BISHOP PROPERTY RESTORATION PLAN
ANSON COUNTY, NORTH CAROLINA

North Carolina Ecosystem Enhancement Program
Raleigh, North Carolina

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1.0 INTRODUCTION

The North Carolina Ecosystem Enhancement Program (EEP) is currently evaluating stream and wetland restoration opportunities on the Bishop Property Restoration Site located approximately 3 miles north of the Town of Ansonville in northern Anson County, North Carolina (Figure 1). The Bishop Property consists of three parcels, owned by Mr. John Bishop, collectively encompassing approximately 900 acres of land. The proposed restoration area, including approximately 195 acres within the three parcels, has been placed under a conservation easement and will hereafter be referred to as the Site (Figure 2).

The Site is located at the confluence of the Rocky River and the Pee Dee River, immediately upstream from the approximately 8,000-acre Pee Dee National Wildlife Refuge. In the Site vicinity, the Rocky and Pee Dee River floodplains have largely been cleared of forest vegetation and are currently utilized as fertile pasture, hay fields, or agricultural fields (row crop production). The Site has potential to serve as an important wildlife corridor along two major waterways extending to the Pee Dee National Wildlife Refuge.

The Site is primarily utilized for row crop production and recreational activities (hunting and wildlife viewing). Removal of riparian vegetation, dredging/straightening of on-Site streams, annual clearing, plowing, and additions of nutrient fertilizers appear to have resulted in degraded water quality (sediment inputs and agricultural runoff into the Rocky and Pee Dee Rivers), unstable channel characteristics (stream entrenchment, erosion, and bank collapse), and decreased wetland function.

The purpose of this study is to establish stream and wetland enhancement/restoration concepts which will result in benefits to water quality and wildlife by providing stable streams and wetlands within a wildlife corridor located adjacent to two major waterways and an important wildlife refuge. This detailed restoration plan is expected to outline activities to be included in construction planning documents. The objectives of this study include the following:

- Classify the on-Site streams based on fluvial geomorphic principles.
- Identify jurisdictional wetlands and/or hydric soils within the Site boundaries.
- Identify a suitable reference forest, stream, and wetland to model Site restoration attributes.
- Develop a detailed plan of stream and wetland enhancement/restoration activities within the Site.
- Establish success criteria and a method of monitoring the Site upon completion of restoration implementation.

After implementation, restoration activities are expected to provide the following:

1. 5,663 linear feet of stream restoration
2. 1,190 linear feet of stream enhancement - level 1
3. 7,306 linear feet of stream enhancement - level 2
4. 11,250 linear feet of stream preservation
5. 5.6 acres of wetland restoration
6. 0.9 acres of wetland enhancement
7. 10.2 acres of wetland preservation

This document represents a detailed restoration plan summarizing activities proposed within the Site. The plan includes 1) descriptions of existing conditions; 2) reference stream, wetland, and forest studies; 3) restoration/enhancement plans; and 4) Site monitoring and success criteria. Upon approval of this plan by regulatory agencies, engineering construction plans will be prepared and activities implemented as outlined. Proposed restoration activities may be modified during the civil design stage due to constraints such as access issues, sediment-erosion control measures, drainage needs (floodway constraints), or other design considerations.

2.0 METHODS

Natural resource information was obtained from available sources. United States Geological Survey (USGS) 7.5-minute topographic quadrangle (Millstone Lake, NC), United States Fish and Wildlife Service (FWS) National Wetlands Inventory (NWI) mapping, Natural Resource Conservation Service (NRCS) soils mapping for Anson County (NRCS 2000), and recent Anson County aerial photography were utilized to evaluate existing landscape, stream, and soil information prior to on-Site inspection.

Reference stream geometry methods have been used to orient channel reconstruction design. Reference stream and floodplain systems were identified and measured in the field to quantify stream geometry, substrate, and hydrodynamics. Stream characteristics and detailed restoration plans were developed according to constructs outlined in Rosgen (1996), Dunne and Leopold (1978), Harrelson *et al*. (1994), Chang (1988), and State of North Carolina Interagency Stream Mitigation Guidelines (USACE *et al.* 2003). Stream pattern, dimension, and profile under stable environmental conditions were measured along reference (*i.e.* relatively undisturbed) stream reaches and applied to the degraded channel within the Site. Reconstructed stream channels and hydraulic geometry relationships have been designed to mimic stable channels identified and evaluated in the region.

Files at the North Carolina Natural Heritage Program (NHP) were evaluated for the presence of protected species. Characteristic and target natural plant community patterns were classified according to Schafale and Weakley's, *Classification of the Natural Communities of North Carolina* (1990). Plant communities were delineated and described by structure and composition.

Detailed field investigations were performed between September 2003 and May 2004 including generation of Site channel cross-sections, profiles, and plan-views; valley cross-sections; detailed soil mapping; and mapping of on-Site resources. Hydrology, vegetation, and soil attributes were analyzed to determine the status of jurisdictional areas. Jurisdictional wetlands and adjustments to hydric soil boundaries were delineated using Global Positioning System (GPS) technology. Recent (2003) aerial photography was evaluated to determine primary hydrologic features and to map relevant environmental attributes.

Information collected on-Site and in reference ecosystems was compiled in a database and incorporated with field observations to evaluate the on-Site stream under existing conditions. Subsequently, this restoration plan was developed to facilitate restoration success and to provide stream and wetland restoration to the EEP.

3.0 EXISTING CONDITIONS

3.1 Physiography, Topography, and Land Use

The Site is located in northern Anson County near the border of Stanly, Montgomery, and Richmond Counties, approximately 3 miles north of Ansonville, North Carolina. The Site falls in two USGS 14-digit Hydrologic Units (HUs).

The Site is underlain by the Carolina Slate Belt geologic formation, immediately adjacent to the Chatham Group of the Triassic Basin geologic formation, within the Piedmont physiographic province of North Carolina. The hydrophysiographic region is characterized by dissected irregular plains, some hills, linear ridges, and isolated monadnocks (Griffith 2002) (Figure 4). This region is characterized by moderate rainfall with precipitation averaging approximately 47 inches per year (NRCS 2000).

The Site is located within and adjacent to the Rocky River floodplain immediately upstream of the confluence of the Rocky River with the Pee Dee River. Slopes adjacent to the Rocky River floodplain are relatively steep and range in elevation from approximately 320 feet National Geodetic Vertical Datum (NGDV) at the upper reaches of smaller on-Site tributaries to a low of approximately 190 feet NGDV in the lower portions of the Rocky River floodplain (Figure 4).

The Site includes approximately 5,500 linear feet of frontage adjacent to the Rocky River and approximately 23,000 linear feet of channel associated with four additional streams: Camp Branch, Unnamed Tributary (UT) to Camp Branch, Dula Thoroughfare, and UT to Dula Thoroughfare (Figure 2). Camp Branch is characterized as a second-order stream extending through relatively wide, moderately sloped valley (approximately 0.0022 rise/run). Dula Thoroughfare and the UTs are characterized as first-order streams extending through relatively narrow, steeply sloped valleys (approximately 0.022 and 0.0047 rise/run). The drainage area at the Camp Branch outfall is approximately 2.9 square miles. The drainage area at the Dula Thoroughfare and UT outfall are approximately 0.36 and 0.23 square miles, respectively (Figure 4).

The watersheds for Camp Branch, Dula Thoroughfare, and the UTs are characterized predominately by agricultural land (row crops and livestock production) and forest with sparse residential development. Drainage basins for Dula Thoroughfare and the UTs are contained almost completely within property owned by Mr. Bishop or his immediate neighbor. The Camp Branch drainage basin extends upstream and encompasses several state maintained roadways, residential and agricultural structures adjacent to the roadways, and a rail line. Impervious surfaces in drainage basins upstream from the Site are expected to cover less than 5 percent of the land area.

Agricultural row crop production dominates the lower elevation floodplain terraces adjacent to the Rocky River, accounting for approximately 85 percent of the floodplain land area. Streams which cross through the floodplains are generally fringed by a disturbed stream-side assemblage; however, Dula Thoroughfare is devoid of a riparian fringe for much of its reach through the floodplain. As the streams grade upslope toward their headwaters, timber production is the dominant land use. Forested areas are characterized by a mixture of pine and hardwood species approximately 10 to 15 years old. Recreational activities, specifically hunting, occur throughout the Site and various tree stands and food plots occur throughout the Site and adjacent properties.

Two man-made impoundments located in the UT to Camp Branch stream complex encompass approximately 2.4 acres of land. The smaller impoundment (approximately 0.1 acre) is located at the UT headwaters and the larger impoundment (approximately 2.3 acres) has been created at the outer Camp Branch floodplain edge. These impoundments appear to have been created for irrigation of crops and recreational uses.

3.2 Soils

Site soils have been mapped by the NRCS and include the Badin – Goldston complex, as well as the McQueen, Shellbluff, Tetotum, and Chewacla series (NRCS 2000) (Figure 5). A general description of each soil and its hydric/non-hydric status is included in Table 1.

Table 1 – On-Site soils mapped by NRCS

Series	Hydric Status	Family	Description
Badin Channery Silt Loam (BaB, BaC)	Non-Hydric	*Typic Hapludults*	moderately deep, well drained, moderately permeable
Badin-Goldston Complex (BgD)	Non-Hydric	*Typic Hapludults-Typic Dystrudepts*	shallow to moderately deep, well drained, moderate to moderately rapid permeability
McQueen (MrB)	Non-Hydric	*Typic Hapludults*	deep, well drained, slow permeability
Shellbluff (ShA)	Non-Hydric	*Fluventic Dystrudepts*	very deep, well drained, moderate permeability
Tetotum (ToA)	Non-Hydric	*Aquic Hapludults*	very deep, moderately well drained, moderate permeability
Chewacla (ChA)	Non-Hydric; may contain hydric inclusions	*Fluventic Dystrudepts*	very deep, somewhat poorly drained, moderate permeability

Badin Channery Silt Loam BaB, BaC:
This series is typically found on Piedmont uplands with moderate to steep slopes (2 to 8 percent or 8 to 15 percent). The soil solum is moderately deep and well drained with moderate permeability. Depth to seasonal high water table is greater than 6.0 feet, and depth to bedrock is 20 to 40 inches to soft bedrock and over 40 inches to hard bedrock. Badin Channery Silt Loam typically occurs on upland side slopes adjacent to area streams and tributaries.

