Restoration Plan

Lewis Creek Stream Restoration

Henderson County, North Carolina
Catalog Unit 06010105
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Ecosystem Enhancement Program

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EXECUTIVE SUMMARY

Executive Summary

Lewis Creek is located in Henderson County, North Carolina, northeast of the City of Hendersonville. The project area consists of approximately 1,750 linear feet of stream Restoration within Lewis Creek, beginning at North Ridge Road and continuing downstream 1,750-feet to the project terminus. Lewis Creek generally flows from southeast to northwest. Currently, Lewis Creek is characterized as incised, over-widened, and exhibiting bank erosion, with an unstable channel and exposed banks. The contributing factors to the stream's worsening condition are the channelization/straightening and berming of Lewis Creek and the activities associated with the apple orchards upstream of the project site. Approximately 10 acres of forested wetlands are located along the south side of Lewis Creek. This area is owned by the Carolina Mountain Land Conservancy (CMLC) and is not being preserved by The North Carolina Ecosystem Enhancement Program (EEP). CMLC is involved in the preservation and conservation of the wetland, and has been informed of the proposed project. A jurisdictional determination has not been conducted on the area; however, the wetland has been previously delineated (however not surveyed). Based on professional judgment, the wetland is clearly jurisdictional. There will be no impacts to the existing wetlands due to the proposed project. The EEP will acquire an easement along both banks of the stream. In areas not associated with CMLC land, the conservation easement and proposed disturbance limits extends 30 feet from the proposed top of bank. According to Deborah Daniel of EEP, the CMLC is flexible in granting the easement on their side of Lewis Creek and some disturbance within CMLC land may be necessary beyond 30 feet from the banks. All stream restoration efforts will be implemented within the established conservation easement limits.

The stream is incised in certain segments along the project reach; however, there are sections along the project reach that are connected with the floodplain. Representatives of CMLC and the adjacent landowner (Mark Searles) have witnessed overbank flooding at least one to two times per year on site. JJG's initial assessment of the site revealed signs of bank erosion, areas of heavy sediment deposition, and indicators of sinuosity forming in the incised channel. These three characteristics signal that lateral erosion is currently on-going and vertical erosion (i.e. incision) is stabilizing. This phenomenon falls within typical scenarios of stream evolution as presented by Rosgen (1996).

Refer to Table 1.1 for a summary of the proposed mitigation efforts.

This project is located in a local watershed planning area (LWP). The LWP was developed by the Mud Creek Watershed Restoration Council with assistance from EEP and the North Carolina Division of Water Quality (DWQ). Some of the goals included in the LWP that will be met by the Lewis Creek Stream Restoration Project are to reduce nonpoint source pollution (sediment and nutrient loading) and improve habitat degradation.

i. Project Goals and Objectives

The following goals have been established for the Lewis Creek Stream Restoration project.

- Restore a natural, stable dimension, pattern and profile along Lewis Creek using natural channel design techniques.
- Stabilize and protect degraded or vulnerable streambanks along Lewis Creek to reduce sediment loading and loss of land.
- Enhance floodplain connection along Lewis Creek.
- Establish a bankfull bench along Lewis Creek to reduce velocity and shear stress associated with bankfull and higher storm flows.
- Introduce a natural meander pattern along Lewis Creek.
- Improve aquatic and riparian habitat for macroinvertebrate and fish communities.

To meet these goals, the following objectives have been established for the Lewis Creek Stream Restoration project.

- Restoring approximately 1,750 linear feet of Lewis Creek.
- Restoration efforts will consist of constructing an appropriately sized channel for the existing watershed and sediment load within a new naturally sinuous pattern.
- The project will include establishing a floodplain at an appropriate elevation for the current stream bed, creating bankfull benches, stabilizing streambanks, and grading back bank slopes.
- The streambanks and riparian zone will be replanted using native species appropriate to the area.

ii. Existing Amount of Streams

Within the easement limits of Lewis Creek, the existing stream available for restoration consists of the following component.

- 1,663 linear feet along Lewis Creek.

iii. Amount of Streams Designed

Lewis Creek will be restored using natural channel design procedures. This restoration effort will consist of returning the appropriate dimension, pattern, and profile to the degraded stream. By creating a new bankfull bench at the existing channel elevation, floodplain connection will be re-established, and storm flow velocities and shear stresses will be reduced. At higher flows, this will allow the stream to spread its water onto the floodplain, decreasing the potential for bank erosion or channel incision.

Stabilization structures such as cross-vanes and Root Wad/J-Hook Log Vane combos will be installed to redirect the thalweg away from the streambank and toward the center of the stream, thereby reducing in-channel erosion.

Adjacent streambanks and riparian zones of Lewis Creek will be replanted using native species appropriate to the area. Bare root, live stakes, on-site transplants, and container plants will be used to replant the riparian zone using native vegetation, such as river birch (*Betula nigra),* silky dogwood *(Cornus amomum)*, willow (*Salix sp.)*, alder (*Alnus serrulata),* and ninebark *(Physocarpus sp.)*. Indigenous plant species will be planted at elevations according to their ability to be saturated.

Refer to Table 1.1 below for a summary of project restoration structure and objectives included within the scope of work.

Table 1.1
Project Restoration Structure and Objectives

Lewis Creek						
Segment/Reach	**Stationing**	**Restoration Type**	**Priority Approach**	**Existing Linear Footage or Acres**	**Design Linear Footage or Acres**	**Comments**
Lewis Creek	0 – 17+50	Restoration	P2	16+63.05	17+50	Channel restoration, relocation with use of grade control and bank protection structures.

SECTION 1

PROJECT SITE IDENTIFICATION AND LOCATION

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1.1 Directions to Project Site

To access the site from Interstate 26, take the US 64 East exit. Travel five miles and turn right on Laycock Road. Continue 0.4 miles and turn left on North Ridge Road. Lewis Creek flows between the CMLC and Ingles properties. Entrance is to the left just before North Ridge Road crosses Lewis Creek. Refer to Figure 1.1 for a location map of the project site.

1.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

Lewis Creek is located in Henderson County, North Carolina, east of the city of Hendersonville and is located on the Bat Cave USGS Quadrangle Map (Figure 2.1). The stream lies within the French Broad River Basin, Catalog Unit 06010105, DWQ Subbasin 04-03-02. Lewis Creek is a third order tributary to Clear Creek with an approximate drainage area of four square miles at the upstream point of the project area. The lat/long of the center point of the project site is 35°22'41" N/82°20'57" W.

1.3 Project Site Vicinity Map

Refer to Figure 1.1 for a location map of the project site.

SECTION 2
WATERSHED CHARACTERIZATION

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WATERSHED CHARACTERIZATION

2.1 Drainage Area

Lewis Creek drains approximately four square miles at the farthest downstream point of the EEP project easement. The Lewis Creek drainage basin is situated in Henderson County, NC. In general, Lewis Creek flows southeast to northwest through its watershed. The landscape within the watershed is comprised of steep to strongly sloping upland ridges near headwater streams to gently sloping to broad, flat areas along the floodplain of Lewis Creek. Elevations range between 2,730 ft near the watershed's headwaters to approximately 2,150 ft at the farthest downstream point of the EEP project easement. Refer to Figure 2.1, USGS Quad Map and Figure 2.2, Project Site Watershed Map for details of the project's drainage area. Table 2.1 summarizes the drainage area for the project reach.

Table 2.1
Drainage Area

Lewis Creek		
Reach	**Drainage Area (acres)**	**Drainage Area (square miles)**
Lewis Creek (Restoration)	2560	4

Drainage to Lewis Creek within the project easement includes drainage directly from the upstream reach of Lewis Creek and sheet/overland flow and runoff from rainfall.

2.2 Surface Water Classification/Water Quality

The segment of Lewis Creek in the project reach has been classified by the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Quality (DWQ) as Class C; Trout (Tr) waters (NCDWQ, 2007). Class C waters are protected for secondary recreation, fishing, wildlife, fish and aquatic life propagation and survival, and agriculture. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner. There are no restrictions on watershed development or types of discharges for Class C waters. In addition, these waters have also received a Tr supplemental classification intended to protect freshwaters for natural trout propagation and survival of stocked trout. This designation affects wastewater quality but not the type of discharges. There are also no watershed development restrictions except stream buffer zone requirements of NC Division of Land Resources (NCDWQ, 2007).

2.3 Physiography, Geology and Soils

The Lewis Creek project study area is located within the Blue Ridge Physiographic Province of the East Flank Blue Ridge Belt in the southern Appalachian Mountains. Elevations in the Blue Ridge range from 1,500 feet above mean sea level near its border with the Piedmont to 6,684 feet at its highest peak at Mount Mitchell. Within the project area, elevations range from 2,155 to 2,160 feet. According to the Geologic Map of North Carolina (1991), the underlying geology within the project area is comprised primarily of uneven-grained monzonitic to granodioritic Henderson gneiss. These rocks are estimated to be 460 million years old and have undergone several deformations over time resulting in folding, fracturing, crushing, and shearing. In addition to these processes, chemical and physical weathering of these rocks has generated soil profiles generally referred to as saprolite.

Most of the soils in the Blue Ridge Province are residual soils derived from weathering of the underlying bedrock. They can generally be described as brown, micaceous, sandy silt near the surface, grading downward to loose firm, red-brown and dark brown, micaceous silty medium to coarse sand. The shallow groundwater surface in the Blue Ridge Province generally occurs within the residual and alluvial soils. Groundwater flow in the Blue Ridge Province generally follows the topography. Recharge occurs from infiltration of precipitation on the hill and mountain slopes, while discharge generally occurs at the streams and springs. The Blue Ridge is characterized by deeply dissected mountains, numerous steep mountain ridges, intermontane basins, and trench valleys that interact at all angles and give the area its rugged mountain character.

According to the Ecoregions of North Carolina and South Carolina Map, the project study area is also located within the Blue Ridge, Broad Basins (Level IV) ecoregion (Griffith et al., 2002). The Broad Basin ecoregion is drier and has lower elevations and less relief than some of the more mountainous Blue Ridge ecoregions. The Broad Basin ecoregion is also comprised of more saprolite and less bouldery colluvium than surrounding regions within the Blue Ridge.

Although some areas of this region are mostly forested, overall it has become more pasture, cropland, industrial land uses, and human settlement than any of the other Blue Ridge ecoregions (Griffith et al., 2002).

The project study area resides in a Valley Type VIII. These valley types are characterized by wide, gentle valley slopes with well-developed floodplains adjacent to river terraces. Stream types "C" and "E", which are slightly entrenched and meandering channels that develop a riffle/pool bedform, normally develop in the Type VIII Valley (Rosgen, 1996).

The *Soil Survey of Henderson County, North Carolina* (USDA, 2007) was consulted to determine soil-mapping units within the study area. According to the soil data, two soil-mapping units occur within the proposed project area. These soil mapping units were compared to the USDA-NRCS *Hydric Soils of the United States* (http://soils.usda.gov/use/hydric/lists/state.html) to determine if hydric soils are known to occur within the project study area. Two map units, Codorus loam (Co) and Hatboro loam (Ha) appear on the USDA-NRCS *Hydric Soils of the United States* and are both designated a 2B3 hydric criterion. Hydric soil unit types denoted by a letter B indicate map units with inclusions of hydric soils or that have wet spots. In Henderson County, Co map unit contains approximately 5% hydric inclusions. According to the USDA-NRCS *Hydric Soils of the United States*, inclusions within the Co map unit consist of the Toxaway silt loam (To), which is 80% hydric and occurs along depressional floodplain areas. Approximately 90% of the Ha map unit is hydric consisting of wet spots found primarily along depressional floodplain areas.

Since Co and Ha map units have a hydric B status, field observations were performed to determine areas within the easement as having hydric conditions. Throughout the easement area, soil samples were collected to determine the hydromorphic condition. In general, field observations of reduced chroma and aquic moisture regime were used in determining whether a particular area was hydric. Field observations revealed that no wetlands exist within the project easement area and only relict hydric soils remain. This appears to be primarily due to anthropogenic impacts (manmade levees, drainage ditches, dirt fill, and other earth movement) which have ultimately lowered the existing water table and reduced the number of over the top-of-bank flood events within the project area.

Field observations reveal that soils within the project area formed in sandy, loamy alluvium inside and along the Lewis Creek levee within the project area. However, in areas along both sides of the Lewis Creek floodplain, but outside the project easement, soils appear to have formed in a clayey, loamy alluvium. Field observations suggest that hydric soils likely have developed within these areas due to the poor drainage and slow permeability of clayey, loamy alluvium. In addition, areas beyond the levees are lower in elevation and are typically ponded during significant flood events; therefore, the upper soil pedon is saturated long enough in some of these floodplain areas during the winter and spring for aquic conditions to develop.

The floodplain area along the north side of Lewis Creek appears to have lost much of its connectivity with Lewis Creek during typical "out-of-bank" flooding events and therefore no longer develops aquic conditions.

Manmade levees along the north side of an incised Lewis Creek now restrain "typical" floodwaters, thereby reducing the amount of ponding and water storage occurring within the floodplain depressional areas. The morphology of much of these soils, however, indicates that some aquic conditions were present prior to anthropogenic modification of the hydrology. Typically, the upper 12 inches of soils identified as hydric exhibited soil matrix colors of 10YR 5/2 or 10YR 3/2. Iron concentration (mottling) were typically 10yr 4/4.

Of the two mapping units which occur within the project study area, both are considered as prime farmland soils or farmland of statewide importance. Refer to Figure 2.3 for a Soil Map of the site. Below is a brief description of soil mapping units that occur within the project study area.

- **Codorus loam (Co)** - These soils are nearly level, very deep, and somewhat poorly drained to moderately well drained soils found along floodplains. They formed in recent alluvium have a loamy surface layer and subsoil. Permeability is moderate and shrink-swell potential is low. Seasonal high water table is within a depth of 1.0 to 2.0 feet. These soils are subject to frequent flooding.

  Hatboro loam (Ha) –These soils are nearly level, very deep, and poorly drained soils found along floodplains. They formed in alluvial deposits and have a loamy surface layer and subsoil. Permeability is moderate and shrink-swell potential is low. Seasonal high water table is within a depth of 0.5 foot. These soils are subject to frequent flooding.

In addition to the above map soil units, a brief description of the Toxaway silt loam, (To) map unit, which is a hydric soil inclusion sometimes found within the Co mapped soil unit, is provided below.

- **Toxaway silt loam (To)** – These soils are nearly level, very deep, poorly drained and very poorly drained soils are located along floodplains near the upland contact. These soils formed in recent alluvium and the surface layer is thick, dark colored, and loamy. The underlying material is stratified sand, gravel, and cobble within a depth of 40 inches. Permeability is moderately rapid in the surface layer and rapid in the underlying material. Shrink-swell potential is low. Seasonal high water table is within a depth of 1.0 foot. These soils are subject to frequent flooding.

2.4 Historical Land Use and Development Trends

The watershed land use is dominated by agriculture land and forest. The primary agricultural activities range from apple orchards to row crops. Forested land in the watershed is being converted to apple orchards and sod farms. Also, many upslope areas are being developed into residential gated communities. The majority of the site has been historically disturbed due to past and current agricultural use and construction of man made levees on the north side of Lewis Creek. The Henderson County land use coverage was approximated using aerial photography taken in March 2001. Arc GIS 9.1 was used to delineate agricultural, forested, commercial, public/institutional, and residential areas within the Lewis Creek watershed area. A land use summary is provided in Table 2.2. These data were obtained from http://www.hendersoncountync.org/gis/main.html.

Table 2.2
Land Use of Watershed

Land Use	Acres (ac)	Percentage (%)
Agriculture	1,300	**53**
Forested	705	**29**
Commercial	13	**0.52**
Public/Institutional	38	**1.5**
Residential	404	**16**
Total	**2,460**	**100**

2.5 Endangered / Threatened Species

Under terms of Section 7 of the Endangered Species Act, federal agencies shall "*ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary to be critical...*" The USACE requires protected species surveys for project sites that involve a Section 404 of the Clean Water Act permit.

Prior to the field studies, an office review of available resources was performed to develop a list of potential federal- and state-listed species for Henderson County, North Carolina. The tentative list of known protected species was compiled by review of the United States Fish and Wildlife Service (USFWS) county database (http://www.fws.gov/nc-es/es/es.html, 2007).

Prior to the field survey, a letter was submitted to the North Carolina Ecological Services field office of USFWS to obtain information regarding the listed species within Henderson County, North Carolina. The letter requests any information of known occurrence within the vicinity of the project area. To date (October 2007), no response has been issued from the USFWS.

The species/habitat matrix document (Table 2.4) was utilized during the field surveys to ascertain suitable presence/absence of protected species. The field surveys established that no protected species are likely to occur within the proposed project area; however, suitable habitat is present for two species of concern, the Tennessee heelsplitter (*Lasmigona holstonia*) and Eastern small-footed bat (*Myotis leibii*). However, since the project will be constructed during winter months, occurrence of the Eastern small-footed bat is unlikely as no suitable hibernaculum exists within the project area. Additionally, due to stringent use of BMP's implemented during project construction, sedimentation and erosion will be minimized and therefore, this project is not likely to affect the Tennessee heelsplitter or its preferred habitat.

Suitable habitat for forested wetland species (i.e., Diana fritillary butterfly) occurs adjacent to the project area; however no impacts will occur to this habitat as it lies outside the proposed disturbance boundaries. Therefore, this project is not likely to affect this species or the preferred habitat.

Table 2.3 provides a summary of federal- and state-listed species for Henderson County, North Carolina as reported by the U.S. Fish and Wildlife Service's (USFWS) Region 4 North Carolina Ecological Services field office website. A species/habitat matrix included in Table 2.4 provides information on listed species and their preferred habitat. Brief descriptions of the federal and state protected species are provided in Tables 2.3 and 2.4.

Table 2.3
Summary of Federally Listed Species for Henderson County, NC

Species	Vernacular Name	Federal Rank	Preferred Habitat	Habitat Present
Faunal				
Clemmys muhlenbergii	Bog turtle	T (S/A)	mountain bog wetlands and open scrub-shrub wetlands	No
Myotis leibii	Eastern small-footed bat	FSC	usually found in buildings, towers, hollow trees, beneath the loose bark of trees, in crevices of cliffs, and beneath bridges. During winter, these colonial bats move into caves and abandoned mines	Yes
Aneides aeneus	Green salamander	FSC	found in damp rock crevices that remain humid and are protected from the sun and direct rain	No
Cryptobranchus alleganiensis	Hellbender	FSC	found in mountain streams and rivers with large rocky substrate, snags, or woody debris.	No
Erimystax insignis eristigma	Mountain blotched chub	FSC	found in medium to large clear streams in moderate current with a substrate of cobble to gravel	No
Desmognathus wrightii	Pygmy salamander	FSC	inhabits spruce-fir forests, also (in lower abundance) hardwood forests at lower elevations	No
Neotoma floridana haematoreia	Southern Appalachian eastern woodrat	FSC	occurs in high elevation forests and rock ledges	No
Sphyrapicus varius appalachiensis	Yellow-bellied sapsucker	FSC	inhabits deciduous or mixed deciduous-coniferous forest	No
Alasmidonta raveneliana	Appalachian elktoe	E	found in riffles, runs, and shallow flowing pools with stable, relatively silt-free, coarse sand and gravel substrate associated with cobble, boulders, and/or bedrock.	No
Speyeria diana	Diana fritillary butterfly	FSC	inhabits forested or scrub-shrub wetland areas within the riparian zones of drainages, wet meadows, or mixed deciduous forest	Yes
Cambarus reburrus	French broad crayfish	FSC	inhabits moderate to high gradient headwaters of streams	No
Epoiblasma capsaeformis	Oyster mussel	E	inhabits small to medium rivers in areas with coarse sand to boulder substratum (rarely in mud) and moderate to swift currents	No
Lasmigona holstonia	Tennessee heelsplitter	FSC	occurs in the vicinity of riffles but may be in backwaters or pool-like habitats. It usually is found in fine-particle substrates (e.g., sand, mud) shallow water depths. It often occurs in headwaters and may be the only mussel inhabiting such areas	Yes

Species	Vernacular Name	Federal Rank	Preferred Habitat	Habitat Present
Floral				
Pakera millefolium	Blue Ridge ragwort	FSC	occurs in sandy soils that form on and around granite outcrops. Usually in full sun in cracks or small depressions in granite domes and ledges, but occasionally in light shade.	No
Narthecium americanum	Bog asphodel	C	mountain bog wetlands	No
Sagittaria fasciculata	Bunched arrowhead	E	inhabits seep areas with very low water flow but no stagnation. Soils are sandy loams overlain by muck l0-24 inches deep. Some shade is beneficial for the plants growth	No
Juglans cinera	Butternut	FSC	typically grows in rich mesophytic forests, lower slopes, ravines, and various types of bottomland, including banks and terraces of creeks and streams, and floodplain forests	No
Carex communis var. amplisquama	Fort Mountain sedge	FSC	inhabits moist, rich slopes in deep soils with adequate moisture	No
Lysimachia fraseri	Fraser's loosestrife	FSC	generally found in wet areas such as alluvial meadows, moist stream and river banks, flats along streams, moist pastures, and roadside.	No
Hexastylis rhombiformis	French broad heartleaf	FSC	inhabits deciduous forests on sandy river bluffs or on sandy soil in ravines	No
Lilium grayi	Gray's lily	FSC	inhabits openings or balds in the mountains	No
Marshallia grandiflora	Large-flowered Barbara's buttons	FSC	found along the flood-scoured banks of large, high-gradient rivers in the central Appalachians. The species is also reported from rocky lake shores, creek banks, bluffs and flood plains.	No
Silene ovata	Mountain catchfly	FSC	inhabit moist, rich slopes in deep soils with adequate moisture	No
Hexastylis contracta	Mountain heartleaf	FSC	found in acidic soils in deciduous forests, generally associated with kalmia and rhododendron	No
Sarracenia rubra ssp. *jonesii*	Mountain sweet pitcherplant	E	inhabits bogs and streamsides on granite rock faces along the Blue Ridge Divide	No
Juncus caesariensis	New Jersey rush	FSC	occurs in open to shaded streambanks, seepy pond margins, swales, pine barren savannas, and Atlantic white cedar (Chamaecyparis thyoides) swamps, frequently within pine barrens	No
Isotria medeoloides	Small whorled pogonia	T	found in montane oak-hickory or acidic cove forests	No
Thalistrum macrostylum	Small-leaved meadow-rue	FSC	found in moist, open places throughout northern temperate regions	No

Species	Vernacular Name	Federal Rank	Preferred Habitat	Habitat Present
Helonias bullata	Swamp pink	T	inhabits wetlands that are saturated but not flooded, including southern Appalachian bogs and swamps. This plant is commonly associated with some evergreens, including white cedar, pitch pine, American larch, and black spruce	No
Monotropsis odorata	Sweet pinesap	FSC	inhabits pine dominated forests and pine-oak heaths. The species is very small and seems to blend into the adjacent pine forest floor which is covered with thousands of brown pine needles	No
Platanthera integrilabia	White fringless orchid	C	found in red maple-blackgum swamps, along sandy, damp stream margins, or seepy, rocky, thinly vegetated slopes	No
Sisyrinchium dichotomum	White irisette	E	inhabits rich, basic soils probably weathered from amphibolites, in clearings and the edges of upland woods where the canopy is thin and often where down slope runoff has removed much of the deep litter layer ordinarily present on these sites	No

E = Endangered; T=threatened; FSC = Federal Species of Concern; C=Candidate species

Table 2.4
Species/Habitat Matrix

Habitat	Sub-Habitat	Species
Terrestrial	usually found in buildings, towers, hollow trees, beneath the loose bark of trees, in crevices of cliffs, and beneath bridges.	Eastern small-footed bat, Green salamander
	found in damp rock crevices that remain humid and are protected from the sun and direct rain	Green salamander
	inhabits spruce-fir forests, also (in lower abundance) hardwood forests at lower elevations	Pygmy salamander
	occurs in high elevation forests and rock ledges	Southern Appalachian Eastern woodrat
	thin, sandy soils that form on and around granite outcrops. Usually in full sun in cracks or small depressions in granite domes and ledges, but occasionally in light shade.	Mountain sweet-pitcher plant
	mountain bog wetlands	Bog asphodel, Bog turtle, Mountain sweet-pitcher plant
	inhabits seep areas with very low water flow but no stagnation. Soils are sandy loams overlain by muck 10-24 inches deep. Some shade is beneficial for the plants growth	Bunched arrowhead, New Jersey rush

Habitat	Sub-Habitat	Species
	typically grows in rich mesophytic forests, lower slopes, ravines, and various types of bottomland, including banks and terraces of creeks and streams, and floodplain forests	Butternut, French broad heartleaf, Diana's fritillary
	generally found in wet areas such as alluvial meadows, moist stream and river banks, flats along streams, moist pastures, and roadside.	Fraser's loosestrife, Diana's fritillary, Swamp pink, Small-leaved meadow rue
	inhabits deciduous forests on sandy river bluffs or on sandy soil in ravines	French broad heartleaf, Yellow-bellied sapsucker, Mountain heartleaf
	found along the flood-scoured banks of large, high-gradient rivers in the central Appalachians. The species is also reported from rocky lake shores, creek banks, bluffs and flood plains.	Large flowered Barbara's buttons
	occurs in open to shaded streambanks, seepy pond margins, swales, pine barren savannas, and Atlantic white cedar (Chamaecyparis thyoides) swamps, frequently within pine barrens	Swamp pink, Yellow-bellied sapsucker
	found in montane oak-hickory or acidic cove forests	Small whorled pagonia, Yellow-bellied sapsucker, Mountain heartleaf, French broad heartleaf
	found in red maple-blackgum swamps, along sandy, damp stream margins, or seepy, rocky, thinly vegetated slopes	White fringeless orchid, Yellow-bellied sapsucker, Diana's fritillary
	inhabits rich, basic soils probably weathered from amphibolites, in clearings and the edges of upland woods where the canopy is thin and often where down slope runoff has removed much of the deep litter layer ordinarily present on these sites	White irisette
	openings and balds on mountains	Gray's lily
	deciduous and coniferous forests	Yellow-bellied sapsucker, Diana's fritillary, Sweet pinesap
Aquatic	found in mountain streams and rivers with large rocky substrate, snags, or woody debris.	Hellbender, Appalachian elktoe, Oyster mussel, French broad crayfish, Mountain blotched chub
	species occurs in the vicinity of riffles but may be in backwaters or pool-like habitats. It usually is found in fine-particle substrates (e.g., sand, mud) shallow water depths. It often occurs in headwaters and may be the only mussel inhabiting such areas	Tennessee heelsplitter

2.5.1 Species Description

Appalachian elktoe – Appalachian elktoe has a thin, kidney-shaped shell, reaching up to about four inches in length. Juveniles generally have a yellowish-brown outer shell, while the outer shell of the adults is usually dark brown to greenish-black in color. Although rays are prominent on some shells, particularly in the posterior portion of the shell, many individuals have only obscure greenish rays. The inside shell surface is shiny, often white to bluish-white, changing to a salmon, pinkish, or brownish color in the central and beak cavity portions of the shell; some specimens may be marked with irregular brownish blotches. The species has been reported from relatively shallow, medium-sized creeks and rivers with cool, clean, well-oxygenated, moderate- to fast-flowing water. The species is most often found in riffles, runs, and shallow flowing pools with stable, relatively silt-free, coarse sand and gravel substrate associated with cobble, boulders, and/or bedrock. Stability of the substrate appears to be critical to the Appalachian elktoe, and the species is seldom found in stream reaches with accumulations of silt or shifting sand, gravel, or cobble. The Appalachian elktoe is known only from the mountain streams of western North Carolina and eastern Tennessee (USFWS, 2007). There is no habitat for this species within the Lewis Creek restoration reach; therefore, it is unlikely to occur within project area. Specialized aquatic surveys would be required to definitively determine the presence/absence of this species. Relict mollusk shells were not observed during field surveys.

