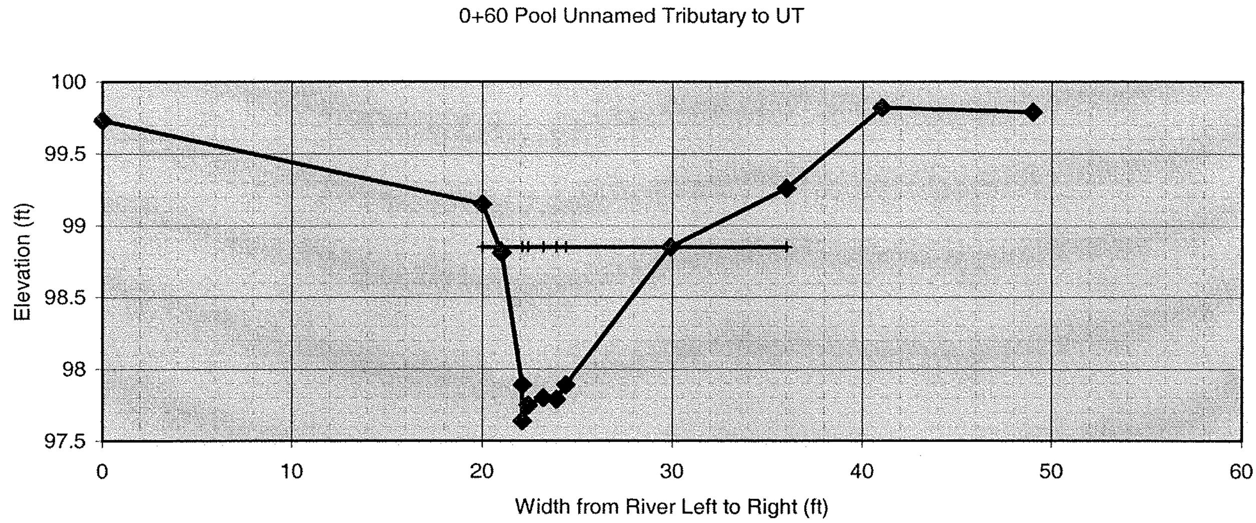
FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
7.11				
98.54	---			

dimensions			
3.2	x-section area	0.5	d mean
6.3	width	6.6	wet P
0.8	d max	0.5	hyd radi
0.0	bank ht	12.6	w/d ratio
0.0	W flood prone area	0.0	ent ratio

hydraulics	
0.0	velocity (ft/sec)
0.0	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
0.000	unit stream power (lbs/ft/sec)
0.00	Froude number
0.0	friction factor u/u*
0.0	threshold grain size (mm)

check from channel material			
3	measured D84 (mm)		
50.4	relative roughness	12.5	fric. factor
0.000	Manning's n from channel material		

Cross Section



section: 0+60
Pool
Unnamed Tributary to UT
Billy's Creek
description:
height of instrument (ft): 105.65

notes	omit pt.	distance (ft)	FS (ft)	elevation
	☑	0	5.92	99.73
LTOB	☐	20	6.5	99.15
LBKF	☐	21	6.84	98.81
LEW/WS	☐	22.1	7.76	97.89
TW	☐	22.1	8.01	97.64
	☐	22.4	7.9	97.75
	☐	23.2	7.85	97.8
	☐	23.9	7.86	97.79
REW/WS	☐	24.4	7.76	97.89
RBKF	☐	29.9	6.8	98.85
	☐	36	6.39	99.26
	☑	41	5.83	99.82
	☑	49	5.86	99.79