Badin-Goldston Complex BgD:
This series shares many characteristics with the Badin Channery Silt Loam described above; however, the addition of Goldston in the complex produces additional ranges for some values. These soils are also found in the Piedmont on slopes of 15 to 25 percent. Depths can range from shallow to moderately deep, and permeability can be moderate to moderately rapid, though typically well drained. Depth to the seasonal high water table is greater than 6.0 feet,

and depth to bedrock varies from 10 to 20 inches and 20 to 40 inches to soft bedrock. Depth to hard bedrock is between 10 to 20 inches and greater than 40 inches. Badin-Goldston Complex occurs at the base of steep slopes adjacent to Dula Thoroughfare.

Chewacla ChA:
These frequently flooded soils can be found in floodplains of the Piedmont, Upper Coastal Plains, and Sandhills. Soils are very deep and somewhat poorly drained with moderate permeability. During the months of November through April the seasonal high water table can be at a depth of 0.5 to 1.5 feet. Depth to bedrock is more than 60 inches. Chewacla soils occur in low elevation depressions within the Rocky River floodplain.

McQueen MrB:
This series, found in the Piedmont, Upper Coastal Plain, and Sandhills along major streams and rivers, is very deep and well drained. Permeability is slow, and the seasonal high water table through the months of January through March is at a depth of 4 to 6 feet. Depth to bedrock is greater than 60 inches. McQueen soils occur in floodplains adjacent to the Rocky River and Camp Branch.

Shellbluff (ShA):
This soil series is also found in floodplains of the Piedmont, Upper Coastal Plain, and Sandhills landscapes. Shellbluff soils are typically very deep and well drained with moderate permeability. Slopes are quite flat, ranging between 0 and 2 percent. From December to March the seasonal high water table can vary between 3 and 5 feet, and depth to bedrock is more than 60 inches. Shellbluff soils occur in crowned agricultural fields within the Rocky River floodplain.

Tetotum (ToA):
These soils are located on low stream terraces in the Piedmont, Upper Coastal Plain, and Sandhills landscapes. Tetotum soils are classified as very deep and moderately well drained with moderate permeability. These soils are found in low slope areas with slopes ranging from 0 to 3 percent. Seasonal high water tables in the months of December to April are between 1.5 and 2.5 feet. Bedrock can be found at depths greater than 60 inches. Tetotum soils occur in low elevation depressions downstream from a man-made pond in the UT to Camp Branch and in the floodplain to Dula Thoroughfare.

3.3 Jurisdictional Wetlands

Jurisdictional areas are defined using the criteria set forth in the U.S. Army Corps of Engineers (USACE) Wetlands Delineation Manual (DOA 1987). Wetlands are defined by the presence of three criteria: hydrophytic vegetation, hydric soils, and evidence of wetland hydrology during the growing season (DOA 1987). Open water systems and wetlands receive similar treatment and consideration with respect to Section 404 review. Site jurisdictional areas include surface water in bank-to-bank streams, vegetated wetlands, and open water ponds.

Site jurisdictional areas were delineated and located using GPS technology between August 27 and Oct 2, 2003 (Figure 6). The delineation was reviewed and approved by the USACE (Steve Lund regional field office representative) on January 13, 2004. Based on the jurisdictional boundary mapping, approximately 15.4 acres of jurisdictional wetlands and 28,518 linear feet of jurisdictional streams, including 5,500 linear feet of Rocky River frontage, were delineated within the Site.

Two distinct jurisdictional wetlands types occur within the Site boundaries: 1) groundwater seep depressions and 2) shallow surface water conveyances.

<u>Groundwater Seep Depressions</u>

Groundwater seep depressions occur at the upper headwaters of small tributaries and at the outer floodplain edge. These wetlands are formed by surface expression of groundwater over dense, low permeability clays or other impervious sub-surface horizons. On-Site groundwater seep depressions are underlain by loamy to clayey soils which are gleyed in color with frequent mottling, potentially indicating a fluctuating water table. Vegetation in these areas is frequently disturbed by land clearing in support of agriculture or timber harvest and consists of dense thickets of shrub and herbaceous species such as blackberry (*Rubus* sp.), black willow (*Salix nigra*), climbing hempweed (*Mikania scandens*), and tearthumb (*Polygonum sagittatum*).

<u>Shallow Surface Water Conveyances</u>

Shallow surface water conveyances occur in portions of the Rocky River floodplain where streams have been dredged, straightened, and altered from their original flow path. The reach of Dula Thoroughfare across the Rocky River floodplain is characterized by exceedingly low slopes resulting in ponding and sloughing of ditch banks, thereby creating a shallow, wide depression that remains inundated throughout most of the year. Although the area is inundated for extended periods, soils remain brightly colored (approximately 10YR 4/4 to 10 YR 4/6) which is characteristic of Triassic Basin area wetlands. Vegetation in these areas is characterized by row crop production and herbaceous species such as knotweed (*Polygonum* spp.), cat tail (*Typha latifolia*), rushes (*Juncus* spp.), and sedges (*Carex* spp.).

3.4 Hydrology

3.4.1 Surface Water

The primary hydrologic feature at the Site is the Rocky River. The Rocky River is approximately 240 feet in width and 25 feet in depth at the Site boundary. Hydro-electric facilities on the Pee Dee River, located immediately upstream from the confluence of the Rocky River and Pee Dee River, have periodic releases resulting in back-flow conditions in the Rocky River, often leading to fluctuations in the normal hydrologic flow regime. Back-flow conditions affect on-Site surface water flow patterns at the confluence of Site streams with the Rocky River.

Smaller area tributaries initiate as groundwater driven, depressional seepages on slopes adjacent to the Rocky River floodplain. Tributaries descend as first-order streams down moderate to steeply sloped, narrow valleys. As the tributaries coalesce, they form larger second and third order streams. Once the streams enter the Rocky River floodplain, they are generally impacted by agricultural practices, vegetation clearing, and channel dredging/straightening. Upon convergence with the Rocky River, the channels tend to incise to depths consistent with the dominant hydrologic feature, the Rocky River.

Discharge within the Site appears to be dominated by a combination of upstream basin catchments, groundwater flow, and precipitation. Based on regional curves (Harman *et al.* 1999) and infield measurements of channel bankfull cross-sectional area, bankfull discharges for on-Site streams include the following:

Stream Name	Drainage Area (square miles)	Bankfull Discharge (cubic feet per second)
Camp Branch	2.9	192
Dula Thoroughfare	0.4	46
UT to Dula Thoroughfare	0.2	28

Current research indicates bankfull discharge would be expected to occur approximately every 1.3 to 1.5 years (Rosgen 1996).

3.4.2 Groundwater

Groundwater seepage results from upland terrestrial catchments, subsurface lateral groundwater flow, and expression of the groundwater table in jurisdictional wetland pockets or area stream margins. Groundwater seepage is related to the size and characteristics of the catchment basin, while subsurface lateral flow is related to the porosity/conductivity of drainage basin soils. The drainage basin upstream of the Site is characterized largely by mature forest and open pasture with little impervious surface. With the exception of roads and roadside ditches, precipitation is expected to penetrate area soils and enter the groundwater table to be discharged into area wetlands and streams.

Several groundwater seepages areas were identified within the Site. Groundwater seepage areas were delineated as jurisdictional wetlands and are depicted in Figure 6. Groundwater seepage areas are located at two distinct landscape positions: 1) at the upper extend of area tributaries, or 2) at the outer floodplain edge, adjacent to steep valley slopes. Both seepage types occur in depressions induced by soil saturation and function for surface water storage, pollutant removal, wildlife habitat, and nutrient cycling (Marble 1992).

3.5 Stream Characterization

Stream geometry and substrate data have been evaluated to orient stream restoration based on a classification utilizing fluvial geomorphic principles (Rosgen 1996). This classification stratifies streams into comparable groups based on pattern, dimension, profile, and substrate characteristics. Primary components of the classification include degree of entrenchment, width/depth ratio, sinuosity, channel slope, and stream substrate composition. Each stream type is modified by a number from 1 through 6 (example: E6) denoting a stream type which indicates a substrate dominated by 1) bedrock, 2) boulders, 3) cobble, 4) gravel, 5) sand, or 6) silt/clay.

On-Site streams were measured and characterized as E-type (narrow and deep), C-type (wide and shallow), and G-type (gully) channels. The location of each stream type is depicted in Figure 7. Figures 8 through 8I and Table 2A and 2B (Appendix B) depict morphological characteristics of existing on-Site channels. Individual cross-section data and other morphological information are included in Appendix C.

Camp Branch - Reach 1 (E-Type): Upstream of Headcut

Location: Extends from the upstream northern property boundary to a channel headcut which is migrating upstream due to disturbances associated with on-Site land management practices (Figure 8).

Dimension (Figure 8A)
Bankfull Channel Cross Sectional Area - 38.7 $feet^2$
Existing Channel Cross Sectional Area - 38.7 to 52.8 $feet^2$ (slightly enlarged)
Bank Height Ratio -1.1 to 1.3 (slight to moderate erosion hazard)
Width/Depth Ratio - 8 -12

Notes: Dimension values for this reach appear suitable for E-type streams in the vicinity.

Pattern
Sinuosity - 1.18

Notes: Pattern values for this reach appear suitable for E-type streams in the vicinity.

Profile (Figure 8B)
Valley Slope - 0.0047 rise/run
Water Surface Slope - 0.0029 rise/run
Pool Slope - 0 to 0.0013 rise/run
Riffle Slope - 0.0008 to 0.0167 rise/run

Notes: The upper range of riffle slopes are higher than expected, possibly due to headcut migration into the lower portions of the reach.