Blue Ridge ragwort – Blue Ridge ragwort can be recognized by the dissected leaves, the divisions mostly less than 0.1 inches in width, the rachis of basal leaves not winged, and none of the basal leaves entire. Blue Ridge ragwort inhabits thin, sandy soils that form on and around granite outcrops in cracks or small depressions in granite domes and ledges, but generally in full sunlight (NatureServe, 2007). There is no habitat for this species; therefore, no specimens were observed.

Bog asphodel – Bog asphodel is a perennial herb with slender fibrillose rhizomes. The leaves are mostly basal with perfectly shaped flowers. This plant inhabits mountain bogs (NatureServe, 2007). There is no habitat for this species; therefore, no specimens were observed.

Bog turtle – Bog turtles are easily distinguished from other turtles by the large, conspicuous bright orange, yellow or red blotch found on each side of the head. Adult bog turtle shells are three to five inches in length and range in color from light brown to ebony. Bog turtles inhabit mountain bog and open scrub-shrub wetlands (USFWS, 2007). There is no habitat for this species; therefore, no specimens were observed.

Bunched arrowhead – Bunched arrowhead is an emergent aquatic plant that grows approximately six to thirteen inches in height with spatulate shaped leaves that grow up to twelve inches long. This plant inhabits seep areas with very low water flow but no stagnation. Soils are sandy loams overlain by muck at least ten inches in depth. Some shade is beneficial for the plant's growth (USFWS, 2007). There is no habitat for this species; therefore, no specimens were observed.

Butternut – Butternut typically grows in rich mesophytic forests, lower slopes, ravines, and various types of bottomland, including banks and terraces of creeks and streams, and floodplain forests. This species achieves its best growth in well-drained bottomland and floodplain soils. Butternut can grow up to 90 feet in height. It has grayish-brown bark with smooth ridges and dark brown pith. Butternut generally forms leaflets of eleven to seventeen (NatureServe, 2007). There is no habitat for this species; therefore, no specimens were observed.

Diana fritillary butterfly – The male fritillaries have a two-tone brownish underside hindwing with some silver along its margins with no silver spots, and solidly dark basal portion and almost unmarked orange outer third of both wings above are diagnostic. Typically, females lack any orange spots on the hindwing and have an extensive blue color on the hindwing. The forewings are generally rows of white or bluish white spots. This butterfly inhabits forested or scrub-shrub wetland areas within the riparian zones of drainages, wet meadows, or mixed deciduous forest (NatureServe, 2007). Potential habitat for this species occurs within the wetland feature adjacent to the project area; however, no specimens were observed during field surveys. Additionally, no impacts are proposed to the wetland and, therefore, no impacts would occur to the species or its preferred habitat.

Eastern small-footed bat – The eastern small-footed bat is the smallest member of the genus *Myotis* in North America. Its two main distinguishing characteristics are a distinct black mask across the face, and the tiny feet that average only approximately 0.5 inches in length. During the summer, these bats are usually found in buildings, towers, hollow trees, beneath the loose bark of trees, in crevices of cliffs, and beneath bridges. During winter, these colonial bats move into caves and abandoned mines where they either hang individually or in small clusters of twenty-five to thirty. Suitable habitat for this species does occur within the proposed project area. However, since the project will be constructed during winter months, occurrence of the Eastern small-footed bat is unlikely within the project area as no suitable hibernaculum exists within the study area. As a result, this project is not likely to affect this species or its preferred habitat.

Fort Mountain sedge – Plants densely cespitose; rhizomes ascending, reddish brown to purplish brown, 0 to 0.1 inches in size. The inflorescences usually have both staminate and pistillate spikes. Fort Mountain sedge inhabits moist, rich slopes in deep soils with adequate moisture. There is no habitat for this species; therefore, no specimens were observed.

Fraser's loosestrife –Fraser's loosestrife is an herbaceous perennial plant with erect stems approximately three to five feet in height. Fraser's loosestrife has yellow terminal inflorescences (flowers are grouped at the end of the main stem) and small leaves mixed with the flowers. The inflorescence is made up of multiple racemes, with leaves of three to five. This plant is generally found in wet areas such as alluvial meadows, moist stream and river banks, and flats along streams, moist pastures, and roadside. In North Carolina, where Fraser's loosestrife is most abundant, occurrence records are predominantly along roadsides. The plant also occurs in wooded habitat including montane, oak-hickory forest, both with sparse and closed canopy cover, and stream side rock outcrops (Radford et al. 1968). There is no habitat for this species; therefore, no specimens were observed.

French Broad crayfish – The French broad crayfish is generally cylindrical in shape with double stripes of reddish-blue down its dorsal abdomen. Its cervical spine is very strong. While cephalic and brachiostegal spines are present, its marginal spines are absent (NatureServe, 2007). There is no habitat for this species within the Lewis Creek restoration reach; therefore, it is unlikely to occur within project area. Specialized aquatic surveys would be required to definitively determine the presence/absence of this species.

French Broad heartleaf – French Broad heartleaf inhabits deciduous forests on sandy river bluffs or on sandy soil in ravines. Common shrub and herbaceous layer associates include great laurel (*Rhododendron maximum*), mountain laurel (*Kalmia latifolia*), trailing arbutus (*Epigaea repens*), and spotted wintergreen (*Chimaphila maculata*) (NatureServe, 2007). There is no habitat for this species; therefore, no specimens were observed.

Gray's lily – Gray's lily has a stem approximately six feet in height with one to nine nodding flowers. The leaves form whorls of five to eleven and are generally elliptic in shape. This lily inhabits openings or balds in the mountains. There is no habitat for this species; therefore, no specimens were observed.

Green salamander – The green salamander is a cliff dweller. This species can be found in damp rock crevices that remain humid and are protected from the sun and direct rain (NatureServe, 2007). There is no habitat for this species; therefore, no specimens were observed.

Hellbender – The hellbender can be found in mountain streams and rivers with large rocky substrate, snags, or woody debris (USFWS, 2007). There is no habitat for this species within the Lewis Creek restoration reach; therefore, it is unlikely to occur within project area. Specialized aquatic surveys would be required to definitively determine the presence/absence of this species.

Large-flowered Barbara's buttons – This plant is found along the flood-scoured banks of large, high-gradient streams in the central Appalachians. The species is also reported from rocky lake shores, creek banks, bluffs and flood plains. It tends to occur in moist to wet sandy soil, in sand/cobble alluvium or in bedrock crevices along rivers (NatureServe, 2007). There is no habitat for this species; therefore, no specimens were observed.

Mountain blotched chub – The blotched chub can be found in medium to large clear streams in moderate current with a substrate of cobble to gravel. There is no habitat for this species within the Lewis Creek restoration reach; therefore, it is unlikely to occur within the project area. Specialized aquatic surveys would be required to definitively determine the presence/absence of this species.

Mountain catchfly – Mountain catchflies are perennial plants with creeping rhizome. The stems are generally erect approximately twelve to sixty inches in height. The mountain catchfly is a very distinctive species with large, ovate, acuminate, sessile, paired leaves, and very narrowly lobed white petals. The flowers open at night and are moth-pollinated. Mountain catchflies inhabit moist, rich slopes in deep soils with adequate moisture (NatureServe, 2007). There is no habitat for this species; therefore, no specimens were observed.

Mountain heartleaf – Mountain heartleaf is a small plant found in the leaf litter of deciduous forests with acidic soils, generally associated with mountain laurel and rhododendron. These plants have small leathery petioled heart-shaped leaves without any hairs. There is no habitat for this species; therefore, no specimens were observed.

Mountain sweet pitcherplant – Mountain sweet pitcherplant has hollow, tubular leaves with heart-shaped hoods. The flower is erect, maroon in color and usually consists of one per stalk. The plant is eight to twenty-eight inches in height. This plant inhabits bogs and streamsides on granite rock faces along the Blue Ridge Divide (USFWS, 2007). There is no habitat for this species; therefore, no specimens were observed.

New Jersey rush – New Jersey rush is usually found in very acidic, extremely wet spring or seep areas with a stable source of flowing water, and without standing water. It occurs in open to shaded streambanks, seepy pond margins, swales, pine barren savannas, and Atlantic white cedar (*Chamaecyparis thyoides*) swamps, frequently within pine barrens. This plant is often associated with sphagnum species (NatureServe, 2007). There is no habitat for this species; therefore, no specimens were observed.

Oyster mussel – The oyster mussel is a small freshwater mussel approximately two inches in height. Its outer shell surface has a dull to sub-shiny yellowish to green colored shell with numerous narrow dark green rays. The shells of females are slightly inflated and quite thin and fragile towards the shell's posterior margin. The inside shell surface is whitish to bluish-white in color. The oyster mussel inhabits small to medium rivers in areas with coarse sand to boulder substratum (rarely in mud) and moderate to swift currents. It is associated with water-willow (*Justicia americana*) beds and in pockets of gravel between bedrock ledges in areas of swift current (USFWS, 2007). There is no habitat for this species within the Lewis Creek restoration reach; therefore, it is unlikely to occur within project area. Specialized aquatic surveys would be required to definitively determine the presence/absence of this species. Relict mollusk shells were not observed during field surveys.

Pygmy salamander – Pygmy salamander is one of the smallest salamander species and inhabits spruce-fir forests and hardwood forests at lower elevations (in lower abundance). Hides under moss, leaf litter, logs, bark on stumps, and rocks. The pygmy salamander spends winter in underground seepages. Eggs are laid in underground cavities among rocks of spring seeps (NatureServe, 2007). There is no habitat for this species; therefore, no specimens were observed.

Small whorled pogonia – Small whorled pogonia is a perennial with long, pubescent roots and a smooth, hollow stem approximately four to ten inches in height. The leaves are elliptical and are somewhat pointed. A flower, or occasionally two flowers, is produced at the top of the stem. Flowering occurs from about mid-May to mid-June, with the flowers apparently lasting only a few days to a week or so. Also, this plant doesn't necessarily flower annually. Usually only one flower is produced per plant. This species is typically found in montane oak-hickory or acidic cove forests. The understory structure and composition of occupied sites can be quite variable, ranging from dense rhododendron thickets to open/sparse shrub and sub-shrub strata. Herbaceous cover tends to be sparse, however at least two sites are characterized by fairly dense stands of New York fern (*Thelypteris noveboracensis*) (USFWS, 2007). There is no habitat for this species; therefore, no specimens were observed.

Small-leaved meadow rue – The small-leaved meadow rue has compound leaves and clusters of small white, yellowish, or purplish flowers. The flowers are small and apetalous (no petals), but have numerous long stamens, often are produced in conspicuous dense inflorescences. This plant is a tall perennial approximately seven feet in height. Meadow rues are found in moist, open places throughout northern temperate regions; in the United States they are especially abundant in the Northeast. There is no habitat for this species; therefore, no specimens were observed.

Southern Appalachian eastern woodrat – The southern Appalachian eastern woodrat occurs in high elevation forests and rock ledges. This species is a subspecies of the Florida woodrat (*Neotoma floridana*) and occurs less frequently. There is no habitat for this species; therefore, no specimens were observed (NatureServe, 2007).

Swamp pink – Swamp pink has a basal rosette of leaves with a hollow-stemmed flower stalk that can grow approximately eight to thirty-five inches in height during the flowering period. It can also grow up to five feet in height during seed maturation. Swamp pink has small pink flowers in a clustered of thirty to fifty at the tip of the stem. Swamp pink inhabits wetlands that are saturated but not flooded, including southern Appalachian bogs and swamps.

This plant is commonly associated with some evergreens, including white cedar, pitch pine, American larch, and black spruce (USFWS, 2007). There is no habitat for this species; therefore, no specimens were observed.

Sweet pinesap – Sweet pinesap is an inconspicuous perennial saprophytic plant approximately 2.5 inches in height, nodding during early flowering and erect when mature. Its leaves and flowers are variable in color ranging from purplish, pinkish, or brownish. Sweet pinesap inhabits pine dominated forests and pine-oak heaths. The species is very small and seems to blend into the adjacent pine forest floor which is covered with thousands of brown pine needles (NatureServe, 2007). There is no habitat for this species; therefore, no specimens were observed.

Tennessee heelsplitter – The Tennessee heelsplitter occurs near riffles but may occur in backwaters or pool-like habitats in shallow water of headwater streams with fine particle substrates (e.g., sand, mud). This small to medium-sized freshwater mussel typically measures less than 3.0 inches (76 mm) in length. The Tennessee heelsplitter is thin-shelled and somewhat elongated in shape. The periostracum (outer shell surface) is a dull, greenish brown or yellow-brown color in younger specimens and becomes dark brown with age. The outer surface of the shell is roughened with numerous darkened lines. The nacre (internal layer of the shell) is bluish white (GMNH, 2007). Suitable habitat for this species does occur within the proposed project area. However, due to stringent use of BMP's implemented during construction, sedimentation and erosion will be minimized. As a result of these practices, this project is not likely to affect this species or its preferred habitat.

White fringeless orchid – White-fringeless orchid is a perennial herb with 2 to 3 stem leaves along a strong central vein and distinctive white flower. White-fringeless orchid is found in red maple-blackgum swamps along sandy, damp stream margins or seepy, rocky, thinly vegetated slopes (USFWS, 2007). There is no habitat for this species; therefore, no specimens were observed.

White irisette – White irisette grows in a dichotomously-branching pattern. The plant is four to eight inches in height and has basal leaves that are pale bluish-green in color. The flowers are tiny and white with petals in a cluster of four to six at the ends of winged stems. The fruit is round with approximately three to six seeds. White flowers and dichotomous branching pattern distinguish it from similar species. This plant inhabits rich, basic soils probably weathered from amphibolites, in clearings and the edges of upland woods where the canopy is thin and often where down slope runoff has removed much of the deep litter layer ordinarily present on these sites (USFWS, 2007). There is no habitat for this species; therefore, no specimens were observed.

Yellow-bellied sapsucker – This bird inhabits deciduous or mixed deciduous-coniferous forest. During the winter migration, these birds are also in a variety of forest and open woodland habitats, parks, or orchards. The yellow-bellied sapsucker drills holes in coniferous and deciduous trees and laps up sap and insects with its tongue. It also eats ants, wasps, mayflies, moths, spruce budworms, and beetles, etc (NatureServe, 2007). There is no habitat for this species; therefore, no specimens were observed.

2.5.2 Biological Conclusion

The proposed project consists of Restoration to Lewis Creek; therefore, all impacts associated with this project will occur within the proposed easement. Field surveys were conducted in January 2007 and no observations were made of any federally protected species; however, suitable habitat occurs within the project area for two species of concern, the Tennessee heelsplitter and the Eastern small-footed bat. However, since the project will be constructed during winter months, occurrence of the Eastern small-footed bat is unlikely as no suitable hibernaculum exists within the project area. Additionally, due to stringent use of BMP's implemented during project construction, sedimentation and erosion will be minimized and therefore, this project is not likely to affect the Tennessee heelsplitter or its preferred habitat.

Suitable habitat for forested wetland species (i.e., Diana fritillary butterfly) occurs adjacent to the project area; however no impacts will occur to this habitat as it lies outside the proposed disturbance boundaries. Therefore, this project is not likely to affect this species or its preferred habitat.

2.5.3 Federal Designated Critical Habitat

2.5.3.1 Habitat Description

The project area is not designated as Federal Critical Habitat. The project area has been impacted from historic and current land use practices (agricultural).

2.5.3.2 Biological Conclusion

Since the project area has not been designated as Federal Critical Habitat, the project will not have an affect on a critical habitat area.

2.5.4 USFWS Concurrence

Prior to the field survey, a letter was submitted to the USFWS North Carolina Ecological Services field office requesting information regarding federally listed species with known occurrences in Henderson County and the project vicinity. At this time, no response has been issued from the USFWS.

2.6 Cultural Resources

Site Evaluation Methodology

A review of the National Register of Historic Places database (http://www.nr.nps.gov/) indicates that there are no records of any historic places within the proposed project area. No known archeological resources will be affected by the proposed project and no historic properties will be affected. Should cultural resources be identified during construction, the USACE and State Historic Preservation Officer would be contacted.

Field Evaluation

Potential for Historic Architectural Resources

Impacts to any historical structures are not anticipated as a result of the construction of this project. There is a low probability of intact architectural resources occurring within the project area and no standing structures over 50 years old were observed during surveys.

As a result of the history of disturbance on the project reach due to channelization and agricultural practices, it is unlikely that disturbances resulting from temporary construction access and channel work would result in impacts to potential areas of archaeological significance. No archeological artifacts have been observed or noted during preliminary surveys of the site for restoration purposes.

SHPO/THPO Concurrence

A letter was submitted to the State Historic Preservation Office (SHPO) regarding the cultural resource information; and a written response was received which requested that an archaeological survey be performed. A Phase 1 comprehensive archaeological survey was conducted to identify and evaluate the significance of archaeological remains that could possibly be damaged or destroyed by the proposed project. EEP is currently awaiting the results from the survey and SHPO's approval is pending. The submitted letter and response letter can be seen in the Lewis Creek ERTR (JJG, 2007).

There are no other compliance issues known at this time.

2.7 Potential Constraints

The Federal Highway Administration (FHWA), in cooperation with NCEEP and various state and federal agencies, has developed environmental screening and documentation guidelines for NCEEP projects to be processed as a Categorical Exclusion (CE). The CE was prepared and approved as a part of the Environmental Resources Technical Report (ERTR) (JJG, 2007).

The CE confirmed that the site has not been designated as Federal Critical Habitat; therefore, the project will not have an effect on any endangered species or habitat.

In regards to the Farm Practices Protection Act (FPPA), the Natural Resources Conservation Service (NRCS) has determined that the Lewis Creek project area contains prime farmland soils. The USDA was contacted and a completed AD-1006 (Farmland Conversion Impact Rating) Form was submitted to the NRCS for review. This documentation allows the project to comply with the FPPA (JJG, 2007).

There is not expected to be any constraints due to the finding of archaeological remains on the project site but this will not be determined until after the survey is performed. EEP has informed JJG to proceed with the restoration design as if there weren't any issues with SHPO.

2.7.1 Property Ownership and Boundary

The parcels that the proposed Lewis Creek restoration project will occur on are owned by the CMLC, Mark Searles, and the Ingle family. Restoration will occur within conservation easement limits maintained by the EEP.

2.7.2 Site Access

Access will occur through an easement donated by Mark Searles off of N. Ridge Road at the upstream end of the project. Please refer to Section 5.8 for a summary of proposed access.

2.7.3 Utilities

There are no utilities or utility easements within the project site.

2.7.4 FEMA Hydrological Trespass

A FEMA FIRM map (effective date March 1, 1982) has been obtained for the project area. According to the FEMA 100-year floodplain, approximately all of the project conservation easement is in the floodplain. The site is located within a FEMA Zone A. Zone A is the flood insurance rate zone that corresponds to the 1-percent annual chance floodplains that are determined in the Flood Insurance Study by approximate methods of analysis. Because detailed hydraulic analyses are not performed for such areas, no Base Flood Elevations or depths are shown within this zone. A hydraulic model (HEC-RAS) has been produced to determine the possible flooding effects due to proposed topographic changes that would be associated with restoring the stream. The model indicates that there will not be a rise in the water surface elevation for the 100-year floodplain due to the proposed conditions. The EEP Floodplain Checklist will be submitted to the Henderson County LFPA, EEP, and FEMA. A No-Rise Certification will be completed if necessary to verify that the project will not increase water surface elevations. The restoration of Lewis Creek is not anticipated to produce hydrological trespass conditions on the project site.

Jordan Jones & Goulding

SECTION 3

PROJECT SITE STREAMS (EXISTING CONDITIONS)

SECTION 3
PROJECT SITE STREAMS (EXISTING CONDITIONS)

Existing conditions within the project reach indicate a trend toward departure from a stable system due to various land use activities. Lewis Creek is slightly incised and appears to have been modified or straightened in the past. The channel is no longer connected to its floodplain, due to channel incision and levees built on the right top of bank (terrace). The reach has actively eroding, unstable banks with areas of mass wasting, bank slumping, and sediment deposition evident throughout the project reach. Many trees have fallen into the stream due to the streambank erosion and instability. In some areas, excess sediment from the eroding banks has deposited within the stream and covered the native substrate. These sediment deposits have likely reduced in-stream habitat for fish and macroinvertebrates. In certain areas, the sediment has formed sandbars, and these sandbars, as well as the fallen trees, tend to re-direct the stream flow into the banks exacerbating potential erosion. The substrate throughout the project appears to be dominated by fine sand with isolated areas of gravel and cobble substrate.

Several active beaver dams were observed throughout the project reach. Overall, the instability of the stream is contributing to stream bank loss, increased sedimentation, and less viable biological habitat.

3.1 Channel Classification

Lewis Creek was classified using the Rosgen stream classification system, based on surveyed morphological measurements (Rosgen, 1996).

The existing surveyed reach of Lewis Creek was classified as an E5/C5. Typically, E5 stream types are riffle/pool systems, exhibit low channel W/D ratios and display moderate channel sinuosities, which result in the high meander width ratio values. E5 channels exhibit predominantly sand-sized bed substrates, with channel slopes usually less than 2% (Rosgen, 1996). By and large, E5 channel streambanks are composed of materials finer than that of the dominant channel bed materials. These finer streambank materials are usually stabilized with extensive riparian or wetland vegetation that forms densely rooted sod mats from grasses, sedges, and rushes, as well as woody species (Rosgen, 1996). These channels are considered hydraulically efficient maintaining a high sediment transport capacity. E5 stream channels are very stable streams but can become vulnerable to erosion if streambanks are disturbed, and/or significant changes in sediment supply and streamflow occur. The C5 designation was added to the stream classification because the project reach of Lewis Creek has a lower sinuosity that resembles more of a C- type channel than an E-type channel.

3.2 Discharge (bankfull, trends)

Using USGS rural regression equations for North Carolina's Blue Ridge Piedmont hydrologic area (2001), peak flows for the 2-, 5-, 10-, 25-, 50- and 100-year storms were calculated for Lewis Creek to determine the existing discharges.

The peak flows for the 2-, 5-, 10-, 25-, 50- and 100-year storms were also modeled using Hydrologic Engineering Centers River Analysis System (HEC-RAS). Table 3.1 presents the estimated discharges calculated for Lewis Creek. A typical cross-section for Lewis Creek was modeled in HEC-RAS to determine bankfull discharge (the water surface at which flow reached the bankfull indicator) (Table 3.2). Refer to Section 3.5 for information on regional curve bankfull discharge and crest gauge results.

Table 3.1
Peak Discharges (Q) from Regression Equations

Reach	Q2 (cfs)	Q5 (cfs)	Q10 (cfs)	Q25 (cfs)	Q50 (cfs)	Q100 (cfs)
Lewis Creek	357	619	836	1164	1452	1772

Table 3.2
Bankfull Discharge (Qbkf) from HEC-RAS

Reach	Qbkf -Calculated (cfs)
Lewis Creek	140

3.3 Channel Morphology (pattern, dimension, profile)

Existing stream morphological conditions for Lewis Creek are summarized in Table 3.3. Additional morphological data is provided in Appendix 9. All geomorphic assessments (cross-section, longitudinal, and pebble counts) were performed following guidelines outlined in Stream Channel Reference Sites: An Illustrated Guide to Field Techniques (Harrelson et al., 1994). A topographic survey of the project site was completed by R.J. Harris. The survey consisted of collecting detailed data for all stream and floodplain areas and the location of trees within the established conservation easement.

Currently, Lewis Creek is deeply incised (Bank Height Ratio of 1.53 to 1.79) with highly erosive and unstable banks. The channel has down-cut and widened over the course of time in some areas. Lateral stability varies depending upon tree rooting and existing rocks within the soil. There are a number of large trees along the bank that provide good bank protection and appear stable. Channel widening and lack of stability have affected the stream pattern. The channel pattern is slightly sinuous (1.11) within the restoration project limits. The right top of bank significantly increases towards the middle of the project reach where a berm has been built on the top of bank (terrace).

The cross-sectional area for Lewis Creek ranges from 51.41-55.22 ft^2. The W/D ratio (8.25-11.51) of the existing channel is low, which is typical for an E-type channel. The average water surface slope of project reach is 0.0030 ft/ft. The low slope and in-stream bank failure are factors in the high sediment deposition rate occurring within the channel. Typically, upstream bank failure leads to downstream aggradation. These areas of aggradation are also indicating a shift in stream bed form; some of the areas where riffles are expected are flat, filled with sediment, and evolving into runs. Lewis Creek is characterized by a mean riffle and pool D50 of

0.28 millimeters (mm), indicating a channel substrate dominated by sand-sized particles. The stream was probably once characterized by a gravel and cobble substrate before land disturbance activities and instability of the streambanks shifted the substrate to a sandy substrate.

Table 3.3
Existing Morphology

	Parameter	Main Reach MIN	Main Reach MAX
General	Drainage Area (sq mi)	4	
	Stream Type (Rosgen)	E5/C5	
	Valley Type	VIII	
Dimension	BKF Mean Velocity (Vbkf) (ft/s)	2.72	2.54
	Bankfull Discharge (Qbkf)(cfs)	140*	
	Bankfull XSEC Area, Abkf (sq ft), n=3	51.41	55.22
	Bankfull Width, Wbkf (ft), n=3	21.11	25.21
	Bankfull Mean Depth, dbkf (ft), n=3	2.12	2.56
	Width to Depth Ratio, W/D (ft/ft), n=3	8.25	11.51
	Width Floodprone Area, Wfpa (ft)	>100	
	Entrenchment Ratio, Wfpa/Wbkf) (ft/ft), n=6	>2.2	
	Max Depth @ bkf, Dmax (ft), n=3	3.55	4.58
	Max Depth Ratio, Dmax/dbkf, n=3	1.67	1.79
	Max Depth @ tob, Dmaxtob (ft), n=6	6.34	7.2
	Bank Height Ratio, Dtob/Dmax (ft/ft), n=3	1.53	1.79
	Pool Max Depth, Dmaxpool (ft), n=3	3.48	4.72
	Pool Max Depth Ratio, Dmaxpool/dbkf, n=3	1.64	1.84
	Pool Area, Apool (sqft), n=3	50.81	57.88
	Pool Area Ratio, Apool/Abkf, n=3	12.26	14.6
	Pool Width, Wpool (ft), n=3	16.73	29.52
	Pool Width Ratio, Wpool/Wbkf, n=3	0.79	1.17
	Pool Length, Lpool (ft), n=19	6.9	294.11
	Pool Length Ratio, Lpool/Wbkf, n=19	0.33	13.93
	Pool-Pool Spacing, Lps (ft), n=16	35.6	84.58
	Pool-Pool Spacing Ratio, Lps/Wbkf, n=16	1.69	4.01
Pattern	Meander Length, Lm (ft), n=26	43	163
	Meander Length Ratio, Lm/Wbkf, n=26	2.04	6.47
	Radius of Curvature, Rc (ft), n=29	14.37	69.28
	Rc Ratio, Rc/Wbkf, n=29	0.68	2.75
	Belt Width, Wblt (ft), n=26	22	51
	Meander Width Ratio, Wblt/Wbkf (ft), n=26	1.04	2.02
	Sinuosity, K	1.11	
Profile	Valley Slope, Sval (ft/ft)	0.0033	
	Channel Slope, Schan (ft/ft)	0.003	
	Slope Riffle, Srif (ft/ft), n=9	0	0.022
	Riffle Slope Ratio, Srif/Schan, n=9	0	7.32
	Riffle Length, Rlength (ft), n=9	7.64	21.5
	Riffle Length Ratio, Rlength/Wbkf, n=9	0.36	1.02
	Slope Pool, Spool (ft/ft), n=19	0	0.0058
	Pool Slope Ratio, Spool/Schan, n=19	0	1.93
	Slope Run, Srun (ft/ft), n=16	0	0.0094
	Run Slope Ratio, Srun/Schan, n=16	0	3.13
Substrate		*Riffle*	*Pool*
	d16 (mm)	0.07	0.10
	d35 (mm)	0.16	0.18
	d50 (mm)	0.28	0.28
	d84 (mm)	9.10	0.95
	d95 (mm)	16.00	10.28
Cells noted with a (*)with a were calculated using HEC-RAS, n=number of data points.			