FS bankfull	FS top of bank	W fpa (ft)	channel slope (%)	Manning's "n"
6.8	6.8			
98.85	98.85			

dimensions			
5.6	x-section area	0.6	d mean
9.0	width	9.7	wet P
1.2	d max	0.6	hyd radi
1.2	bank ht	~~14.4~~	w/d ratio
~~0.0~~	W flood prone area	~~0.0~~	ent ratio

hydraulics	
~~0.0~~	velocity (ft/sec)
~~0.0~~	discharge rate, Q (cfs)
0.00	shear stress ((lbs/ft sq)
0.00	shear velocity (ft/sec)
~~0.000~~	unit stream power (lbs/ft/sec)
~~0.00~~	Froude number
~~0.0~~	friction factor u/u*
~~0.0~~	threshold grain size (mm)

check from channel material			
3	measured D84 (mm)		
~~63.2~~	relative roughness	~~13.1~~	fric. factor
~~0.000~~	Manning's n from channel material		

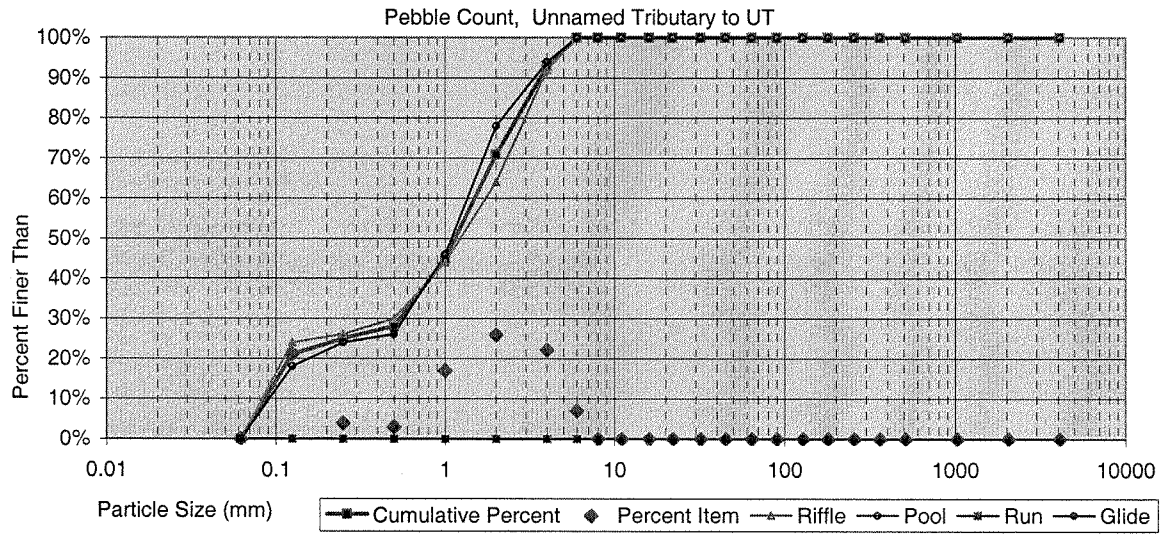
Weighted Pebble Count

Percent Riffle:	51	Percent Run:	
Percent Pool:	49	Percent Glide:	

Pebble Count,
Unnamed Tributary to UT
Billy's Creek

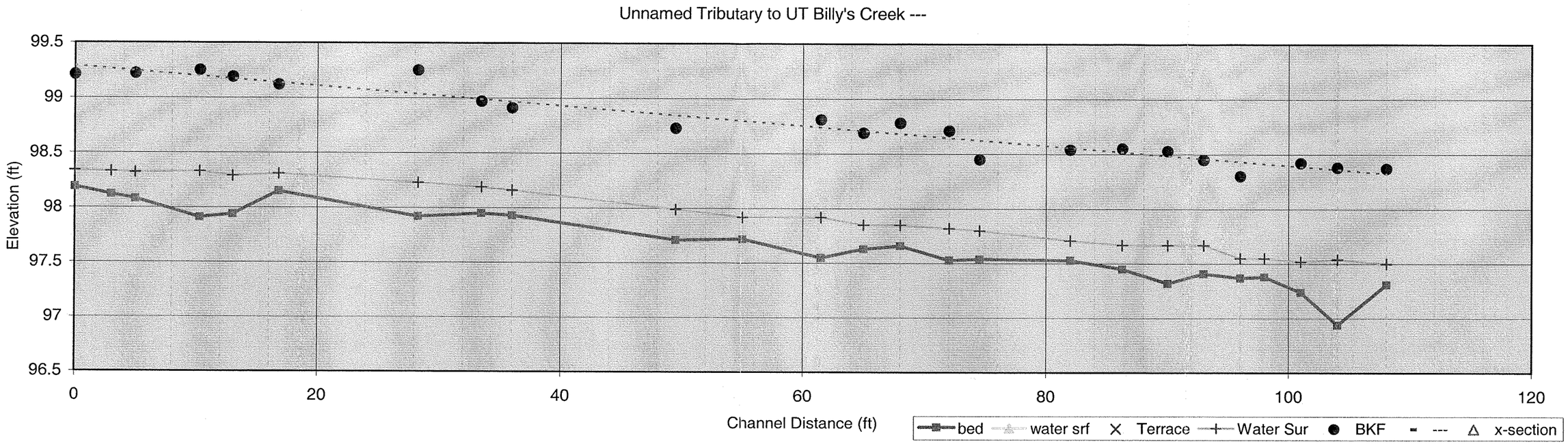
Note:

Material	Size Range (mm)		Total #		
silt/clay	0	0.062	0.0	#	#
very fine sand	0.062	0.13	21.1	#	#
fine sand	0.13	0.25	4.0	#	#
medium sand	0.25	0.5	3.0	#	#
coarse sand	0.5	1	16.9	#	#
very coarse sand	1	2	25.9	#	#
very fine gravel	2	4	22.1	#	#
fine gravel	4	6	7.0	#	#
fine gravel	6	8	0.0	#	#
medium gravel	8	11	0.0	#	#
medium gravel	11	16	0.0	#	#
coarse gravel	16	22	0.0	#	#
coarse gravel	22	32	0.0	#	#
very coarse gravel	32	45	0.0	#	#
very coarse gravel	45	64	0.0	#	#
small cobble	64	90	0.0	#	#
medium cobble	90	128	0.0	#	#
large cobble	128	180	0.0	#	#
very large cobble	180	256	0.0	#	#
small boulder	256	362	0.0	#	#
small boulder	362	512	0.0	#	#
medium boulder	512	1024	0.0	#	#
large boulder	1024	2048	0.0	#	#
very large boulder	2048	4096	0.0	#	#
bedrock			0.0	#	
		Weighted Count:	100		
		True Total Particle Count:	100		



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
0.106	0.66	1.1	3	4	0%	71%	29%	0%	0%	0%

Slope Profile



Appendix C. Reference Reach Photos

Picture 1. Outside meander bend where first pool section was taken.

Picture 2. View of pool and glide.

Picture 3. Looking downstream toward second meander.

Picture 4. Riffle cross section taken in this area, looking across the channel. Note vegetation on banks.

Picture 5. Second riffle cross section.

Picture 6. Large meander bend looking downstream.

Picture 7. Looking upstream below woody debris.

Picture 8. Looking across the channel downstream of woody debris.

Picture 9. Stream side woody vegetation.

Picture 10. Slope vegetation.

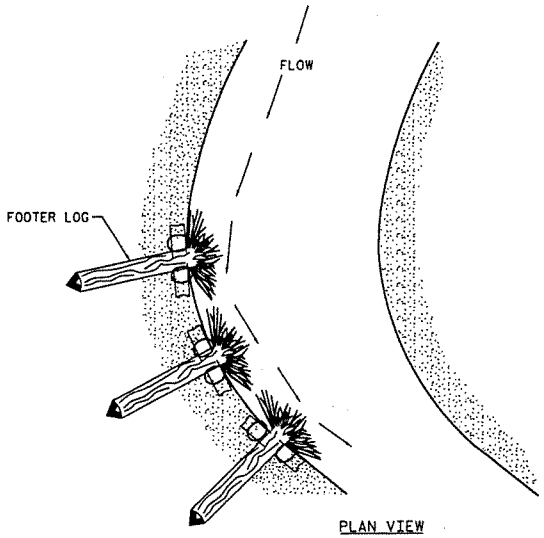
Picture 11. Floodplain vegetation.