Substrate:
D50 - 7 millimeters (fine gravel)

Camp Branch – Reach 2 (E-Type): Headcut to Ford

Location: Extends downstream from the headcut to an active ford, utilized to access fields north of Camp Branch (Figure 8).

Dimension (Figure 8A)
Bankfull Channel Cross Sectional Area - 38.7 $feet^2$
Existing Channel Cross Sectional Area - 51 to 62 $feet^2$ (nearly twice bankfull cross sectional area)
Bank Height Ratio - 1.5 (moderate to high erosion hazard)

Width/Depth Ratio – 8.7
Notes: This reach of Camp Branch is oversized and moderately entrenched.

Pattern
Sinuosity - 1.18

Notes: Pattern values for this reach appear suitable for E-type streams in the vicinity.

Profile (Figure 8B)
Valley Slope - 0.0047 rise/run
Water Surface Slope - 0.0029 rise/run
Pool Slope - 0 to 0.007 rise/run
Riffle Slope - 0.0042 to 0.0144 rise/run

Notes: The steeper facet slopes may result from headcuts and other knick points in the channel bottom.

Substrate:
D50 - 5 millimeters (fine gravel)

Camp Branch – Reach 3 (G-Type): Downstream of Ford

Location: Extends from the ford to a portion of Camp Branch that begins to downcut to the Rocky River (Figure 8).

Dimension (Figure 8C)
Bankfull Channel Cross Sectional Area - 42 feet^2
Existing Channel Cross Sectional Area - 104 to 124 feet^2 (nearly three times the bankfull cross-sectional area)
Bank Height Ratio - 2.2 to 2.4 (high to excessive erosion hazard)
Width/Depth Ratio – 6 to 9

Notes: This reach of Camp Branch is oversized and highly entrenched.

Pattern
Sinuosity - 1.05

Notes: Straightening of the channel has resulted in a loss of pattern variables such as pool-to-pool spacing, meander length, and radius of curvature. Pattern values for this reach are outside the modal concept for stable, E-type streams in the region.

Profile (Figure 8D)
Valley Slope - 0.0047 rise/run
Water Surface Slope - 0.0041 rise/run
Pool Slope - 0.0000 to 0.0020 rise/run
Riffle Slope - 0.0011 to 0.0614 rise/run

Notes: Riffle slope to average water surface slope ratios vary between 0.27 and 15 indicating over-steepened riffle slopes. Similarly, pool slope to average water surface slope varies from 0 to 1.6 indicating over-steepened pool slopes. Over-steepened facet slopes result from dredging and straightening of Camp Branch and impacts from land use activities through the reach.

Substrate:
D50 – 13.8 millimeters (medium gravel)

Notes: Silt and clay particles make up 14 percent of the bed material, possibly indicating bimodal sediment transport from eroding channel banks.

Dula Thoroughfare (E-Type): Upstream Reach

Location: Extends downstream from a piped road crossing to the Rocky River floodplain (Figure 8).

Dimension (Figure 8E)
Bankfull Channel Cross Sectional Area - 5.1 $feet^2$
Existing Channel Cross Sectional Area - 5.1 to 5.5 $feet^2$ (slightly enlarged)
Bank Height Ratio - 1.0 to 1.1 (low erosion hazard)
Width/Depth Ratio – 6.1 to 8.0

Notes: Dimension values for this reach appear suitable for E-type streams in the vicinity.

Pattern
Sinuosity - 1.05

Notes: Although sinuosity values are low for stable E-type streams in the area, the valley is relatively steep and narrow, resulting in relatively straight channel development.

Profile (Figure 8F)
Valley Slope - 0.0239 rise/run
Water Surface Slope - 0.0228 rise/run
Pool Slope - 0 to 0.0161 rise/run
Riffle Slope - 0.0036 to 0.096 rise/run

Notes: Pool slopes and riffle slopes are relatively steep; however, the ratio of these facet slopes to average water surface slope (average riffle 1.6 and average pool 0.13) indicate stable profile values throughout this reach.

Substrate:
D50 – less than 1 millimeter (silt and clay)

Dula Thoroughfare (C-type): Downstream Reach

Location: Contained within the Rocky River floodplain and extends from alluvial fan deposits associated with the upstream reach to the property boundary (Figure 8).

Dimension (Figure 8G)
Bankfull Channel Cross Sectional Area - 5.7 to 8.4 $feet^2$
Existing Channel Cross Sectional Area - 5.7 to 19.7 $feet^2$ (slightly enlarged to highly oversized)

Bank Height Ratio - 1.0 to 2.0 (low to excessive erosion hazard)
Width/Depth Ratio – 23 to 40

Notes: The large variation in these values results from channel dredging and straightening, impounding of the reach for duck habitat, and low slope of the channel as it migrates through an unnatural channel across the Rocky River floodplain. Dimensional values appear to reside outside the modal concept for stable streams in the area.

Pattern
Sinuosity - 1.01

Notes: Dredging and straightening of the channel resulted in no measurable channel features (riffles and pools).

Profile (Figure 8H)
Valley Slope - 0.0019 rise/run
Water Surface Slope - 0.0019 rise/run

Notes: Pool slopes and riffle slopes were not measurable due to dredging and straightening activities and slackwater conditions through the reach; however, these values are not expected to be within the acceptable range for stable streams in the area.

Substrate:
D50 – less than 1 millimeter (silt and clay)

UT to Dula Thoroughfare (G-type): Upstream Reach

Location: Extends through an eroded section of channel for approximately 195 linear feet at the upper reaches of the stream (Figure 8).

Dimension (Figure 8I)
Bankfull Channel Cross Sectional Area – 4.8 feet^2
Existing Channel Cross Sectional Area – 12.8 feet^2 (more than 2.5 times bankfull cross sectional area)
Bank Height Ratio - 1.9 (excessive erosion hazard)
Width/Depth Ratio – 2.8

Notes: This reach of UT to Dula Thoroughfare is oversized and highly entrenched.

Pattern
Sinuosity - 1.09

Notes: Although sinuosity values are low for stable E-type streams in the area, the valley is relatively steep and narrow, resulting in relatively straight channel development.

Profile
Valley Slope – Not Measured

Water Surface Slope – Mot Measured

Notes: Pool slopes and riffle slopes are appear relatively steep due to headcut formation within the reach.

Substrate:
D50 – Not Measured

UT to Dula Thoroughfare (E-type): Downstream Reach

Location: Extends from the entrenched, upstream reach to a forded crossing of Dula Thoroughfare (Figure 8).

Dimension (Figure 8I)
Bankfull Channel Cross Sectional Area – 4.4 to 5.1 feet^2
Existing Channel Cross Sectional Area – 6.9 (slightly enlarged)
Bank Height Ratio - 1.5 to 2.3 (high to excessive erosion hazard)
Width/Depth Ratio – 6

Notes: This reach of UT to Dula Thoroughfare is slightly oversized and highly entrenched. Spoil castings on stream banks and within the adjacent floodplain occur through much of the reach.

Pattern
Sinuosity - 1.17

Notes: Shoot cutoffs and channel realignment is prevalent through this reach.

Profile
Valley Slope – Not Measured
Water Surface Slope – Mot Measured

Notes: Pool slopes and riffle slopes appear relatively steep due to headcut formation within the reach.

Substrate:
D50 – Not Measured

3.6 Plant Communities

The Site is characterized by broad expanses of agricultural fields, along with mesic mixed pine/hardwood forest, upland slope forest, bottomland hardwood forest, and game species food plots. Site forests do not exhibit climax conditions due to past timber practices. Primary agricultural crops include corn, cotton, and soy beans, with interspersed patches of sorghum and clover for game species. Invasive species identified in agricultural fields during fallow times or prior to planting of crops consists primarily of morning glory (*Convolvulus arvensis*), clover (*Trifolium campestre*), cocklebur (*Xanthium strumarium*), and sicklepod (*Cassia obtusifolia*).

Mesic mixed pine/hardwood forest occurs adjacent to undisturbed streams descending from slopes adjacent to the Rocky River floodplain. The community occurs as narrow bands adjacent to smaller tributaries such as UT to Camp Branch, the upper reaches of Dula Thoroughfare, and the UT to Dula Thoroughfare. Species present include loblolly pine (*Pinus taeda*), red maple (*Acer rubrum*), American sycamore (*Platanus occidentalis*), green ash (*Fraxinus pennsylvanica*), and hackberry (*Celtis laevigata*). Vines present within this community include poison ivy (*Toxicodendron radicans*), greenbriar (*Smilax rotundifolia*), and muscadine (*Vitus rotundifolia*).

Upland slope forest occurs on steep, dry slopes adjacent to floodplains and includes species such as white oak (*Quercus alba*), water oak (*Quercus nigra)*, Virginia pine (*Pinus virginiana*), and various hickories (*Carya* spp.). Understory species include red maple, winged sumac (*Rhus copallinum*), and dogwood (*Cornus florida*) while vines present include poison ivy and muscadine.

Bottomland hardwood forest is located in moist, frequently flooded flats adjacent to the Rocky River and Camp Branch. This community is characterized by species such as American sycamore, black willow, green ash, American elm (*Ulmus americana*), tulip poplar (*Liriodendron tulipifera*), and sugarberry (*Celtis laevigata*). The shrub component of this community includes Chinese privet (*Ligustrum sinense*), Japanese honeysuckle (*Lonicera japonica*), red maple, sweetgum, and muscadine.

3.7 Protected Species

3.7.1 Federally Protected Species

Species with the Federal classification of Endangered (E), Threatened (T), or officially Proposed (P) for such listing are protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). The term “Endangered species” is defined as “any species which is in danger of extinction throughout all or a significant portion of its range”, and the term “Threatened species” is defined as “any species which is likely to become an Endangered species within the foreseeable future throughout all or a significant portion of its range” (16 U.S.C. 1532).