3.4 Channel Stability Assessment

3.4.1 Channel Evolution

Any change within and around a channel typically results in a period of instability and adjustments to re-establish a state of dynamic equilibrium with the sediment load and discharge of the stream (Leopold et al., 1992, Simon, 1989, and Rosgen, 2004a). The sequence of adjustments that a channel undergoes can be predicted using Simon's (1989) conceptual evolution model. Determining the stream type evolution can be predicted using Rosgen's (2006a) successional stages of channel evolution.

Simon's (1989) model predicts that following some type of disturbance, such as straightening or channelization, degradation occurs, resulting in an incised channel with vertical banks. When critical bank heights of a channel are exceeded, extensive bank failure and mass wasting occurs beginning the widening stage of the channel evolution process (Simon, 1989). As the widening and bank failure continue upstream, aggradation will occur downstream. The final stage of the channel evolution process results in the development of a new channel within the alluvium deposits downstream. The new channel is now at a lower elevation and typically has similar dimension and pattern to that of the pre-modified channel (Simon, 1989). Rosgen (2006a) describes nine different stream type channel evolution scenarios to assist the observer in determining the appropriate stage and evolution direction of a stream.

The process for a channel to naturally evolve through these stages to re-establish a state of dynamic equilibrium typically occurs over a long period of time depending upon channel inputs and channel substrate characteristics (10's to 1000's of years). This evolution can result in excessive stream bank erosion rates, which is a major cause of non-point source pollution (Rosgen, 2001). Using the stream evolution prediction models, the current trends in a disturbed stream can be identified, and the direction in which the stream is moving can be predicted. The current and future stage of evolution of a stream should be assessed before selecting appropriate restoration action to undertake. For this study, both concepts were applied to Lewis Creek to assess current conditions and provide guidance for future trends.

According to Rosgen's stream channel succession scenarios, (Rosgen, 2006b), Lewis Creek generally falls under Scenario 1 and 5, which follows the stream type evolution from E→C→Gc→F→C→E or E→Gc→F→C→E, respectively. Using Simon's conceptual channel evolution model, Lewis Creek is in two different stages within the project limits. The upper reach, which is upstream of the drainage seep from the CMLC wetland, appears to be in the later part of stage IV; degradation and widening. The lower reach of Lewis Creek, downstream of the wetland drainage, appears to be approaching stage VI, where the stream is reaching a state of dynamic equilibrium.

3.4.2 Stream Bed and Bank Stability

Stream bed and bank composition provide indicators for changes in channel form, hydraulics, erosion rate and sediment supply (Doll et al., 2003). Streambank erosion rate (lateral erosion rate) and sediment supply (tons/yr) is a very important variable in the river stability assessment. One consequence of a disturbed stream is streambank erosion and associated land-loss and sediment supply to the system. Extensive streambank erosion rates tend to create a loss of in-stream habitats, leaving a homogenized environment due to extensive sedimentation (Waters, 1995 and Brooks et al., 2002).

Rosgen (2001) developed a channel stability assessment using the channel dimension relationships, river profile and bed features, vertical stability (degradation/aggradation), lateral stability, degree of confinement, degree of incision, channel enlargement, channel evolution, and near bank velocity stresses along the channel. Two prediction methodologies are used in Rosgen's channel stability assessment to determine the potential for bank erosion: Bank Erodibility Hazard Index (BEHI) and Near-Bank Stress (NBS). BEHI assesses the physical properties of the streambank to determine the possible sources of bank instability, such as removal of vegetation, livestock access, high bank height ratios, bank angle, lack of vegetative or rock surface protection, and poor, non-cohesive bank/soil material type. The second factor in channel stability assessment is NBS, which assesses the bank with respect to the stress associated with the velocity in that portion of the channel. Using these methodologies, the expected annual sediment load produced from a stream system is estimated. The second factor in channel stability assessment is NBS, which assesses the bank with respect to the stress associated with the velocity in that portion of the channel. Using these methodologies, the expected annual sediment load produced from a stream system is estimated.

Tables 3.4 and 3.5 summarize the BEHI/NBS results and sediment export estimates for Lewis Creek within the project study area. Both the left and right sides of bank on Lewis Creek are showing signs of instability. Visual indicators such as vertical, bare banks and the results from the BEHI analysis indicate that areas along the right bank appear to be eroding at a much faster rate than the left bank. This instability could be due to historic channelization and the levee that was built along the north side of Lewis Creek. Straightening a stream channel typically results in an increase in slope, which increases velocity resulting in potential down-cutting and incision. Unnatural levees can inhibit the stream to spread its water onto the floodplain during flooding events, leading to channel instability. In conclusion, Lewis Creek is contributing a large amount of sediment from within the stream channel. Refer to Appendix 9 for BEHI/NBS raw data tables and calculations.

Table 3.4
BEHI and Sediment Export Estimates for Project Site Stream

Reach	Bank	Linear Footage	Extreme		Very High		High		Moderate		Low		Very Low		Sediment Export*
			ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	Tons/yr
Lewis Creek	Left	1,005	0	*N/A*	15	*1*	209	*21*	246	*25*	535	*53*	0	*N/A*	20.5
	Right	1,018	79	*8*	132	*13*	110	*11*	271	*26*	426	*42*	0	*N/A*	113
Project Total		**2,023**	**79**	***4***	**147**	*7*	**319**	***16***	**517**	***25***	**961**	***48***	**0**	***N/A***	**133.5**

*Sediment export estimates were calculated as follows (ft^3/yr): (Section Length*Bank Height*Erosion Rate (ft/yr)) and converted to tons/year as follows: $(ft^3/yr)*(1yd^3/27\ ft^3)*(1.8\ tons/yd^3)$.

Table 3.5
Near Bank Stress Estimates for Project Site Stream

Reach	Bank	Linear Footage	Extreme		Very High		High		Moderate		Low		Very Low	
			ft	%	ft	%	ft	%	ft	%	ft	%	ft	%
Lewis Creek	Left	1,005	0	*N/A*	15	*1*	189	*19*	181	*18*	620	*62*	0	*N/A*
	Right	1,018	0	*N/A*	0	*N/A*	202	*20*	202	*20*	614	*60*	0	*N/A*
Project Total		**2,023**	**0**	***NA***	**15**	***1***	**391**	***19***	**383**	***19***	**1,234**	***61***	**0**	***NA***

3.5 Bankfull Verification

Visual bankfull indicators were difficult to identify in the field because the existing channel of Lewis Creek is incised. Within the existing main channel, below the project reach, the channel appears stable and has developed a bankfull bench within the incised channel. JJG used the cross-sectional area from this section as a reference for determining bankfull within the project site. Refer to Appendix 9 for the on-site reference cross-section morphological measurements. A typical cross-section for Lewis Creek was modeled in HEC-RAS to determine bankfull discharge (the water surface at which flow reached the bankfull indicator). The calculated discharge was compared to the North Carolina Regional Curves for Rural Mountain streams. The calculated bankfull discharge for Lewis Creek is lower than the regional curves associated with the drainage area predicted. A possible reason for the calculated discharge being lower than the predicted discharge on Lewis Creek could be due to the low gradient of the stream (0.0030 ft/ft). Table 3.6 illustrates calculated and predicted bankfull discharges for Lewis Creek.

Table 3.6
Existing Bankfull Discharge (Qbkf)

Reach	Drainage Area (sq miles)	Qbkf -Calculated (cfs)	Qbkf-Regional Curve (cfs)
Lewis Creek	4	140	289

Near the end of the project reach along the main channel of Lewis Creek a crest-gauge was installed to record high stage during storm events. The crest-gauge was installed to assist in verifying that a bankfull discharge or greater is occurring within the project reach. This device is used to make a quick estimate of the highest gauge height the stream reached during a storm.

At least one recorded bankfull event occurred during the month of August with a high water mark on the crest-gauge just above the bankfull elevation.

3.6 Vegetation

The project site appears to be located within an intermediate zone which exhibits both characteristics of a Montane Alluvial Forest and a Piedmont /Low Mountain Alluvial Forest community. According to Schafale and Weakly (1990) many of "these" intermediate areas exist within the French Broad River Basin. "These" intermediate areas typically lack dominant vegetation, such as sweet-gum (*Liquidambar styraciflua*), box elder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), and winged elm (*Ulmus alata*), found in a Piedmont /Low Mountain Alluvial Forest community, and eastern hemlock (*Tsuga Canadensis*) and Yellow birch (*Betula alleghaniensis*) found in a Montane Alluvial Forest. In addition, portions of the Lewis Creek flood plain consist of Toxaway a silt loam which is more characteristic of a Montane Alluvial Forest. However, the climate and hydrology (i.e., average rainfall and flood frequencies) within the Lewis Creek watershed are more indicative of a Piedmont /Low Mountain Alluvial Forest and/or communities located within the lower elevations.

On the side of the stream not associated with CMLC land, the conservation easement extends 30 feet from the proposed top of bank. The CMLC is flexible in granting the easement on their side of Lewis Creek and it will be a minimum of 30 feet from the proposed top of bank. The narrow riparian area that immediately surrounds the stream consists of the following dominant species: river birch (*Betula nigra*), tulip tree (*Liriodendron tulipifera*), black cherry (*Prunus serotina*), black locust (*Robinia pseudoacacia*), sumac (*Rhus glabra*), alder (*Alnus glutinosa*), black willow (*Salix nigra*), and silky dogwood (*Cornus amomum*). Several invasive species including reed canary grass (*Phalaris arundinacea*), multiflora rose (*Rosa multiflora*), and Japanese honeysuckle (*Lonicera japonica*) occur throughout the project area and are dominant in several areas along the right streambank of Lewis Creek within the project area. The adjacent CMLC property consists of an approximate 10-acre wetland area and a replanted riparian area. Replanted trees have protective tubes on them, and most trees are less than 24-inches in height. The CMLC property extends to the southwest. The Ingle's property located on the northeast side of the stream consists of open and planted areas. There is a large planted area consisting of river birch ranging from 4 to 6 inches in diameter at breast height (DBH).

SECTION 4
REFERENCE STREAMS

SECTION 4
REFERENCE STREAMS

After multiple attempts searching for an E5/C5 type reference stream, JJG concluded that no local reference reaches were available. JJG assessed stream reaches within the watershed and walked several miles of streams in the area and segments of Lewis Creek upstream and downstream of the project reach, but none of them appeared stable for a linear footage equal to 20 bankfull widths. All the potential reference sites JJG identified were ruled out due to incompatible parameters or instability.

JJG used collected data from a site located in Haywood County, North Carolina with similar physiographic conditions, valley type, topography, and stream type as Lewis Creek. The site was obtained from the North Carolina Department of Transportation (NCDOT) Reference Reach Database (http://www.ncdot.org/doh/preconstruct/highway/hydro/Stream/).

The following reference reach site was selected.

> Raccoon Creek: Located in Haywood County, North Carolina is an E5 stream type (NCDOT Stream ID 42).

4.1 Watershed Characterization

Raccoon Creek is located in the Blue Ridge Physiographic Province. The reference reach site consists of steep to strongly sloping upland ridges near headwater streams to gently sloping to broad, flat areas along the floodplain. According to the Generalized Geologic Map of North Carolina, the Racoon Creek reference reach site is underlain by sedimentary and metamorphic rocks of the High Mountains of the Blue Ridge Physiographic Province, respectively (NCGS, 1991).

Raccoon Creek is situated in Haywood County, North Carolina, east of the City of Waynesville. The surveyed reference reach is located within the French Broad River Basin, USGS Hydrologic Unit 06010106, subbasin 04-03-05. Raccoon Creek is a third order stream with an approximate drainage area of 2.9 square miles.

Refer to Figure 4.1 for a site location map and Figure 4.2 for a watershed map of Raccoon Creek.

4.2 Channel Classification

The Raccoon Creek reference reach was classified as an E5 stream type using the Rosgen stream classification system based on surveyed morphological measurements (Rosgen, 1996). Typically, E5 stream types are riffle/pool systems, exhibit low channel W/D ratios and display moderate channel sinuosities, which result in the high meander width ratio values. E5 channels exhibit predominantly sand-sized bed substrates, with channel slopes usually less than 2% (Rosgen, 1996).

By and large, E5 channel streambanks are composed of materials finer than that of the dominant channel bed materials. These finer streambank materials are usually stabilized with extensive riparian or wetland vegetation that forms densely rooted sod mats from grasses, sedges, and rushes, as well as woody species (Rosgen, 1996). These channels are considered hydraulically efficient maintaining a high sediment transport capacity. E5 stream channels are very stable streams but can become vulnerable to erosion if streambanks are disturbed, and/or significant changes in sediment supply and streamflow occur.

4.3 Discharge (bankfull, trends)

The bankfull cross-sectional area and velocity were previously determined and reported in the NCDOT Reference Reach Database. Table 4.1 presents the bankfull discharge estimated using regional curves developed by North Carolina State University Stream Restoration Institute (Harman, et al., 1999) and the calculated discharge from the NCDOT database.

Table 4.1
Reference Bankfull Discharge (Qbkf)

Reach	Drainage Area (sq miles)	Qbkf -NCDOT (cfs)	Qbkf-Regional Curve (cfs)
Raccoon Creek	2.9	131	192

4.4 Channel Morphology (pattern, dimension, profile)

Table 4.2 summarizes the results from the reference reach survey reported in the NCDOT Database.

4.5 Channel Stability Assessment

Personal communication with Ronald Morris (2007) of the Waynesville USDA Service Center who performed the survey for the NCDOT database informed JJG that the reference reach was stable at the time of the survey and did not illustrate any signs of lateral or vertical instability. Morris also stated that the stream bed features were stable and did not show signs of migration. The sediment deposition appeared to be normal for the stream type; no heavy sediment deposition or degradation was occurring.

4.6 Bankfull Verification

Bankfull cross-sectional area, discharge and velocity were previously determined and reported in the (NCDOT) Reference Reach Database and the bankfull discharges can be seen above in Table 4.1.

Table 4.2
Reference Reach Morphology

	Parameter	Raccoon Creek MIN	Raccoon Creek MAX
General	Drainage Area (sq mi)	2.9	
	Stream Type (Rosgen)	E5	
	Valley Type	VIII	
Dimension	BKF Mean Velocity (Vbkf) (ft/s)	5.5	
	Bankfull Discharge (Qbkf)	131	
	Bankfull XSEC Area, Abkf (sq ft)	23.74	23.76
	Bankfull Width, Wbkf (ft)	15.44	15.9
	Bankfull Mean Depth, dbkf (ft)	1.49	1.54
	Width to Depth Ratio, W/D (ft/ft)	10.03	10.67
	Width Floodprone Area, Wfpa (ft)	100	100
	Entrenchment Ratio, Wfpa/Wbkf) (ft/ft)	6.29	6.48
	Max Depth @ bkf, Dmax (ft)	2.40	2.7
	Max Depth Ratio, Dmax/dbkf	1.61	1.75
	Max Depth @ tob, Dmaxtob (ft)	3.00	3.38
	Bank Height Ratio, Dtob/Dmax (ft/ft)	1.25	1.25
	Pool Max Depth, Dmaxpool (ft)	3.25	3.7
	Pool Max Depth Ratio, Dmaxpool/dbkf	2.18	2.40
	Pool Area, Apool (sqft)	29.39	31.99
	Pool Area Ratio, Apool/Abkf	1.24	1.35
	Pool Width, Wpool (ft)	14.70	16.31
	Pool Width Ratio, Wpool/Wbkf	0.95	1.03
	Pool Length, Lpool (ft)	-	-
	Pool Length Ratio, Lpool/Wbkf	-	-
	Pool-Pool Spacing, Lps (ft)	42.00	163.00
	Pool-Pool Spacing Ratio, Lps/Wbkf	2.68	10.4
Pattern	Meander Length, Lm (ft)	30.00	84
	Meander Length Ratio, Lm/Wbkf	1.91	5.36
	Radius of Curvature, Rc (ft)	8.50	15.8
	Rc Ratio, Rc/Wbkf	0.54	1.01
	Belt Width, Wblt (ft)	52	
	Meander Width Ratio, Wblt/Wbkf (ft)	3.32	
	Sinuosity, K	1.3	
Profile	Valley Slope, Sval (ft/ft)	0.014	
	Channel Slope, Schan (ft/ft)	0.0109	
	Slope Riffle, Srif (ft/ft)	0.019	
	Riffle Slope Ratio, Srif/Schan	1.74	
	Riffle Length, Rlength (ft)	-	-
	Riffle Length Ratio, Rlength/Wbkf	-	-
	Slope Pool, Spool (ft/ft)	0.0003	0.006
	Pool Slope Ratio, Spool/Schan	0.03	0.55
	Slope Run, Srun (ft/ft)	0.036	
	Run Slope Ratio, Srun/Schan	3.30	
	Slope Glide, Sglide (ft/ft)	0.003	
	Glide Slope Ratio, Sglide/Schan	0.28	
Substrate		**Reachwide**	
	d16	0.12	
	d35	0.30	
	d50	0.75	
	d84	64.00	
	d95	150.00	

4.7 Vegetation

Reference vegetative communities must be established for stream restoration sites. Streambank, riparian, and floodplain restoration should be based on reference areas found within close proximity of the project site and should be based on initial riparian assessments of the proposed restoration area. Reference vegetative communities are areas on which to model restoration efforts of the restoration site in relation to soils, topography, hydrology, and vegetation. Reference sites should represent pre-disturbed conditions and be as pristine as possible (i.e., undisturbed areas which are free of exotic vegetation).

Reference vegetative surveys were conducted along the existing onsite channels by JJG ecologists. The survey was used to guide plant community restoration that is presented in Section 5.7). In general, riparian areas along the left bank of the middle to lower reaches of the Lewis Creek Restoration project share characteristics of both a Montane Alluvial Forest and a Piedmont /Low Mountain Alluvial Forest community (Schafale and Weakley, 1990). These community types display the following characteristics.

- **Soils:** Resembles mostly that of a *Montane Alluvial Forest* - Likely series include Toxaway (Cumulic Humaquept), Rosman (Fluventic Haplumbrept), and Tusquitee (Humic Hapludult).

- **Hydrology:** Resembles mostly that of a *Piedm ont /Low Mountain Alluvial Forest* - Palustrine, seasonally or intermittently flooded.

- **Vegetation**: Displays features of a *Montane Alluvial Forests* and a *Piedmont /Low Mountain Alluvial Forest.*

  Montane Alluvial Forests - Canopy a mixture of bottomland and mesophytic tree species, usually Eastern hemlock and sycamore, but also yellow birch (*Betula alleghaniensis*), white oak (Quercus alba), red maple, tulip poplar, and river birch. Typical understory species are ironwood (*Carpinus caroliniana*), American witchhazel (*Hamamelis virginiana*), and black willow. The most typical shrubs are Great Laurel (*Rhododendron maximum*), alder, and fetterbush (*Leucothoe fontanesiana*).

  Piedmont /Low Mountain Alluvial Forest - Canopy a mixture of bottomland and mesophytic trees, including river birch, sycamore, sweet-gum (*Liquidambar styraciflua*), tulip poplar, American elm (*Ulmus Americana*), sugar berry (*Celtis laevigata*), black walnut (*Juglans nigra*), green ash (*Fraxinus pennsylvanica*), bitternut hickory (*Carya cordiformis*), shagbark hickory (*Carya ovata*), shingle oak (*Quercus imbricaria*), red maple, and in the west, white ash (*Fraxinus Americana*) and Carolina silverbell (*Halesia tetraptera*). Understory trees include box elder (*Acer negundo*), Florida maple (*Acer floridanum*), red maple, Pawpaw (*Asimina triloba*), American holly (*Ilex opaca*), and ironwood. Shrubs may include spicebush (*Lindera benzoin*), strawberry bush (*Evonymus*) *americana*, painted buckeye (*Aesculus sylvatica*), redtwig doghobble (*Leucothoe recurva*), beaked hazelnut (*Corylus cornuta*), and silky dogwood (*Cornus amomum*).

SECTION 5
PROJECT SITE RESTORATION PLAN

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PROJECT SITE RESTORATION PLAN

5.1 Restoration Project Goals and Objectives

The following goals have been established for the Lewis Creek Stream Restoration project and will be met by restoring Lewis Creek.

- Restore a natural, stable dimension, pattern and profile along Lewis Creek using natural channel design techniques.
- Stabilize and protect degraded or vulnerable streambanks along Lewis Creek to reduce sediment loading and loss of land.
- Enhance floodplain connection along Lewis Creek.
- Establish a bankfull bench along Lewis Creek to reduce velocity and shear stress associated with bankfull and higher storm flows.
- Introduce a natural meander pattern along Lewis Creek.
- Improve aquatic and riparian habitat for macroinvertebrate and fish communities.

This project is located in a local watershed planning area (LWP). The LWP was developed by the Mud Creek Watershed Restoration Council with assistance from EEP and the North Carolina Division of Water Quality (DWQ). Some of the goals included in the LWP that will be met by the Lewis Creek Stream Restoration Project are to reduce nonpoint source pollution (sediment and nutrient loading) and improve habitat degradation.

5.1.1 Designed Channel Classification

Field observations and analysis determined that the mitigation effort will consist of Restoration. Since the streambed elevation cannot be raised due to the existing upstream and downstream bridges, the restoration effort will "tie-in" to the existing channel elevation at the upstream and downstream ends of the project reach. The restoration plan for Lewis Creek includes the following objectives:

- Restoring approximately 1,750 linear feet of Lewis Creek.
- Restoration efforts will consist of constructing an appropriately sized channel for the existing watershed and sediment load within a new naturally sinuous pattern.
- The project will include establishing a floodplain at an appropriate elevation for the current stream bed, creating bankfull benches, stabilizing streambanks, and grading back bank slopes.
- The streambanks and riparian zone will be replanted using native species appropriate to the area.

A jurisdictional determination has not been conducted on the area; however, the wetland on the CMLC side has been previously delineated (however not surveyed). Based on professional judgment, the wetland is clearly jurisdictional. There will be no impacts to the existing wetlands due to the proposed project.

The mitigation effort for Lewis Creek was determined to be restoration, using a Priority Level 2 approach. Stream dimension, pattern and profile have been designed so the new stream will maintain stability while conveying its watershed's runoff and transporting its sediment load. The proposed stream was designed as an E/C channel, which are typically stable. Most of the design parameters are associated with an E channel but the pattern measurements resemble a C type stream. A new meander pattern will be introduced into the proposed channel to mimic the natural sinuosity pattern and establish riffle/pool sequences that occur in typical naturally stable streams. Ratios of radius of curvature to bankfull width are designed to be 2.0 to 3.0, which provide a moderate to very low potential for bank erosion to occur.

The meandering will also allow the stream to dissipate energy and decrease shear stress. Typical riffle and pool cross-sections have been designed and will include a bankfull bench floodplain. The designed channel will provide a stable bedform found in E5/C5 streams with riffle, run, pool, and glide features and will also improve in-stream habitat for macroinvertebrates. Root Wad/Log Vane J-Hook Combo structures will be installed on the outside bends of meanders to protect the streambanks while vegetation is established and to provide habitat. Rock cross-vanes will be used at the upstream and downstream ends of the project to center stream flow to the middle of the channel and to provide grade-control. The rock cross-vane at the upstream end of the project will also be used to remove the mid-channel sand bar in the middle of the channel that is contributing to the stream's instability. They're will be a rock cross-vane at the downstream end of the project to smoothly transition the flow of the restored reach back into the existing channel of Lewis Creek.

The proposed grading of the Lewis Creek project reach typically will include a 10 foot bench on outside meander bends grading up to existing grade at a 2:1 slope. On inside meander bends, the ground will be graded out to tie into outside meander bend grading so the water can flow down valley during larger storm events.

All the restoration work will occur within the conservation easement limits. The streambanks and riparian zone will be replanted using native species appropriate to the area. Some of this material will be harvested from the existing channel. Additionally, the Ingle property contains several large river birches (*Betula nigra*) that are available for transplanting.

The designed dimensions were based on a combination of the dimensionless ratios from the reference reach Raccoon Branch, the NC Regional Curve for Rural Mountain Streams, Rosgen's stable reference reach data ranges (Rosgen, 2004a), and existing conditions.

Refer to Design Sheets in Section 9 for a more detailed plan of the stream restoration site, and Table 5.1 for the design values and dimensionless ratios. Components of this restoration plan may be modified based on construction and access constraints.

Table 5.1
Design Values for Proposed Conditions

	Parameter	Existing Stream MIN	Existing Stream MAX	Reference Reach MIN	Reference Reach MAX	Design Stream MIN	Design Stream MAX
General	Drainage Area (sq mi)	4		2.9		4	
	Stream Type (Rosgen)	E5/C5		E5		E5/C5	
	Valley Type	VIII		VIII		VIII	
Dimension	BKF Mean Velocity (Vbkf) (ft/s)	2.72	2.54	5.5		2.52	
	Bankfull Discharge (Qbkf)	140		131		140	
	Bankfull XSEC Area, Abkf (sq ft)	51.41	55.22	23.74	23.76	55.5	
	Bankfull Width, Wbkf (ft)	21.11	25.21	15.44	15.9	24.71	
	Bankfull Mean Depth, dbkf (ft)	2.12	2.56	1.49	1.54	2.25	
	Width to Depth Ratio, W/D (ft/ft)	8.25	11.51	10.03	10.67	11	
	Width Floodprone Area, Wfpa (ft)	60		100	100	60	
	Entrenchment Ratio, Wfpa/Wbkf) (ft/ft)	2.4		6.29	6.48	2.4	
	Max Depth @ bkf, Dmax (ft)	3.55	4.58	2.40	2.7	3.39	
	Max Depth Ratio, Dmax/dbkf	1.67	1.79	1.61	1.75	1.51	
	Max Depth @ tob, Dmaxtob (ft)	6.34	7.2	3.00	3.38	3.4	
	Bank Height Ratio, Dtob/Dmax (ft/ft)	1.53	1.79	1.25	1.25	1.00	
	Pool Max Depth, Dmaxpool (ft)	3.48	4.72	3.25	3.7	4.90	5.39
	Pool Max Depth Ratio, Dmaxpool/dbkf	1.64	1.84	2.18	2.40	2.18	2.4
	Pool Area, Apool (sqft)	50.81	57.88	29.39	31.99	52.84	56.93
	Pool Area Ratio, Apool/Abkf	14.60	12.26	1.24	1.35	1.24	1.35
	Pool Width, Wpool (ft)	16.73	29.52	14.70	16.31	23.52	25.35
	Pool Width Ratio, Wpool/Wbkf	0.79	1.17	0.95	1.03	0.95	1.03
	Pool Length, Lpool (ft)	6.9	294.11	-	-	30.30	125.4
	Pool Length Ratio, Lpool/Wbkf	0.33	13.93	-	-	1.23	5.08
	Pool-Pool Spacing, Lps (ft)	35.60	84.58	41.38	165.36	76.30	172.00
	Pool-Pool Spacing Ratio, Lps/Wbkf	1.69	4.01	2.68	10.4	3.09	6.96
Pattern	Meander Length, Lm (ft)	43.00	163.00	30.00	84	197.67	296.50
	Meander Length Ratio, Lm/Wbkf	2.04	6.47	1.94	5.28	8.00	12.00
	Radius of Curvature, Rc (ft)	14.3742	69.275	8.50	15.8	49.42	76.60
	Rc Ratio, Rc/Wbkf	0.68	2.75	0.55	0.99	2.00	3.10
	Belt Width, Wblt (ft)	22.00	51.00	52		49.42	98.83
	Meander Width Ratio, Wblt/Wbkf (ft)	1.04	2.02	3.37	3.27	2.00	4.00
	Sinuosity, K	1.11		1.3		1.32	
Profile	Valley Slope, Sval (ft/ft)	0.0033		0.014		0.0033	
	Channel Slope, Schan (ft/ft)	0.0030		0.0109		0.0025	
	Slope Riffle, Srif (ft/ft)	0.0000	0.0220	0.019		0.0060	0.0072
	Riffle Slope Ratio, Srif/Schan	0.00	7.32	1.74		2.40	2.88
	Riffle Length, Rlength (ft)	7.64	21.5	-	-	9.7	121.9
	Riffle Length Ratio, Rlength/Wbkf	0.36	1.02	-	-	0.39	4.93
	Slope Pool, Spool (ft/ft)	0.0000	0.0058	0.0003	0.006	0	
	Pool Slope Ratio, Spool/Schan	0.00	1.93	0.03	0.55	0	
	Slope Run, Srun (ft/ft)	0.0000	0.0094	0.036			
	Run Slope Ratio, Srun/Schan	0.00	3.13	3.30			
	Slope Glide, Sglide (ft/ft)			0.003			
	Glide Slope Ratio, Sglide/Schan			0.28			
Substrate		**Riffle**	**Pool**	**Reachwide**			
	d16	0.07	0.1	0.12			
	d35	0.16	0.18	0.30			
	d50	0.28	0.28	0.75			
	d84	9.1	0.95	64.00			
	d95	16	10.28	150.00			

5.2 Sediment Transport Analysis

A sediment transport competency analysis was conducted on Lewis Creek to ensure that the design stream will move its sediment load without significant potential for aggradation or degradation. Stream competency was analyzed to determine what sediment particle sizes are typically available for mobility at bankfull flows. Characterizing the streambed sediment stratification also provided the means to calculate and verify the channel's existing and proposed critical dimensionless shear stress, target design slope, and the required minimum mean depth needed for channel stability.