APPENDIX D. DETAILS

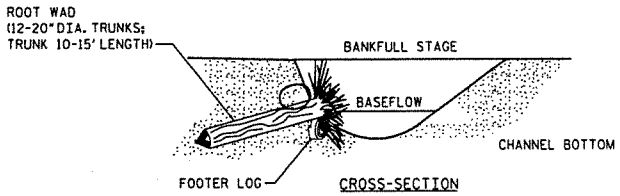
APPENDIX D

TRIBUTARY TO BILLY'S CREEK

NOT TO SCALE

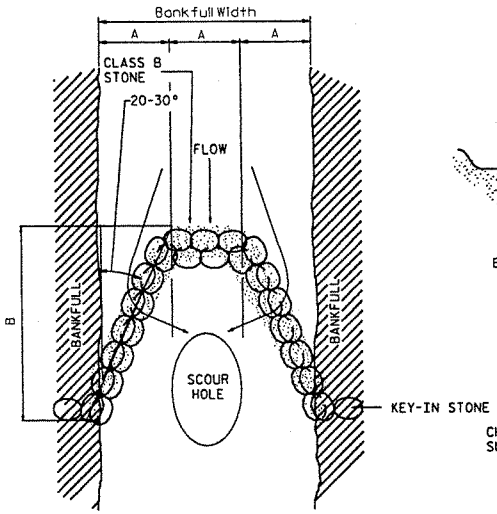


PLAN VIEW

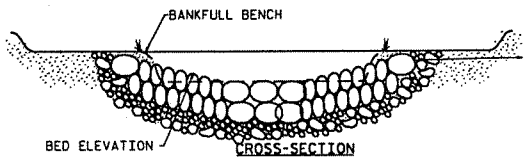


ROOT WADS SHOULD BE INSTALLED ONTHE OUTSIDE OF MEANDER BENDS. THEY SHOULD BE ANGLED UPSTREAM TO DEFLECT THE STREAM FLOW AWAY FROM THE BANK.

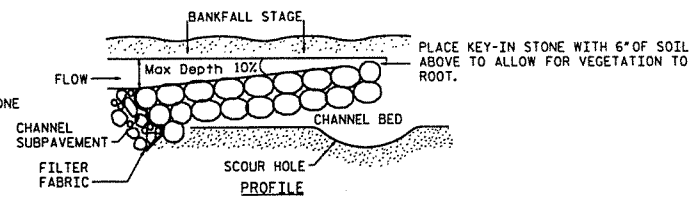
ROOT WAD



PLAN VIEW



PLACE KEY-IN STONE WITH 6"OF SOIL ABOVE TO ALLOW FOR VEGETATION TO ROOT.