The following Federally protected species are listed for Anson County (5 February 2003 FWS list):

Common Name	Scientific Name	Status
Bald eagle	*Haliaeetus leucocephalus*	T
Red-cockaded woodpecker	*Picoides borealis*	E
Carolina heelsplitter	*Lasmigona decorata*	E
Schweinitz’s sunflower	*Heilanthus schweinitizii*	E

Bald Eagle

The bald eagle is a large raptor with a wingspan greater than 6 feet. Adult bald eagles are dark brown with a white head and tail. Immature eagles are brown with whitish mottling on the tail, belly, and wing linings. Bald eagles typically feed on fish but may also take birds and small mammals. In the Carolinas, nesting season extends from December through May (Potter *et al*. 1980). Bald eagles typically nest in tall, living trees in a conspicuous location near open water. Eagles forage over large bodies of water and utilize adjacent trees for perching (Hamel 1992). Disturbance activities within a primary zone extending 750 to 1500 feet from a nest tree are considered to result in unacceptable conditions for eagles (USFWS 1987). The FWS recommends avoiding disturbance activities, including construction and tree-cutting, within this primary zone. Within a secondary zone, extending from the primary zone boundary out to a distance of 1.0 mile from a nest tree, construction and land-clearing activities should be restricted to the non-nesting period. The FWS also recommends avoiding alteration of natural shorelines where bald eagles forage, and avoiding significant land-clearing activities within 1500 feet of known roosting sites.

The Site is located near open water systems which may be suitable for bald eagle feeding habitat. However, on-Site perching and nesting trees are limited to a disturbed, narrow fringe (approximately 25 to 50 feet in width) adjacent to the Rocky River. NHP records show the nearest elemental occurrence of bald eagle approximately 3.1 miles north of the Site, immediately south of Lake Tillery's Norwood Dam. NHP records and a lack of perching and nesting habitat indicate that, this project is not expected to adversely effect known populations of Bald Eagle.

BIOLOGICAL CONCLUSION NO EFFECT

Red-Cockaded Woodpecker

This small woodpecker (7 to 8.5 inches in length) has a black head, prominent white cheek patches, and a black-and-white barred back. Males often have red markings (cockades) behind the eye, but the cockades may be absent or difficult to see (Potter *et al*. 1980). Primary nest sites for red-cockaded woodpeckers include open pine stands greater than 60 years of age with little or no mid-story development. Foraging habitat is comprised of open pine or pine/mixed hardwood stands 30 years of age or older (Henry 1989). Nest cavities are constructed in the heartwood of living pines, generally older than 70 years, which have been infected with red-heart disease. Nest cavity trees tend to occur in clusters, which are referred to as colonies (USFWS 1985). The woodpecker drills holes into the bark around the cavity entrance, resulting in a shiny, resinous buildup around the entrance that allows for easy detection of active nest trees. Ideal nesting and foraging sites for this woodpecker include pine flatwoods or pine-dominated savannas which have been maintained by frequent natural or prescribed fires. Development of a thick understory may result in abandonment of cavity trees.

Field investigations indicate no suitable nesting or foraging habitat (pine stands greater than 30 years of age) within, or adjacent to, the Site. Based on NHP records, observations conducted during field investigations, and existing conditions of the Site, this project is not expected to adversely effect known populations of red-cockaded woodpecker.

BIOLOGICAL CONCLUSION **NO EFFECT**

Carolina Heelsplitter

The Carolina heelsplitter has an ovate, trapezoid shaped, unsculptured shell which grows to a maximum of approximately 4.5 inches length, by 2.7 inches height, and 1.5 inches in width (USFWS 1996). The shell varies in color from a greenish brown to dark brown on the outer surface and is often pearly to whitish blue, grading to orange on the inside surface. The dorsal margin is straight and may end in a slight wing, and the umbo is flattened. Beak sculpture is depressed and double looped, extending slightly past the hinge line. Lateral teeth are generally, thin and pseudo-cardinal teeth are lamellar and parallel to the dorsal margin (TSCFTM 1990).

Historically, this species was reported in the Abbeville district of South Carolina and Mecklenburg County in North Carolina (Clarke 1985). The Abbeville district is bordered on the south by the Savannah River and on the north by the Saluda River. Presently the species range is limited to only six small streams and one small river. The heelsplitter is usually found in mud, muddy sand, or muddy gravel substrates along stable, well-shaded stream banks (Keferl and Shelly 1988). Currently, the heelsplitter is found in only two small remnant populations in North Carolina: 1) a tributary (Goose Creek) to the Rocky River located in Union County and 2) in a tributary (Waxhaw Creek) to the Catawba River located in Union County (USFWS 2003).

NHP records indicate that this species has not been documented within 2.0 miles of the Site. However, the Site is located within the Rocky River drainage basin, and portions of Site streams are characterized by stable, vegetated stream banks; therefore, detailed surveys for presence of this species were necessary prior to initiation of Site implementation.

The Catena Group, Inc was retained to complete a field survey for the Carolina heelsplitter in the waters of Camp Branch, UT to Camp Branch, Dula Thoroughfare, UT to Dula Thoroughfare, and Rocky River. It was found that the streams surveyed were generally not suitable as freshwater mussel habitat, and no Carolina Heelsplitter mussels were found in the survey. There is a slight possibility that mussel populations exist downstream of the project site on the Rocky River, but it is unlikely that these populations include the Carolina Heelsplitter. For this reason, the Catena Group anticipates the stream mitigation within the Bishop tract to be **"Not Likely To Adversely Effect"** the Carolina Heelsplitter (Freshwater Mussel Survey, Appendix E).

BIOLOGICAL CONCLUSION **NOT LIKELY TO ADVERSELY EFFECT**

Schweinitz's Sunflower

Schweinitz's sunflower is an erect, unbranched, rhizomatous, perennial herb that grows to approximately 6 feet in height. The stem may be purple and is usually pubescent; however, the stems are sometimes nearly smooth. Leaves are sessile, opposite on the lower stem but alternate above and are lanceolate in shape, averaging 5 to 10 times as long as wide. The leaves are rather thick and stiff, with a few small serrations. The upper leaf surface is rough and the lower surface is usually pubescent with soft white hairs. Schweinitz's sunflower blooms from September to frost. Flower heads are yellow and approximately 0.6 inches in diameter. The current range of this species is within 60 miles of Charlotte, North Carolina, occurring on upland interstream flats or gentle slopes. The plants usually occur in soils that are thin or clay in texture. The species needs open areas protected from shade or excessive competition, reminiscent of Piedmont prairies. Disturbances such as fire maintenance or regular mowing help sustain preferred habitat (USFWS 1994).

NHP records indicate that this species has not been documented within 2.0 miles of the Site. Schweinitz's sunflower needs open areas protected from shade or excessive competition, reminiscent of Piedmont prairies. Roadside edges have been maintained as an open herbaceous community and appear to be suitable habitat for Schweinitz's sunflower. Agricultural field edges may provide additional habitat, providing that they are not intensively maintained and that competition from agricultural weeds is not excessive. Detailed surveys for this species were conducted on September 21 and 22, 2004, using systematic transects along all possible habitat areas. No specimens of Schweinitz's sunflower were found. Based on NHP records, field surveys, and professional judgment, this project will not affect Schweinitz's sunflower.

BIOLOGICAL CONCLUSION NO EFFECT

3.7.2 State Protected Species

Plant and animal species which are on the North Carolina State list as Endangered (E), Threatened (T), Special Concern (SC), Candidate (C), Significantly Rare (SR), or Proposed (P) (Amoroso 2002) receive limited protection under the North Carolina Endangered Species Act (G.S. 113-331 *et seq.*) and the North Carolina Plant Protection Act of 1979 (G.S. 106-202 *et seq.*). A records search of NHP files indicates one element occurrence within 2.0 miles of the Site. The thin-pod white wild indigo (*Baptisia albescens*) is not federally listed; however, it is listed in North Carolina as SR-P* (-P = species at the periphery of its range in North Carolina, * = historic record, not seen since 1979). Restoration activities are not expected to adversely affect this species.

4.0 REFERENCE STUDIES

4.1 Reference Channel

A fundamental concept of stream classification entails the development and application of regional reference curves to stream reconstruction and enhancement. Regional reference curves can be utilized to predict bankfull stream geometry, discharge, and other parameters in altered systems. Development of regional reference curves for North Carolina was initiated in 1995. The curves characterize a broad range of streams within the Piedmont physiographic province. Small watersheds or deviations in valley slope, land use, or geologic substrate may not be accurately described by the curves; therefore, verification of individual watersheds may be necessary. On-Site and off-site reference reaches have been utilized in conjunction with regional curves for detailed planning and characterization of this restoration project.

In order to develop proposed geometric parameters for on-Site, degraded channels, three nearby streams were measured for reference. The primary reference reaches for larger, lower slope on-Site channels are located 1) within Camp Branch at the upper on-Site reaches of the channel and 2) approximately 35 miles northwest of the Site on an unnamed tributary to Crane Creek. These reference streams are characterized by E-type channels.

The primary reference reach for smaller, higher slope on-Site channels is located approximately 34 miles west of the Site on an unnamed tributary to Reedy Creek. This reference stream is characterized as an E-type channel.

Table 3 (Appendix B) includes a summary of dimension, profile, and pattern data for the reference reaches used to establish reconstruction parameters. Channel cross-sections were measured at systematic locations and stream profiles were developed via laser level and GPS. Stream substrates were quantified through systematic pebble counts along the reference reach. Individual cross-section data and other morphological information are included in Appendix D.

Initially, reference streams were visited and classified by stream type (Rosgen 1996). This classification stratifies streams into comparable groups based on geometric characteristics. Reference reaches identified in the vicinity were characterized primarily as E-type (highly sinuous) channels with sand or gravel substrate. E-type streams are slightly entrenched, highly sinuous (>1.5) channels which exhibit high meander width ratios (belt width/bankfull width). In North Carolina, E-type streams occur in narrow to wide valleys with well-developed alluvial floodplains (Valley Type VIII). These streams exhibit a sequence of riffles and pools associated with a sinuous flow pattern.