5.2.1 Methodology

Entrainment data was collected within Lewis Creek. A bar sample was collected at cross-section 1, and a wetted pebble count was conducted at the cross-section to calculate entrainment and velocity. Calculated fields consisted of critical dimensionless shear stress (cdss), mean depth of bankfull (d_{BKF}), and water surface/bankfull slope. Using the Shields Curve and the Rosgen Colorado Curve, maximum grain diameter and shear stresses were determined to verify entrainment calculations (Rosgen, 2006). The Shields Curve and the Rosgen Colorado Curve can be used to predict two stream parameters. Shear stress can be predicted using the largest particle size (Di) from a bar or subpavement sample, or the Di can be predicted using a calculated shear stress. Field collection and calculations followed methods described by Rosgen (2004 a, b), and North Carolina Stream Restoration Institute (Doll et. al., 2003).

5.2.2 Calculations and Discussion

Tables 5.2 and 5.3 summarize the results of the sediment transport analysis for Lewis Creek.

Table 5.2
Entrainment Calculations

Parameter	Main Channel
Existing Bankfull Slope (ft/ft)	0.0030
Median particle size-wetted pebble count, D50 (mm)	17.65
Largest particle size from subpavement, Di (mm)	42.0
Di/D50	2.38
Critical Dimensionless Shear Stress, cdss	0.0180
Minimum Mean Bankfull Depth, dBKF (ft)	1.37
Minimum Bankfull/Water Surface Slope (ft/ft)	0.0030

Table 5.3
Sediment Transport Validation

Parameter		Main Channel	
		Existing-E5/C5	Design-E5/C5
Bankfull Shear Stress (lbs/sqft):	*γRS*	0.42	0.33
Grain Diameter (mm)*	*Using Bankfull Shear Stress*	22.16	18.03
Grain Diameter (mm)**		79.91	66.31
Predicted Shear Stress (lbs/sqft)*	*Using Di*	0.70	0.70
Predicted Shear Stress (lbs/sqft)**		0.20	0.20

* Results using Shields Curve, ** Results using Rosgen CO curve
Source for Curve Data from Watershed Assessment of River Stability and Sediment Supply (Rosgen, 2006b)

5.2.3 Results

Competency

Using Shields and Rosgen CO Curves, the largest particle available for transport is respectively, 22.16 and 79.91 mm for the existing channel and the design.
The critical dimensionless shear stress required to mobilize and transport the Di is 0.018.
To entrain the Di, the minimum bankfull depth and slope required for the design are 1.37 ft, and 0.0030 ft/ft, respectively.
The calculated existing bankfull shear stress is 0.42 lbs/ft^2 and the design bankfull shear stress is 0.33 lbs/ft^2. Shields predicted a shear stress value of 0.70 lbs/ft^2, which is greater than the calculated bankfull shear stress, and indicates a potential for aggradation. However, the Rosgen CO Curve predicted a shear stress value of 0.2 lbs/ft^2, which is similar to the calculated value, indicating neither aggradation, nor degradation is likely to occur.

Summary

From the sediment transport analysis of Lewis Creek, it can be assumed there is not a significant potential for aggradation or degradation to occur within the proposed channel design.

5.3 HEC-RAS Analysis

A hydraulic model was developed for the project reach of the main channel of Lewis Creek using HEC-RAS software to determine water surface elevations along the project reach and to identify the extent of flooding for both the existing stream geometry and proposed stream geometry. Peak flow rates discussed in section 3.2 were used in the model. The model was also used to verify that the proposed restoration will not increase the water surface elevation of the FEMA 100-year floodplain. The model indicates that there will not be a rise in the water surface elevation for the 100-year floodplain due to the proposed conditions. These results can be seen in the following table. Refer to Table 5.4 for the 100-year water surface elevations for the existing and proposed conditions.

Table 5.4
100-year Water Surface Elevations (WSE) for Existing and Proposed Conditions

Cross-Section	Existing Conditions 100-yr WSE (ft)	Proposed Conditions 100-yr WSE (ft)	Difference in WSE from Existing to Proposed (ft)
1	2158.09	2157.12	0.97
2	2158.09	2157.00	1.09
3	2157.86	2156.60	1.26
4	2157.35	2155.83	1.52
5	2155.22	2154.47	0.75
6	2154.28	2153.61	0.67
7	2152.51	2152.46	0.05
8	2152.11	2152.05	0.06

5.3.1 No-Rise, LOMR, CLOMR

A No-Rise Certification is being submitted to Henderson County to verify that the project will not increase the water surface elevation of the 100-year floodplain. A copy of the No-Rise Certification will be submitted to the EEP once received from the county. A LOMR will be required if the decrease in water surface elevation is less than -0.1 ft.

5.3.2 Hydrologic Trespass

The proposed restoration project was designed to avoid hydrologic trespass. Hydrologic trespass occurs when there is a rise in the 100-year storm floodplain (water surface elevation) when compared to the published FEMA FIRM map. According to the FEMA FIRM map of the project area (effective date March 1, 1982), approximately all of the project conservation easement is in the 100-year floodplain. The HEC-RAS model of the proposed restoration reach indicates that the 100-year floodplain elevations on adjacent properties will not increase.

5.4 Storm Water Best Management Practices

There are not any site specific storm water concerns for the Lewis Creek project site. All on-site storm water discharges will be sheet flow or overland flow with the exception of the discharge that comes from the North Ridge Road. There is a minimum possibility of fertilizer and nutrient rich runoff from the residential area on the south side of the project, but the proposed riparian buffer should provide sufficient filtering and treatment of any potential nutrients from reaching Lewis Creek. No other significant storm water concerns are prevalent within the project limits.

5.4.1 Narrative of Site-Specific Storm Water Concerns

During construction, all disturbed areas, access roads, and stock piles within the project site will have appropriate prevention methods installed to avoid erosion and sedimentation impacts on Lewis Creek.

5.4.2 Device Description and Application

Erosion and sedimentation control measures will consist of installing silt fencing around disturbed areas prior to disturbance, and maintaining throughout the construction phases. All newly constructed streambanks will be matted and staked at the end of each work day.

5.5 Soil Restoration

Typically, the soils of the Piedmont/Mountain Alluvial Forest community are prime farm and planting soils due to their fertility and periodic flooding (Schafale and Weakely, 1990). The existing soils within the proposed stream restoration areas consist mostly of Codorus loam which is naturally fertile and well-suited for planting (USDA, 1980). Most of the areas within the project easement will be heavily planted with the species shown below in Table 5.5. Soils along the left side of the Lewis Creek easement do not appear to have been regularly plowed or disturbed; therefore, they are unlikely to have been over utilized for agriculture purposes. Recent disturbances and manipulation to soils along the right side of the Lewis Creek easement area however are apparent. Top soil taken from cut areas along the stream will be reserved for the top soil dressing in nutrient poor areas located along the right side of Lewis Creek. The soil along the streambanks is naturally fertile due to its alluvial nature, so this top soil should be well suited for planting. Subsequently, the remaining culms will be disked to work additional organic matter into the soil. Disking the soil prior to planting will not only add organic manner, but also diminish any compaction and increase the rooting volume (Clewel and Lea, 1990). In addition, disking will ensure adequate drainage and beneficial microtopography for planting and drainage. Prior to planting, soil analysis will be performed by the Contractor to determine what, if any, soil amendments need to be added to establish correct soil conditions for the trees/shrubs to be planted.

5.6 Natural Plant Community Restoration

5.6.1 Narrative & Plant Community Restoration

The stream restoration area and the areas of disturbance associated with the grading and sloping of banks will be planted with species similar to those found in reference stream vegetation areas located in floodplain areas and riparian areas along the left bank of the middle to lower reaches of the Lewis Creek project reach. Selected species will be strategically planted to achieve a Montane Alluvial Forest and Piedmont/Mountain Alluvial Forest intermediate community type as described in Schafale and Weakely (1990). The streambanks and immediately adjacent riparian areas associated with disturbance due to bank stabilization will be planted with species similar to those currently found there to maintain a Montane Alluvial Forest and Piedmont/Mountain Alluvial Forest intermediate community (Schafale and Weakely 1990).

The species list found in Table 5.6 is developed based on on-site inventories and Schafale and Weakley's species descriptions. Species selected for live staking are based on on-site inventories, past experience, and results of field trials reported by Calabria *et al.* (2006). Refer to Table 5.6 for a list of live staking material. A map of proposed communities is provided in Figure 5.1.

Table 5.5
Montane Alluvial Forest - Piedmont/Mountain Alluvial Forest Intermediate Community
Streambanks and Adjacent Riparian Planting List - Woody Species

Zone(s)	Common Name	Scientific Name	Wetl Ind. Stat.	Size	Spacing	Quantity
Trees/Overstory						
3	Tulip tree	*Liriodendron tulipifera*	FAC	24" or > b.r.	10-feet O.C. random	127
3	Black Cherry	*Prunus serotina*	FACU	24" or > b.r.	10-feet O.C. random	127
3	White oak	Quercus alba	FACU	24" or > b.r.	10-feet O.C. random	127
3	American sycamore	*Platanus occidentalis*	FACW-	24" or > b.r.	10-feet O.C. random	380
3	River birch	*Betula nigra*	FACW	24" or > b.r.	10-feet O.C. random	253
3	Red maple	*Acer rubrum*	FAC	24" or > b.r.	10-feet O.C. random	253
	Total Trees					1,267
Shrubs/Understory						
3	American holly	*Ilex opaca*	FAC-	24" or > b.r.	6-feet O.C. random	146
3/2	Alder	*Alnus serrulata*	FACW	24" or > b.r.	6-feet O.C. random	76 / 146
2	Silky dogwood	*Cornus amomum*	FACW	24" or > b.r.	6-feet O.C. random	76 / 194
3/2	Spicebush	*Lindera benzoin*	OBL	24" or > b.r.	6-feet O.C. random	51 / 194
3/2	Ironwood	*Carpinus caroliniana*	FAC	24" or > b.r.	6-feet O.C. random	51 / 97
3	Smooth sumac	*Rhus glabra*	N/A	24" or > b.r.	6-feet O.C. random	97
	Total shrubs					254 / 874
Live Stakes						
1	Black willow	*Salix nigra*	FACW	36" or >	3-feet O.C. random	1,586
1	Ninebark	*Physiocarpus opulifolius*	FAC-	36" or >	3-feet O.C. random	1,539
1	Silky dogwood	*Cornus amomum*	FACW	36" or >	3-feet O.C. random	1,539
	Total stakes					4,664

On-site Invasive Species Management

Several invasive species including reed canary grass (*Phalaris arundinacea*), multiflora rose (*Rosa multiflora*), and Japanese honeysuckle (*Lonicera japonica*) occur throughout the project area and are dominant in several areas along the right streambank of Lewis Creek within the project area. Reed grass located along much of the right stream bank of Lewis Creek is providing most of the existing stream bank stability within the project area. It is anticipated that the above invasive species will likely persist within the project area after restoration of the stream channel and riparian areas despite efforts to control its growth. Therefore, it is in the opinion of JJG ecologists that a long-term solution to vegetation restoration would likely prove to be more beneficial. This long-term solution would consist of allowing the natural succession of a riparian forest to eventually eliminate the amount of available habitat (i.e., sunlight) of the reed grass. This long-term approach to vegetation restoration would likely result in an overall greater success of the project, be more cost effective, and would surely prove to be more beneficial to water quality and the overall bank stability following restoration. If invasive species appear to be deterring growth of planted species during monitoring, the use of an herbicide approved for use in aquatic areas will be explored.

5.8 Construction Access Plan

To access the site, a temporary construction easement will be located off a public road: North Ridge Road. The access point from North Ridge Road shall be protected with a construction entrance according to Details Sheets of the Construction Plans.

Communication with the CMLC and Ingle family representatives indicate that construction access should not be hindered as access may be necessary beyond the current conservation easement limits.

SECTION 6
PERFORMANCE CRITERIA

SECTION 6
PERFORMANCE CRITERIA

6.1 Streams

To evaluate the success of the stream restoration effort on Lewis Creek, morphological and biological monitoring should be conducted. Specific morphological and biological monitoring requirements to evaluate the success of this project will be determined by EEP accordingly.

6.1.1 Dimension, Pattern, and Profile

An initial as-built longitudinal profile and permanent cross-sections will be established and surveyed for Lewis Creek which will serve as base-line data for future monitoring years. Each assessment following the initial as-built survey should include re-surveying the same longitudinal profile and permanent cross-sections. Geomorphologic data (profile, pattern, and dimension) will be collected and evaluated to determine whether the stream is stable or unstable. The surveyed data collected will be assessed to determine whether the stream channel is indicating a lateral and/or vertical migration. Reach-wide and cross-sectional pebble counts will also be collected to monitor changes in channel substrate composition. Determining success on the Lewis Creek project should include, but not be limited to, evaluating any significant change in the dimension, pattern, profile, and substrate criteria, such as the following parameters:

- Width to depth ratio
  Cross-sectional area
  Bank height ratio
  Substrate composition (D50)
- Bankfull verification (occurs at least twice within the 5-year monitoring period)
- Sediment transport: neither aggradation nor degradation occurring
  Survivability of planted riparian vegetation

6.2 Storm Water Management Devices

All storm water management devices will be removed once construction has concluded; therefore, describing performance criteria is not necessary.

6.3 Vegetation

Vegetative success at the restoration site will be measured by survivability over a five-year monitoring period. Success for the site will be based on the survival of at least 320 planted woody stems per acre at the end of year three, 290 planted woody stems per acre at the end of year four, and 260 planted woody stems per acre at the end of year five of the monitoring period.

In addition to the above-listed success criteria, noxious/invasive species will be identified and controlled so that none become dominant or alter the desired community structure of the site. If noxious plants are identified as problematic on the site, the "Monitoring Team" will develop and implement a species-specific control plan. During the five-year monitoring period, the "Monitoring Team", where necessary, will remove, treat, or otherwise manage undesirable plant or animal species, including physical removal and use of herbicides.

Monitoring will also include photo documentation of vegetative communities within monitoring plots. Photographs will be taken from the monument control (southwest corner of the plot). Site specific vegetation monitoring protocol will be developed and finalized by the EEP.

6.4 Schedule/Reporting

Monitoring, scheduling, and reporting will be finalized by EEP. Typically, there is an initial as-built monitoring survey and a monitoring plan established immediately following construction. The establishment of monitoring features and the collection and summarization of monitoring data shall be conducted in accordance with the most current EEP document entitled "Content, Format, and Data Requirements for EEP Monitoring Reports." Subsequently, the site will be monitored and reported on annually for five years, or until success criteria are met, whichever occurs last.

SECTION 7
REFERENCES

SECTION 7
REFERENCES

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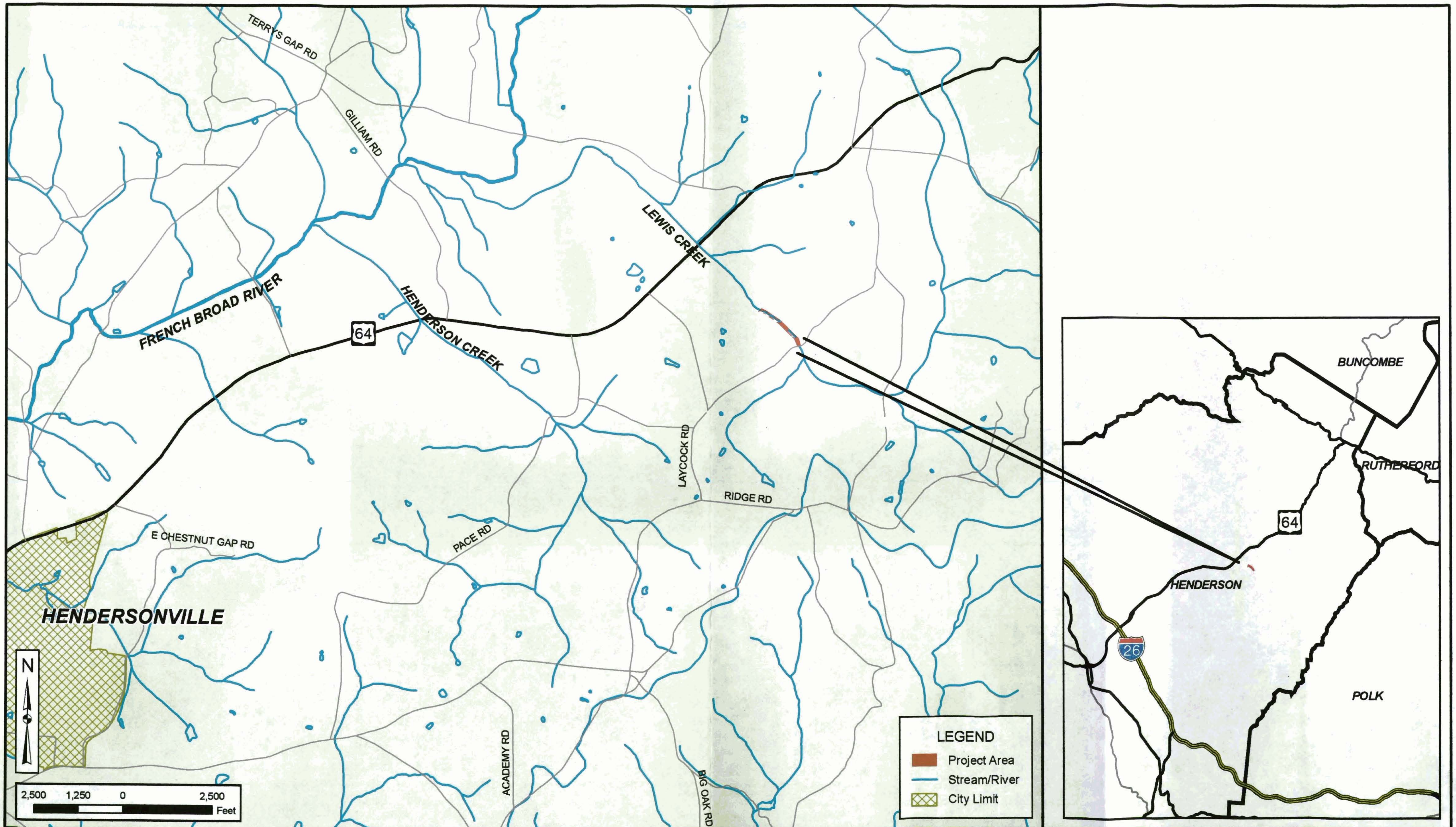
Jordan
Jones &
Goulding

SECTION 8
FIGURES

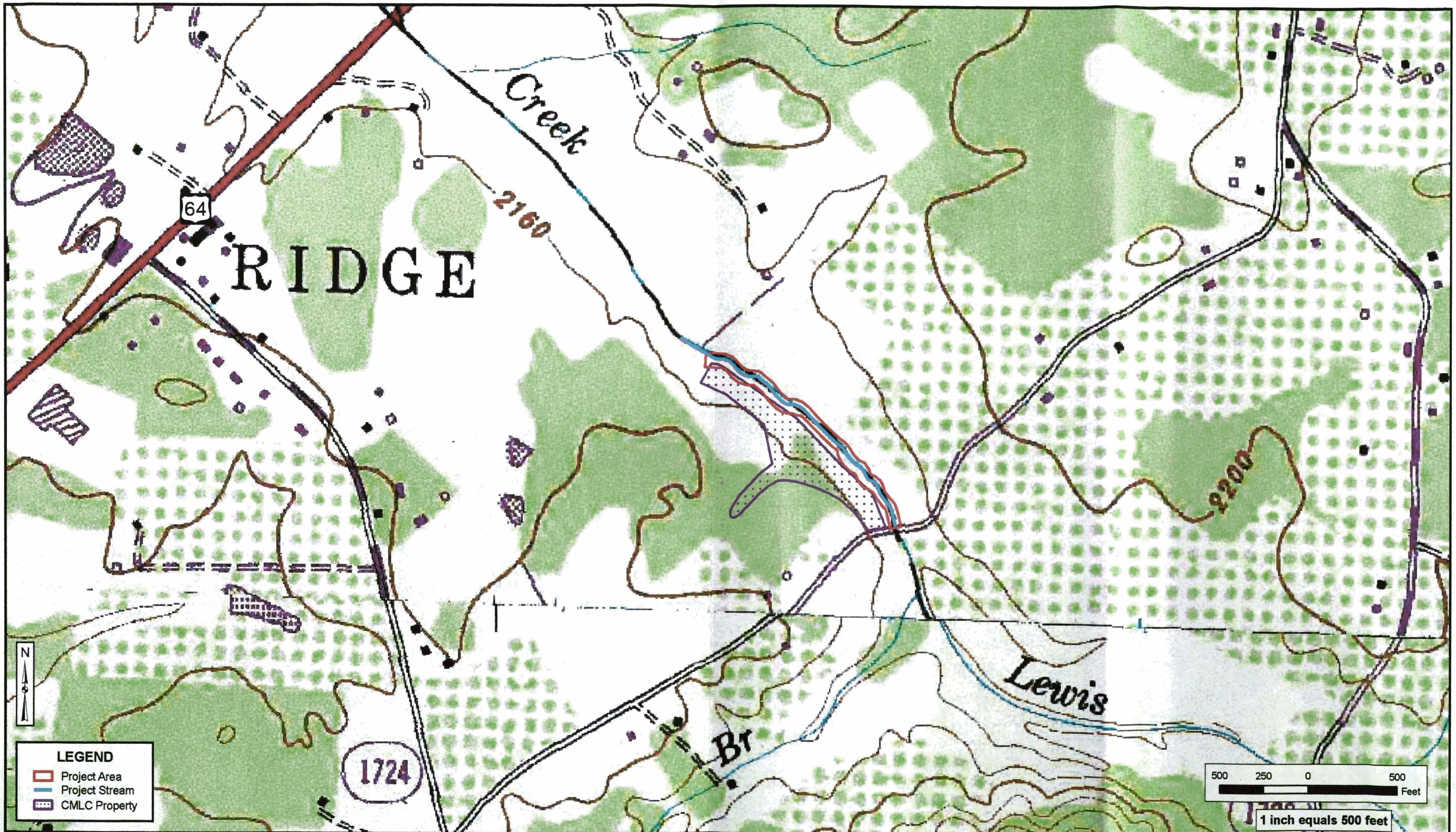


Ecosystem Enhancement

JORDAN JONES & GOULDING

Lewis Creek Stream Restoration Project
Project Location Map
Henderson County, NC

Figure 1.1
December 2007
Project No: 3060003

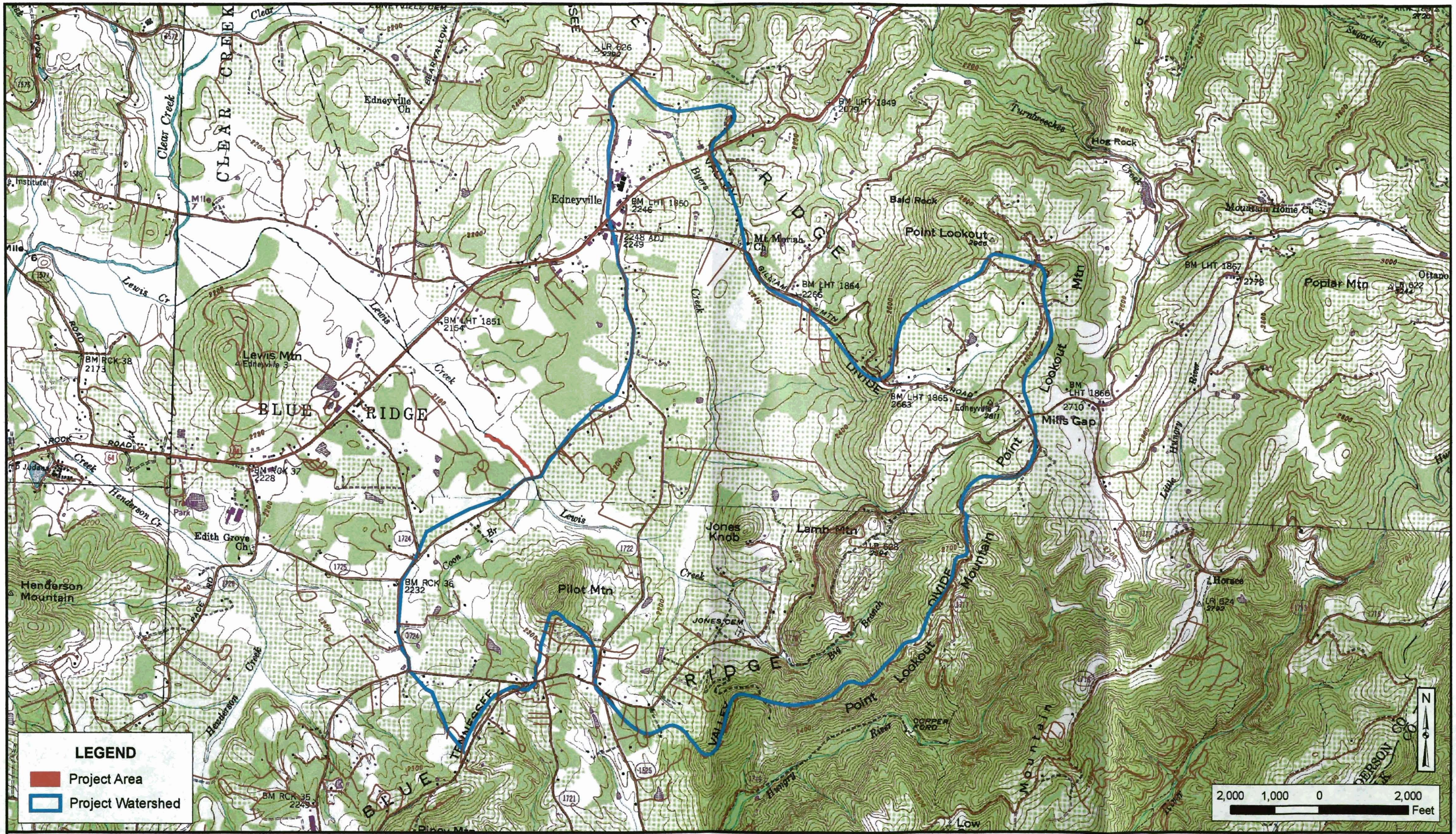


Ecosystem Enhancement Program

JORDAN JONES & GOULDING

Lewis Creek Stream Restoration Project
USGS Quadrangle Location Map, Bat Cave, NC
Henderson County, NC