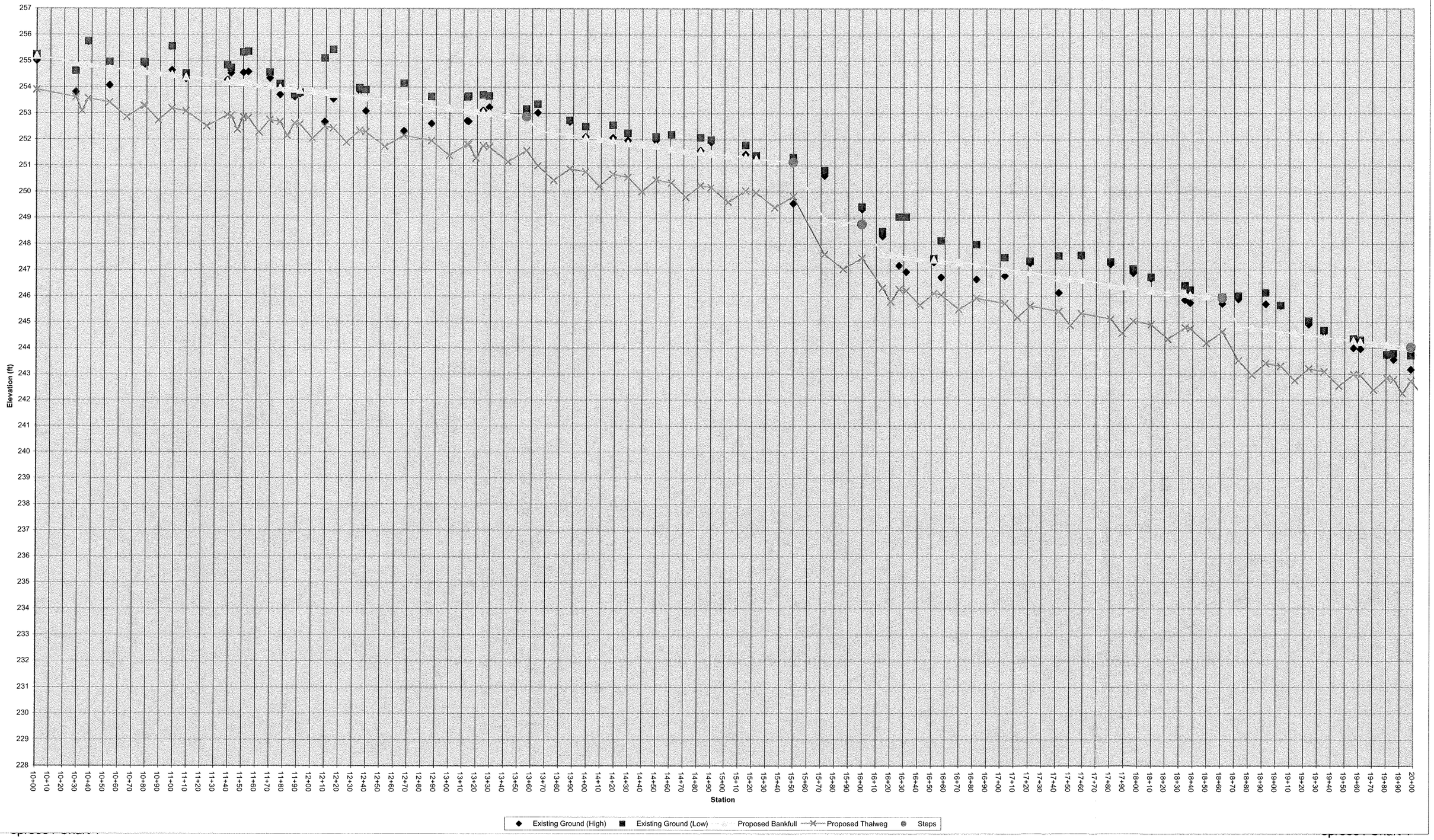
NOTE: THERE SHOULD BE NO GAPS BETWEEN THE ROCKS IN THE CROSS VANE.

CROSS VANE

EXCAVATE A TRENCH AT THE WIDTHS AND ELEVATIONS SPECIFIED ON THE PLANS. A MIXTURE OF CLASS B AND CLASS A STONE SHOULD BE PLACED IN THE TRENCH TO SERVE AS FOUNDATION STONE. THE SLOPE OF THE STRUCTURE SHOULD NOT EXCEED 10%. ROCKS ARE PLACED IN THE TRENCH FOR FOOTERS PER THE DIRECTION OF THE ENGINEER. HEADER ROCKS SHOULD BE PLACED ON TOP OF THE FOOTER ROCKS AND KEY-IN STONE WILL BE USED TO TIE IN TO THE BANKS. THE TOP OF THE KEY-IN STONE SHALL BE APPROXIMATELY 6"BELOW THE BANKFULL ELEVATION TO ALLOW VEGETATION TO ROOT. PLACE FILTER FABRIC ALONG THE UPSTREAM SIDE OF THE STRUCTURE TO JUST BELOW THE BOTTOM OF THE FOOTER STONES. BACK FILL WITH SOIL AND COMPACT TO A SIMILAR DENSITY OF THE UNDISTURBED SOIL.

APPENDIX E. PROPOSED PROFILE

Proposed Longitudinal Profile



Proposed Longitudinal Profile