<u>Dimension</u>

Camp Branch - Reach 1 (E-Type): Upstream of Headcut (Figure 8)

Bankfull Channel Cross Sectional Area – 38.7 feet^2
Existing Channel Cross Sectional Area – 38.7 to 44.1 feet^2 (slightly enlarged)
Bank Height Ratio – 1.0 to 1.3 (slight erosion hazard)
Width/Depth Ratio – 8 to 12

UT to Crane Creek

Bankfull Channel Cross Sectional Area – 20.5 $feet^2$
Existing Channel Cross Sectional Area – 23.5 to 30.7 $feet^2$ (slightly enlarged)
Bank Height Ratio – 1.1 to 1.2 (low erosion hazard)
Width/Depth Ratio – 5 to 6

UT to Reedy Creek

Bankfull Channel Cross Sectional Area – 15.5 $feet^2$
Existing Channel Cross Sectional Area – 14.2 to 20.6 $feet^2$ (slightly enlarged)
Bank Height Ratio - 1.0 to 1.2 (low erosion hazard)
Width/Depth Ratio – 6 to 8

<u>Pattern</u>

Camp Branch - Reach 1 (E-Type): Upstream of Headcut (Figure 8)

Sinuosity - 1.18

UT to Crane Creek

Sinuosity - 1.8

UT to Reedy Creek

Sinuosity - 1.55

<u>Profile</u>

Camp Branch - Reach 1 (E-Type): Upstream of Headcut (Figure 8)

Valley Slope – 0.0047 rise/run
Water Surface Slope – 0.0029 rise/run
Riffle Slope – 0.0008 to 0.0167 rise/run
Pool Slope – 0 to 0.0013 rise/run

UT to Crane Creek

Valley Slope – 0.0025 rise/run
Water Surface Slope – 0.0014 rise/run
Riffle Slope – 0.0006 to 0.0033 rise/run
Pool Slope – 0 to 0.0006 rise/run

UT to Reedy Creek

Valley Slope – 0.0172 rise/run
Water Surface Slope – 0.0111 rise/run
Riffle Slope – 0.0105 to 0.0221 rise/run
Pool Slope – 0.0016 to 0.0182 rise/run

<u>Substrate</u>:

Camp Branch - Reach 1 (E-Type): Upstream of Headcut (Figure 8)

D50 – 7.2 millimeters

UT to Crane Creek

D50 – 1.9 millimeters

UT to Reedy Creek

D50 – 0.05 millimeters

4.2 Reference Forest Ecosystem

According to Mitigation Site Classification (MiST) guidelines (EPA 1990), Reference Forest Ecosystems (RFEs) must be established for restoration sites. RFEs are forested areas on which to model restoration efforts of the restoration site in relation to soils, hydrology, and vegetation. RFEs should be ecologically stable climax communities and should represent believed historical (pre-disturbance) conditions of the restoration site. Quantitative data describing plant community composition and structure are collected at the RFEs and subsequently applied as reference data for design of the restoration site planting scheme.

There were two RFE areas chosen to guide plant community restoration within the on-Site floodplain, channel banks, and adjacent floodplain slopes. The RFEs are both found within the Southern Outer Piedmont Ecoregion, one west and one northwest of the Site. Both RFEs support plant community, landform, and hydrological characteristics that restoration efforts will attempt to emulate. Circular, 0.1-acre plots were randomly established within the selected RFEs. Data collected within each plot include 1) tree, shrub, and herb species composition; 2) number of stems for each tree and shrub species; and 3) diameter at breast height (DBH) for each tree and shrub species. Field data (Table 4A and 4B [Appendix B]) indicate importance values (IV) of dominant tree species calculated based on relative density, dominance, and frequency of tree species composition (Smith 1980). Hydrology, surface topography, and habitat features were also evaluated.

The northwestern RFE is located in the floodplain of the UT to Crane Creek in Rowan County, North Carolina. Three 0.1-acre plots were established which best characterize expected steady-state forest composition. Forest vegetation was dominated by swamp chestnut oak (*Quercus michauxii*) (IV=0.17), green ash (IV=0.13), American elm (IV=0.10), and shagbark hickory (*Carya ovata*) (IV=0.09) (Table 4A [Appendix B]). Portions of the canopy were also dominated by willow oak (*Quercus phellos*), boxelder (*Acer negundo*), tulip poplar, black tupelo (*Nyssa sylvatica*), and red maple.

The western RFE is located in the floodplain of Reedy Creek in Mecklenburg County, North Carolina. Within the RFE, vegetative sampling at four 0.1-acre plots indicate that forest tree vegetation was dominated by tulip poplar (IV=0.12), American elm (IV=0.10), northern red oak (*Quercus rubra*) (IV=0.08), and black walnut (*Juglans nigra*) (IV=0.07) (Table 4B [Appendix B]). Other, less dominant tree species within the sample plots were green ash, boxelder, and American sycamore.

5.0 STREAM POWER AND SHEAR STRESS STUDIES

5.1 Discharge

Discharge estimates for the Site utilize an assumed definition of "bankfull" and the return interval associated with the bankfull discharge. For this study, the bankfull channel is defined as the channel dimensions designed to support the "channel forming" or "dominant" discharge (Gordon *et al.* 1992). Research indicates that a stable stream channel may support a return interval for bankfull discharge, or channel-forming discharge, between 1 to 2 years (Gordon *et. al.* 1992, Dunne and Leopold 1978). The methods of Rosgen (1996) indicate calibration of bankfull dimensions based on a potential bankfull return interval between 1.3 and 1.5 years for rural conditions.

Discharge within the Site appears to be dominated by a combination of upstream basin catchment, groundwater flow, and precipitation. Based on regional curves (Harman *et al.* 1999), the bankfull discharge for a 2.9 square mile watershed is expected to average approximately 192 cubic feet per second. Current research estimates a bankfull discharge of 192 cubic feet per second would be expected to occur approximately every 1.3 to 1.5 years (Rosgen 1996).

5.2 Stream Power, Shear Stress, and Stability Threshold

5.2.1 Stream Power

Stability of a stream refers to its ability to adjust itself to in-flowing water and sediment load. One form of instability occurs when a stream is unable to transport its sediment load, leading to aggradation, or deposition of sediment onto the stream bed. Conversely, when the ability of the stream to transport sediment exceeds the availability of sediments entering a reach, and/or stability thresholds for materials forming the channel boundary are exceeded, erosion or degradation occurs.

Stream power is the measure of a stream's capacity to move sediment over time. Stream power can be used to evaluate the longitudinal profile, channel pattern, bed form, and sediment transport of streams. Stream power may be measured over a stream reach (total stream power) or per unit of channel bed area. The total stream power equation is defined as:

$$\Omega = \rho g Q s$$

where Ω = total stream power (ft-lb/s-ft), ρ = density of water (lb/ft^3), g = gravitational acceleration (ft/s^2), Q = discharge (ft^3/sec), and s = energy slope (ft/ft). The specific weight of water (γ = 62.4 lb/ft^3) is equal to the product of water density and gravitational acceleration, ρg. A general evaluation of power for a particular reach can be calculated using bankfull discharge and water surface slope for the reach. As slopes become steeper and/or velocities increase, stream power increases and more energy is available for re-working channel materials. Straightening and clearing channels increases slope and velocity and thus stream power. Alterations to the stream channel may conversely decrease stream power. In particular, over-widening of a channel will dissipate energy of flow over a larger area. This process will decrease stream power, allowing sediment to fall out of the water column, possibly leading to aggradation of the streambed.

The relationship between a channel and its floodplain is also important in determining stream power. Streams that remain within their banks at high flows tend to have higher stream power and relatively coarser bed materials. In comparison, streams that flood over their banks onto adjacent floodplains have lower stream power, transport finer sediments, and are more stable. Stream power assessments can be useful in evaluating sediment discharge within a stream and the deposition or erosion of sediments from the streambed.

5.2.2 Shear Stress

Shear stress, expressed as force per unit area, is a measure of the frictional force that flowing water exerts on a streambed. Shear stress and sediment entrainment are affected by sediment supply (size and amount), energy distribution within the channel, and frictional resistance of the streambed and bank on water within the channel. These variables ultimately determine the ability of a stream to efficiently transport bedload and suspended sediment.

For flow that is steady and uniform, the average boundary shear stress exerted by water on the bed is defined as follows:

$$\tau = \gamma Rs$$

where τ = shear stress (lb/ft^2), γ = specific weight of water, R = hydraulic radius (ft), and s = the energy slope (ft/ft). Shear stress calculated in this way is a spatial average and does not necessarily provide a good estimate of bed shear at any particular point. Adjustments to account for local variability and instantaneous values higher than the mean value can be applied based on channel form and irregularity. For a straight channel, the maximum shear stress can be assumed from the following equation:

$$\tau_{max} = 1.5\tau$$

for sinuous channels, the maximum shear stress can be determined as a function of plan form characteristics:

$$\tau_{max} = 2.65\tau(R_c / W_{bkf})^{-0.5}$$

where R_c = radius of curvature (ft) and W_{bkf} = bankfull width (ft).

Shear stress represents a difficult variable to predict due to variability of channel slope, dimension, and pattern. Typically, as valley slope decreases channel depth and sinuosity increase to maintain adequate shear stress values for bedload transport. Channels that have higher shear stress values than required for bedload transport will scour bed and bank materials, resulting in channel degradation. Channels with lower shear stress values than needed for bedload transport will deposit sediment, resulting in channel aggradation.

The actual amount of work accomplished by a stream per unit of bed area depends on the available power divided by the resistance offered by the channel sediments, plan form, and vegetation. The stream power equation can thus be written as follows:

$$\omega = \rho g Q s = \tau v$$

where ω = stream power per unit of bed area (N/ft-sec, Joules/sec/ft^2), τ = shear stress, and v = average velocity (ft/sec). Similarly,

$$\omega = \Omega / W_{bkf}$$

where W_{bkf} = width of stream at bankfull (ft).