Figure 2.1
December 2007
Proj. No: 3060003

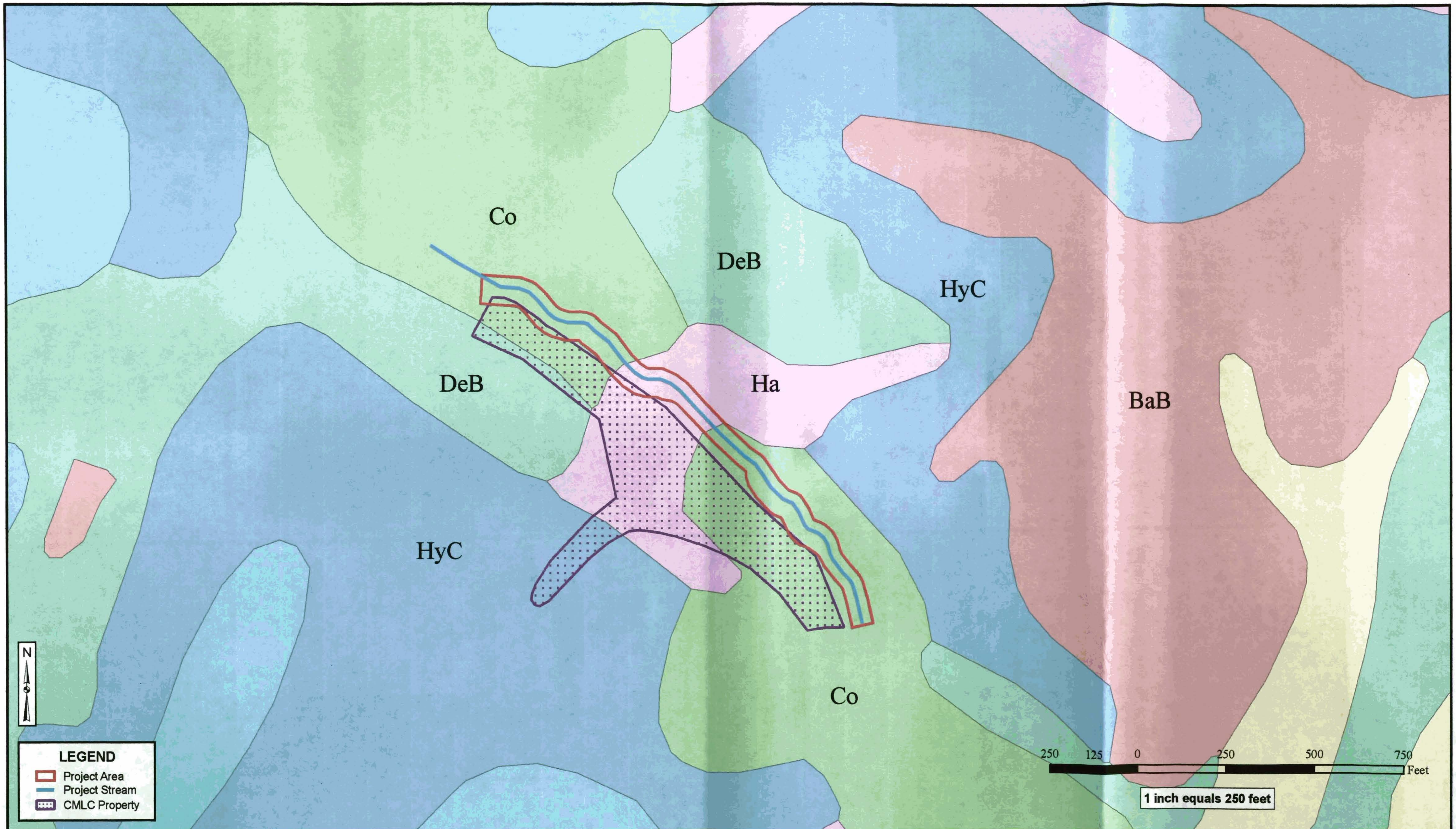


Lewis Creek Stream Restoration Project
Project Site Watershed Map, Bat Cave, NC
Henderson County, NC

Ecosystem Enhancement Program

JORDAN JONES & GOULDING

Figure 2.2
December 2007
Proj. No: 3060003



Ecosystem Enhancement Program

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Lewis Creek Stream Restoration Project
Project Site Soils Map
Henderson County, NC

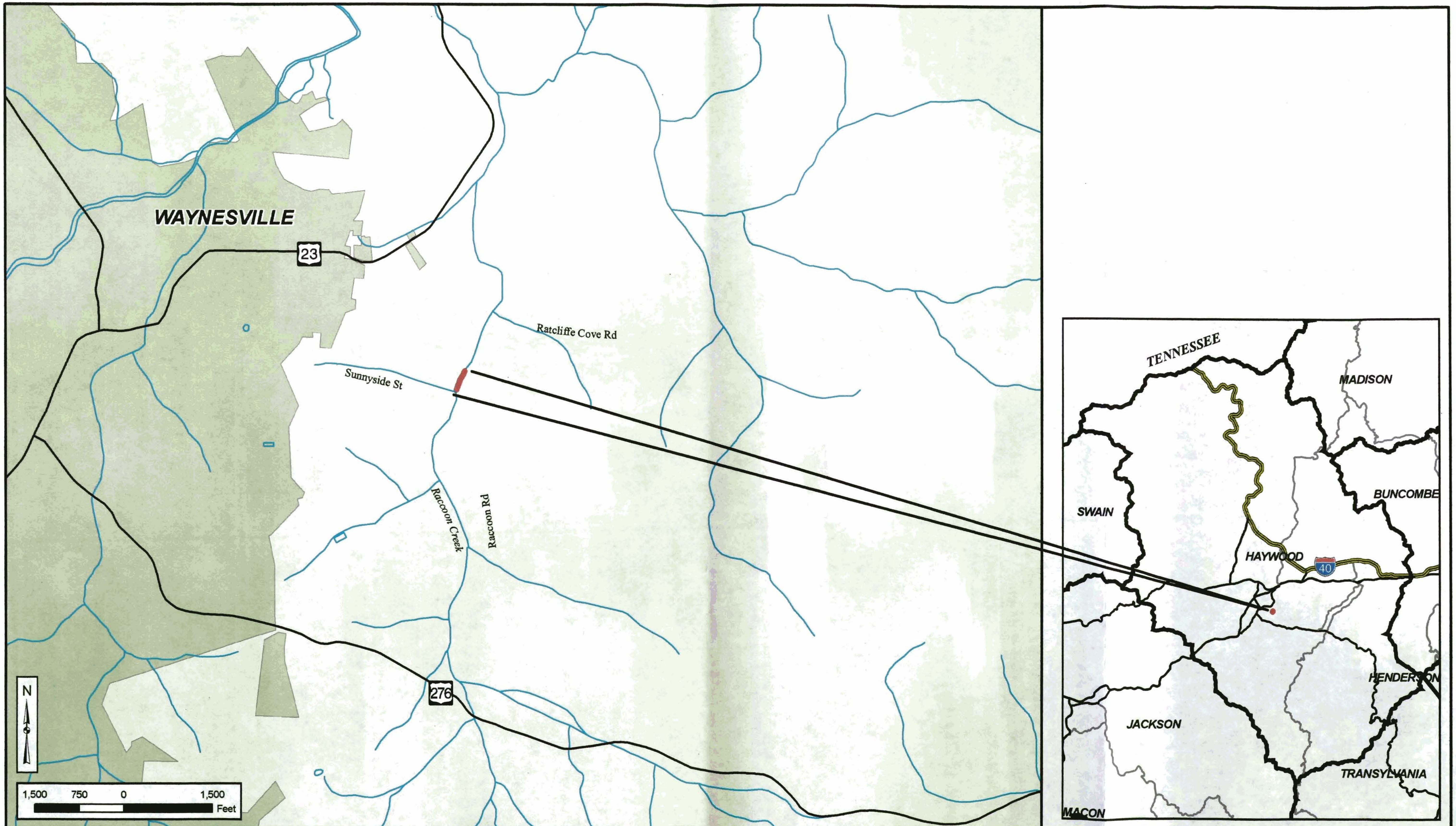
Figure 2.3
December 2007
Proj. No: 3060003

Ecosystem Enhancement

JORDAN JONES & GOULDING

Lewis Creek Stream Restoration Project
Existing Vegetative Communities Map
Henderson County, NC

Figure 3.1
December 2007
Project No: 3060003

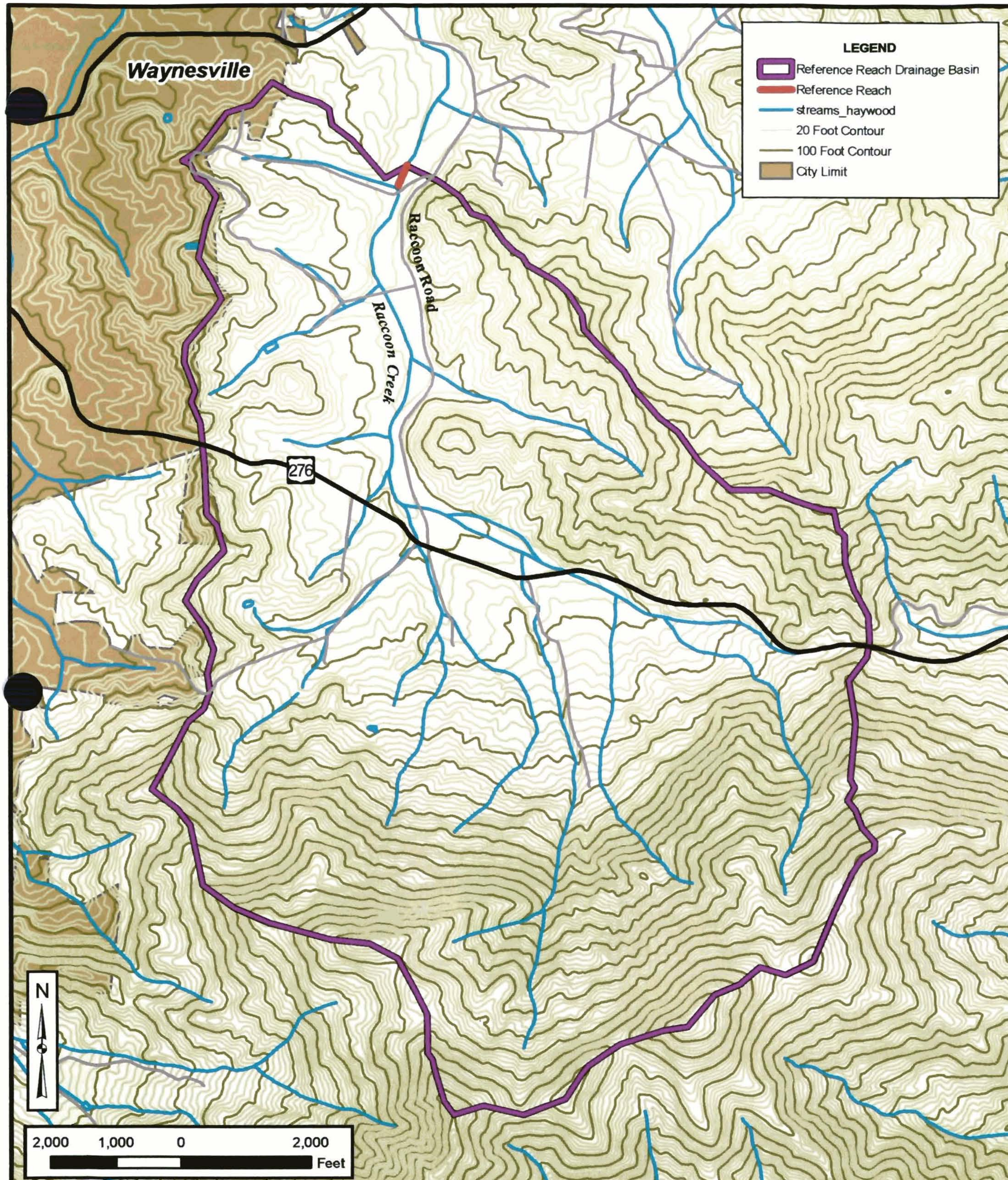


Ecosystem Enhancement

JORDAN JONES & GOULDING

Lewis Creek Stream Restoration Project
Raccoon Creek Reference Reach Site Map
Haywood County, NC

Figure 4.1
December 2007
Project No: 3060003



Ecosystem Enhancement PROGRAM

JORDAN JONES & GOULDING

Lewis Creek Stream Restoration Project
Raccoon Creek Reference Reach Watershed Map
Haywood County, NC

Figure 4.2
October 2007
Project No: 3060003

Ecosystem Enhancement Program

JORDAN JONES & GOULDING

Lewis Creek Stream Restoration Project
Proposed Vegetative Communities Map
Henderson County, NC

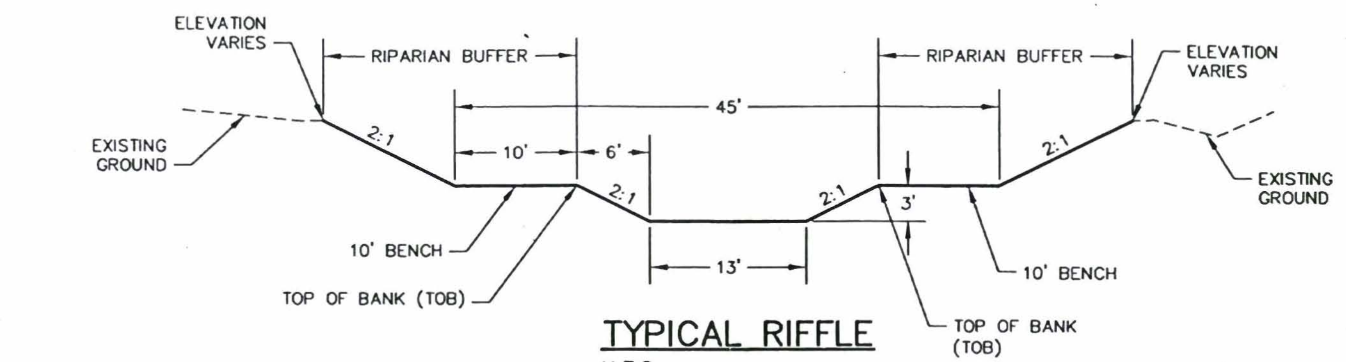
Figure 5.1
December 2007
Project No: 3060003

SECTION 9
DESIGN SHEETS

TYPICALS

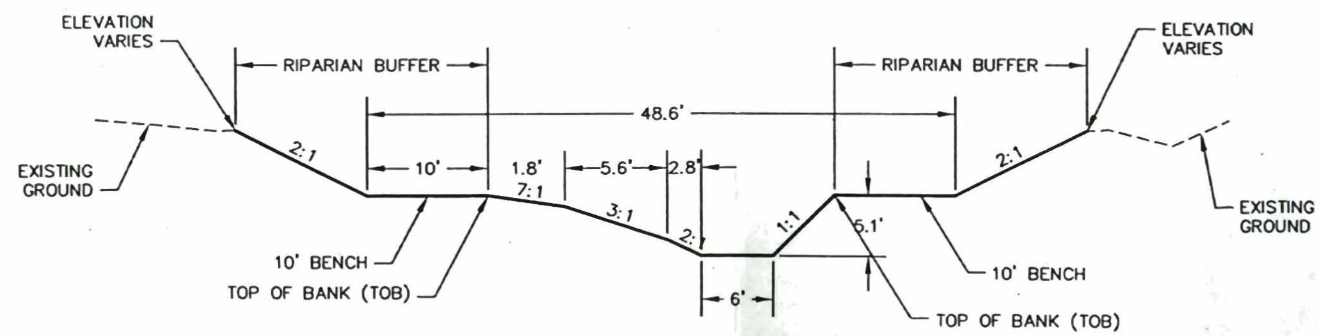
NOT TO SCALE

LEWIS CREEK TYPICALS



TYPICAL RIFFLE

N.T.S.



TYPICAL POOL

N.T.S.

PLANS PREPARED FOR

Ecosystem Enhancement PROGRAM

REVIEW COORDINATOR SALAM MURTADA

PROJECT MANAGER DEBORAH DANIEL

PROJECT ENGINEER MATTHEW CLABAUGH, PE (704) 527-4106 mclabaugh@jjg.com

NO.	DATE	DESCRIPTION OF REVISION
A	12-17-07	RESPONSE TO 60% COMMENTS

JORDAN JONES & GOULDING

NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

NOT RELEASED FOR CONSTRUCTION

LEWIS CREEK STREAM RESTORATION PROJECT

TYPICALS

SCO NO: 06-06799-01

DESIGNED: MMC | CHECKED: | DATE: OCTOBER, 2007

DRAWN: MXD | JOB NO. 03060003 | SCALE: AS SHOWN

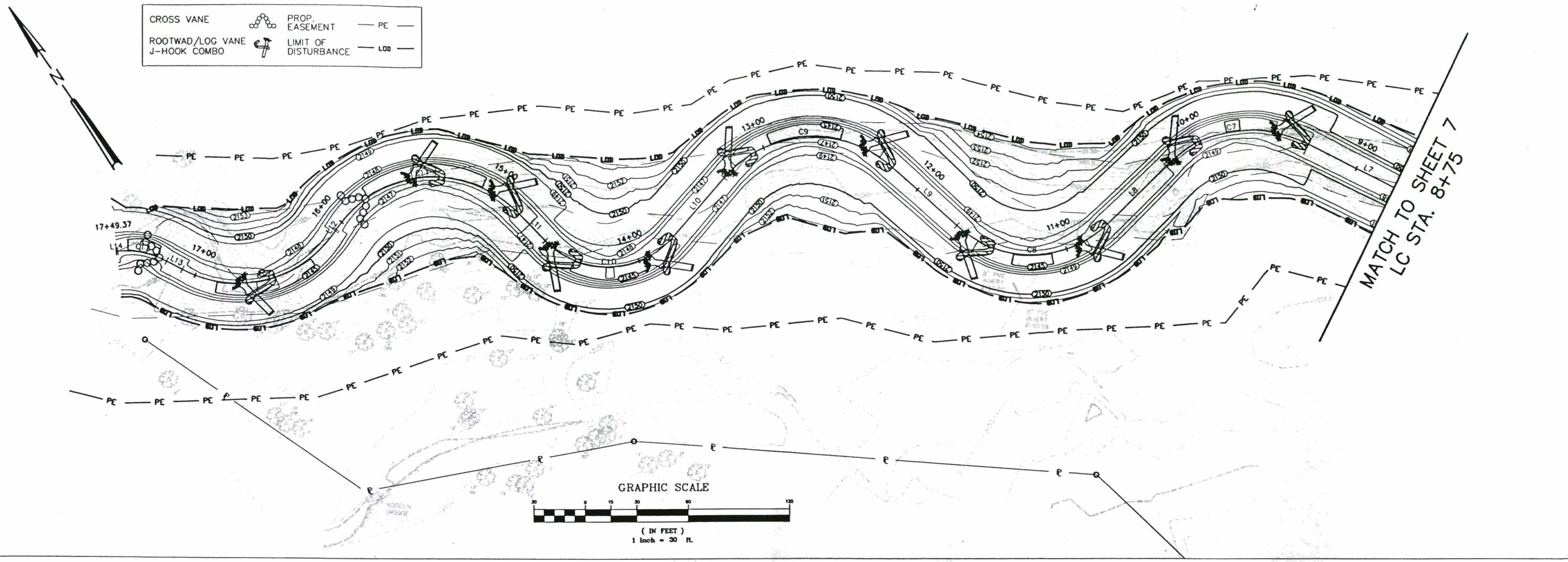
SHEET 5 | REV A

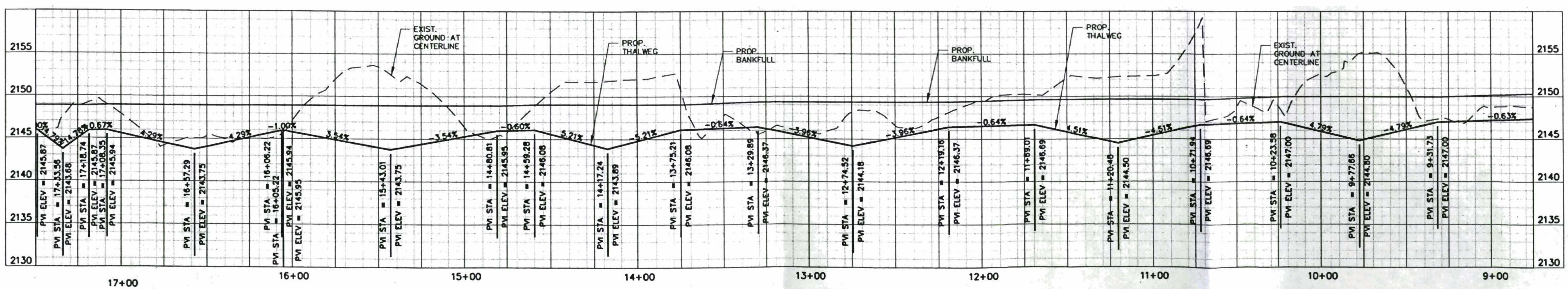
THIS LINE IS ONE INCH LONG WHEN PLOTTED FULL SCALE

TBMILLER

P:\03\03060\003\DWG\nce003TYPC.dwg 12/17/2007 4:42:59 PM

nce003TYPC.dwg 12.17.07





LC PROFILE STA. 8+75 TO END

HOR. SCALE 1"=30'
VER. SCALE 1"=6'

PLANS PREPARED FOR
Ecosystem Enhancement PROGRAM

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SALAM MURTADA
PROJECT MANAGER
DEBORAH DANIEL
PROJECT ENGINEER
MATTHEW CLABAUGH, PE
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NO.	DATE	DESCRIPTION OF REVISION
A	12-17-07	RESPONSE TO 60% COMMENTS

JORDAN JONES & GOULDING

NORTH CAROLINA
ECOSYSTEM ENHANCEMENT
PROGRAM

NOT RELEASED FOR CONSTRUCTION

LEWIS CREEK
STREAM RESTORATION PROJECT

PLAN & PROFILE

SCO NO: 06-06799-01
DESIGNED: MMC | CHECKED: | DATE: OCTOBER, 2007 | SHEET 8 | REV A
DRAWN: MXD | JOB NO. 03060003 | SCALE: AS SHOWN

nce003CS02.dwg
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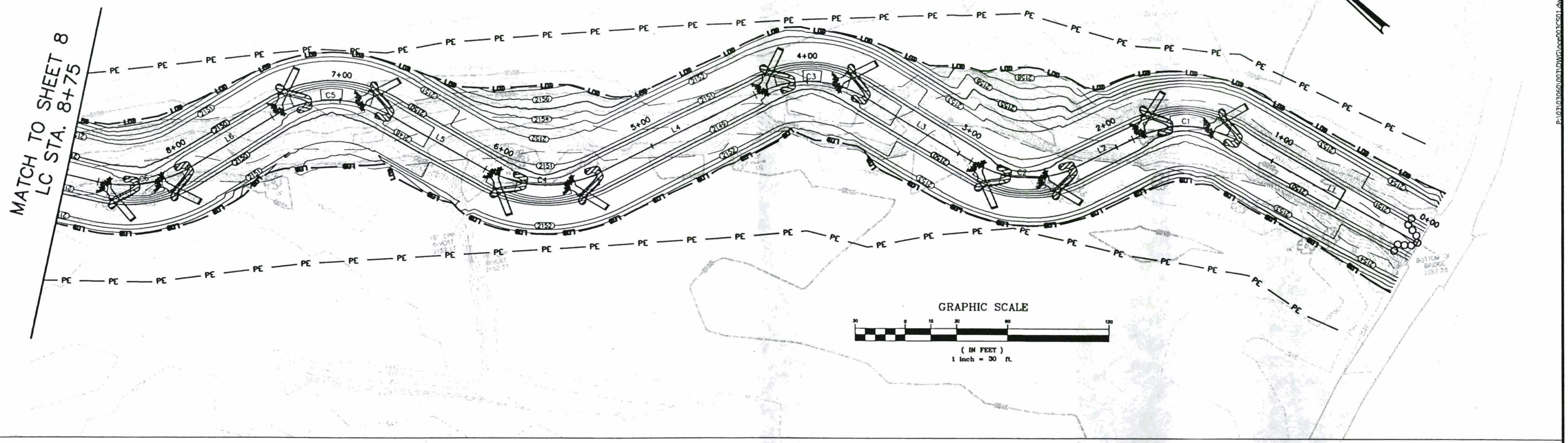
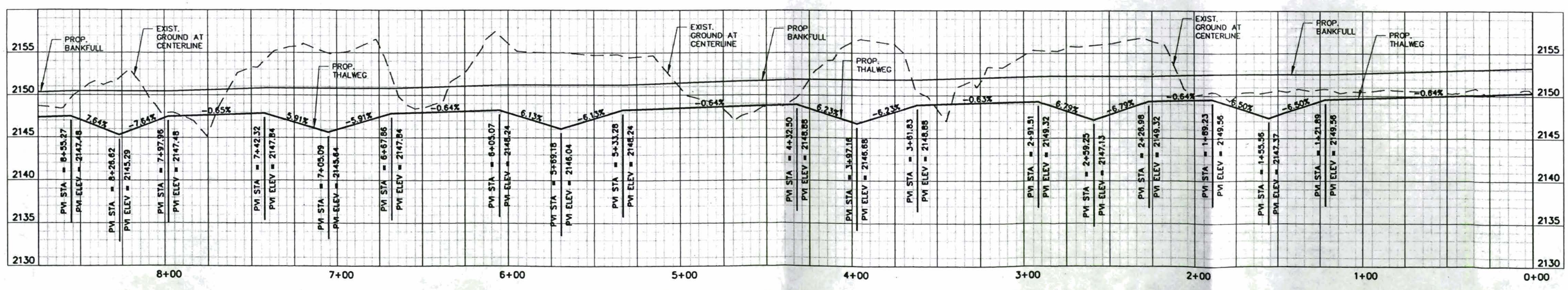
CROSS VANE		PROP. EASEMENT — PE —
ROOTWAD/LOG VANE J-HOOK COMBO		LIMIT OF DISTURBANCE — LOD —





LC PROFILE STA. 0+00 TO 8+75

HOR. SCALE 1"=30'
VER. SCALE 1"=6'

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STREAM ALIGNMENT DATA

LINE TABLE						
LINE	LENGTH	BEARING	START NORTHING	START EASTING	END NORTHING	END EASTING
L1	121.89	N11°48'56"W	608780.7940	1002324.8909	608900.0988	1002299.9332
L2	37.75	N66°56'16"W	608950.1712	1002258.8374	608964.9587	1002224.1051
L3	70.31	N10°03'12"W	609013.4171	1002185.5656	609082.6523	1002173.2910
L4	100.79	N67°53'39"W	609135.2870	1002130.7081	609173.2147	1002037.3305
L5	62.79	N11°32'50"W	609226.2359	1001993.2792	609287.7549	1001980.7104
L6	55.64	N72°29'34"W	609340.5003	1001933.1850	609357.2386	1001880.1213
L7	76.46	N28°42'42"W	609392.7344	1001836.9046	609459.7923	1001800.1739
L8	48.37	S81°07'16"W	609497.8635	1001722.8192	609490.3985	1001675.0336
L9	50.14	N13°19'01"W	609539.6476	1001601.7488	609588.4429	1001590.1989
L10	45.31	S76°02'41"W	609640.2531	1001505.1995	609629.3247	1001461.2225
L11	21.52	N09°29'58"W	609670.4025	1001398.6223	609691.6306	1001395.0702
L12	1.01	S68°40'02"W	609745.2818	1001300.5651	609744.9158	1001299.6279
L13	10.40	N27°44'40"W	609777.5326	1001212.2107	609786.7328	1001207.3714
L14	1.00	N61°41'50"W	609807.4791	1001186.8263	609807.9532	1001185.9459