5.2.3 Stream Power and Shear Stress Methods and Results

Channel degradation or aggradation occurs when hydraulic forces exceed, or do not approach, the resisting forces in the channel. The amount of degradation or aggradation is a function of relative magnitude of these forces over time. The interaction of flow within the boundary of open channels is only imperfectly understood. Adequate analytical expressions describing this interaction have yet to be developed for conditions in natural channels. Thus, means of characterizing these processes rely heavily upon empirical formulas.

Traditional approaches for characterizing stability can be placed in one of two categories: 1) maximum permissible velocity and 2) tractive force, or stream power and shear stress. The former is advantageous in that velocity can be measured directly. Shear stress and stream power cannot be measured directly and must be computed from various flow parameters. However, stream power and shear stress are generally better measures of fluid force on the channel boundary than velocity.

Using these equations, stream power and shear stress were estimated for

1) Camp Branch Reach 1 and 2: Upstream of Headcut to Ford,
2) Camp Branch Reach 3: Downstream of Ford,
3) Dula Thoroughfare: Upstream Reach,
4) Dula Thoroughfare: Downstream Reach,
5) Camp Branch, Reference Reach,
6) UT to Reedy Creek (reference area),
7) UT to Crane Creek (reference area), and
8) Proposed on-Site conditions.

Important input values and output results (including stream power, shear stress, and per unit shear power and shear stress) are presented in Table 5. Average stream velocity and discharge values were calculated for existing on-Site stream reaches, reference reaches, and proposed conditions.

Table 5. Stream Power (Ω) and Shear Stress (τ) Values

Stream Reach	Discharge (Q) (ft^3/sec)	Water surface Slope (s) (ft/ft)	Total Stream Power (Ω) = γ Qs	Ω/W	Hydraulic Radius (R) = A/WP	Shear Stress (τ) = γ Rs (lb/ft^2)	Velocity (v) (ft/sec)	τ v
Camp Branch								
Reach 1 and 2 (E-type) Upstream to Ford	168	0.0029	30.40	1.66	1.72	0.31	4.34	1.35
Reach 3 (G-type) Downstream of Ford	182	0.0041	**46.56**	2.62	1.86	**0.48**	4.33	2.06
Dula Thoroughfare								
Upstream Reach	19.3	0.0228	27.46	4.58	0.65	0.93	3.78	3.52
Downstream Aggrading Reach	30	0.0019	**3.56**	0.25	0.47	**0.06**	4.29	0.24
Reference								
Camp Branch	168	0.0029	30.40	1.55	1.64	0.30	4.34	1.29
UT to Reedy Creek	44	0.0111	30.48	2.93	1.17	0.81	2.84	2.31
UT to Crane Creek	119	0.0014	10.40	1.03	1.45	0.13	5.80	0.74
Proposed Camp Branch								
Camp Branch upstream	168	0.0031	32.50	1.51	1.51	0.29	4.44	1.29
Camp Branch Middle Reach	182	0.0031	35.21	1.57	1.60	0.31	4.33	1.34
Proposed Dula (non-braided reach)								
Proposed Dula	23	0.007	10.05	1.17	0.62	0.27	3.71	1.60

As would be expected, stream power and shear stress are lowest in the aggrading reaches (Dula Thoroughfare) and low slope reference reaches. Conversely, stream power and shear stress are highest in the on-Site reaches which are currently showing signs of degradation (Camp Branch Reach 3). Stream power is the highest for the dredged and straightened, G-type reach, where slopes have been steepened, cross-sectional area is high, width-to-depth ratio is low, bank erosion is high, and the channel is highly incised.

In order to maintain sediment transport functions of a stable stream system, the non-braided reaches of proposed channels should exhibit stream power and shear stress values that neither aggrade nor degrade. Results of the analysis indicate that the non-braided proposed channel reaches are expected to maintain stream power values of approximately 10 to 35 and shear stress values of approximately 0.27 to 0.31 (similar to that of reference reaches and considerably less than that of the existing degrading reaches). Therefore, the design channel is expected to effectively transport sediment through the Site, resulting in stable channel characteristics.

6.0 RESTORATION PLAN

The primary goals of this restoration plan include 1) construction of stable, riffle-pool stream complexes; 2) construction of a backwater slough, braided stream complex, 3) creation of a natural vegetation buffer along enhanced and restored stream channels; 4) maximize the re-establishment of historic wetland function; 5) restoration of wildlife functions associated with a riparian corridor, and 6) protection of the Site in perpetuity.

The complete restoration plan is depicted in Figure 9. The proposed restoration plan is expected to provide the following:

1. 5,663 linear feet of stream restoration
2. 1,190 linear feet of stream enhancement - level 1 (restoration of dimension and profile)
3. 7,306 linear feet of stream enhancement – level 2 (remove from agriculture, remove spoil from the banks, and re-vegetate)
4. 11,250 linear feet of stream preservation
5. 10.2 acres of wetland preservation
6. 5.6 acres of wetland restoration
7. 0.9 acres of wetland enhancement

Components of this plan may be modified based on construction or access constraints.

Primary activities proposed at the Site include 1) stream enhancement/restoration, 2) wetland enhancement/restoration, 3) soil scarification, and 4) plant community restoration. A monitoring plan is outlined in Section 7 of this document.

6.1 Stream Enhancement/Restoration

This stream enhancement/restoration effort is designed to reconstruct stable, meandering streams that approximate hydrodynamics, stream geometry, and local microtopography relative to reference conditions. This effort consists of 1) stream reconstruction on new location, 2) stream reconstruction in place, and 3) ford construction. Geometric attributes for the proposed, stable channels are listed in Table 6A and 6B (Appendix B).

6.1.1 Reconstruction on New Location

Reaches proposed for reconstruction on new location are depicted on Figure 9A to 9C. Primary activities designed to reconstruct the channel on new location include 1) belt-width preparation and grading, 2) floodplain bench excavation, 3) channel excavation, 4) installation of channel plugs, and 5) backfilling of the abandoned channel.

<u>Belt-width Preparation and Grading</u>

Care will be taken to avoid the removal of existing, deeply rooted vegetation within the belt-width corridor which may provide design channel stability. Material excavated during grading will be stockpiled immediately adjacent to channel segments to be abandoned and backfilled. These segments will be backfilled after stream diversion is completed.

Spoil material may be placed to stabilize temporary access roads and to minimize compaction of the underlying floodplain. However, all spoil will be removed from floodplain surfaces upon completion of construction activities.

Floodplain Bench Excavation

The creation of a bankfull, floodplain bench is expected to 1) remove the eroding material and collapsing banks, 2) promote overbank flooding during bankfull flood events, 3) reduce the erosive potential of flood waters, and 4) increase the width of the active floodplain. Bankfull benches may be created by excavating the adjacent floodplain to bankfull elevations or filling eroded/abandoned channel areas with suitable material. After excavation, or filling of the bench, a relatively level floodplain surface is expected to be stabilized with suitable erosion control measures. Planting of the bench with native floodplain vegetation is expected to reduce erosion of bench sediments, reduce flow velocities in flood waters, filter pollutants, and provide wildlife habitat.

After excavation of the floodplain bench, the design channel and updated profile survey will be developed and the location of each meander wavelength plotted and staked along the profile. Pool locations and relative frequency configurations may be modified in the field based on local variations in the floodplain profile.

Channel Excavation

The channel will be constructed within the range of values depicted in Table 6A and 6B (Appendix B). The channel will be excavated to the approximate dimensions depicted on Figure 10. The channel should be excavated to the proposed channel depth and width. Material excavated from the proposed design channel will be stockpiled adjacent to the reach of channel to be backfilled or will be wasted on upland portions of the Bishop property, as directed by the field engineer.

Stream banks and local belt-width area of constructed channels will be immediately planted with shrub and herbaceous vegetation. Particular attention will be directed toward providing vegetative cover and root growth along the outer bends of each stream meander. Live willow stake revetments will be constructed as conceptually depicted in Figure 11. Available root mats or biodegradable, erosion-control matting may be embedded into the break-in-slope to promote more rapid development of an overhanging bank. Willow stakes will be purchased and/or collected on-Site and inserted through the root/erosion mat into the underlying soil.

Channel Plugs

Impermeable plugs will be installed along abandoned channel segments at locations depicted on Figure 9A to 9C. The plugs will consist of low-permeability materials or hardened structures designed to be of sufficient strength to withstand the erosive energy of surface flow events across the Site. Dense clays may be imported from off-site or existing material, compacted within the channel, may be suitable for plug construction. The plug will be sufficiently wide and deep to form an imbedded overlap in the existing banks and channel bed.

Channel Backfilling

After impermeable plugs are installed, the abandoned channel will be back-filled. Backfilling will be performed primarily by pushing stockpiled materials into the channel. The channel will be filled to the extent that on-Site material is available and compacted to maximize microtopographic variability, including ruts, ephemeral pools, and hummocks in the vicinity of the backfilled channel.

In-Stream Structures

Stream restoration under natural stream design techniques normally involves the use of in-stream structures for bank stabilization, grade control, and habitat improvement. Primary activities designed to achieve these objectives may include the installation of cross-vane weirs, J-hook vanes, and log vanes.

Cross-vane Weirs

The purpose of the vane is to 1) sustain bank stability, 2) direct high velocity flows during bankfull events toward the center of the channel, 3) maintain average pool depth throughout the reach, 4) preserve water surface elevations and reconnect the adjacent floodplain to flooding dynamics from the stream, and 5) modify energy distributions through increases in channel roughness and local energy slopes during peak flows.

Cross-vane weirs will be constructed as conceptually depicted in Figure 12. Cross-vane weir construction will be initiated by imbedding footer rocks into the stream bed for stability and to prevent undercutting of the structure. Header rocks will then be placed atop the footer rocks at the design elevation. Footer and header rocks create an arm that slopes from the center of the channel upward at approximately 7 to 10 degrees, tying in at the bankfull floodplain elevation. The cross-vane arms at both banks will be tied into the bank with a sill to eliminate the possibility of water diverting around the structure. Once the header and footer stones are in place, filter fabric will be buried into a trench excavated around the upstream side of the vane arms. The filter fabric is then draped over the header rocks to force water over the vane. The upstream side of the structure can then be backfilled with suitable material to the elevation of the header stones.

J-hook/log vanes

The primary purpose of the J-hook and log vanes is to direct high-velocity flows during bankfull events toward the center of the channel. J-hook vanes will be constructed using the same type and size of rock employed in the construction of cross-vane weirs (Figure 13). Log vanes will be constructed utilizing large tree trunks harvested from the Site or imported from off-site. The tree stem harvested for a log-vane arm must be long enough to be imbedded into the stream channel and extend several feet into the floodplain (Figure 14). A trench will be dug into the stream channel that is deep enough for the head of the log to be at or below the channel invert. The trench is then extended into the floodplain and the log is set into the trench such that the log arm is below the floodplain elevation. If the log is not of sufficient size to completely block stream flow (gaps occur between the log and channel bed) then a footer log or stone footers will be installed beneath the header log. Boulders will then be situated at the base of the log and at the head of the log to hold the log in place.

Similar to a cross vane, the arm of the J-hook vane and the log vane (which forms an arm) must slope from the center of the channel upward at approximately 7 to 10 degrees, tying in at the bankfull floodplain elevation. Once these vanes are in place, filter fabric is toed into a trench on the upstream side of the vane and draped over the structure to force water over the vane. The upstream side of the structure is then backfilled with suitable material.

6.1.2 Stream Reconstruction In-Place

Stream reconstruction in-place is expected in 1) areas where channel pattern has not been altered; however, the channel has incised due bed or bank erosion, or 2) areas where backwater slough conditions will persist once restoration has been completed. Reaches proposed for reconstruction in-place are depicted in Figure 9A to 9C. Primary activities designed to achieve these objectives may include 1) installation of in-stream structures, 2) creation of a floodplain bench, 3) excavation of a backwater slough/braided channel system, 4) spoil removal, 5) backfilling abandoned channels, and 6) diversion of bankfull flows to historic channels.

Installation of in-stream structures and creation of a floodplain bench has been described in detail in Section 6.1.1 (Stream Reconstruction on New Location) of this document. The design, installation, and function of in-stream structures and floodplain bench are similar for stream reconstruction in-place.

Excavation of a Backwater Slough/Braided Channel System

Backwater slough/braided channel systems will be designed to mimic reference wetland and stream conditions found within the Rocky River floodplain. Conditions include 1) convoluted interception of groundwater and flood flows, 2) average slope of upland-wetland interface and slough surface, 3) micro-topographic variation along the slough surface, and 4) soil modification and debris deposition.

Backwater slough/braided channel construction will occur within, and adjacent to, the existing Dula Thoroughfare aggrading ditch/channel (Figure 9B). Construction of the backwater slough/braided channel system will initiate at the confluence of Dula Thoroughfare and the Rocky River floodplain. The system will extend approximately 1195 feet downstream as a series of shallow, irregularly shaped depressions interspersed between shallow, braided stream channels. The depressions will range to a maximum of 1-foot below the proposed surface elevation in the center of the depression. The isolated depressions are expected to fill with organic matter and sediment, with development of braided channel occurring passively over time.

Spoil Removal

Spoil material deposited adjacent to the downstream reaches of Dula Thoroughfare and the UT to Dula Thoroughfare will be removed from channel banks and deposited in abandoned channels or wasted in upland portions of the Site/adjacent agricultural fields. Spoil removal areas are depicted in Figure 9B and 9C. Removal of spoil material is expected to facilitate overbank flooding, thereby extending floodprone areas and reducing scour potential of local flood flows.

Backfilling Abandoned Channels

Several reaches of the UT to Dula Thoroughfare are characterized by shoot cutoffs; secondary channels that have been blocked from normal flows by spoil castings; and excavated channels adjacent to an historic, abandoned channel. Backfilling of these abandoned channels with spoil material or material excavated from the floodplain will redirect stream flow through the historic, abandoned reaches of channel.

Diversion of Bankfull Flows

Bankfull discharge currently appears to be re-directed through a ditch connecting the downstream reach of Dula Thoroughfare to the Rocky River. This ditch effectively splits stormwater discharge from Dula Thoroughfare during bankfull flood events. Conversely, the ditch transmits water to Dula Thoroughfare during high volume flood flows from the Rocky River. Filling this ditch, and redirecting bankfull discharge through Dula Thoroughfare will allow for "channel forming" flows to continue natural evolutionary channel processes within on-Site and downstream reaches of Dula Thoroughfare.

6.1.3 Ford Construction

Landowner constraints will necessitate the installation of three channel fords to allow access to portions of the property isolated by the conservation easement and/or stream and wetland restoration activities. Proposed channel ford locations are depicted on Figure 9. The fords are expected to consist of shallow depressions in stream banks where vehicular crossings can be made (Figure 15). The fords will be constructed of hydraulically stable rip-rap or suitable rock and will be large enough to handle the weight of anticipated vehicular traffic. Approach grades to the ford will be at a minimum 15:1 slope and constructed of hard, scour-resistant crushed rock or other permeable material, which is free of fines. The bed elevation of the ford will equal the stream bed elevation above and below the ford to reduce the risk of headcutting.

6.2 Wetland Enhancement/Restoration

Site alterations to wetland areas and/or areas underlain by hydric soils are designed to re-establish a fully functioning wetland system which will provide surface water storage, nutrient cycling, removal of imported elements and compounds, and will create a variety and abundance of wildlife habitat. Wetland enhancement/restoration activities are expected to restore approximately 5.6 acres of jurisdictional wetland and enhance approximately 0.9 acre of jurisdictional wetland (Figure 9). The proposed conservation easement also encompasses approximately 10.2 acres of existing, relatively undisturbed jurisdictional wetland which will be preserved in-perpetuity.

Portions of the Site underlain by hydric soil have been impacted by vegetative clearing, earth movement associated with the dredging and straightening of Dula Thoroughfare and compaction by placement of spoil on the floodplain. Wetland enhancement/restoration options will focus on 1) the establishment of backwater slough/braided channel systems, 2) excavation and grading of elevated spoil and sediment embankments, and 3) reestablishing hydrophytic vegetation.

Establishment of Backwater Slough / Braided Channel Systems

The existing dredged and straightened reach of Dula Thoroughfare represents the primary on-Site wetland restoration feature. Currently, Dula Thoroughfare drains from the valley wall slopes as a channelized, E-type stream. Upon entering the Rocky River Floodplain, the channel has been dredged and straightened and is currently characterized as a shallow, wide, slackwater ditch that has been isolated from the adjacent floodplain. Measures outlined in Section 6.2.1 (Stream Reconstruction In-Place - Excavation of a Backwater Sough/Braided Channel System), including excavation of a floodplain and shallow non-linear depressions connected by braided channel systems is expected to result in approximately 5.6 acres of jurisdictional wetland restoration within the Rocky River floodplain.

It should be noted that floodplains adjacent to the dredged and straightened reach of Dula Thoroughfare are underlain by brightly colored soils (approximately 10YR 4/4 to 10YR 4/6), which are characteristic of wetlands in the area. USACE representatives conducted a field visit to the Site on January 13, 2004 (Notification of Jurisdictional Determination can be found in Appendix F), and confirmed these brightly colored soils were indicative of a hydric soil for the region.

<u>Excavation and Grading of Elevated Spoil and Sediment Embankments</u>
Reaches of Dula Thoroughfare and its UT have experienced both natural and unnatural sediment deposition. Spoil piles appear to have been cast adjacent to the channels during dredging and straightening of the stream or during agricultural field clearing. Major flood events may have also deposited additional sediment adjacent to stream banks from eroding banks and upstream agricultural fields. The removal of spoil material and/or filling of on-Site ditches with spoil material represent a critical element of wetland restoration.

<u>Hydrophytic Vegetation</u>
On-Site wetland areas have endured significant disturbance from land use activities such as land clearing, row crop agriculture, and other anthropogenic maintenance. Wetland areas will be re-vegetated with native vegetation typical of wetland communities in the region. Emphasis will focus on developing a diverse plant assemblage. Sections 6.4 (Plant Community Restoration) and 6.4.2 (Planting Plan) provide detailed information concerning community species associations. Re-vegetation of portions of the Site underlain by hydric soils is expected to represent an important wetland enhancement/restoration component.

6.3 Floodplain Soil Scarification

Microtopography and differential drainage rates within localized floodplain areas represent important components of floodplain functions. Reference forests in the region exhibit complex surface microtopography. Small concavities, swales, exposed root systems, seasonal pools, oxbows, and hummocks associated with vegetative growth and hydrological patterns are scattered throughout these systems. As discussed in the stream reconstruction section, efforts to advance the development of characteristic surface microtopography will be implemented.

In areas where soil surfaces have been compacted, ripping or scarification will be performed. After construction, the soil surface is expected to exhibit complex microtopography ranging to 1 foot vertical asymmetry across local reaches of the landscape. Subsequently, community restoration will be initiated on complex floodplain surfaces.

6.4 Plant Community Restoration

Restoration of floodplain forest and stream-side habitat allows for development and expansion of characteristic species across the landscape, in addition to reducing the presence of invasive species. Ecotonal changes between community types contribute to diversity and provide secondary benefits, such as enhanced feeding and nesting opportunities for mammals, birds, amphibians, and other wildlife.

RFE data, on-Site observations, and community descriptions from Classification of the Natural Communities of North Carolina (Schafale and Weakley 1990) were used to develop the primary plant community associations that will be promoted during community restoration activities. These community associations include 1) stream-side assemblage, 2) bottomland hardwood forest, and 3) slope forest (Figure 16). Figure 17 identifies the location, based on elevation and position relative to restored streams and wetlands, of each target community to be planted. Planting elements within each map unit are listed below.