CURVE TABLE				
CURVE	RADIUS	LENGTH	CHORD	BEARING
C1	70.00	67.34	64.78	N39°22'36"W
C2	65.00	64.53	61.92	S38°29'44"E
C3	70.00	70.67	67.70	N38°58'26"W
C4	73.00	71.79	68.93	S39°43'14"E
C5	70.00	74.46	71.00	N42°01'12"W
C6	75.00	57.31	55.93	S50°36'08"E
C7	75.00	91.85	86.22	N63°47'43"W
C8	65.00	97.07	88.30	S56°05'53"E
C9	70.00	110.74	99.54	N58°38'10"W
C10	51.00	84.08	74.87	S56°43'39"E
C11	70.00	124.41	108.67	N60°24'58"W
C12	70.00	102.12	93.30	S69°32'19"E
C13	50.00	29.63	29.20	N44°43'15"W

STRUCTURE LOCATION TABLE

STREAM STRUCTURE LOCATIONS		
STRUCTURE TYPE	STATION	SIDE OF STREAM(LOOKING D/S)
Cross Vane	0	Mid
Root Wad/Log Vane J-Hook Combo	121.9	R
Root Wad/Log Vane J-Hook Combo	164.2	R
Root Wad/Log Vane J-Hook Combo	227.0	L
Root Wad/Log Vane J-Hook Combo	266.5	L
Root Wad/Log Vane J-Hook Combo	361.8	R
Root Wad/Log Vane J-Hook Combo	407.5	R
Root Wad/Log Vane J-Hook Combo	533.3	L
Root Wad/Log Vane J-Hook Combo	580.1	L
Root Wad/Log Vane J-Hook Combo	667.9	R
Root Wad/Log Vane J-Hook Combo	717.3	R
Root Wad/Log Vane J-Hook Combo	798.0	L
Root Wad/Log Vane J-Hook Combo	830.3	L
Root Wad/Log Vane J-Hook Combo	931.7	R
Root Wad/Log Vane J-Hook Combo	998.6	R
Root Wad/Log Vane J-Hook Combo	1071.9	L
Root Wad/Log Vane J-Hook Combo	1144.0	L
Root Wad/Log Vane J-Hook Combo	1219.2	R
Root Wad/Log Vane J-Hook Combo	1304.9	R
Root Wad/Log Vane J-Hook Combo	1375.2	L
Root Wad/Log Vane J-Hook Combo	1434.3	L
Root Wad/Log Vane J-Hook Combo	1480.8	R
Root Wad/Log Vane J-Hook Combo	1530.6	R
Cross Vane	1580.2	Mid
Root Wad/Log Vane J-Hook Combo	1651.8	L
Cross Vane	1723.4	Mid

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STREAM ALIGNMENT & STRUCTURE LOCATION

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DRAWN: MXD | JOB NO. 03060003 | SCALE: AS SHOWN

9 SHEET | A REV

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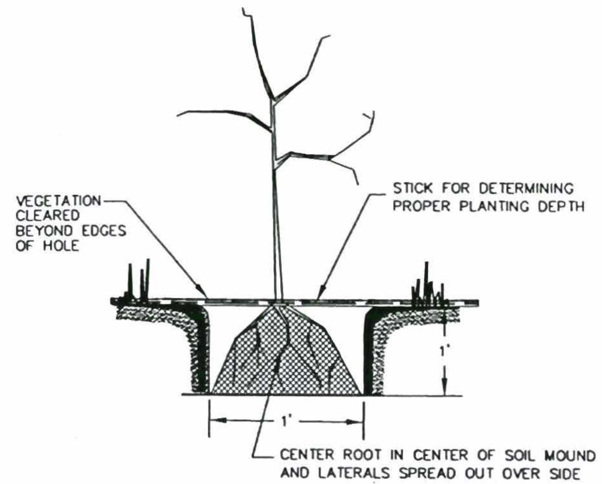
PLANTING DETAILS

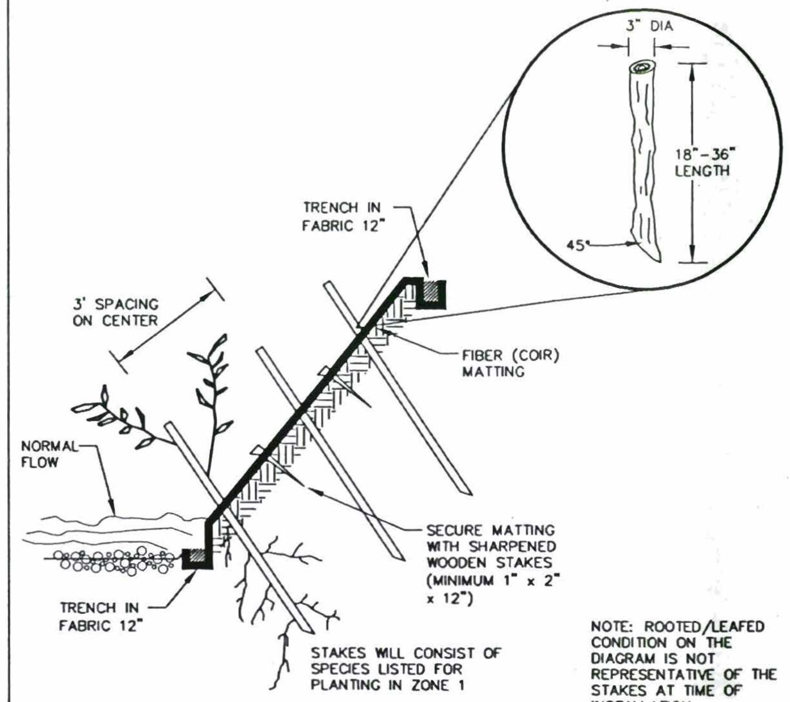
NOT TO SCALE



1. SOAK ROOTS OVERNIGHT
2. CUT BROKEN ROOTS BACK TO HEALTHY TISSUE
3. DIG A HOLE LARGE ENOUGH TO ACCOMMODATE FULL ROOT LENGTH
4. SPREAD ROOTS OUTWARD AND DOWNWARD
5. BACK-FILL SOIL; WORK IN AND TAMP AROUND ROOTS
6. WATER, AND LET THE SOIL SETTLE
7. RE-ADJUST THE TREE SO THAT ROOT CROWN IS AT GRADE LEVEL
8. FILL THE REST OF THE HOLE, AND TAMP SOIL
9. SOAK WITH WATER
10. MULCH

BARE ROOT USING A SHOVEL

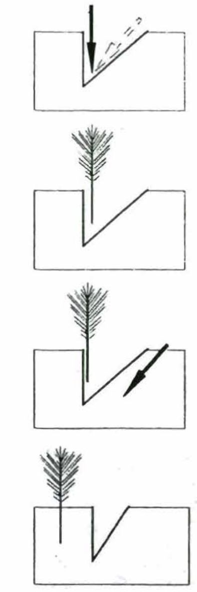
N.T.S.



NOTE: ROOTED/LEAFED CONDITION ON THE DIAGRAM IS NOT REPRESENTATIVE OF THE STAKES AT TIME OF INSTALLATION.

LIVE STAKING

N.T.S.



1. Insert dibble as shown and pull handle towards planter

2. Remove dibble and place seedling at correct depth

3. Insert dibble at an angle 3-4 inches toward planter from seedling. Push handle of dibble forward from planter

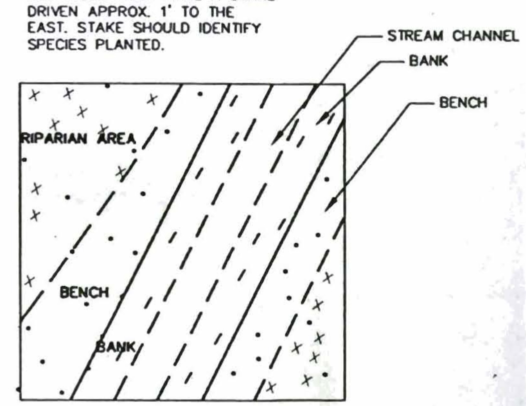
4. Soil at this point must be firmly packed around the seedling that the seedling doesn't move when given a firm tug. Leave the second hole

Citation:
Prepared by: Robert Bardon and Bill Gardner, Extension Forestry Specialists, North Carolina State University
Published by: NORTH CAROLINA COOPERATIVE EXTENSION SERVICE

PLANTING WITH A DIBBLE "PLANTING" BAR

N.T.S.

ALL TREES MUST HAVE A STAKE DRIVEN APPROX. 1' TO THE EAST. STAKE SHOULD IDENTIFY SPECIES PLANTED.

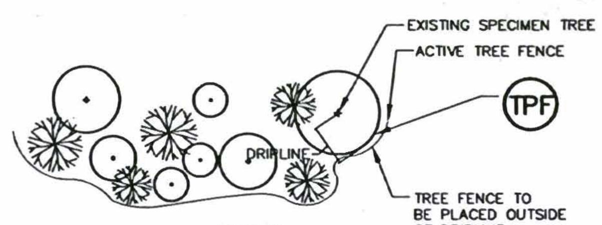


× TREE – 10' o.c.
• SHRUB – 6' o.c
/ LIVE STAKE – 3' o.c

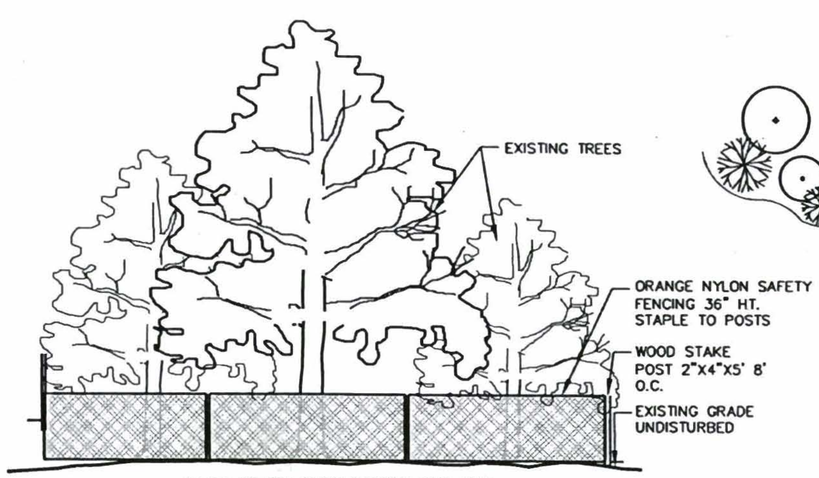
NOTES:
1. ALL TREE PLANTINGS 10' APART. ALL SHRUB PLANTINGS MIN. 6' APART.
2. ALL PLANTINGS MIN. 5' FROM ZONE EDGES.
3. SPECIES AND PLANTING ZONES ARE IDENTIFIED ON PLAN.
4. PLANT RANDOMLY BY SPECIES AND SPACING.

RANDOM PLANTING DETAIL

NTS



PLAN



ALLOW NO FILL OVER CANOPY DRIP LINE

ELEVATION

TREE PROTECTION FENCING DETAIL

N.T.S.

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DRAWN: MXD	JOB NO. 03060003	SCALE: AS SHOWN		

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TBMILLER

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PLANTING DETAILS

NOT TO SCALE

Montane Alluvial Forest - Piedmont/Mountain Alluvial Forest Intermediate Community
Stream banks and Adjacent Riparian Planting List - Woody Species

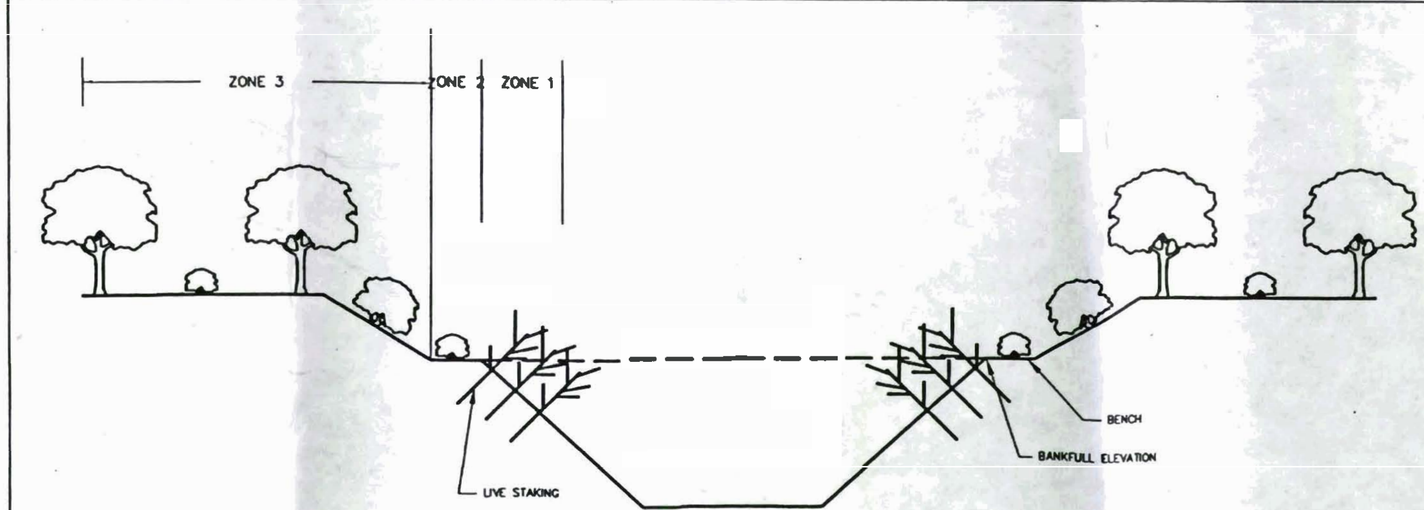
Zone(s)	Common Name	Scientific Name	Wetl Ind. Stat.	Size	Spacing	Quantity
Trees/Overstory						
3	Tulip tree	*Liriodendron tulipifera*	FAC	24" or > b.r.	10-feet O.C. random	127
3	Black Cherry	*Prunus serotina*	FACU	24" or > b.r.	10-feet O.C. random	127
3	White oak	Quercus alba	FACU	24" or > b.r.	10-feet O.C. random	127
3	American sycamore	*Platanus occidentalis*	FACW-	24" or > b.r.	10-feet O.C. random	380
3	River birch	*Betula nigra*	FACW	24" or > b.r.	10-feet O.C. random	253
3	Red maple	*Acer rubrum*	FAC	24" or > b.r.	10-feet O.C. random	253
	Total Trees					1,267
Shrubs/Understory						
2	American holly	*Ilex opaca*	FAC-	24" or > b.r.	6-feet O.C. random	146
3/2	Alder	*Alnus serrulata*	FACW	24" or > b.r.	6-feet O.C. random	76 / 146
3/2	Silky dogwood	*Cornus amomum*	FACW	24" or > b.r.	6-feet O.C. random	76 / 194
3/2	Spicebush	*Lindera benzoin*	OBL	24" or > b.r.	6-feet O.C. random	51 / 194
3/2	Ironwood	*Carpinus caroliniana*	FAC	24" or > b.r.	6-feet O.C. random	51 / 97
2	Smooth sumac	*Rhus glabra*	N/A	24" or > b.r.	6-feet O.C. random	97
	Total shrubs Zones 3/2					254 / 874
Live Stakes						
1	Black willow	*Salix nigra*	FACW	36" or >	3-feet O.C. random	1,586
1	Ninebark	*Physiocarpus opulifolius*	FAC-	36" or >	3-feet O.C. random	1,539
1	Silky dogwood	*Cornus amomum*	FACW	36" or >	3-feet O.C. random	1,539
	Total stakes					4,664

Temporary Seeding Specification

Species	Common Name	Planting Dates (Mountains)	Seed Mixture	Seed (lbs/acre)
Secale cereale	Rye grain	August 15 - May 15	40%	30
Triticum aestivum	Winter Wheat	August 15 - May 15	40%	30
Setaria italica	German millet	May 15 - August 15	10%	10
Urachloa ramosa	Browntop millet	May 15 - August 15	10%	10
Total			100%	80
* Seed available from Ernst Seeds:				
www.ernstseed.com				
800-873-3321				
814-336-5191 (fax)				

Grass Seeding Specification - Permanent Seed Mix

Species	Common Name	Type	Optimal Planting Dates	Seed Mixture	Seed (lbs/acre)
Panicum virgatum	Switchgrass	warm season	Dec 1 - April 15	33%	5
Panicum clandestinum	Deer tongue	warm season	Dec 1 - April 15	23%	3.5
Sorghastrum nutans	Indian grass	warm season	Dec 1 - April 16	17%	2.5
Elymus hystrix	Eastern bottlebrush grass	Cool season	March 1 - May 15, July 15 - Aug. 15	13%	2
Juncus effusus	Soft rush	wetland	Dec 1 - May 15, Aug. 15 - Oct 15	13%	2
Total				100%	15
* Seed available from Ernst Seeds:					
www.ernstseed.com					
800-873-3321					
814-336-5191 (fax)					



TYPICAL PLANTING DETAIL

N.T.S.

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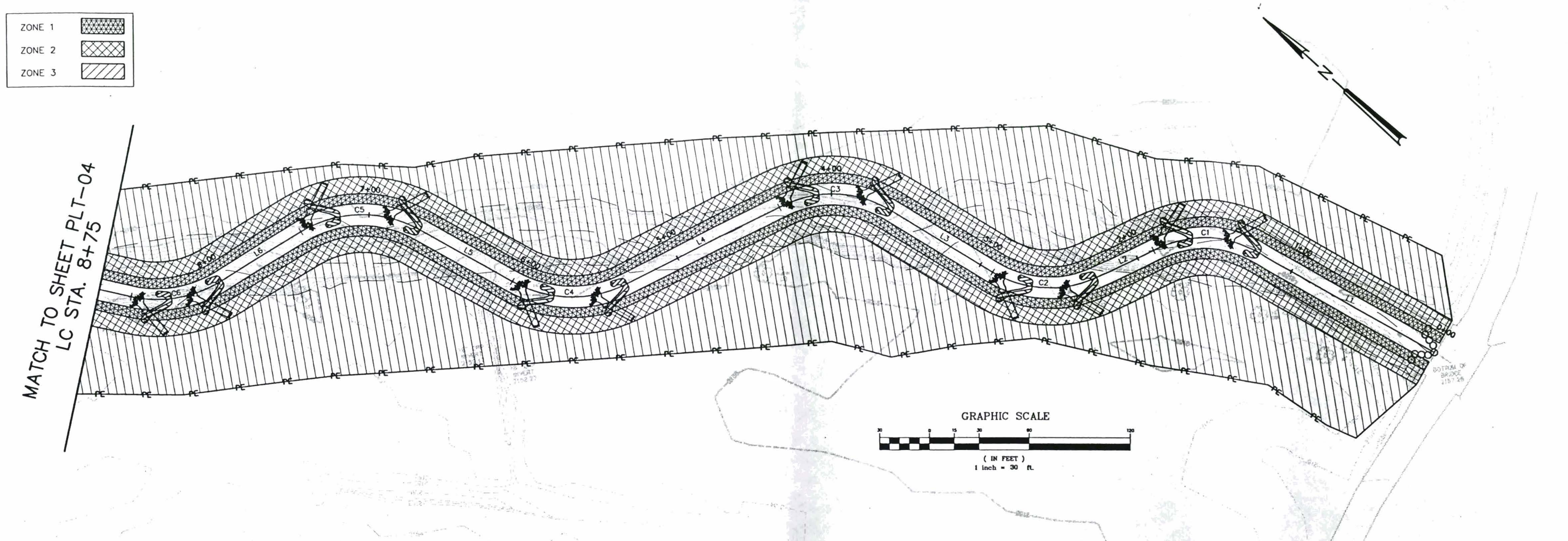

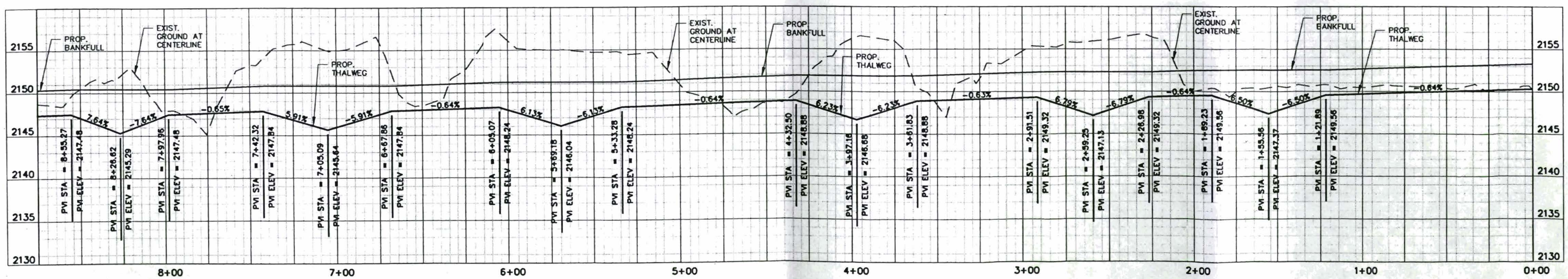

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VER. SCALE 1"=6'

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PLT-03
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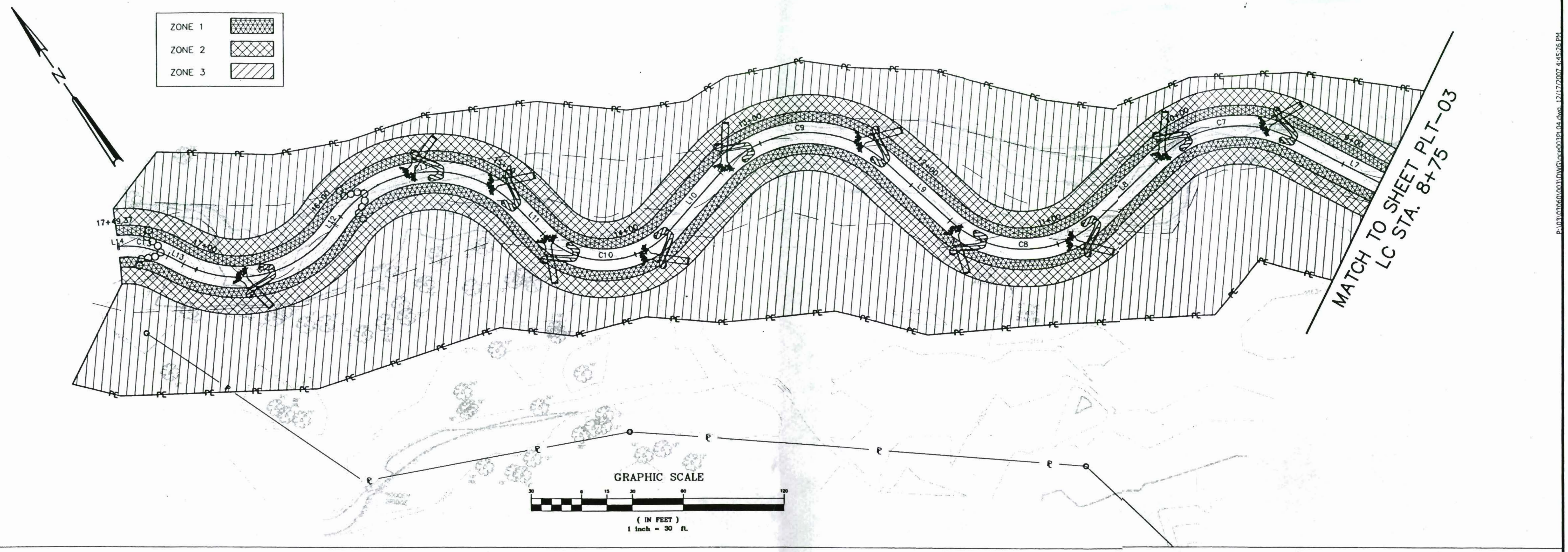

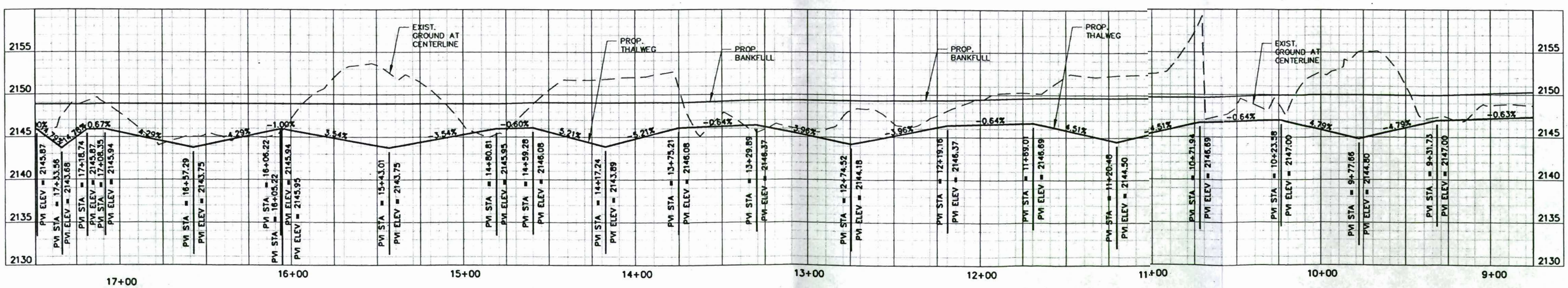

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SECTION 10
APPENDICES

Appendix 1 - Project Site Photos

Appendix 2 - Project Site NCDWQ Stream Classification Forms

Appendix 3 – Reference Site Photos

Appendix 4 - Reference Site NCDWQ Stream Classification Forms

Appendix 5 – HEC-RAS Analysis

Appendix 6 – Supporting Documentation

APPENDIX 1
PROJECT SITE PHOTOS

1. Main Channel Bank Erosion
7.3.2007

2. Vertical, Bare Bank
7.3.2007

3. Typical Beaver Dam
7.3.2007

4. Wetland Ditch
7.3.2007

Prepared For: Ecosystem Enhancement Program	Lewis Creek Restoration Plan	Date: December 2007
	Appendix 1. Project Site Photos	Jordan Jones & Goulding Incorporated

5. Mid-Channel Bar at RD Bridge
7.3.2007

6. Sediment Deposition
7.3.2007

7. Crest Gauge Looking Downstream
7.3.2007

Prepared For: Ecosystem Enhancement Program	Lewis Creek Restoration Plan	Date: December 2007
	Appendix 1. Project Site Photos	Jordan Jones & Goulding Incorporated

8. Main Channel Typical Riffle Cross-Section
Looking Upstream 7.3.2007

9. Main Channel Typical Riffle Cross-Section
Looking Downstream 7.3.2007

10. Main Channel Typical Run Cross-Section
Looking Upstream 7.3.2007

11. Main Channel Typical Run Cross-Section
Looking Downstream 7.3.2007

Prepared For: Ecosystem Enhancement Program	Lewis Creek Restoration Plan	Date: December 2007
	Appendix 1. Project Site Photos	Jordan Jones & Goulding

12. Main Channel Typical Pool Cross-Section
Looking Upstream 7.3.2007

13. Main Channel Typical Pool Cross-Section
Looking Downstream 7.3.2007

Prepared For:	Lewis Creek Restoration Plan	Date: December 2007
Ecosystem	**Appendix 1. Project Site Photos**	Jordan Jones & Goulding

APPENDIX 2
PROJECT SITE NCDWQ STREAM CLASSIFICATION FORMS

NCDWQ Stream Classification Form

Project Name: LEWIS CREEK River Basin: FRENCH BROAD County: HENDERSON Evaluator: KMY
DWQ Project Number: Nearest Named Stream: LEWIS Latitude: 82° 80' 57" Signature: KMY
Date: FEBRUARY/2007 USGS QUAD: BAT CAVE Longitude: 35° 22' 41" Location/Directions:

***PLEASE NOTE:** *If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used**

Primary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	2	3
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	1	2	3
3) Are Natural Levees Present?	0	1	2	3
4) Is The Channel Sinuous?	0	1	2	3
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	3
6) Is The Channel Braided?	0	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	3
8) Is There A Bankfull Bench Present?	0	1	2	3
9) Is a Continuous Bed & Bank Present?	0	1	2	3
*(*NOTE: If Bed & Bank Caused By Ditching And WITHOUT Sinuosity Then Score=0*)*				
10) Is a 2nd Order Or Greater Channel (As Indicated On Topo Map *And/Or* In Field) Present?	*Yes*=3		*No*=0	

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 13

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	3

PRIMARY HYDROLOGY INDICATOR POINTS: 1

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	1	0
2) Are Rooted Plants Present In Streambed?	3	2	1	0
3) Is Periphyton Present?	0	1	2	3
4) Are Bivalves Present?	0	1	2	3

PRIMARY BIOLOGY INDICATOR POINTS: 4

Secondary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	0	.5	1	1.5
2) Is There A Grade Control Point In Channel?	0	.5	1	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	1.5

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 1

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last Year's) Leaflitter Present In Streambed?	1.5	1	.5	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	1	1.5
3) Are Wrack Lines Present?	0	.5	1	1.5

4) Is Water In Channel *And* >48 Hrs. Since Last *Known* Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5
5) Is There Water In Channel During Dry Conditions *Or* In Growing Season)?	0	.5	1	1.5
6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)?		*Yes=1.5*		*No*=0

SECONDARY HYDROLOGY INDICATOR POINTS: 6.5

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fish Present?	0	.5	1	1.5
2) Are Amphibians Present?	0	.5	1	1.5
3) Are AquaticTurtles Present?	0	.5	1	1.5
4) Are Crayfish Present?	0	.5	1	1.5
5) Are Macrobenthos Present?	0	.5	1	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5	1	1.5
7) Is Filamentous Algae Present?	0	.5	1	1.5

8) Are Wetland Plants In Streambed?	SAV	Mostly OBL	Mostly FACW	Mostly FAC	Mostly FACU	Mostly UPL
(NOTE: If Total Absence Of All Plants In Streambed As Noted Above Skip This Step UNLESS SAV Present*).*	2	1	.75	.5	0	0

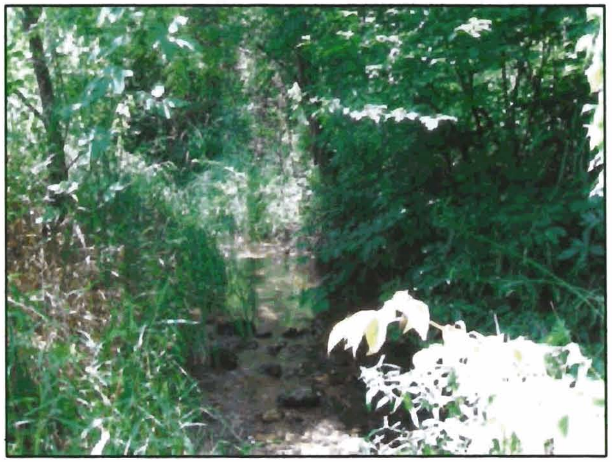
SECONDARY BIOLOGY INDICATOR POINTS: 2.5

TOTAL POINTS **(Primary + Secondary) =** 28 ***(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)***

Notes:

APPENDIX 3
REFERENCE SITE PHOTOS

1. Raccoon Creek Typical Riffle Cross-Section
7.12.2007



2. Raccoon Creek Typical Pool Cross-Section
7.12.2007

3. Raccoon Creek Typical Pool Cross-Section
7.12.2007

4. Raccoon Creek Typical Run Cross-Section
7.12.2007

Prepared For: Ecosystem Enhancement Program	Lewis Creek Restoration Plan	Date: December 2007
	Appendix 3. Reference Site Photos	Jordan Jones & Goulding

APPENDIX 4
REFERENCE SITE NCDWQ STREAM CLASSIFICATION FORMS

NCDWQ Stream Classification Form

Project Name: RACCOON CREEK River Basin: FRENCH BROAD County: HAYWOOD Evaluator: KMY
DWQ Project Number: Nearest Named Stream: RACCOON Latitude: 35.4795 Signature: [illegible]
Date: JULY 2007 USGS QUAD: WAYNESVILLE Longitude: -82.9646 Location/Directions:

PLEASE NOTE:** ***If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used*

Primary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	2	3
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	1	2	3
3) Are Natural Levees Present?	0	1	2	3
4) Is The Channel Sinuous?	0	1	2	3
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	3
6) Is The Channel Braided?	0	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	3
8) Is There A Bankfull Bench Present?	0	1	2	3
9) Is a Continuous Bed & Bank Present?	0	1	2	3

*(*NOTE: If Bed & Bank Caused By Ditching And WITHOUT Sinuosity Then Score=0*)*

10) Is a 2nd Order Or Greater Channel (As Indicated On Topo Map *And/Or* In Field) Present? *Yes*=3 *No*=0

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 18

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	3

PRIMARY HYDROLOGY INDICATOR POINTS: 2

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	1	0
2) Are Rooted Plants Present In Streambed?	3	2	1	0
3) Is Periphyton Present?	0	1	2	3
4) Are Bivalves Present?	0	1	2	3

PRIMARY BIOLOGY INDICATOR POINTS: 10

Secondary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	0	.5	1	1.5
2) Is There A Grade Control Point In Channel?	0	.5	1	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	1.5

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 2.5

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last Year's) Leaflitter Present In Streambed?	1.5	1	.5	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	1	1.5
3) Are Wrack Lines Present?	0	.5	1	1.5

4) Is Water In Channel ***And*** >48 Hrs. Since Last ***Known*** Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5
5) Is There Water In Channel During Dry Conditions ***Or*** In Growing Season)?	0	.5	1	1.5
6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)?		*Yes=1.5*		*No=0*

SECONDARY HYDROLOGY INDICATOR POINTS: 5.5

III. Biology	**Absent**	**Weak**	**Moderate**	**Strong**
1) Are Fish Present?	0	.5	1	1.5
2) Are Amphibians Present?	0	.5	1	1.5
3) Are AquaticTurtles Present?	0	.5	1	1.5
4) Are Crayfish Present?	0	.5	1	1.5
5) Are Macrobenthos Present?	0	.5	1	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5	1	1.5
7) Is Filamentous Algae Present?	0	.5	1	1.5

8) Are Wetland Plants In Streambed?	**SAV**	**Mostly OBL**	**Mostly FACW**	**Mostly FAC**	**Mostly FACU**	**Mostly UPL**
(NOTE: If Total Absence Of All Plants In Streambed As Noted Above Skip This Step UNLESS SAV Present*).*	2	1	.75	.5	0	0

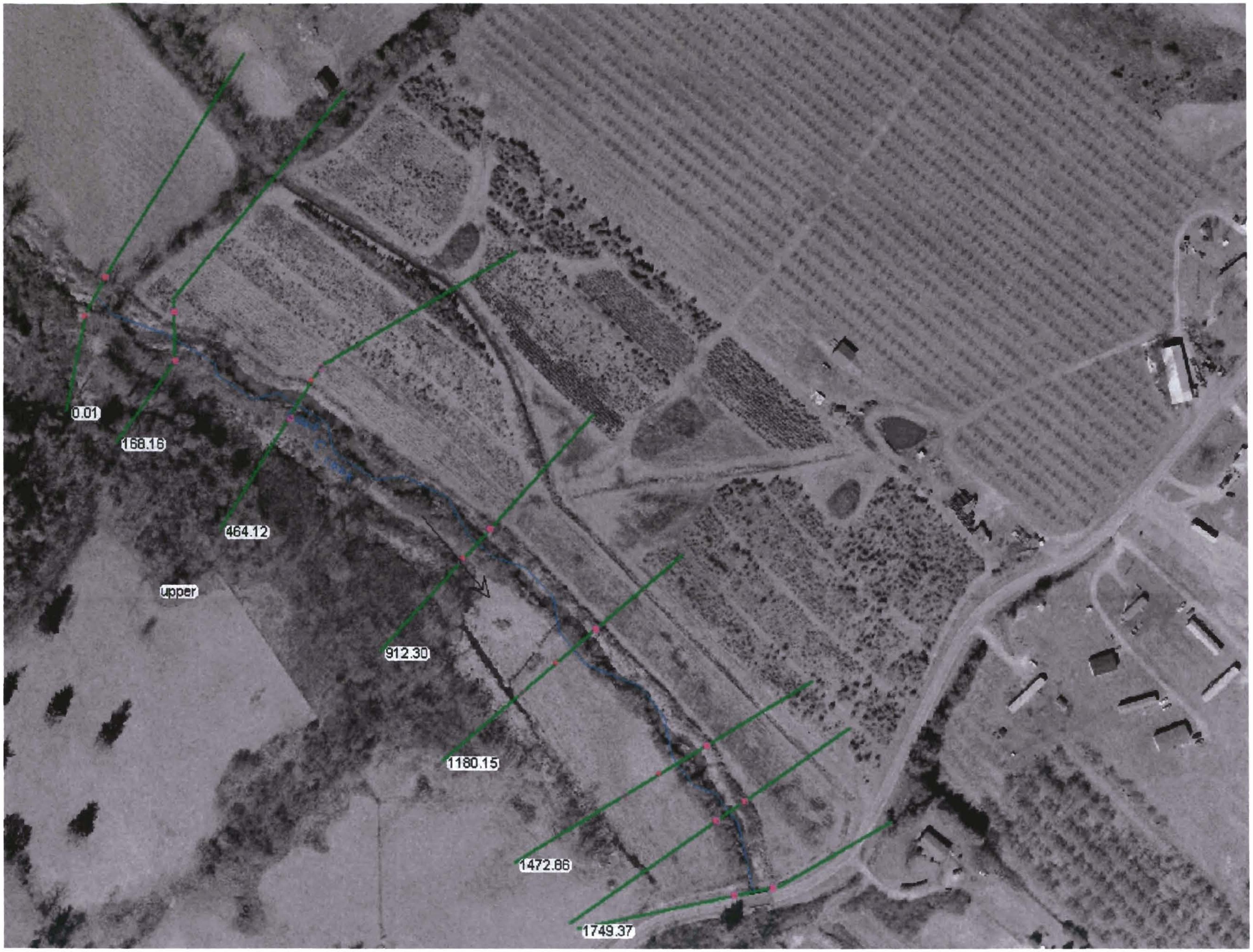
SECONDARY BIOLOGY INDICATOR POINTS: 5

TOTAL POINTS* (Primary + Secondary)** = 41 ***(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)

Notes:

APPENDIX 5
HEC-RAS ANALYSIS

Lewis Creek Existing HECRAS Geometry and Cross-Section Stations



Lewis Creek Proposed HECRAS Geometry and Cross-Section Stations

HEC-RAS Plan: lewis River: Lewis Creek Reach: upper

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Shear Chan
			(cfs)	(ft)	(ft)	(ft/s)	(ft)	(lb/sq ft)
upper	0.01	2 Yrs	357.00	2145.73	2150.53	2.79	53.60	0.40
upper	0.01	5 Yrs	619.00	2145.73	2149.38	8.10	36.84	3.66
upper	0.01	10 Yrs	836.00	2145.73	2149.95	8.36	46.25	3.85
upper	0.01	25 Yrs	1164.00	2145.73	2151.56	3.43	456.86	0.55
upper	0.01	50 Yrs	1452.00	2145.73	2151.83	3.59	578.42	0.59
upper	0.01	100 Yrs	1772.00	2145.73	2152.11	3.76	602.64	0.63
upper	0.01	(1.5 Yrs)	98.00	2145.73	2148.53	2.03	29.61	0.25
upper	0.01	BKFL	140.00	2145.73	2148.99	2.23	33.46	0.29
upper	189.19	2 Yrs	357.00	2145.98	2151.11	3.12	49.81	0.54
upper	189.19	5 Yrs	619.00	2145.98	2152.00	3.87	52.12	0.76
upper	189.19	10 Yrs	836.00	2145.98	2152.46	3.82	201.56	0.72
upper	189.19	25 Yrs	1164.00	2145.98	2151.98	7.35	52.05	2.75
upper	189.19	50 Yrs	1452.00	2145.98	2152.05	8.95	52.23	4.06
upper	189.19	100 Yrs	1772.00	2145.98	2152.51	7.94	202.32	3.07
upper	189.19	(1.5 Yrs)	98.00	2145.98	2149.02	2.37	18.06	0.33
upper	189.19	BKFL	140.00	2145.98	2149.55	2.71	24.38	0.43
upper	457.53	2 Yrs	357.00	2145.74	2152.23	3.48	53.08	0.64
upper	457.53	5 Yrs	619.00	2145.74	2153.07	3.54	225.12	0.60
upper	457.53	10 Yrs	836.00	2145.74	2153.43	4.05	229.66	0.77
upper	457.53	25 Yrs	1164.00	2145.74	2153.88	2.27	613.60	0.23
upper	457.53	50 Yrs	1452.00	2145.74	2154.18	2.44	627.30	0.27
upper	457.53	100 Yrs	1772.00	2145.74	2154.28	2.85	631.61	0.36
upper	457.53	(1.5 Yrs)	98.00	2145.74	2149.72	2.31	13.49	0.29
upper	457.53	BKFL	140.00	2145.74	2150.48	2.57	19.98	0.37
upper	887.10	2 Yrs	357.00	2147.77	2153.81	3.38	31.46	0.57
upper	887.10	5 Yrs	619.00	2147.77	2154.52	4.32	184.25	0.89
upper	887.10	10 Yrs	836.00	2147.77	2155.02	4.74	202.99	1.03
upper	887.10	25 Yrs	1164.00	2147.77	2153.95	10.54	32.12	5.50
upper	887.10	50 Yrs	1452.00	2147.77	2154.88	8.72	197.73	3.52
upper	887.10	100 Yrs	1772.00	2147.77	2155.22	9.30	210.42	3.90
upper	887.10	(1.5 Yrs)	98.00	2147.77	2151.00	2.83	16.37	0.47
upper	887.10	BKFL	140.00	2147.77	2151.88	2.68	23.91	0.42
upper	1138.67	2 Yrs	357.00	2148.40	2154.66	3.82	26.01	0.72
upper	1138.67	5 Yrs	619.00	2148.40	2155.69	5.05	37.44	1.21
upper	1138.67	10 Yrs	836.00	2148.40	2155.97	3.12	298.84	0.45
upper	1138.67	25 Yrs	1164.00	2148.40	2156.76	2.97	316.34	0.39
upper	1138.67	50 Yrs	1452.00	2148.40	2156.93	3.47	319.86	0.52
upper	1138.67	100 Yrs	1772.00	2148.40	2157.35	3.62	329.97	0.55
upper	1138.67	(1.5 Yrs)	98.00	2148.40	2151.97	2.70	15.11	0.41
upper	1138.67	BKFL	140.00	2148.40	2152.74	2.85	18.55	0.44
upper	1420.41	2 Yrs	357.00	2148.17	2155.55	2.59	41.39	0.34
upper	1420.41	5 Yrs	619.00	2148.17	2156.92	1.74	310.34	0.14
upper	1420.41	10 Yrs	836.00	2148.17	2156.63	4.48	49.28	0.96
upper	1420.41	25 Yrs	1164.00	2148.17	2157.19	2.91	318.32	0.39
upper	1420.41	50 Yrs	1452.00	2148.17	2157.45	3.25	325.96	0.48
upper	1420.41	100 Yrs	1772.00	2148.17	2157.86	3.40	337.53	0.51

HEC-RAS Plan: lewis River: Lewis Creek Reach: upper (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Shear Chan
			(cfs)	(ft)	(ft)	(ft/s)	(ft)	(lb/sq ft)
upper	1420.41	(1.5 Yrs)	98.00	2148.17	2152.63	1.85	18.40	0.19
upper	1420.41	BKFL	140.00	2148.17	2153.42	2.01	24.24	0.22
upper	1542.86	2 Yrs	357.00	2149.92	2155.78	2.58	40.00	0.32
upper	1542.86	5 Yrs	619.00	2149.92	2156.96	3.30	42.73	0.49
upper	1542.86	10 Yrs	836.00	2149.92	2157.14	4.28	43.07	0.82
upper	1542.86	25 Yrs	1164.00	2149.92	2157.24	5.83	43.39	1.51
upper	1542.86	50 Yrs	1452.00	2149.92	2157.70	3.99	294.09	0.70
upper	1542.86	100 Yrs	1772.00	2149.92	2158.09	2.72	496.80	0.32
upper	1542.86	(1.5 Yrs)	98.00	2149.92	2152.88	2.51	23.61	0.39
upper	1542.86	BKFL	140.00	2149.92	2153.66	2.30	31.38	0.31
upper	1691.34	2 Yrs	357.00	2149.48	2156.00	1.83	46.69	0.15
upper	1691.34	5 Yrs	619.00	2149.48	2157.27	2.40	52.11	0.24
upper	1691.34	10 Yrs	836.00	2149.48	2157.64	3.01	53.69	0.38
upper	1691.34	25 Yrs	1164.00	2149.48	2158.13	3.83	56.46	0.60
upper	1691.34	50 Yrs	1452.00	2149.48	2158.02	4.87	55.33	0.98
upper	1691.34	100 Yrs	1772.00	2149.48	2158.09	5.87	55.90	1.42
upper	1691.34	(1.5 Yrs)	98.00	2149.48	2153.18	1.22	34.65	0.08
upper	1691.34	BKFL	140.00	2149.48	2153.90	1.31	37.73	0.09

HEC-RAS Plan: Lewis Prop. River: Lewis Creek Reach: upper

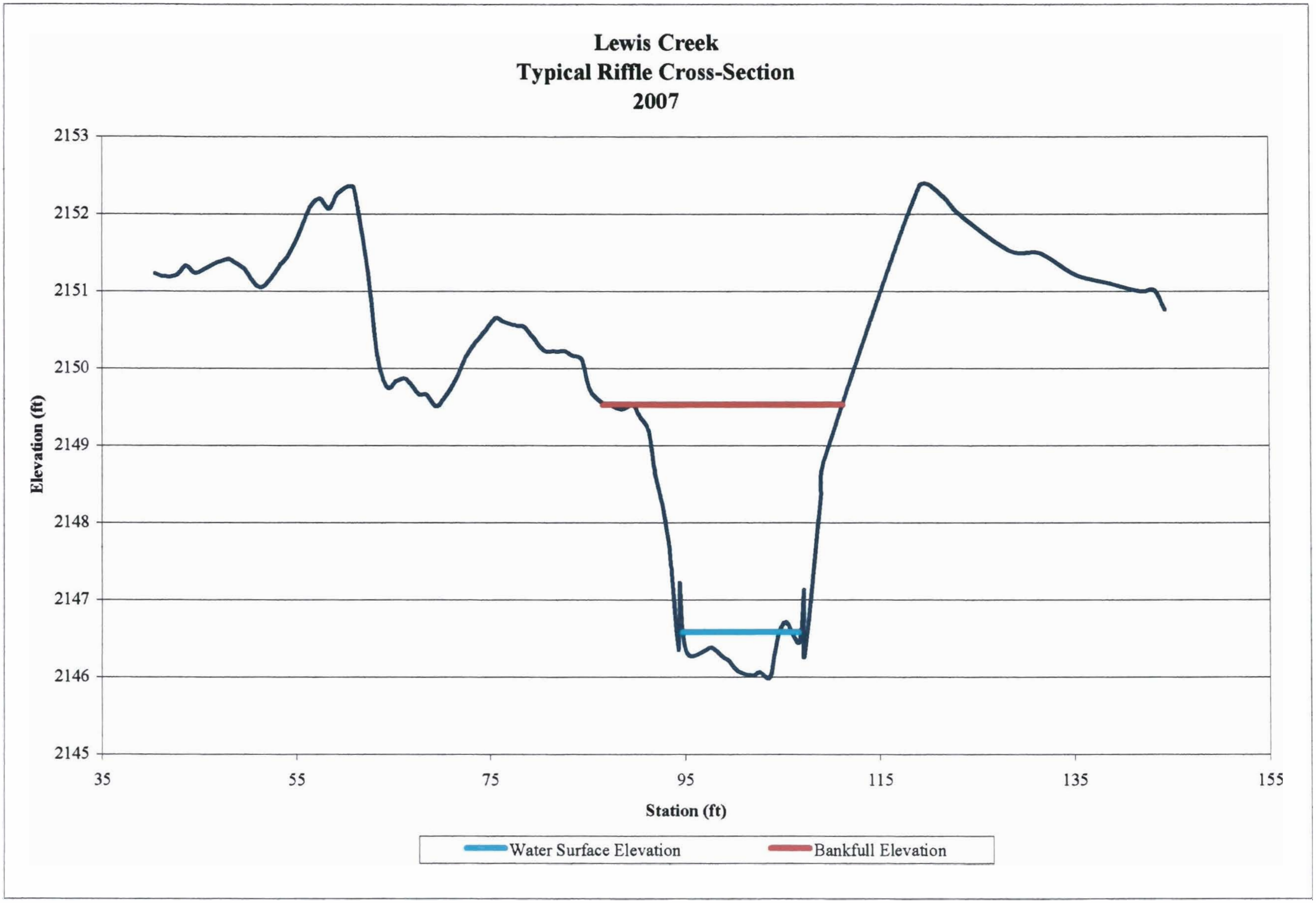
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Shear Chan
			(cfs)	(ft)	(ft)	(ft/s)	(ft)	(lb/sq ft)
upper	0.01	2 Yrs	357.00	2145.87	2150.25	2.47	364.21	0.34
upper	0.01	5 Yrs	619.00	2145.87	2150.76	2.78	396.38	0.40
upper	0.01	10 Yrs	836.00	2145.87	2151.09	2.92	418.62	0.43
upper	0.01	25 Yrs	1164.00	2145.87	2151.50	3.09	446.34	0.47
upper	0.01	50 Yrs	1452.00	2145.87	2151.80	3.21	467.14	0.50
upper	0.01	100 Yrs	1772.00	2145.87	2152.05	3.32	626.67	0.52
upper	0.01	(1.5 Yrs)	98.00	2145.87	2148.32	2.24	22.81	0.29
upper	0.01	BKFL	140.00	2145.87	2149.23	1.85	54.12	0.22
upper	168.16	2 Yrs	357.00	2145.10	2150.63	2.37	60.86	0.30
upper	168.16	5 Yrs	619.00	2145.10	2151.19	3.32	66.05	0.56
upper	168.16	10 Yrs	836.00	2145.10	2151.52	3.91	165.68	0.75
upper	168.16	25 Yrs	1164.00	2145.10	2151.92	4.61	200.08	1.02
upper	168.16	50 Yrs	1452.00	2145.10	2152.21	5.12	412.77	1.24
upper	168.16	100 Yrs	1772.00	2145.10	2152.46	5.47	418.83	1.39
upper	168.16	(1.5 Yrs)	98.00	2145.10	2148.66	1.82	23.75	0.18
upper	168.16	BKFL	140.00	2145.10	2149.55	1.54	50.81	0.14
upper	464.12	2 Yrs	357.00	2144.57	2151.17	2.19	79.30	0.25
upper	464.12	5 Yrs	619.00	2144.57	2151.98	2.76	311.33	0.37
upper	464.12	10 Yrs	836.00	2144.57	2152.45	2.89	391.12	0.39
upper	464.12	25 Yrs	1164.00	2144.57	2152.98	3.00	408.75	0.41
upper	464.12	50 Yrs	1452.00	2144.57	2153.32	2.89	590.75	0.37
upper	464.12	100 Yrs	1772.00	2144.57	2153.61	3.07	601.86	0.41
upper	464.12	(1.5 Yrs)	98.00	2144.57	2149.04	1.70	23.43	0.16
upper	464.12	BKFL	140.00	2144.57	2149.93	1.50	50.62	0.13
upper	912.30	2 Yrs	357.00	2146.05	2151.98	2.57	53.11	0.35
upper	912.30	5 Yrs	619.00	2146.05	2152.94	3.23	57.99	0.50
upper	912.30	10 Yrs	836.00	2146.05	2153.42	3.79	60.43	0.67
upper	912.30	25 Yrs	1164.00	2146.05	2153.95	4.55	145.22	0.94
upper	912.30	50 Yrs	1452.00	2146.05	2154.17	5.33	174.82	1.28
upper	912.30	100 Yrs	1772.00	2146.05	2154.47	5.97	186.20	1.57
upper	912.30	(1.5 Yrs)	98.00	2146.05	2149.71	2.15	21.49	0.26
upper	912.30	BKFL	140.00	2146.05	2150.66	1.92	46.18	0.23
upper	1180.15	2 Yrs	357.00	2146.00	2152.62	2.59	56.62	0.36
upper	1180.15	5 Yrs	619.00	2146.00	2153.65	3.09	64.95	0.47
upper	1180.15	10 Yrs	836.00	2146.00	2154.26	3.46	78.65	0.57
upper	1180.15	25 Yrs	1164.00	2146.00	2154.95	3.65	263.18	0.61
upper	1180.15	50 Yrs	1452.00	2146.00	2155.39	3.83	281.19	0.65
upper	1180.15	100 Yrs	1772.00	2146.00	2155.83	3.95	292.01	0.68
upper	1180.15	(1.5 Yrs)	98.00	2146.00	2150.24	2.15	17.65	0.25
upper	1180.15	BKFL	140.00	2146.00	2151.19	2.14	24.71	0.25
upper	1472.86	2 Yrs	357.00	2148.25	2153.47	2.93	55.44	0.47
upper	1472.86	5 Yrs	619.00	2148.25	2154.49	3.38	64.21	0.58
upper	1472.86	10 Yrs	836.00	2148.25	2155.15	3.68	106.44	0.66
upper	1472.86	25 Yrs	1164.00	2148.25	2155.77	3.86	276.59	0.69
upper	1472.86	50 Yrs	1452.00	2148.25	2156.19	3.99	283.87	0.72
upper	1472.86	100 Yrs	1772.00	2148.25	2156.60	4.12	295.37	0.75

HEC-RAS Plan: Lewis Prop. River: Lewis Creek Reach: upper (Continued)