Bottomland Hardwood Forest

1. Swamp chestnut oak (*Quercus michauxii*)
2. American elm (*Ulmus americana*)
3. Sugarberry (*Celtis laevigata*)
4. Green ash (*Fraxinus pennsylvanica*)
5. Shagbark hickory (*Carya ovata*)
6. Willow oak (*Quercus phellos*)
7. Northern red oak (*Quercus rubra*)
8. Southern red oak (*Quercus falcata*)
9. Black gum (*Nyssa sylvatica*)
10. American sycamore (*Platanus occidentalis*)

Stream-Side Assemblage

1. Black willow (*Salix nigra*)
2. Elderberry (*Sambucus canadensis*)
3. River birch (*Betula nigra*)
4. American sycamore (*Platanus occidentalis*)
5. Swamp dogwood (*Cornus stricta*)
6. Tag alder (*Alnus serrulata*)
7. Buttonbush (*Cephalanthus occidentalis*)
8. Arrow-wood viburnum (*Viburnum dentatum*)
9. Possumhaw viburnum (*Viburnum nudum*)
10. Highbush blueberry (*Vaccinium corymbosum*)

Slope Forest

1. Mockernut hickory (*Carya tomentosa*)
2. Pignut hickory (*Carya glabra*)
3. White oak (*Quercus alba*)
4. Sourwood (*Oxydendrum arboreum*)
5. American holly (*Ilex opaca*)

6. Flowering dogwood (*Cornus florida*)

Stream-side trees and shrubs include species with high value for sediment stabilization, rapid growth rate, and the ability to withstand hydraulic forces associated with bankfull flow and overbank flood events. Stream-side trees and shrubs will be planted within 15 feet of the channel throughout the meander belt-width. Shrub elements will be planted along the banks of the reconstructed stream, concentrated along outer bends.

Bottomland hardwood forest vegetation is targeted for areas located in the floodplain and backwater slough/braided channel system. Species common along slope forests will be planted on slopes adjacent to the floodplain.

The following planting plan is the blueprint for community restoration. The anticipated results stated in the Success Criteria (Section 7.8) are expected to reflect potential vegetative conditions achieved after steady-state conditions prevail over time.

6.5 Planting Plan

The purpose of a planting plan is to re-establish vegetative community patterns across the landscape. The plan consists of 1) acquisition of available plant species, 2) implementation of proposed Site preparation, and 3) planting of selected species.

Species selected for planting will be dependent upon availability of local seedling sources. Advance notification to nurseries (1 year) will facilitate availability of various non-commercial elements.

Bare-root seedlings of tree species will be planted within specified map areas at a density of approximately 680 stems per acre on 8-foot centers. Shrub species in the streamside assemblage will be planted at a density of 1360 stems per acre on 4-foot centers. Table 7 depicts the total number of stems and species distribution within each vegetation association. Planting will be performed between December 1 and March 15 to allow plants to stabilize during the dormant period and set root during the spring season. A total of 63,454 diagnostic tree and shrub seedlings may be planted during restoration.

Table 7: Planting Plan

Vegetation Association	Bottomland Hardwood Forest		Stream-side Assemblage		Slope Forest		Backwater Slough		Total
Area (acres)	**51.7**		**4.1**		**27.2**		**6.2**		
Species	**number planted**	**% of total**	**number planted**	**% of total**	**number planted**	**% of total**	**number planted**	**% of total**	**Number Planted**
Swamp Chestnut Oak	3516	10					633	15	4149
American Elm	3516	10							3516
Sugarberry	1758	5							1758
Green Ash	7031	20					633	15	7664
Shagbark Hickory	3516	10							3516
Willow Oak	3516	10							3516
Northern Red Oak	1758	5							1758
Southern Red Oak	1758	5							1758
Black Gum	3516	10							3516
American Sycamore	5274	15	558	10					5832
River Birch			558	10					558
Swamp Dogwood			279	5					279
Black Willow			1115	20					1115
Tag Alder			558	10			633	15	1191
Buttonbush			279	5			422	10	701
Elderberry			558	10					558
Arrow-wood Vibernum			558	10					558
Possumhaw Vibernum			558	10					558
Highbush Blueberry			558	10					558
Mockernut Hickory					3699	20			3699
Pignut Hickory					3699	20			3699
White Oak					3699	20			3699
Sourwood					3699	20			3699
American Holly					1850	10			1850
Flowering Dogwood					1850	10			1850
Overcup Oak							633	15	633
Swamp Cottonwood							633	15	633
Cherrybark Oak							633	15	633
Total	**35159**	**100**	**5579**	**100**	**18496**	**100**	**4220**	**100**	**63454**

7.0 MONITORING PLAN

Monitoring of Site restoration efforts will be performed for the first five growing seasons following site construction. If necessary, monitoring will continue through additional growing seasons. Monitoring is proposed for single-strand stream channels, as well as wetland components of hydrology and vegetation. A general Site monitoring plan is depicted in Figure 18.

Stream measurements are not proposed in the backwater slough/braided channel system due to typical characteristics of a D-type (braided) stream consisting of multiple braided channels. D-type stream systems are not conducive to measurement of pattern, dimension, and profile; therefore, the stream will be visually assessed and photographically documented annually to semi-annually and any potential problem area(s) will be identified. If a problem area is noted during the review, the area will be evaluated to determine the corrective action required to resolve the problem.

7.1 Stream Monitoring

Site stream reaches proposed to be monitored for geometric activity are conceptually depicted in Figure 18. Each stream reach will extend for a minimum of 450 feet along the restored channel. Annual fall monitoring will include development of channel cross-sections on riffles and pools, pebble counts, and a water surface profile of the channel. The data will be presented in graphic and tabular format. Data to be presented will include 1) cross-sectional area, 2) bankfull width, 3) average depth, 4) maximum depth, 5) width-to-depth ratio, 6) meander wavelength, 7) belt-width, 8) water surface slope, 9) sinuosity, and 10) stream substrate composition. The stream will subsequently be classified according to stream geometry and substrate (Rosgen 1996). Significant changes in channel morphology will be tracked and reported by comparing data in each successive monitoring year.

7.2 Stream Success Criteria

Success criteria for stream restoration will include 1) successful classification of the reach as a functioning stream system (Rosgen 1996) and 2) channel variables indicative of a stable stream system. Stream restoration success criteria will follow the constructs outlined by interagency guidance (*Stream Mitigation Guidelines* [USACE *et*. *al*. 2003]).

The channel configuration will be measured on an annual basis in order to track changes in channel geometry, profile, or substrate. These data will be utilized to determine the success in restoring stream channel stability. Specifically, the channel should exhibit the following characteristics:

1) Insignificant change in dimension from as-built measurements or the previous years monitoring measurements.
2) Minor changes in channel dimension are allowed; however, dimension changes should not represent a trend towards instability (*e.g.* increased width to depth ratio or decreased width to depth ratio with decreased entrenchment ratio).
3) Little change in longitudinal profile.
4) Pool/riffle spacing should remain fairly constant.
5) Pools should not be aggrading and riffles should not scour.

6) Pebble count should trend toward a desired bed material.

The field indicator of bankfull will be described in each monitoring year and indicated on a representative channel cross-section figure. If the stream channel is down-cutting or the channel width is enlarging due to bank erosion, additional bank or slope stabilization methods may be employed.

The stream is expected to maintain shear stress values to adequately transport sediment through the Site. Pebble counts will be conducted annually to determine D50 and D84 values within the restored stream. Pebble counts would be expected to indicate a general coarsening of materials on the riffles throughout the monitoring period.

Visual assessment of in-stream structures will be conducted to determine if failure has occurred. Failure of a structure may be indicated by collapse of the structure, undermining of the structure, abandonment of the channel around the structure, and/or stream flow beneath the structure.

7.3 Hydrology Monitoring

Groundwater monitoring gauges (one gauge within reference and four gauges on-Site) will be installed to monitor groundwater elevations after hydrological modifications are performed. Hydrological sampling will continue throughout the growing season at intervals necessary to satisfy the hydrology success criteria within each design unit (EPA 1990).

7.4 Hydrology Success Criteria

Target hydrological characteristics include saturation or inundation for at least 12.5 percent of the growing season at lower landscape positions, during average climatic conditions. Upper landscape reaches may exhibit surface saturation/inundation between 5 percent and 12.5 percent of the growing season based on groundwater gauge data. These areas are expected to support hydrophytic vegetation. If wetland parameters are marginal as indicated by vegetation and/or hydrology monitoring, a jurisdictional determination will be performed in these areas.

7.5 Vegetation Monitoring

Restoration monitoring procedures for vegetation are designed in accordance with EEP Vegetation Monitoring Requirements (draft 27 August 2004). A general discussion of the restoration monitoring program is provided. A photographic record of plant growth should be included in each annual monitoring report, in addition to the necessary data forms.

After planting has been completed in winter or early spring, an initial evaluation will be performed to verify planting methods and to determine initial species composition and density. Supplemental planting and additional Site modifications will be implemented, if necessary.

During the first year, vegetation will receive cursory, visual evaluation on a periodic basis to ascertain the degree of overtopping of planted elements by nuisance species. Subsequently, quantitative sampling of vegetation will be performed annually, between May and September, until the vegetation success criterion is achieved.

During quantitative vegetation sampling in summer of the first year, approximately seven sample plots will be randomly placed within the Site. Sample-plot distributions are expected to resemble locations depicted in Figure 18; however, best professional judgment may be necessary to establish vegetative monitoring plots upon completion of construction activities. In each sample plot, vegetation parameters to be monitored include species composition and species density. Visual observations of the percent cover of shrub and herbaceous species will also be recorded.

No quantitative sampling requirements are proposed for herb assemblages as part of the vegetation success criteria. Development of floodplain forests over several decades will dictate the success in migration and establishment of desired understory and groundcover populations. Visual estimates of the percent cover of herbaceous species and photographic evidence will be reported for information purposes.

7.8 Vegetation Success Criteria

Tables and discussion for each of the following success criteria will be provided with each report. The criteria include cover for each species in each plot, strata presence for each species in each plot and stem counts of each planted species in each plot.

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