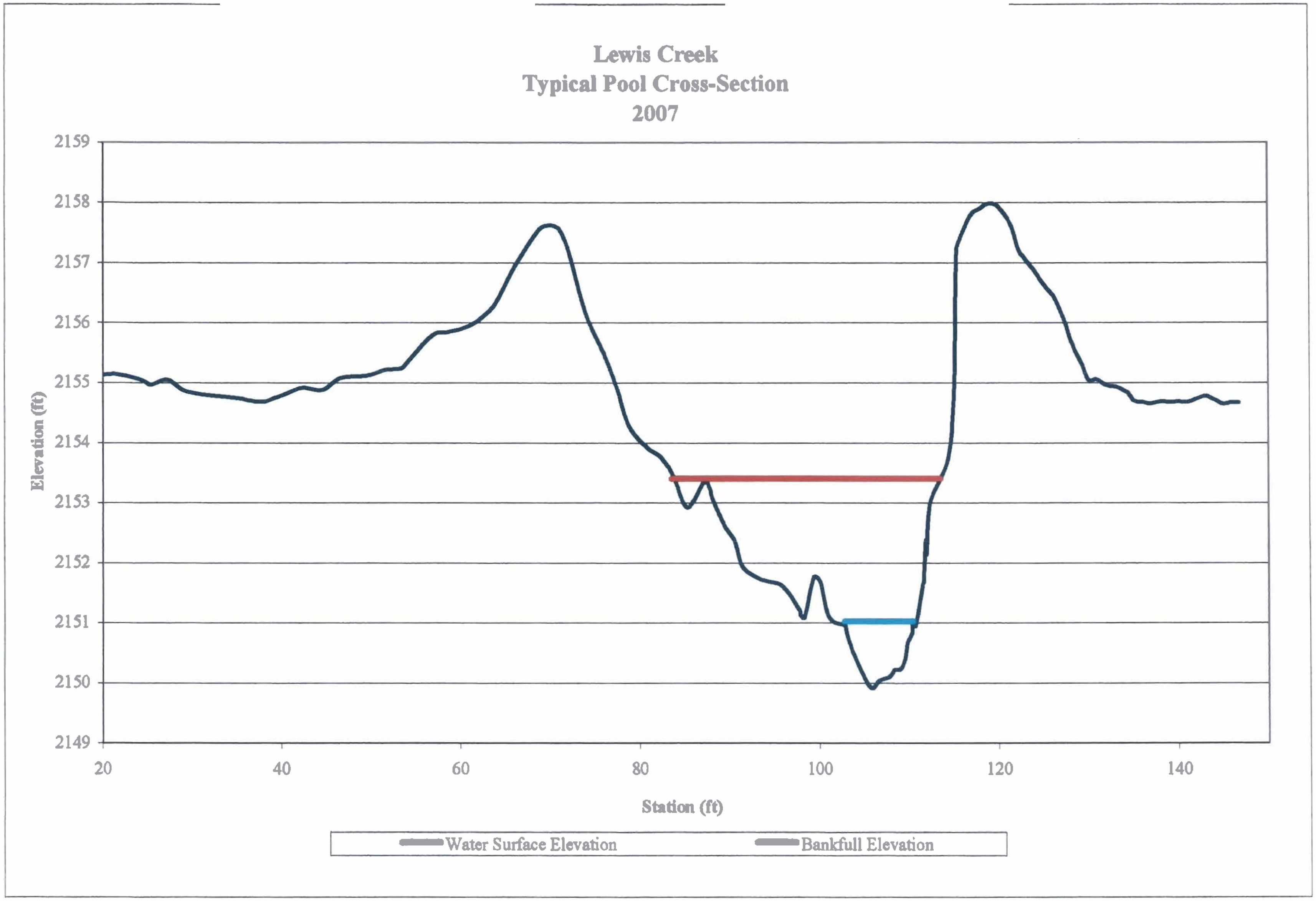
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Shear Chan
			(cfs)	(ft)	(ft)	(ft/s)	(ft)	(lb/sq ft)
upper	1472.86	(1.5 Yrs)	98.00	2148.25	2151.04	2.89	19.70	0.50
upper	1472.86	BKFL	140.00	2148.25	2151.83	2.75	23.18	0.42
upper	1602.68	2 Yrs	357.00	2147.90	2153.89	2.77	49.43	0.40
upper	1602.68	5 Yrs	619.00	2147.90	2154.90	3.44	52.21	0.57
upper	1602.68	10 Yrs	836.00	2147.90	2155.55	3.89	54.02	0.70
upper	1602.68	25 Yrs	1164.00	2147.90	2156.13	4.72	55.62	0.99
upper	1602.68	50 Yrs	1452.00	2147.90	2156.51	5.42	56.64	1.28
upper	1602.68	100 Yrs	1772.00	2147.90	2157.00	3.65	447.19	0.57
upper	1602.68	(1.5 Yrs)	98.00	2147.90	2151.55	2.33	19.78	0.31
upper	1602.68	BKFL	140.00	2147.90	2152.23	2.47	23.52	0.33
upper	1749.37	2 Yrs	357.00	2150.30	2154.37	3.32	50.41	0.61
upper	1749.37	5 Yrs	619.00	2150.30	2155.37	3.86	54.84	0.75
upper	1749.37	10 Yrs	836.00	2150.30	2156.05	4.22	57.80	0.85
upper	1749.37	25 Yrs	1164.00	2150.30	2156.74	4.86	60.87	1.08
upper	1749.37	50 Yrs	1452.00	2150.30	2157.24	5.37	63.07	1.28
upper	1749.37	100 Yrs	1772.00	2150.30	2157.12	6.73	62.55	2.02
upper	1749.37	(1.5 Yrs)	98.00	2150.30	2152.11	3.33	20.10	0.70
upper	1749.37	BKFL	140.00	2150.30	2152.70	3.33	22.47	0.65

APPENDIX 6
SUPPORTING DOCUMENTATION

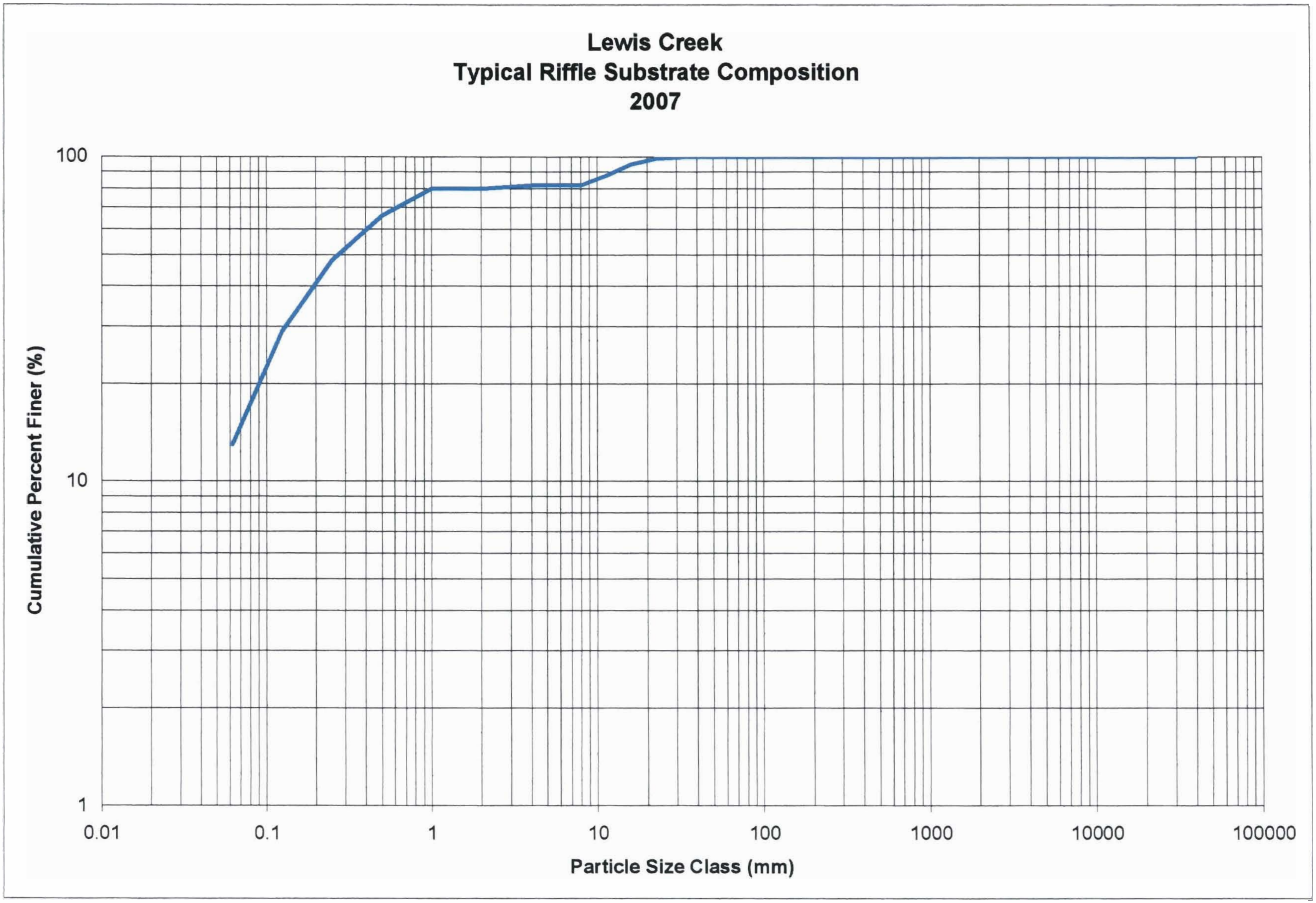
1. **Typical Riffle and Pool Cross-Section and Pebble Count Plots for Lewis Creek.**
2. **Entrainment Plots for Lewis Creek.**
3. **BEHI Raw Data Table for Lewis Creek.**

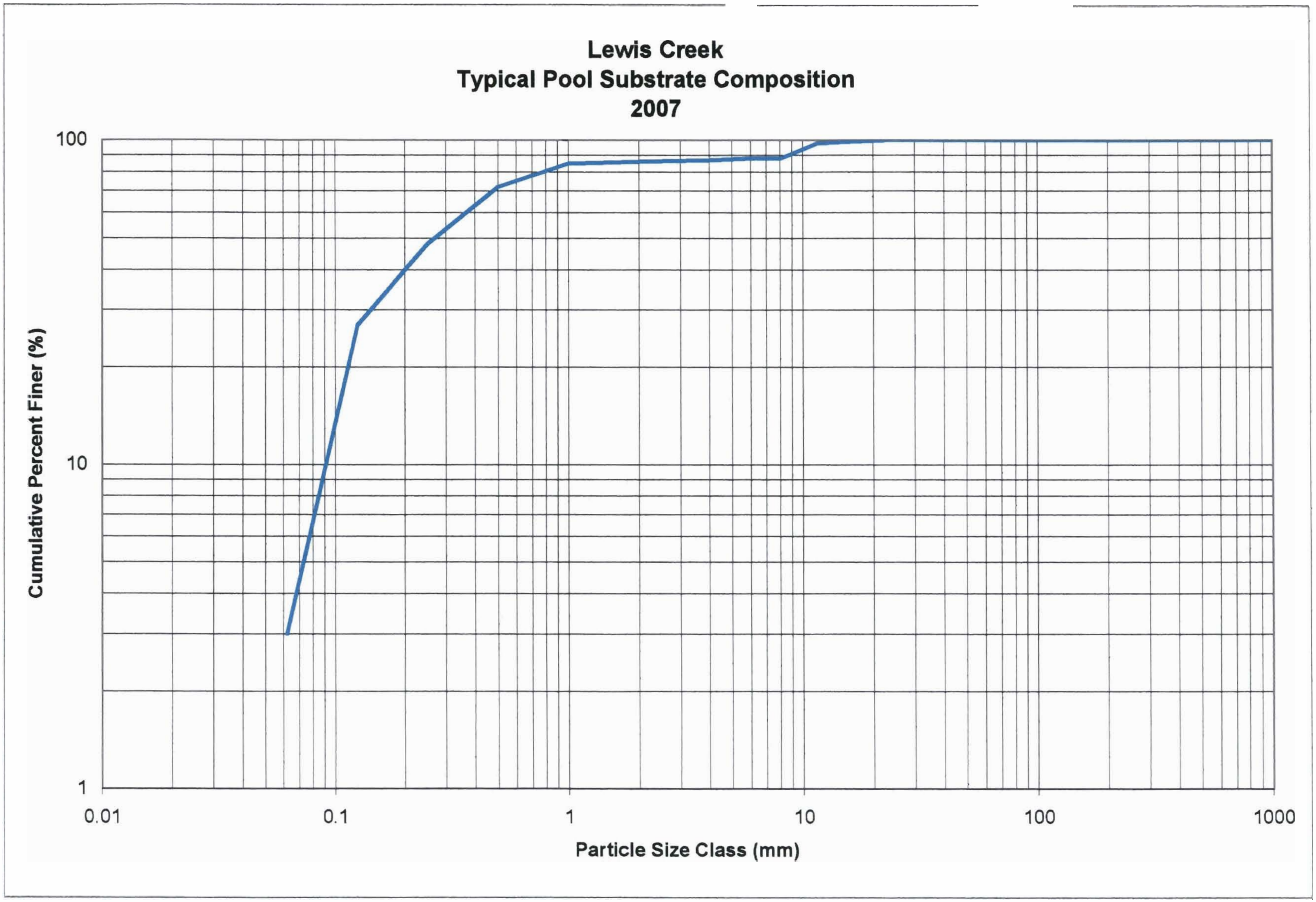


Lewis Creek
Typical Riffle Cross-Section
2007
Elevation (ft)
2153
2152
2151
2150
2149
2148
2147
2146
2145
35
55
75
95
115
135
155
Station (ft)
Water Surface Elevation
Bankfull Elevation

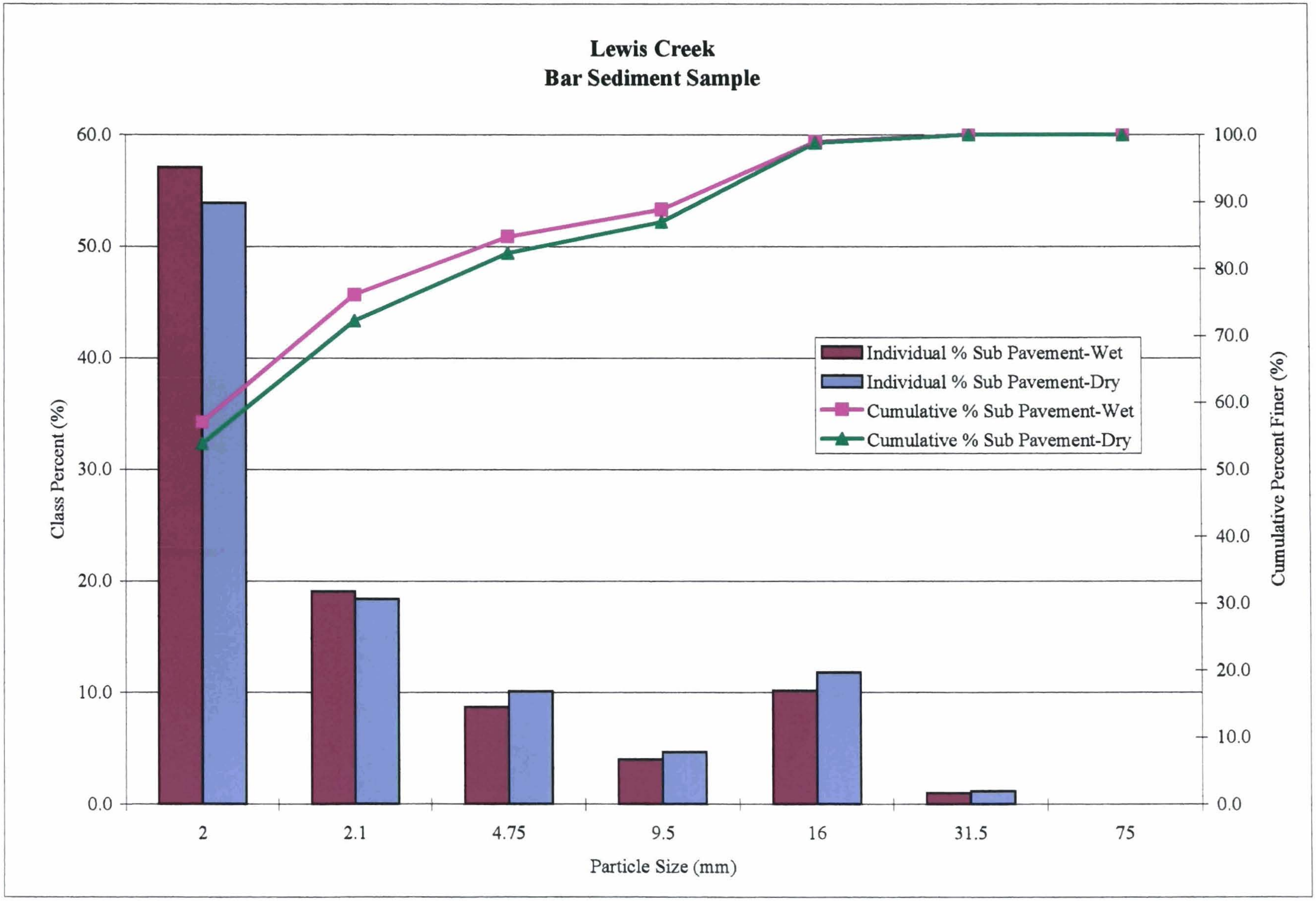


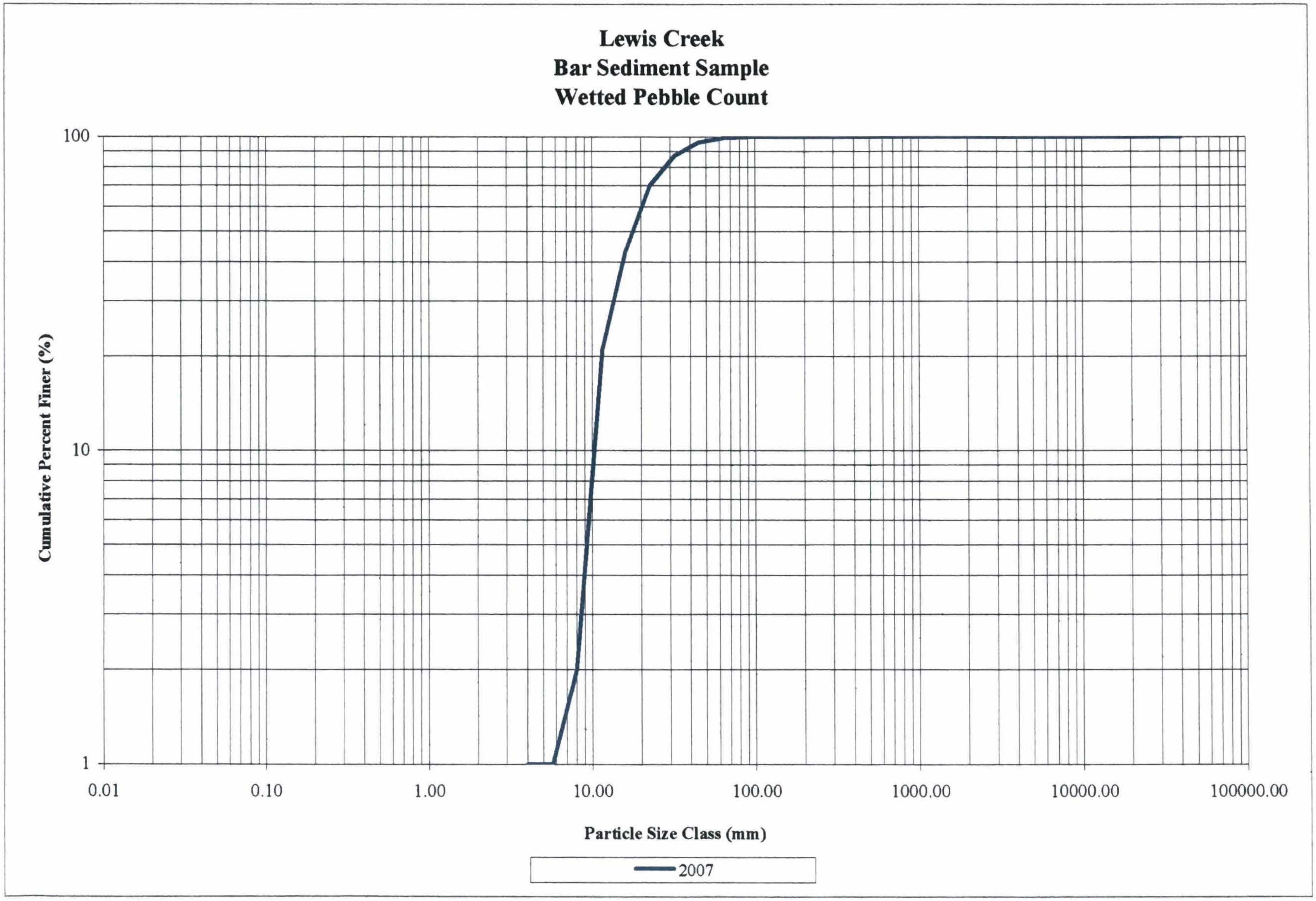
Lewis Creek
Typical Pool Cross-Section
2007
2159
2158
2157
2156
2155
2154
2153
2152
2151
2150
2149
Elevation (ft)
20
40
60
80
100
120
140
Station (ft)
Water Surface Elevation
Bankfull Elevation


Lewis Creek
Typical Riffle Substrate Composition
2007
Cumulative Percent Finer (%)
100
10
1
0.01
0.1
1
10
100
1000
10000
100000
Particle Size Class (mm)

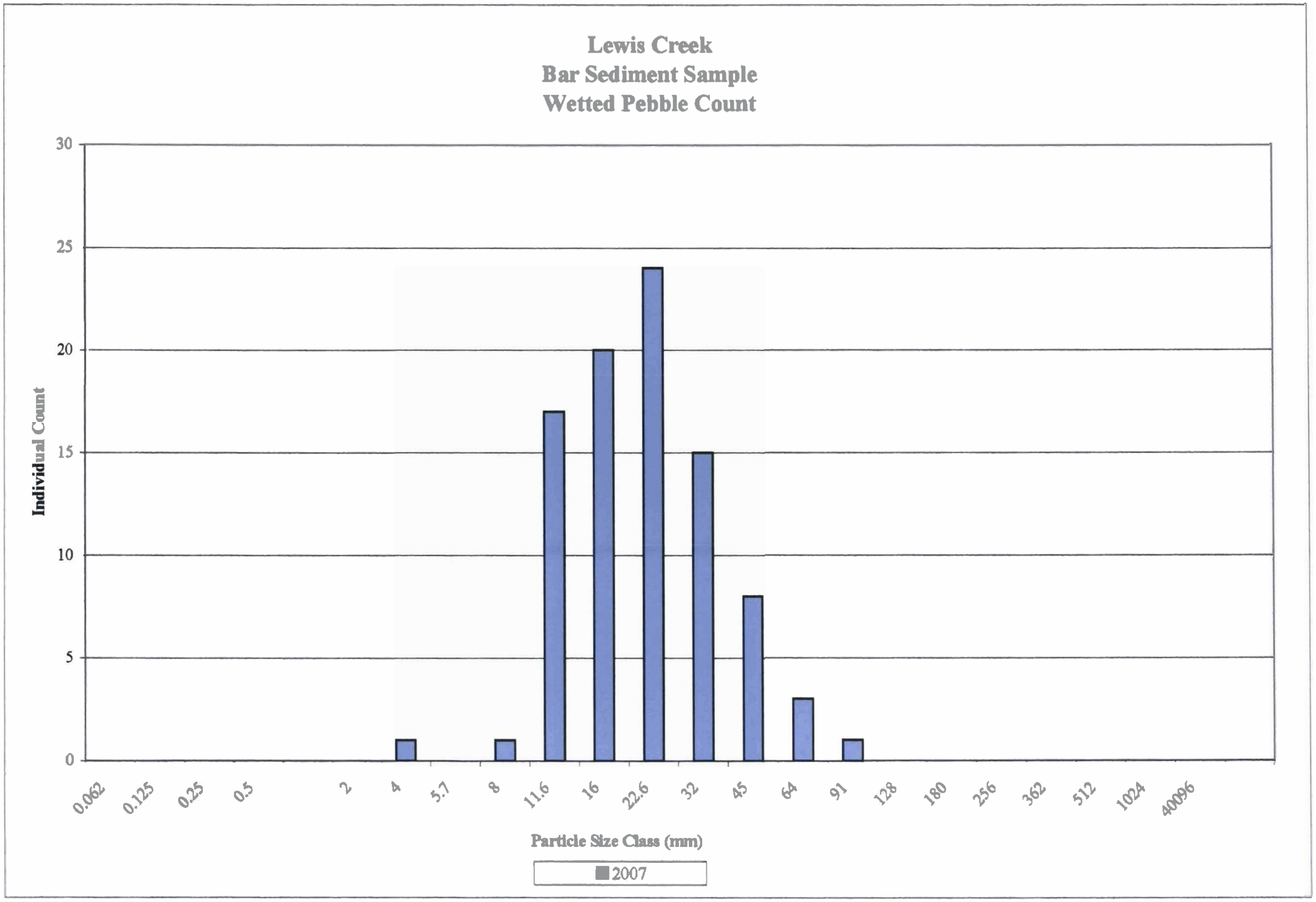


Lewis Creek
Typical Pool Substrate Composition
2007
100
10
1
Cumulative Percent Finer (%)
0.01
0.1
1
10
100
1000
Particle Size Class (mm)


Lewis Creek
Bar Sediment Sample
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Class Percent (%)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Cumulative Percent Finer (%)
Individual % Sub Pavement-Wet
Individual % Sub Pavement-Dry
Cumulative % Sub Pavement-Wet
Cumulative % Sub Pavement-Dry
2
2.1
4.75
9.5
16
31.5
75
Particle Size (mm)



Lewis Creek
Bar Sediment Sample
Wetted Pebble Count
100
10
1
Cumulative Percent Finer (%)
0.01
0.10
1.00
10.00
100.00
1000.00
10000.00
100000.00
Particle Size Class (mm)
2007



Lewis Creek
Bar Sediment Sample
Wetted Pebble Count
30
25
20
15
10
5
0
Individual Count
0.062
0.125
0.25
0.5
2
4
5.7
8
11.6
16
22.6
32
45
64
91
128
180
256
362
512
1024
40096
Particle Size Class (mm)
2007

Stream Name: Lewis Creek
Date: 7.3.2007
Field Crew: K. Young, R. Baggett

LEFT BANK					
Section Length (ft)	Bank Height (ft)	Bank Erosion Potential	Near Bank Stress	Erosion Rate (ft/yr)	Total Stream Bank Erosion (ft3/yr)
15	7	High	Low	0.1	10.5
44	7	High	Moderate	0.15	46.2
45	7	High	Low	0.1	31.5
22	7	High	Low	0.1	15.4
28	7	High	Low	0.1	19.6
25	7	High	High	0.2	35
20	7	Low	Low	0	0
50	7	Low	Low	0	0
20	7	Moderate	Moderate	0.03	4.2
65	7	Low	Low	0	0
20	7	Moderate	Moderate	0.03	4.2
15	7	Moderate	High	0.1	10.5
50	7	Low	Low	0	0
30	7	High	High	0.2	42
20	7	Moderate	Low	0.02	2.8
25	7	Moderate	Low	0.02	3.5
60	7	Low	Low	0	0
34	7	Moderate	High	0.1	23.8
30	6.25	Low	Moderate	0	0
45	8	Moderate	Moderate	0.03	10.8
10	8	Low	Moderate	0	0
50	8	Low	Low	0	0
40	8	Low	Low	0	0
30	8	Low	High	0	0
30	8	Low	Low	0	0
30	8	Low	Low	0	0
70	8	Low	Low	0	0
55	8	Moderate	High	0.1	44
12	8	Moderate	Moderate	0.03	2.88
15	8	Very High	Very High		0
				Left Bank Total (ft3/yr)	306.88

RIGHT BANK					
Section Length (ft)	Bank Height (ft)	Bank Erosion Potential	Near Bank Stress	Erosion Rate (ft/yr)	Total Stream Bank Erosion (ft3/yr)
42		Low	Low	0	0
35	7.25	Very High	Low	0.5	126.875
53	8	Extreme	Low	1	424
20	8	Very High	Low	0.5	80
14	8	Extreme	Low	1	112
12	8	Extreme	Moderate	1.25	120
25	8	Very High	High	0.9	180
20	8	Low	Low	0	0
50	8	Moderate	Low	0.02	8
15	8	Moderate	Moderate	0.03	3.6
50	8	Low	Low	0	0
35	8	High	Moderate	0.15	42
15	8	High	High	0.2	24
50	8	Moderate	Low	0.02	8
30	10	Low	Low	0	0
26	10	Moderate	Low	0.02	5.2
60	10	Low	Low	0	0
30	10	Moderate	Moderate	0.03	9
14	10	Very High	High	0.9	126
50	8	Moderate	High	0.1	40
54	8	Low	Low	0	0
50	8	Moderate	Moderate	0.03	12
40	8	Low	Low	0	0
38	8	Very High	High	0.9	273.6
30	8	Low	Low	0	0
30	8	Low	Moderate	0	0
30	8	Low	Moderate	0	0
30	8	Low	Low	0	0
10	8	Low	Low	0	0
60	8	High	High	0.2	96
				Right Bank Total (ft3/yr)	1690.275